ESG Lab Review

Dell EMC XtremIO X2: Delivering High Performance and Advanced Functionality for Virtualized Environments

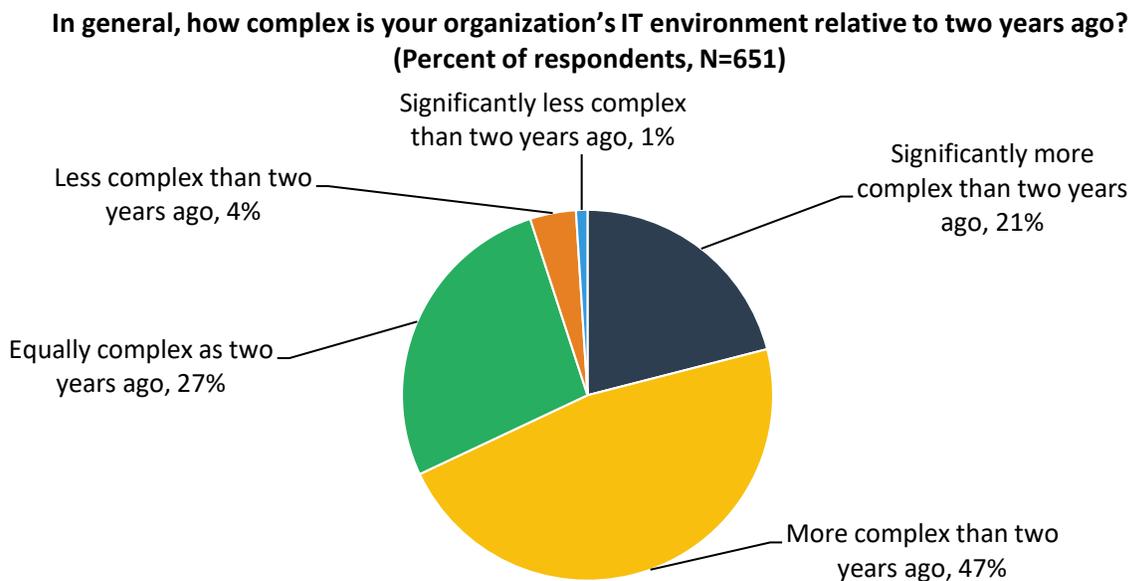**Date:** July 2018 **Author:** Kerry Dolan, Senior IT Validation Analyst

Abstract

This ESG Lab Review documents testing of the Dell EMC XtremIO X2 array with a focus on high performance and advanced features for today's modern, virtualized environments.

The Challenges

There are more technology options than ever before, promising levels of functionality that will truly transform business. But while the vision is exciting, actually delivering is not so easy. The consumerization of IT has led to newly empowered users (as well as senior management) driving functionality requests, believing that anything is possible. This often leaves IT struggling to deliver in reality what the vision promises. It is not surprising, then, that in ESG research, more than two-thirds (68%) of senior IT decision makers believe their organizations' IT environments are more complex today than two years ago.[1] For today's organizations that focus on virtual servers and desktops, private cloud, and hybrid clouds, this complexity can confound even the best intentions for high performance, simple management, and high availability.

Figure 1. IT Complexity

In general, how complex is your organization's IT environment relative to two years ago?
(Percent of respondents, N=651)

- Significantly less complex than two years ago, 1%
- Less complex than two years ago, 4%
- Equally complex as two years ago, 27%
- Significantly more complex than two years ago, 21%
- More complex than two years ago, 47%

Source: Enterprise Strategy Group

Virtualized environments are designed to consolidate workloads for infrastructure and management efficiency, but if IT can only deliver efficiency by reducing performance, the tradeoff may not be worth it. Virtualized workloads generate random varieties of I/O, creating an "I/O blender" effect that stresses traditional back-end storage designs. Other stresses include uptime requirements, and demands for self-service, application integration, and process automation.

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[1] Source: ESG Research Report, *2018 IT Spending Intentions Survey*, February 2018.

How can organizations reduce this complexity? ESG believes the answer lies in IT Transformation, which we define as modernizing the infrastructure to deliver speed, scale, flexibility, efficiency, and cost-effectiveness, while keeping it user-oriented and customer-focused.[2] But delivering all of these is a tall order. To do so requires three essential components: *modernization* of data center technologies, *automation* of IT processes, and *transformation* of business and application workflows fueled by IT. But what does this mean in real IT terms? It means leveraging modern technologies like high-performance flash drives in scale-out systems. It means as-a-service IT delivery, resource elasticity, self-service provisioning, always-on availability, and robust data protection. In our research with IT executives from around the world, we found that while IT Transformation is a major endeavor, it is well worth the outcome: Organizations that are farther along in IT transformation tend to be more innovative, competitive, productive, responsive, and cost-efficient, as well as faster to market.[3]

The Solution: XtremIO X2

XtremIO X2 is Dell EMC's purpose-built all-flash array that takes advantage of modern technologies to provide high performance, process automation, and tight business/IT alignment for today's virtualized data centers. In addition to consistent high performance/low latency, X2 offers inline data services, including thin provisioning and data reduction for storage efficiency; scale-up and scale-out expansion; and "consumer-simple" enterprise features, such as integrated Copy Data Management (iCDM), XtremIO Virtual Copies (XVC), Metadata-Aware Replication, and integration with management orchestration applications from VMware.

Differentiated Architecture

XtremIO X2 delivers consistent, scale-out performance for mixed workloads and private/hybrid clouds. Each X2 X-Brick leverages dual active-active controllers with no single point of failure. Dell EMC has increased flash capacity, with each X-Brick now supporting up to 72 x 400GB or 1.92TB SAS SSDs. It includes an NVRAM card, which handles secure vaulting of journals, eliminating the need for previous generation's Battery Backup Units, reduces cabling and complexity, and enables more flexible scaling; 384 CPU cores per controller; and supports 16Gbps Fibre Channel and 10Gbps iSCSI. XtremIO X2 scales up to 138 TB raw and scales out to eight X-Bricks for 1.1 PB raw, which translates to up to 5.5 PB of effective capacity with data reduction.

XtremIO X2 is different from other flash arrays in ways that enable it to deliver advanced features. Essential components of this difference are:

- *Scale-out, in-memory metadata*. Granular metadata is distributed across all controllers in a share-memory InfiniBand fabric; metadata is never de-staged to the array, enabling consistent, predictable, high performance and low latency, as well as speeding up metadata-intensive operations such as copy data management.
- *Content-aware addressing,* based on 16kb blocks, that provides a unique "fingerprint" for all content. As blocks are written, XtremIO creates a hash that is kept in memory before writing that block to SSD and mapping the hash to the SSD location. When duplicate data blocks arrive, they are checked against the hash table, and only written if they are new; if not, the reference count in the hash is updated. This provides in-memory deduplication that enables efficient storage, data movement, and replication.

Advanced, in-line, always-on data services include:

- Fast, scalable, global deduplication and compression. With the global, dedupe-aware memory cache, XtremIO X2 spreads data evenly across all resources available within a cluster.
- Thin provisioning for efficiency.

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[2] Source: ESG Research Insights Paper: *Research Proves IT Transformation's Persistent Link to Agility, Innovation, and Business Value*, March 2018.
[3] Ibid.

- Protection from dual SSD failures using XtremIO's patented data protection algorithm (XDP) that requires much lower overhead than traditional RAID types.
- Data-at-rest encryption using self-encrypting drives with no performance penalty.
- XtremIO Virtual Copies (XVCs). These space- and-memory-efficient snapshots leverage X2's content-awareness; they are created quickly with no impact on the system and can be used just like a production volume with the same high performance; they also offer the agility to instantly restore or refresh from any parent to child snapshot, or vice-versa.
- XtremIO Metadata-Aware Replication. XtremIO's replication uses content-awareness to minimize the amount of data movement and allows replication with production workloads simultaneously without any performance impact. Enabled by the in-memory metadata and content-aware addressing, XtremIO's replication delivers fast recovery and hundreds of recovery points; in-line data reduction reduces WAN bandwidth needs by only transferring metadata when a block of data that needs to be replicated at the source already exists at the target.

Other virtualization benefits include XtremIO X2 integration with VMware solutions, including VAAI to offload tasks to the array; the Virtual Storage Integrator (VSI) plug-in for ease of configuration; vRealize Operations Manager for storage analytics; vRealize Orchestrator and Automation (VRO and VRA); and VMware Site Recovery Manager (SRM). Finally, the powerful new HTML5 XtremIO Management Server (XMS) GUI includes automated workflow suggestions, advanced reporting and analytics, and global search, reducing administrator time spent on provisioning and performance tuning. All features are included with version 6.1 at no additional charge.

Figure 2. XtremIO X2

XtremIO X2 for Virtual Environments

Key Architectural Advantages:
- 100% in-memory metadata
- Content-aware addressing
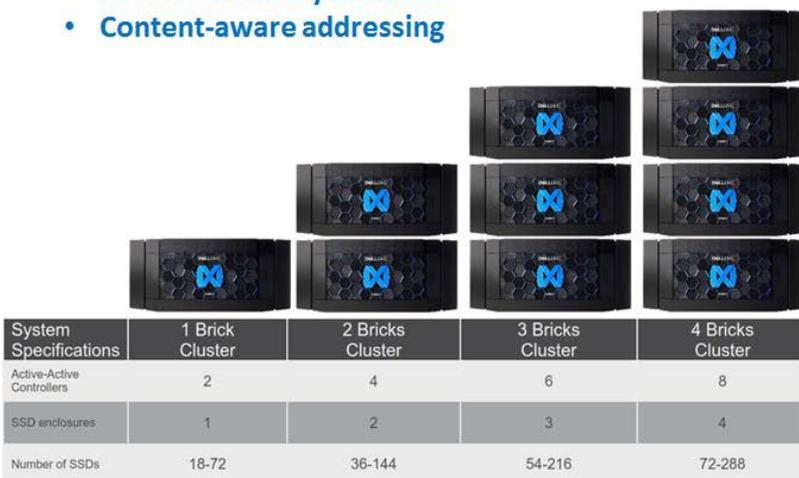
- **Consistent High IOPS, Low latency**
- **Scale up and scale out**
- **Inline, always-on data services w/o impact**
- **XtremIO Virtual Copies**
- **Maximum storage efficiency**
- **Integrated Copy Data management with application integration**
- **Metadata-Aware Replication**

System Specifications	1 Brick Cluster	2 Bricks Cluster	3 Bricks Cluster	4 Bricks Cluster
Active-Active Controllers	2	4	6	8
SSD enclosures	1	2	3	4
Number of SSDs	18-72	36-144	54-216	72-288

Source: Enterprise Strategy Group

ESG Lab Tested

ESG Lab audited testing conducted by Dell EMC focused on performance for virtualized environments, management orchestration, protection, and availability. It should be noted that XtremIO X2 includes a wide range of features, and this ESG Lab validation only scratches the surface.

Performance

Several architectural features enhance performance in XtremIO X2. In addition to the in-memory metadata and content-aware addressing, X2's architecture eliminates legacy SSD tasks such as log structuring and system level garbage collection. Software-driven performance and efficiency features include a Write Boost that delivers lower latency for small block I/Os. (An in-depth exploration of these capabilities is beyond the scope of this paper, but details can be obtained on the Dell EMC website.)

ESG audited Dell EMC performance testing that demonstrates X2 supporting high IOPS and low latency, and consolidated workloads running without impacting one another. The test bed included four XtremIO X2-R X-Bricks, each containing 36 x 1.92TB SAS SSDs; two 10GbE switches; and 9 VMware ESXi servers, each with 512 GB RAM. Two VMware virtual machines leveraged VDBench, an I/O workload generator, to test storage performance:

- DB VM Template. This 100GB VM generated 9,000 IOPS, using an 8k, 80% read/20% write OLTP workload similar to Oracle.
- Generic VM Template. This 100GB VM generated 2,000 IOPS using an 8k, 90% read/10% write workload executing generic server tasks.

First, we viewed testing for overall performance with a heavy workload using the Generic VM template. A new datastore was created with 10 XtremIO volumes over an empty array. A PowerShell script was used to clone 800 VMs using the Generic VM Template, executed in eight iterations of 100 clones at a time; the clones were powered on and began generating I/O after creation. XtremIO X2's metadata awareness enables high performance and efficiency for tasks such as VM cloning; clusters of two or more X-Bricks leverage redundant InfiniBand connectivity between storage controllers for low latency and high throughput.

Using VMware Distributed Resource Scheduler (DRS) and Storage DRS, clones were evenly distributed across compute and storage resources. As each set of VM clones completed and powered on, IOPS rose; after 500 VMs had started up, X2 was serving more than 1 million IOPS with 0.22MS latency, equally balanced across XtremIO X2 volumes, CPUs, and VMware initiator groups. Once all 800 VMs were powered on, performance reached about 1.6 million IOPS, still with sub-millisecond latency of 0.72. Figure 3 shows the XMS web UI, and Figure 4 demonstrates how IOPS scaled and latency remained low throughout the cloning.
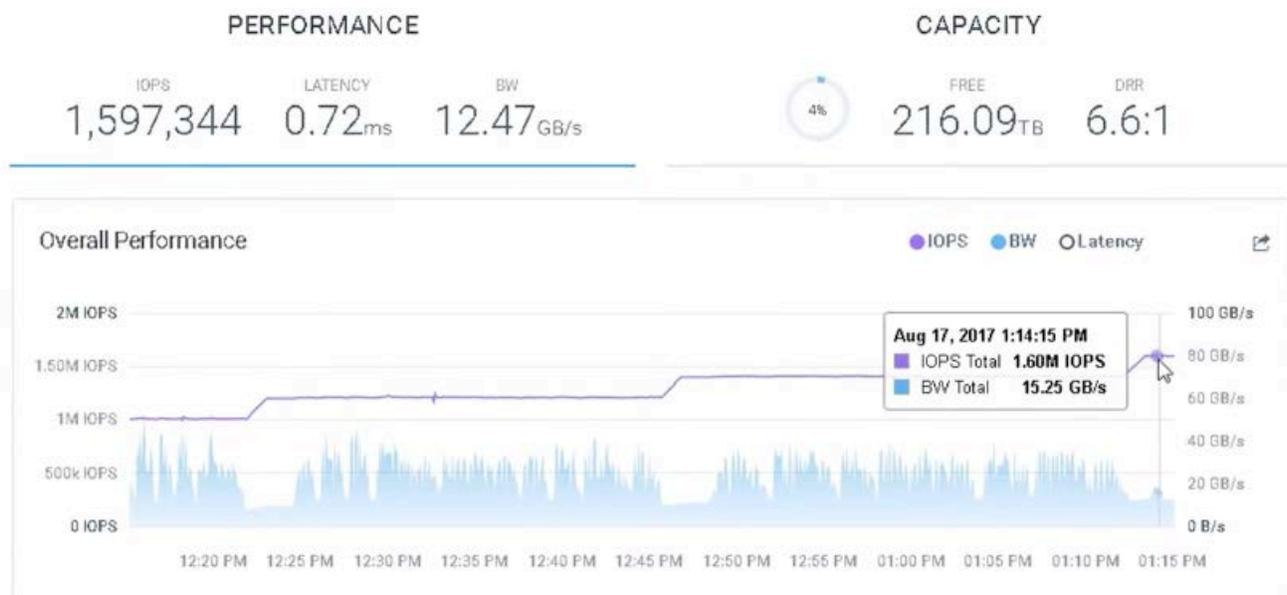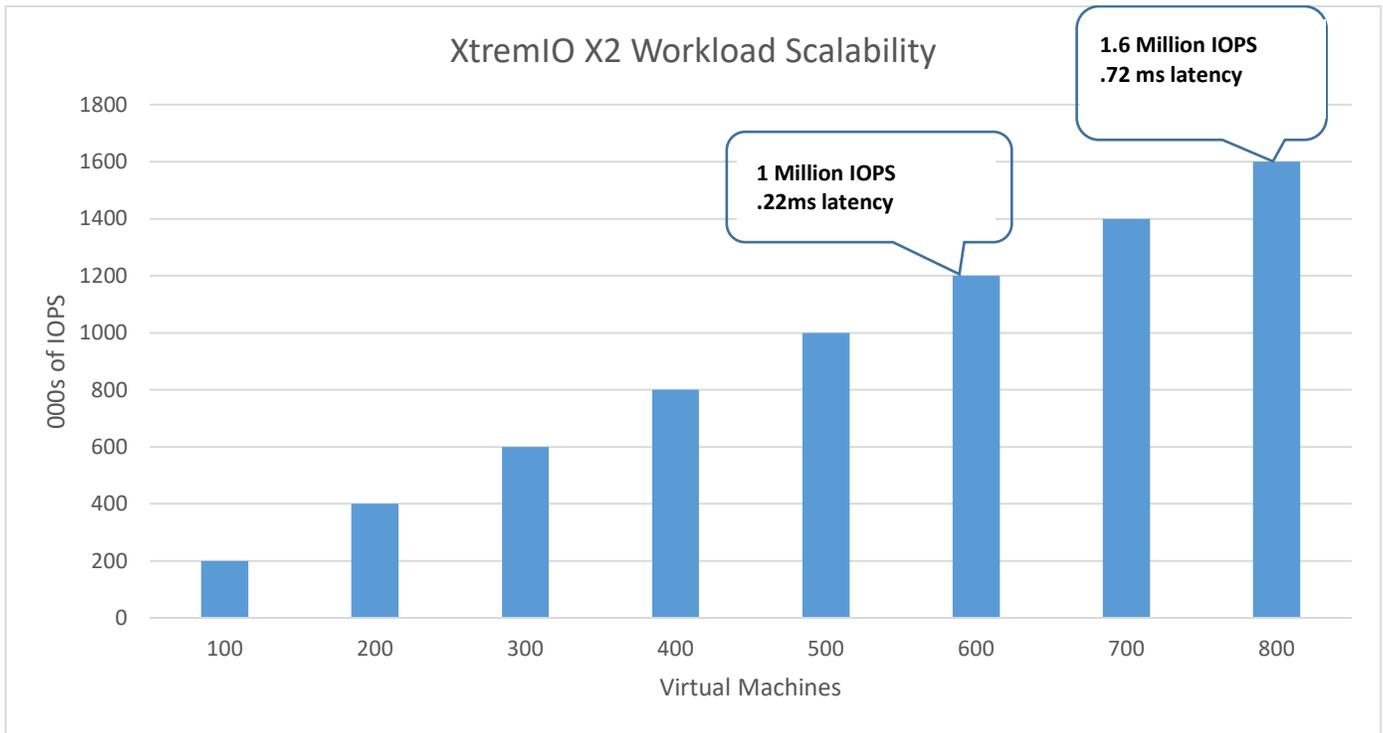
Figure 3. High Performance with Low Latency

Figure 4. XtremIO X2 Workload Scalability: 800 VMs Created and Powered On


Source: Enterprise Strategy Group

Next, ESG observed a test that demonstrated the ability to consolidate mixed workloads and maintain performance for all. We watched as the administrator used the VSI plug-in to request that the X2 array create and power on 100 clones of the Generic VM Template using VMware XCOPY. X2's in-memory metadata accelerates VAAI, an API that enables tasks such as cloning to be offloaded from the ESX host and network to the storage array.

We viewed performance in the XtremIO web UI dashboard. While clones were being created, bandwidth reached more than 160 GBps. Once all 100 clones were powered on, X2 was supporting an average 198K IOPS and 0.13ms latency.

Next, while all 100 Generic VM clones were running, an additional workload was added: 55 clones of the DB VM Template were created and powered on. We viewed the XtremIO web UI dashboard while the Generic workload was running and the database clones were being created, to validate that there was no drop in performance or significant increase in latency.

Once all 55 database workload clones were powered on, both workloads were running full: 100 VMs were generating 2K IOPS of generic server tasks, and 55 VMs were generating 9K IOPS of OLTP database tasks, with workloads balanced across the ESX hosts. At this time, XtremIO X2 was averaging 700K+ IOPS and 0.4ms latency.

The dashboard also shows the free capacity of 224.12 TB and the data reduction ratio of 21.2:1. Additional
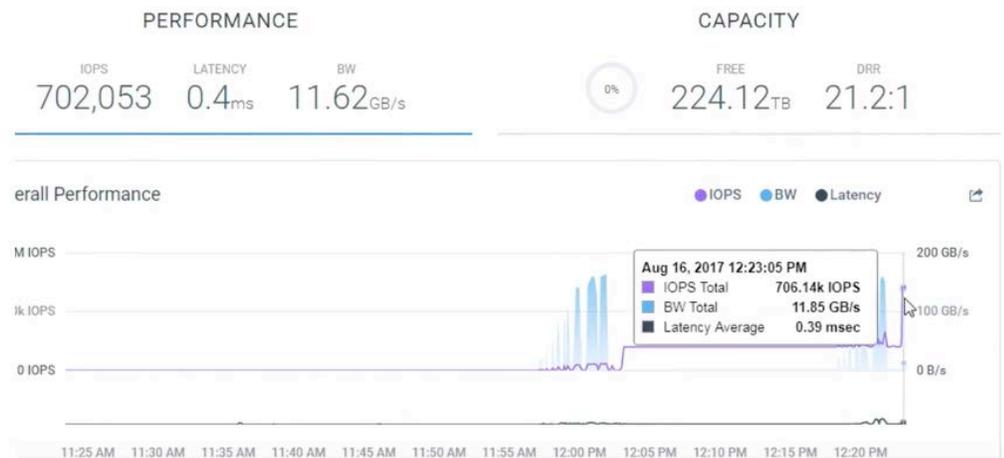
details of capacity, data reduction, and performance are available. In addition, histograms and heat maps show performance and latency by I/O block size. In the histogram below, ESG noted that all block sizes in play—ranging from 4KB to 1MB—showed sub-ms latency.
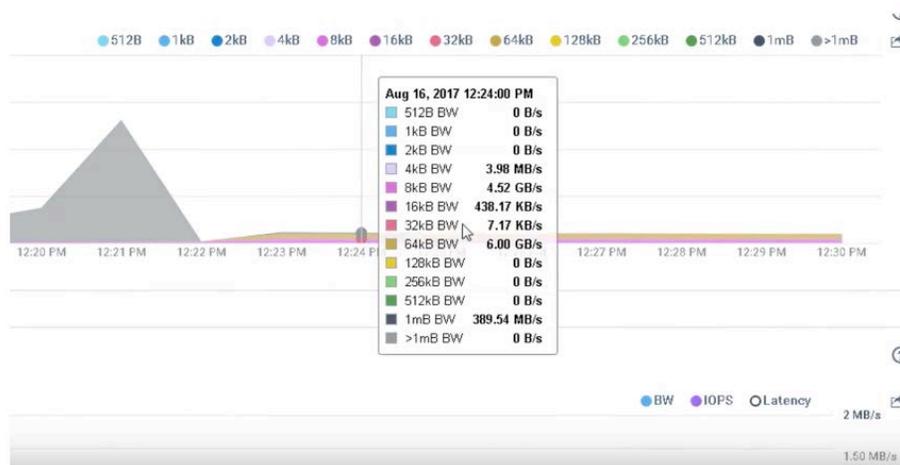
Why This Matters

Virtualization makes it possible to consolidate multiple workloads on less hardware—but if that consolidation hinders performance, it may not be a worthwhile tradeoff for VDI and other virtualized applications. As a result, virtualized infrastructure demands a robust architecture that can handle the randomness of the I/O blender and peak workload performance needs.

ESG Lab validated the scalable high performance and low latency of XtremIO X2, generating 1.6 million IOPS and sub-millisecond latency with a heavy workload of 800 VMs. We also validated X2's ability to run simultaneous generic server and database workloads and copy operations without impacting each other, and still generate 700K IOPS and 0.4 ms latency.

XtremIO Virtual Copies

The proliferation of data copies for test/dev, data analytics, operations, and data protection has become a significant problem of both storage capacity and management. Making copies consumes a lot of storage, can interrupt production operations, and requires IT intervention. XtremIO Virtual Copies are space- and-memory-efficient snapshots that can be used just like production volumes. The copy process is in-memory, without the need to actually copy any metadata, and these copies enjoy the same data services as production volumes. XVCs are:

- Created immediately without impacting system performance.
- Space- and metadata-efficient.
- Usable for production workloads with the same read, write, and latency performance as a production volume.
- Able to instantly refresh or restore any volume or snapshot.

XVCs are the foundation of XtremIO X2 iCDM, Dell EMC's term for a hierarchy of abilities that enables fast, efficient copies to be created for any purpose, while maximizing performance and self-service for users. It includes:

- Consistent, scalable performance and data services.
- XtremIO Virtual Copies.
- Application integration and orchestration.
- Application self-service.

Dell EMC telemetry with existing XtremIO customers shows that more than half are using XVCs as writable copies, such as for text/dev or analytics, not as backup; in addition, XVCs are generating 40% of their I/O traffic.

Management and Orchestration

XtremIO X2 includes numerous features that simplify and streamline management, including the VSI plug-in and integration with vRealize Orchestration and Automation. XtremIO X2 can also leverage PowerShell for automation.

VSI Plug-in

The VSI plug-in enables administrators to manage XtremIO X2 from within vCenter for provisioning, monitoring, reclaiming space, creating snapshots, and other tasks. This is an important feature, as today's IT organizations are leaning more toward generalists than specialists, leaving virtualization administrators executing storage tasks; as a result, features that simplify tasks and reduce administrative effort are essential for effective management. This tool also enables administrators to see not just how much data reduction has occurred, but also how much physical space is being consumed, for better planning of space reclamation. ESG validated the ease of provisioning volumes and formatting VMFS datastores using this tool.

vRealize Orchestration (vRO) and Automation (vRA)

The XtremIO X2 plug-in to vRO provides the ability to use built-in actions and workflows, or to design tailored workflows, to simplify management and to deliver service-based IT. Basic workflows include XtremIO tasks such as mapping volumes, copying snapshots, restoring consistency groups, and adding initiators to an Initiator group. High-level workflows combine XtremIO and VMware functionalities. An example is the workflow vCenter Datastore Expose Storage, which creates an XtremIO volume, maps it to a vCenter cluster, and formats it as a VMFS datastore. ESG Lab watched this high-level workflow in action. After selecting the X-Brick and VMware cluster and assigning names and sizes to the new volume and cluster, we watched both the vRO and XtremIO interfaces as tasks were completed, demonstrating the interaction between VMware and XtremIO. A segment of the Datastore Expose Storage workflow is shown below.

Figure 5. vRO Workflow
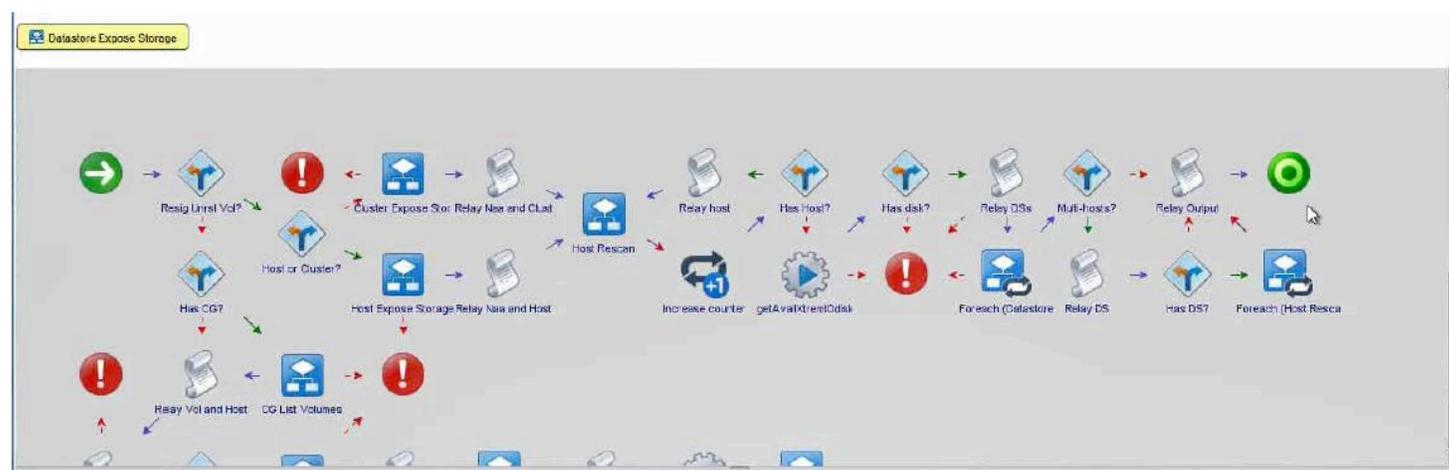
Source: Enterprise Strategy Group

We also watched as a new workflow was designed to create a test/dev environment by replicating it; that environment was subsequently created using a space-efficient XVC, and then deleted.

vRA provides automation of IT tasks to deliver self-service for users. An example is "day-one" service provisioning, which enables fast onboarding for new employees. IT can manage the actions users can and cannot access, to optimize self-service capabilities while maintaining security of the environment; IT prepares the additional infrastructure details in advance, minimizing user self-service inputs. From the *Catalog* we selected *Provision New Datastores* and had to put in only basic information; we requested 2 x 4TB datastores, named them, selected the vCenter Cluster, and submitted the request. The

actions occur in vRO, and we watched in the vRO GUI as the request was fulfilled using the *Datastore Expose Storage* workflow. The vCenter GUI and XMS GUIs both showed the new datastores and XtremIO volumes created.

Next, using vRA, we viewed two actions that had been created for VMware Datastores: **Delete** and **Expand**. We expanded the new datastore to 6 TB, which automatically expanded the XtremIO volume as well, and then deleted it. Under *Xaas Blueprints*, we viewed the **New Developer** service, and watched as this automated workflow created an Active Directory listing and a new Test/Dev environment to work on. This enables a new developer to quickly and easily self-provision the resources needed to begin working.

Together, vRO and vRA enable "anything as a service." With vRO, administrators create workflows, and with vRA they create self-service opportunities, as well as combine tasks into blueprints to execute multiple workflows. This helps virtualized data centers to serve users quickly and easily while simplifying tasks for administrators.

Protection and Availability

Data protection and high availability enable organizations to continue productive operations. XtremIO X2 includes complete data protection: inside the array with XtremIO Virtual copies with near zero RTO, in the data center with ProtectPoint integration, and across data centers with Metadata-Aware Replication. These provide protection for everything from local data corruption to data center, campus, or regional disaster, and can all be managed by vCenter administrators with no storage expertise.

Metadata-Aware Replication

XtremIO's block-level, content-aware addressing is fully leveraged for replication that is fast, efficient, and cost-effective. Traditional solutions replicate all changes before deduplication, so more data is transferred, and WAN bandwidth must be sized—and often, accelerated—to account for that. XtremIO uses content awareness; the source is aware of the target, so only the blocks that already exist on the target are replicated, after being deduplicated at the source. In addition, only unique changes and the metadata hash are replicated, so only bytes of data are transferred, greatly reducing bandwidth and storage needs. Replication is configured at the consistency group level and supports 4-to-1 fan-in with global dedupe across sites.

Figure 6. Metadata-Aware Replication
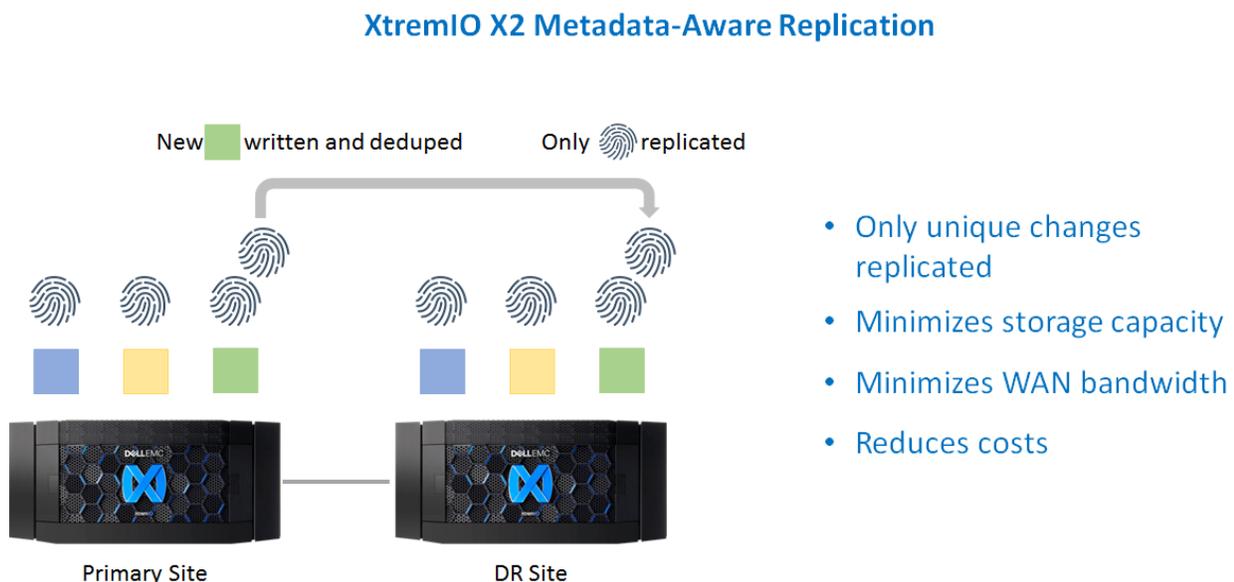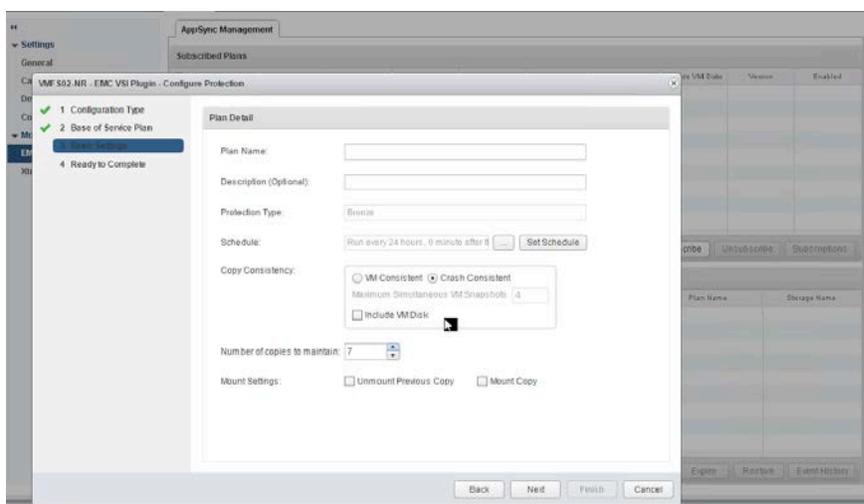

Source: Enterprise Strategy Group

Metadata-Aware Replication uses XtremIO Virtual Copies. It is easy to set up and supports RPOs as low as 30 seconds and up to 500 recovery points; it supports DR replication testing as well. The first step is to get the source in sync with the target. Then, as new data is written, the next snapshot is taken based on the user-defined RPO and differences are identified; dedupe occurs inline and, if blocks are already on the target, these are not copied over. New blocks and metadata are compressed and moved to the replica, and the replica becomes a fully usable point in time.

We validated the ease and speed of replicating two 600GB volumes in a consistency group. Failover is easy and immediate, and any point in time can instantly refresh any volume or snapshot in its tree. As a result, Metadata-Aware Replication can be used for both disaster recovery, and for repurposing (test/dev, analytics) on the primary or DR site; local and remote replication are managed in the same UI. The ability to instantly refresh provides fresher data, improving development and business insight. With other solutions, IT is often reluctant to refresh because of the time and disruption. Metadata-Aware Replication is integrated with iCDM, vRO orchestration, and VMware SRM.

AppSync

AppSync provides the ability to back up and restore VMs or databases with application consistency. AppSync can also be used by application owners and DBAs to create and refresh writable, application-consistent copies for test/dev. It currently supports VMware, Windows, Linux, SQL Server, Oracle, Exchange, and SAP.

ESG Lab validated the ease of configuring AppSync using the VSI plug-in; we subscribed to an existing service plan that creates a VM-consistent copy of a datastore and its VMs daily and retains it for seven days. We ran the task, watched as it created a snapshot of the datastore with the VMs in it, and then restored it. Administrators have the option to restore the entire datastore, or just the specific VM needed. This is a common user request that is made extremely simple with AppSync. A key feature is that these copies can be created by the application owner using AppSync, by the virtualization administrator through vCenter with the VSI plug-in, or by the storage administrator in the XtremIO Management Server. This makes the process simple regardless of your administrative setup.

VMware SRM Integration

VMware SRM provides policy-based, automated failover of entire virtual machine environments to a remote site in case of a disaster. Many array-based replication solutions can replicate data to a remote site for failover, and administrators can restore their virtual environments (such as a complete virtual desktop infrastructure) to the last point in time. However, if the last point in time is corrupted, then restoring it is useless. With XtremIO Metadata-Aware Replication, however, the VSI plug-in enables you to select any point in time for failover, ensuring that you can avoid corrupted data. (This is also available with Dell EMC arrays using RecoverPoint.)

Why This Matters

Traditional data center solutions were not designed to fully exploit or integrate virtualization, automation, or self-service. Today, modern technologies make these possible, helping organizations to reduce costs, improve management efficiency, and deliver IT-as-a-service, even driving functionality down to the user level to manage.

XtremIO X2 is chock-full of these modern technologies and automated processes. ESG Lab validated how easy it is to manage, orchestrate, and automate IT services. These include XVC space-efficient, in-memory copies that can be application-consistent with AppSync; plug-ins to VSI, vRO, and vRA that enable storage management, orchestration, and automation of XtremIO X2 functions through vCenter; Metadata-Aware Replication built on XVCs with speed and storage/ bandwidth efficiency for reliable disaster recovery; and integration with SRM for site recovery, including the ability to select any point in time to avoid corrupted data.

But not only does XtremIO support these features, it also provides a platform on which these services can be used with maximum effectiveness and with minimal impact to operations. For many features, XtremIO X2 offers management options with common tools used by virtualization admins, storage admins, and even application owners. Provisioning tasks that used to take weeks can now be completed in a few clicks by end-users using automation tools. The result is less administrative effort, less interruption to operations, and greater productivity.

The Bigger Truth

When asked to agree or disagree with the statement, "If my IT organization does not embrace IT Transformation, we will not be a competitive company," 81% of respondents to an ESG survey of IT decision makers agreed.[4] IT Transformation—through modernizing data center technologies, automating IT processes, and transforming workflows—can enable virtualized environments to flourish, but they need the right components to make that happen.

Dell EMC's XtremIO X2 was designed to enable these capabilities. IT organizations are using more generalist administrators today, demanding simplification of infrastructure tasks. XtremIO X2 delivers high performance and low, predictable latency for consolidated workloads, streamlined management to reduce costs and increase agility, and user-self-service to safely provision their own resources to speed productivity. Its deep integration with VMware solutions—including vSphere, VAAI, VSI, vRealize, and SRM—demonstrates the real intention to simplify life for administrators. In addition, advanced technologies like content-aware addressing provide in-memory, inline deduplication that enables instant, space-efficient, read and writable XtremIO Virtual Copies that deliver the same performance as the source volume, as well as fast, efficient, flexible Metadata-Aware Replication.

ESG validated the advanced capabilities that are available due to X2's architecture and software. We validated 1.6 million IOPS with sub-millisecond latency for a hefty, 800-VM workload, as well as the ability to run simultaneous workloads and copy operations with no performance impact, delivering more than 700K IOPS and sub-millisecond latency. In addition, we validated the ease of management to create XtremIO Virtual Copies, integration with VMware tools for provisioning, orchestration, and automation, and enhanced protection and availability with space-efficient Metadata-Aware Replication and AppSync. ESG noted that while there is currently no option for NVMe SSDs, that integration is on the roadmap, and in the meantime, the Write Boost technology helps to reduce latency.

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[4]Ibid.

XtremIO X2 includes so much advanced technology, we could only begin to uncover its usefulness in this paper. The unique in-memory metadata and fingerprinting design helps organizations transform using a next-generation platform for virtualization that performs integrated operations faster, and with less impact. IT organizations and modern, virtualized, and cloud data centers are responsible for keeping businesses not just functioning, but flexible, fast, and competitive; most will need to transform in order to do so. ESG believes that X2 provides an excellent foundation for that IT transformation.