CITRIX XENDesktop PERFORMANCE OPTIMIZATION: VIRTUALIZED DESKTOP INFRASTRUCTURE FOR 3,000 DESKTOPS

EMC XtremIO 4.0, Citrix XenDesktop 7.6, VMware vSphere 6.0

• Enhanced user experience
• Reduced cost per desktop
• Simplified deployment and maintenance

EMC Solutions

Abstract
This white paper describes the performance and configuration framework for a VDI supporting 3,000 desktops on an EMC XtremIO X-Brick, using Citrix XenDesktop 7.6 as the desktop broker and VMware vSphere 6.0 as the hypervisor.

January 2016
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Executive summary

This white paper describes the results of our testing of 3,000 desktops deployed on an EMC® XtremIO® X-Brick® using Citrix XenDesktop 7.6 as the desktop broker and VMware vSphere 6.0 as the hypervisor. Testing this solution as outlined in the Citrix Ready VDI Capacity Program for Storage Vendors, we observed the following:

- 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.
- The end-user experience was excellent throughout the test and never reached the Login VSI VSImax figure for the number of desktops being tested. Additionally, the average storage response times were below 2 milliseconds, and no I/O bottlenecks were observed throughout the testing.
- Administrators configured the XtremIO array using three simple steps and left it running. During normal desktop operations, most I/O to XtremIO consisted of random writes, but no cache sizing or tuning was required at any time.
- A data reduction ratio of 4.9:1 was achieved due to the XtremIO array’s inline data reduction technology, yielding the best dollar-per-desktop value.

Business case

Many strategies exist for solving the “storage problem” of virtual desktop infrastructure (VDI). They range from deliberately under-sizing storage requirements to intentionally crippling desktops so that they don’t issue “too many” I/O requests, to introducing additional layers of hardware and software (and their associated management pain). All complicate the administrative experience or potentially degrade the end-user experience, and they often cause VDI projects to stall or end prematurely.

XtremIO is an all-flash storage solution with built in inline data reduction, innovative data protection and load balancing, VAAI integration, and excellent performance for random I/O requests. It enables enterprises to provision virtual desktops that provide user experiences similar to tablets, ultrabooks, and physical desktops containing solid-state drives (SSDs) (as opposed to typical VDI that tries to mimic the experience of a desktop PC with a hard-disk drive). By ensuring the best user experience for VDI end users, simplifying the management of virtual machines for administrators, and providing an attractive cost per desktop, XtremIO provides customers with a great return on their VDI investment.

Table 1 describes the top VDI mistakes relevant to storage, as identified by Citrix, and how XtremIO addresses them.
Table 1. Top VDI mistakes relevant to storage

<table>
<thead>
<tr>
<th>Mistake</th>
<th>Resolution through XtremIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper storage design</td>
<td>XtremIO provides a radically simple design with linear scale-out of both performance and capacity.</td>
</tr>
<tr>
<td>Not enough cache</td>
<td>The XtremIO all-flash array architecture absorbs I/O spikes from storage-intensive applications like boot storms and antivirus scans, while inline data reduction minimizes capacity requirements of dedicated/full-clone and pooled/linked-clone desktops.</td>
</tr>
<tr>
<td>Ignoring virtual desktop optimization</td>
<td></td>
</tr>
<tr>
<td>Not managing boot storms</td>
<td></td>
</tr>
<tr>
<td>Not optimizing antivirus</td>
<td></td>
</tr>
<tr>
<td>Lack of application virtualization strategy</td>
<td>Items are relevant only for pooled/linked clones. XtremIO easily supports dedicated/full-clone desktops, which avoids these issues.</td>
</tr>
<tr>
<td>No profile strategy</td>
<td></td>
</tr>
</tbody>
</table>

Solution overview

A Citrix XenDesktop environment backed by the EMC XtremIO X-Brick for desktop storage and the EMC VNX® unified storage platform for user data provides a high-performance desktop experience with an easy-to-use storage environment. The combination of the XtremIO array and the VNX platform delivers the right storage environment for the complex storage needs of a virtual desktop environment. This system meets or exceeds the requirements of the Citrix Ready VDI Capacity Program.

Figure 1 shows the solution architecture.
Executive summary

**Key results**

The EMC XtremIO X-Brick provides sufficient capacity and performance to support 3,000 knowledge-worker users as defined by the Login VSI benchmark standards. The test case, based on the Login VSI “knowledge worker” workload, generated 58,108 IOPS and demonstrated that the XtremIO array easily handled the workload of 3,000 desktops.

**Document purpose**

This white paper describes the technical details of the validation testing, as outlined in the Citrix Ready VDI Capacity Program documentation, supporting the assertion that an XtremIO X-Brick can support 3,000 virtual desktops.

**Audience**

This paper is intended for system administrators, virtual desktop administrators, and IT professionals interested in reviewing the test results for this solution.

**We value your feedback!**

EMC and the authors of this document welcome your feedback on the solution and the solution documentation. Contact EMC.Solution.Feedback@emc.com with your comments.

**Authors:** Gary Stevenson, Ye Dai, Chhandomay Mandal, John Moran
Technology overview

Overview
The solution uses the following key components:

- Citrix XenDesktop desktop virtualization platform
- EMC XtremIO all-flash storage array

Citrix XenDesktop
Citrix XenDesktop delivers virtual Windows desktops and applications as secure services on any device. It provides a native touch-enabled look and feel that is optimized for the device type as well as the network.

XenDesktop features and benefits include:

- Flexible delivery options including VDI desktops for maximum personalization, as well as VDI desktops with Personal vDisk for maximum personalization with single-image management
- Single-image provisioning that reduces the cost and complexity of application and desktop management
- Self-service delivery of applications and desktops to users, on demand in real time
- Compatibility with five generations of Windows applications, enabling immediate mobile access to corporate applications on unsecured tablets and smartphones
- Simplified security compliance and data protection, with centralized applications and data remaining in the data center

EMC XtremIO
The EMC XtremIO all-flash storage array has a revolutionary architecture with the following elements to enable the agile data center: linear scale-out, inline all-the-time data services, and ample data center services for the workloads.

The basic hardware building block for the XtremIO array is the EMC X-Brick. Each X-Brick is made up of two active-active controller nodes and a disk array enclosure packaged together, presenting no single point of failure.

An X-Brick by itself is a high-availability, high-performance SAN appliance available in 5 TB, 10 TB, 20 TB, and 40 TB capacity configurations that can drive incredible database loads, handle thousands of virtual machines, and support thousands of virtual desktops.

The scale-out, flash-optimized, global data-reduction architecture of XtremIO allows 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 improves 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 have to be disabled, 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.

With XtremIO arrays, the logical usable amount of available storage is substantially higher than the physical flash storage due to thin provisioning and the array’s always-on, inline data reduction technologies. When additional IOPS performance or capacity is required, XtremIO scales out linearly such that two X-Brick building blocks supply twice the IOPS and capacity, four X-Brick building blocks supply four times the IOPS and capacity, and so on. The cluster grows nondisruptively: all applications remain running as you add additional X-Brick blocks to the same cluster. Latency remains consistently low as the system scales due to always-in-memory metadata architecture coupled with powerful remote direct memory access (RDMA) InfiniBand fabric within the system.

If required, the XtremIO All-Flash array can scale out by design, and additional capacity and/or performance can be configured to meet virtually any VDI requirement. If multiple X-Brick building blocks are used to form a cluster, the array inherently maintains balance across all nodes, so all desktops benefit from the entire potential performance of the cluster at all times.

The XtremIO array’s exceptional performance, capacity savings from unique data reduction capabilities, linear predictive scaling from scale-out architecture, and ease of use lead to low total cost of ownership in all virtualized workload environments.
Citrix Ready VDI Capacity Validation results

Introduction

This section outlines the test results obtained for this solution within the parameters defined by the Citrix Ready VDI Capacity Validation program. While this program is intended to provide results that are applicable to real-world environments, the results presented are from benchmark testing and, as performance benchmark results, must be considered within that context.

**Note:**
Benchmark results are highly dependent upon workload, specific application requirements, and system design and implementation. Relative system performance will vary as a result of these and other factors. Therefore, this workload should not be used as a substitute for a specific customer application benchmark when critical capacity planning and/or product evaluation decisions are contemplated.

All performance data contained in this paper was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly.

EMC Corporation does not warrant or represent that a user can or will achieve similar performance expressed in transactions per minute.

The test environment was based on Citrix XenDesktop 7.6 running on virtual machines built on VMware vSphere 6.0. Desktops were hosted on the EMC XtremIO X-Brick with user data and profiles on EMC VNX. Virtual desktops were running Windows 8.1.

User load was applied to the desktops via Login VSI, a highly regarded and respected tool for standardized VDI performance and capacity testing. The “knowledge worker” test load, targeted to two vCPUs per virtual desktop, simulated typical workday tasks such as web browsing, video viewing, email, and document manipulation with Microsoft Office 2013 and other tools. Test pass/fail was determined by whether or not the storage system used could successfully handle the storage demands placed on it without reaching a latency limit called “VSI max.”

Table 2 describes the hardware components on which the test environment was built.

**Table 2. Solution hardware components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Server model</strong></td>
<td>Desktop cluster: Cisco UCS C260-BASE-2646</td>
<td>20</td>
<td>62 servers</td>
</tr>
<tr>
<td></td>
<td>Desktop cluster: Cisco UCS B230-BASE-M2</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infrastructure cluster: Cisco UCS C260-BASE-2646</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Processor(s)</strong></td>
<td>Cisco UCS C260-BASE-2646 @ 2.393 GHz</td>
<td>2</td>
<td>124 CPU sockets</td>
</tr>
<tr>
<td></td>
<td>Cisco UCS B230-BASE-M2 @ 2.263 GHz</td>
<td>2</td>
<td>10 cores per socket</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1,240 cores total</td>
</tr>
</tbody>
</table>
## Configuration

We configured the environment as follows:

- The XtremIO X-Brick was connected to the VMware vCenter cluster via iSCSI block protocol over 10 Gb Ethernet. In practice, an 8 Gb FC network could be used with no change in function.

- Windows 8.1 desktops were provisioned via Citrix XenDesktop 7.6 Provisioning Services (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 to implement the solution.

- Infrastructure services (domain controller, SQL Server, XenDesktop controllers, PVS servers, and so on) were configured on virtual machines hosted on two Cisco UCS C260 servers 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 as long as the product sizing best practices are observed.

### Table: Citrix Ready VDI Capacity Validation results

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco UCS C260-BASE-2646</td>
<td></td>
<td>144 GB per server</td>
</tr>
<tr>
<td></td>
<td>Cisco UCS B230-BASE-M2</td>
<td></td>
<td>256 GB per server</td>
</tr>
<tr>
<td><strong>Disk(s)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco UCS 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 UCS 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><strong>Network adapter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco UCS VIC Ethernet NIC 10,000 Mb</td>
<td>2</td>
<td>124 adapters</td>
</tr>
<tr>
<td><strong>Storage array controller</strong></td>
<td>EMC XtremIO X-Brick: Controller 256 GB cache</td>
<td>2</td>
<td>1 XtremIO X-Brick with 2 controllers for the virtual machine data of the entire 3,000-desktop solution</td>
</tr>
<tr>
<td></td>
<td>EMC VNX5600™: Controller 24 GB cache</td>
<td>2</td>
<td>1 VNX5600 with 2 controllers for the user data of the entire 3,000-desktop solution</td>
</tr>
<tr>
<td><strong>Storage array disks</strong></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>
This test demonstrated the ability of the XtremIO array to service I/O as 3,000 desktops were booted over a period of 28 minutes. The time period started when the first desktop was booted via the XenDesktop Studio console and ended when the last desktop was shown as being registered on the console.

**Boot storm IOPS**

Figure 2 shows the I/O rate across the boot storm test. Notice the predominance of writes.

![XtremIO IOPS - Boot Storm](image)

**Figure 2. Boot storm IOPS**

**Boot storm latency**

Figure 3 shows the latency in microseconds across the boot storm test duration. Notice that array latency peaked at just over 1.7 milliseconds (1,700 microseconds).
Citrix Ready VDI Capacity Validation results

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Figure 3. Boot storm latency

**Boot storm CPU utilization**

Figure 4 shows the utilization of the array's four CPUs across the test duration.

Figure 4. Boot storm CPU utilization
Boot storm data reduction ratio

Figure 5 is a screen capture from the XtremIO Dashboard view that shows the data reduction ratio during the boot storm, demonstrating the efficiency of the array's inline deduplication and compression functionality.

![XtremIO Dashboard](image)

**Figure 5. Boot storm data reduction ratio**

Boot storm summary

The boot storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 desktops performing a nearly simultaneous boot operation. Scenarios of this type have several mitigating factors in real-world environments, but this serves as a reasonable worst-case scenario to ensure that real-world results are more favorable than those realized in the lab. The low capacity utilization noted in Figure 5 is the result of this being a benchmark test with limited variability in the desktop data. In the non-lab environment, capacity utilization will be somewhat higher depending on the specifics of the environment. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.

Test results: Login storm

The primary test 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.

Test success was determined by running the Login VSI “knowledge worker” workload on the desktops without reaching the VSImax threshold.
Login VSI test results

Login VSI (http://www.loginvsi.com) is a virtual desktop benchmarking tool that simulates real-world workloads applied by Microsoft Office (Word, PowerPoint, Excel, Outlook), web browsing, video viewing, and so on. The tool can apply a variety of workloads tailored to VDI configuration and user “productivity,” and determines the maximum system capacity based on measured response time to the various tasks. The performance limit, “VSImax,” denotes the maximum number of desktops supported by the infrastructure.

The “knowledge worker” workload for 2-vCPU desktops was used for this test.

As shown in Figure 6, VSImax was not reached at the target number of 3,000 desktops, which validates that the infrastructure is capable of hosting that number of desktops and delivering an excellent end-user experience. We launched a total of 3,120 desktop sessions to ensure that any issues with the testing platform itself would not cause the number of active tests to fall below the target of 3,000 desktops. The number of desktops that actually completed the test, 3,043, exceeded our target. Login VSI uses scripting and automation tools to simulate the actions of end users, and on occasion some of the test sessions become stuck for reasons unrelated to infrastructure performance, due to Login VSI software limitations. By initiating more test sessions than we actually need, we ensure that our targeted number of sessions successfully complete the testing process.

Figure 6. VSImax–3,000 desktops
Login storm IOPS

Figure 7 shows the I/O rate across the login storm test. Notice the predominance of writes.

![Login storm IOPS](image)

**Login storm latency**

In this test, new users were logged in at an average rate of one every 1.92 seconds, with the “knowledge worker” workload starting immediately upon login.

Figure 8 shows that the array latency averaged below 2 milliseconds throughout the testing, reaching a brief peak of approximately 2.5 milliseconds.
Figure 8. Login storm latency

Login storm CPU utilization

Figure 9 shows the utilization of the array's four CPUs across the test duration.

Figure 9. Login storm CPU utilization
Login storm data reduction ratio

Figure 10 is a screen capture from the XtremIO Dashboard view that shows the data reduction ratio during the login storm, demonstrating the efficiency of the array’s in-line deduplication and compression functionality.

At steady state, the XtremIO array reduces all data before writing to SSDs. No post-process garbage collection or post-process data reduction is needed.

![Figure 10. Login storm data reduction ratio](image)

Login storm summary

The login storm test demonstrates that the XtremIO X-Brick is well within operational thresholds when hosting 3,000 desktops performing a nearly simultaneous login operation. Scenarios of this type have several mitigating factors in real-world environments, but this serves as a reasonable worst-case scenario to ensure that real-world results are more favorable than those realized in the lab. The low capacity utilization noted in Figure 10 is the result of this being a benchmark test with limited variability in the desktop data. In the non-lab environment, capacity utilization will be somewhat higher depending on the specifics of the environment. These results show that the configuration used has ample capacity to deal with additional data storage in the desktop.
Conclusion

A single XtremIO X-Brick (with 2 controllers and 25 SSDs, 10 TB raw capacity) was sufficient to host 3,000 desktops. With Login VSI “knowledge worker” workload, the 3,000 desktop test case generated 58,108 IOPS. The XtremIO array easily handled these loads with lots of headroom still left in the array.

References

The following documents, located on the EMC Online Support or EMC.com websites, provide additional and relevant information. Access to these documents depends on your login credentials. If you do not have access to a document, contact your EMC representative.

- EMC VSPEX End-User Computing Design Guide: Citrix XenDesktop 7.6 and VMware vSphere with EMC XtremIO
- EMC VSPEX End-User Computing Design Guide: Citrix XenDesktop 7.6 and Microsoft Hyper-V with EMC XtremIO
- EMC VSPEX End-User Computing Implementation Guide: Citrix XenDesktop 7.6 and VMware vSphere with EMC XtremIO
- EMC VSPEX End-User Computing Implementation Guide: Citrix XenDesktop 7.6 and Microsoft Hyper-V with EMC XtremIO
- Find the Xen in VDI with XtremIO
- XtremIO Top 10: Why customers choose us for VDI?
- Better Together: Citrix and XtremIO for Desktop Virtualization

For additional information, refer to the following:

- Citrix PVS 7.6 RAM with Overflow on Hard Disk on EMC XtremIO
- Demo: Boot storm with Citrix MCS and XtremIO 4.0
- Demo: Login storm with Citrix MCS and XtremIO 4.0
- Demo: Boot and login storms with Citrix PVS RAM cache to disk overflow
- Demo: Graphics workstation vs. virtualized graphics VDI with XtremIO