Increasing SAP® ASE Performance Using Cache Extension Technology on EMC XtremIO All-Flash Array

A Collaborative SAP Co-Innovation Lab Project with EMC

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White Paper

SAP Co-Innovation Lab

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EXECUTIVE SUMMARY

EMC and SAP have collaborated to highlight the incredible performance improvements by combining the SAP® Adaptive Server® Enterprise (SAP ASE) 16 SP02 database server with the EMC XtremIO All-Flash Array. In the SAP Co-Innovation Lab in Palo Alto, California, we conducted an experiment to demonstrate what can be achieved. We installed SAP ASE 16 SP02 on a Fujitsu machine and attached both an EMC XtremIO All-Flash Array v4.0.x and a Fujitsu Eternus HDD SAN Storage. We enabled the MemScale Option in SAP ASE 16 SP02 and used the new NV cache feature and the XtremIO All-Flash Array to demonstrate between 280% and 420% performance improvements in SAP ASE query response time and the number of database transactions without making any changes to the applications or the way end users/applications interact with the database.

BUSINESS BENEFITS

Running SAP ASE on EMC XtremIO provides many benefits for business that rely on SAP ASE database technology and applications.

- Database acceleration
- SAP application performance acceleration
- Database and application consolidation with increased performance
- Future proof scale-out investment protection for SAP ASE database architectures
- Dramatic simplification of the SAP ASE landscape
- Transformative integration of the SAP HANA® platform with SAP ASE
- Lower total cost of ownership (TCO)

The ROI of running SAP ASE on EMC XtremIO delivers excellent performance improvements, and the above benefits are realized by customers using SAP ASE almost immediately upon deploying the solution.

INTRODUCTION

Bringing Extreme Transaction to the Next Level

SAP ASE 16 Release

In April, 2014, SAP released SAP ASE version 16. SAP ASE 16 delivered increased scalability and speed with extensive optimizations in its transaction concurrency management, query plan execution, data compression, and utilization of computing resources in large SMP (Symmetric Multi-Processing) servers.

In SAP ASE 16, both the security enforcement and system auditability were augmented to deliver customers more flexibility in the way they comply with specific requirements. A broader integration with the SAP DB Control Center systems console and a wealth of other enhancements delivered simplified management of SAP ASE installations, reducing their overall cost of ownership. Additional improvements in the integration with other SAP products, such as SAP Business Suite and SAP HANA, further simplified the management and increased the reliability of SAP-centric installations, also lowering their overall TCO.

SAP ASE 16 SP02 Release

With the release of SAP ASE 16 SP02 in 2015, SAP took transaction processing to the next level. It is built on the foundation of the 2014 release by focusing on acceleration, availability, and agility, as well as further integration with SAP HANA and SAP Business Suite applications.

When it comes to performance acceleration, SAP ASE 16 SP02 reduces latency and improves throughput by leveraging in-memory computing, intelligent data placement, as well as other hardware and software innovations. Most of these enhancements are delivered as part of the SAP ASE database MemScale option. Both transactions and queries will run faster with support for All-Flash Arrays, hardware-based locking, compiled queries, and temperature-based data management.

Buffer Cache Extension Using Flash Storage Integration

Introduced in the SAP ASE 16 SP02 release, the MemScale option significantly increases transaction throughput and minimizes latency. It improves the efficiency of SAP ASE in high-core count machines and leverages newer memory architectures, which results in faster query execution and response time. It also allows faster storage performance.

One of the new features in this new option is non-volatile caching (NV cache). It allows you to create named caches on All-Flash arrays. Flash drives (otherwise known as solid-state drives or SSDs) within an array provide significant performance benefits associated with this new feature.

Configuring a cache for a database and associating named caches with the database allows these objects to automatically map to the NV cache. Once the NV cache is created and the database is bound to it, the transition is smooth and no special/additional action is required from the database administrator in order to start using the NV cache option. As with regular named caches, named NV caches can be created, dropped, and updated dynamically. The NV caches are minimally journaled for easy reconstruction at boot recovery.

HIGH-LEVEL OVERVIEW

An NV cache can be used to maximize the TCO of using SAP ASE as well as improving overall response times on caches with high volatility on the same tables. For example, currently, customers can configure systems with large amounts of memory, much of which is often set aside for caching tempdb. In addition, for performance reasons, tempdb is often assigned to a solid-state flash disk/volume in a server or on an enterprise-class storage platform – which can be expensive. By leveraging the NV cache, customers can do the following:

- Equip commodity systems with server-side local PCIe or SATA-based SSD devices or All-Flash Array volumes from a shared enterprise-class All-Flash Array to be used as the NV cache. Since it is only to be used for caching, this doesn't violate any policy of SAN corporate data storage.
- Bind Tempdb to the NV cache with a smaller tempdb buffer cache. This way, instead of dedicating gigabytes of memory to tempdb, tempdb may only need a few 100 MB of main cache, and now the rest would be in the NV cache. This allows more business data to be cached.

General Design and Operation of NV Cache

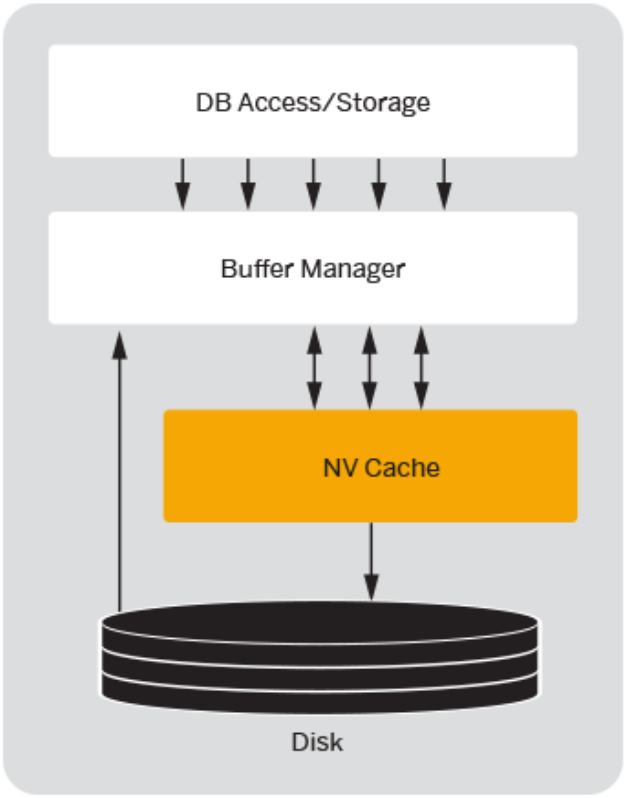


Figure: NV Cache Extension Architecture

Understanding SSD Flash

When leveraging SSD flash technology, customers using SAP ASE have a number of choices as to which flash architecture and topology they prefer. The most popular and common options are:

- Rack scale/direct attached flash (local server-side SSD modules)
- All-Flash Storage Array platforms

What is the difference between Rack-scale flash and Direct attached flash?

Direct attached flash, primarily in the form of SSDs or PCIe flash cards, provides flash storage that is directly attached to an individual server or computing node. This architecture provides fast storage performance but sacrifices all the benefits of shared storage. There are many single points of failure, the need to create multiple copies of data to improve reliability and performance, and stranded IOPS as data has to move among systems in parallel processing infrastructures. Further, there are capacity concerns, which often lead to sacrificing processing power for additional storage space within a server. Finally there are operational concerns, such as no hot swap of devices and no shared data services. Rack-scale flash provides performance levels equal to PCIe flash cards with the added benefits of a shared storage.

What is XtremIO and how is it unique?

XtremIO is a full-featured, scale out All-Flash Array that has been designed from the ground up to unlock the full potential of SSDs. Its powerful architecture was designed to deliver the scale-out performance, reliability, and IT flexibility needed in today's enterprise data centers.

The XtremIO Solution is unique in many ways, but we view scalable performance as a key differentiator. It is linearly scalable, delivering highly consistent and predictable flash I/O and bandwidth across as many eMLC SSD Flash modules as you desire. The blocks of data are inherently load balanced across every flash module via unique designed-for-flash technologies, which results in no tuning needed with the maximum flash performance possible, under all application I/O conditions. XtremIO has inline, global, scalable, wire-speed data reduction (deduplication and compression) and unstoppable data services like highly efficient and agile XtremIO Virtual Copies (XVCs).

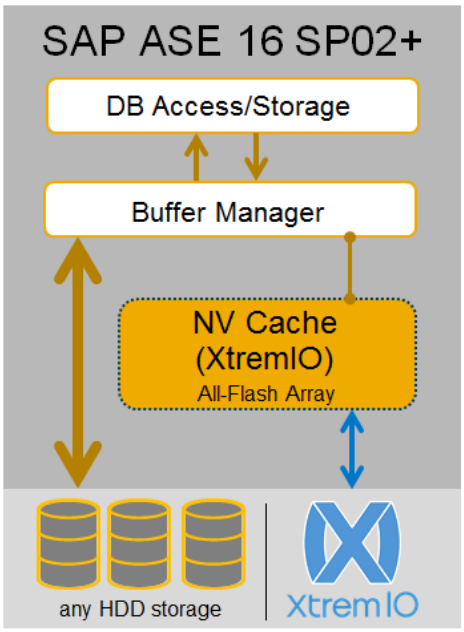
With XtremIO, thousands of servers can experience the power of SSD flash, without the distributed complexity of individually installing and managing thousands of PCIe flash cards and their related software components on the servers.

NV CACHE DEPLOYMENT CHOICES FOR SAP ASE

Customers can deploy the SAP and EMC solutions via two potential hardware/software configurations. Each configuration will deliver slightly different performance characteristics to SAP ASE and different advantages within the customers' overall SAP ASE database environment.

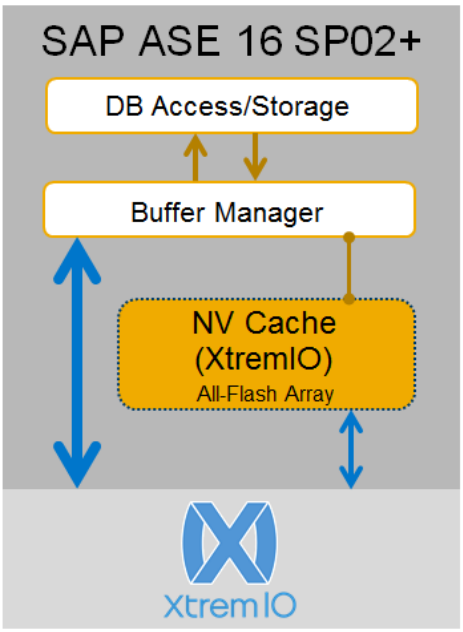
Hybrid configuration

† Observed SAP ASE performance increase: 280%



All-flash configuration

* Potential SAP ASE performance increase: 400+%



Advantages and concerns
(Hybrid architecture)

The Hybrid architecture enables customers using SAP ASE to easily leverage their existing HDD storage architecture and configuration, and a small amount of SSD flash with minimal business impact.

The management complexity of this architecture becomes slightly more difficult, especially in larger SAP ASE database environments and across multiple SAP ASE databases that leverage this technology because multiple storage systems (HDD and all-flash) are used together, making some storage management activities more complex.

No storage re-platforming exercise for SAP ASE is needed in this architecture. The XtremIO storage is simply provisioned to each SAP ASE server, and NV cache is configured in every SAP ASE database.

This architecture delivers exceptional performance gains and is very cost-effective for customers.

Advantages and concerns
(All-flash architecture)

The All-flash architecture allows customers of SAP ASE to leverage all of the data services features to extract the maximum performance benefits from the XtremIO All-Flash Array platform.

The management complexity of this architecture is simplified in larger SAP ASE database environments and across multiple SAP ASE database because a single storage platform is manages all SAP ASE storage. This simplifies SAP ASE support and all storage management activities.

This architecture requires a re-platforming exercise for SAP ASE because the entire SAP ASE database must reside 100% on XtremIO All-Flash storage.

This architecture delivers the fastest performance gains, although more flash storage is required. Deduplication benefits may be experienced across multiple SAP ASE instances that share a single

XtremIO platform, optimizing the cost-effectiveness.

NV CACHE PERFORMANCE GAINS

Significant testing was undertaken at the SAP Co-Innovation Lab in Palo Alto to allow us to understand the performance benefits of the solution. This testing has complexities because it exercises multiple aspects of both the SAP ASE database and the EMC XtremIO Storage platform technologies. The testing team leveraged a number of highly technical SAP methodologies and practices, internal tools, data sets, and I/O access profiles.

In the end, two fundamental sets of results were produced that customers of SAP ASE can leverage.

- **The Hybrid results**
- **The All-flash results**

Below is a set of guidelines on how the tests were designed and executed, and how to interpret the results.

† **Hybrid results**

This test config placed all of the SAP ASE database and log files on HDD disk and only leverages the XtremIO SSD Flash system for the NV cache component of SAP ASE. As indicated, this is the least costly solution for a customer to invest in. Testing the hybrid architecture is a more complicated test suite because it requires complex stress testing of the SAP ASE database working data set and a controlled database transaction profile. The working data set must be larger than the total available SAP ASE server memory cache and the SAP ASE database transaction model must forcefully access the cache in SAP ASE in an exercised manner, making the SAP ASE database constantly read and write data in and out of the NV cache (which resides on the XtremIO All-Flash Array). The SAP Co-Innovation Lab team designed a unique test suite to accomplish this scenario, and the final observed results reflect that testing methodology. Additionally, the SAP Co-Innovation Lab team tested multiple hardware and SAP ASE database configurations at scale, to fully understand the parameters of the NV Cache test results.

This white paper shows only hybrid results from one of the hardware architectures: the very large server and SAP ASE database config with a Fujitsu HDD SAN and the XtremIO All-Flash cluster.

The hybrid performance results show excellent speed improvements for SAP ASE. On average, the SAP Co-Innovation Lab testing observed a 280% performance improvement in the SAP ASE database TPM rate. For full details of the entire test system, please refer to the diagram and tables below.

* **All-Flash results**

This test config places all of the SAP ASE database and log files on the XtremIO storage array, where 100% of the database transactions occur against SSD flash only. This is very different to the hybrid config, and no HDD storage is involved in this testing. As indicated, this solution may potentially have a greater initial investment cost to the customer. (This topic as it is not fully discussed in this white paper; see your SAP or EMC XtremIO specialists for more info.)

Testing the All-flash architecture requires a different test methodology from the hybrid architecture. It doesn't utilize the complex SAP ASE database working data-set controls or the unique DB transaction profiles. Additionally, the All-flash results were executed on slightly different hardware architecture: the smaller server and SAP ASE database config. The slight differences in the tests were necessary from a technical perspective, and are statistically insignificant in the overall outcome. (A deeper discussion on this topic is beyond the scope of this white paper.)

The All-flash performance results show excellent SAP ASE speed and TPM improvements. In order to compare the two

test models, the results must be normalized across all dimensions and then interpreted using the hybrid results as the core baseline. When this is done, the All-flash results scale up the potential performance improvements to greater than 400% for the SAP ASE database.

Please contact your SAP and EMC XtremIO specialists for more details if you require them.

IMPORTANT COST CONSIDERATIONS

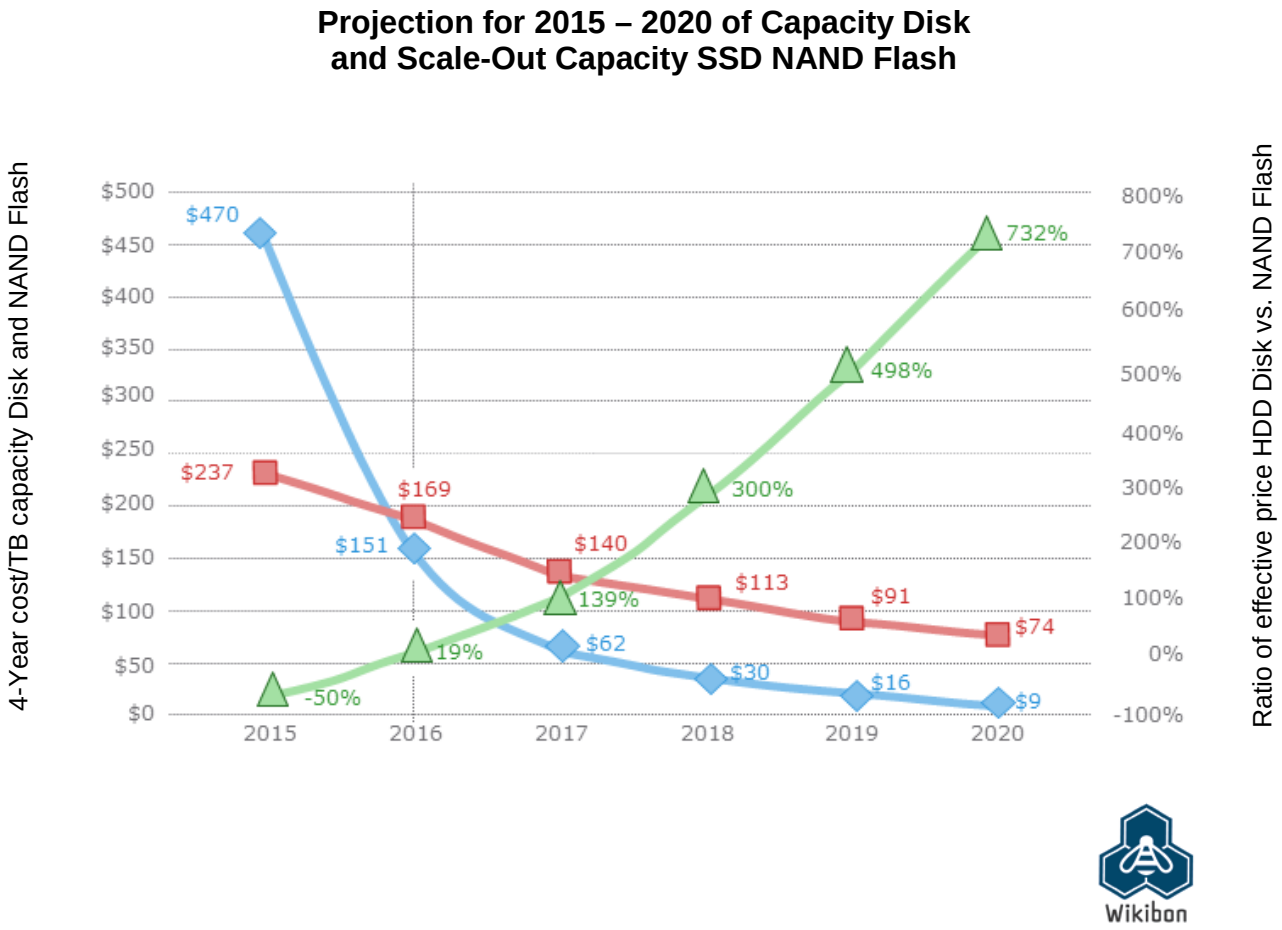
The NV cache solution for SAP ASE leverages the most modern software technologies from SAP and EMC as well as the leading All-flash storage platform available on the market today: the EMC XtremIO All-Flash Array.

We recognize that cost-conscious customers would like to understand the potential return on investment (ROI) and the TCO surrounding an SSD All-flash solution, All-Flash storage platforms in general, and the overall market trend within the HDD storage/SSD All-Flash storage industry, In an effort to help them, we have provided a helpful cost/trend analysis for primary storage media. This analysis was produced by a leading neutral third-party industry analyst, Wikibon.org.

An online version of this analysis can be viewed at: http://wikibon.org/wiki/v/Evolution_of_All-Flash_Array_Architectures

When reviewing the Wikibon analysis, an important observation is clearly visible: 2016 is the inflection point at which a key transformation occurs in the $/GB cost of SSD flash storage when compared to the $/GB cost of HDD storage. SSD flash is now cheaper than HDD. As the chart indicates, there is a strong downward trend in the economics of SSD All-Flash technology. This economic trend is a key factor behind the evolution of the SSD flash–based NV cache solution for SAP ASE, along with the fundamental understanding that SSD NAND flash media (i.e., solid-state disks with no moving parts) is significantly faster than rotational mechanical HDD disk drives (an order of magnitude faster). This is a long-term trend, which EMC and SAP customers are already leveraging in SAP ASE database environments.

Five-Year $/GB SSD Flash Cost Analysis



Additional Aspects to Consider

For deployment flexibility, the XtremIO solution has been tested and is supported under two different I/O topology architectures.

- Direct connect to the SAP ASE servers (via Fibre Channel and iSCSI)
- SAN attach topology (i.e., Fibre Channel or iSCSI SAN fabrics)

FCP and iSCSI are different Storage Area Network (SAN) technologies, and each fabric topology will provide different performance and I/O-path availability characteristics. We tested both, so that customers can have confidence that the solution works well in both SAN types and to determine whether there are any significant advantages of one over the other.

In general, the FCP protocol and SAN will have better overall performance with a greater bandwidth and lower I/O latencies since it is a more simplified SAN protocol. Further, an FCP SAN is a dedicated I/O data fabric compared to a shared Ethernet iSCSI fabric with a heavier protocol overhead. Finally, the FCP SAN I/O stack and storage drivers are generally considered to be more mature and provide more stability under heavy I/O load and bandwidth, giving the customer more confidence in these mission-critical business application scenarios.

Overall, SAP and EMC are confident that iSCSI SAN and FCP SAN technologies have been thoroughly tested and both work well.

Additionally, in order to provide flexible configuration options to customers using SAP ASE, version 16 SP02 can be easily configured to leverage the XtremIO All-Flash volumes via two different data-access methods.

- File system–based I/O (using standard file systems like ext3, ext4, XFS, etc.)
- Raw device Direct I/O access (e.g., /dev/sdc)

The decision to deploy the NV cache architecture for SAP ASE as a file system or a raw block device (LUN) config is purely the customer's choice. Each storage I/O architecture has advantages and disadvantages. Simplicity, complexity, and ease of management are very common drivers that influence this design decision because some raw block LUN device configurations can become complicated at larger scales. Some customers may not be comfortable managing large raw block device LUN storage configurations across multiple SAP ASE systems and databases. In this scenario, a file system model is a good option.

From an I/O and bandwidth performance perspective, our tests reveal that the raw block device storage architectures (i.e., LUNs) do provide an observable performance advantage over the file system–based storage configuration. This is mostly due to the streamlined and optimized I/O stack of the raw block LUN data path and the modern technology design principles behind the XtremIO All-Flash platform. It is optimized for block mode (LUN) I/O transactions and for SSD flash I/O.

Within a database, key processing tables often exhibit cache fluctuation/volatility simply due to the reasonable limits of available memory. Consider the following graph, which shows a common SAP application issue in which two key large tables, CDHDR and QAMV, seem to be driving cache fluctuation with each other while a third table, CDHDR, is demonstrating more desired behavior.

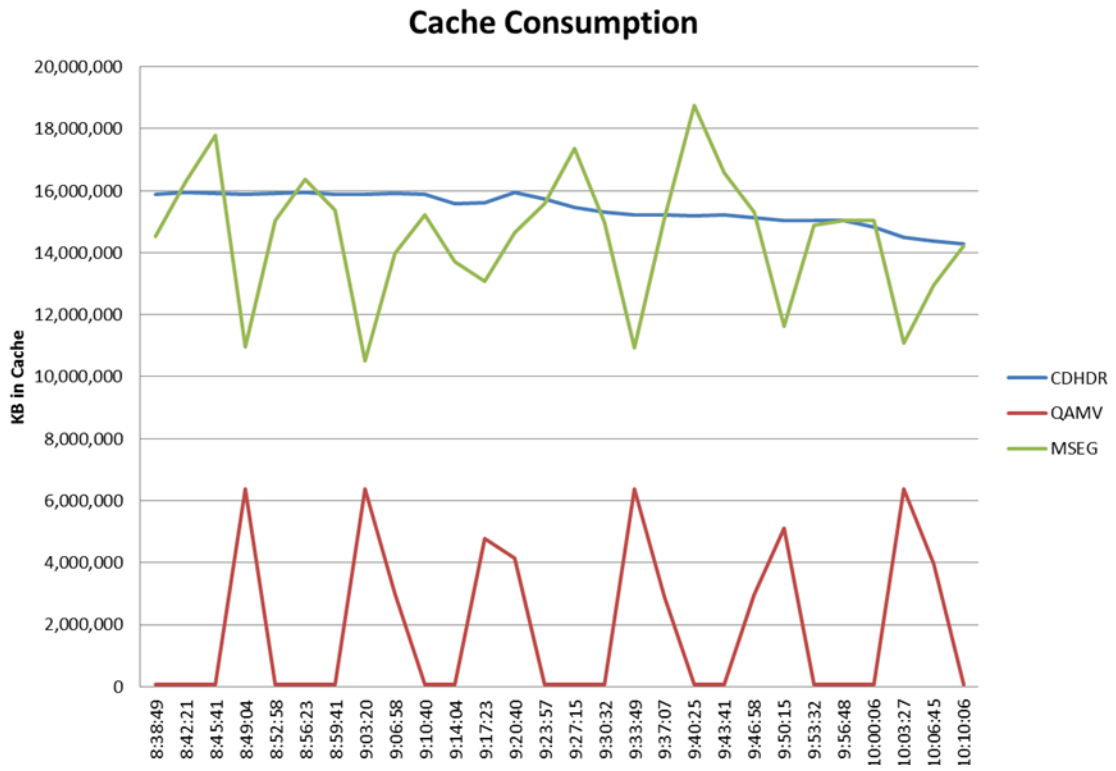


Figure: Normal Cache Fluctuation in SAP Applications

While one obvious solution is to simply increase memory till it is large enough to hold both requirements, this can be expensive and may not even be viable due to hardware limitations. The problem in the above isn't the fluctuation so much as the fact that the exact same set(s) of data is likely be reread from storage every time. This can be a multi-millisecond request – e.g., 8-12ms/IO on RAID 5 and even longer (~20ms/IO+) on RAID 6 – and contends for IO capacity on existing HBA adapters with critical write transactions. By binding both tables to an NV cache, even if the cache fluctuation continues, the reread is not from a physical storage through heavily used HBA adapters, but rather it's re-scanned from the NV cache, which has microsecond response times. The benefit here is that speed is increased by an order of magnitude, and consistent performance achieved by using an XtremIO All-Flash Array rather than disk, without increasing the memory footprint.

EMC XTREMIO ALL-FLASH ARRAY V4.X

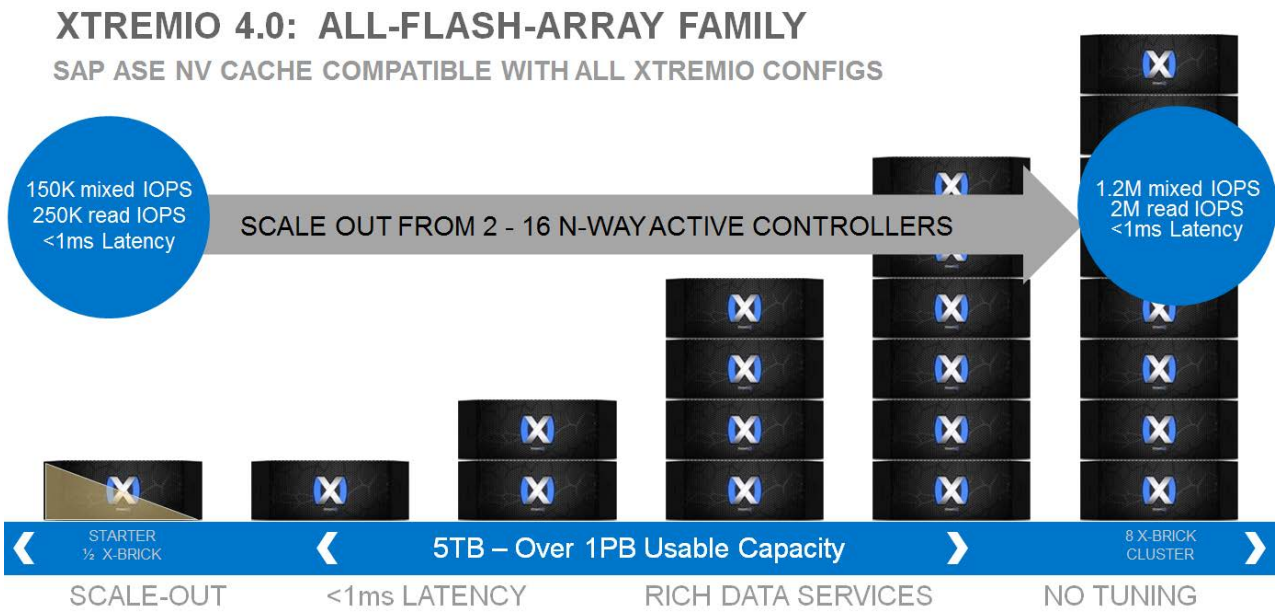
The XtremIO All-Flash Array is a modern Generation-4 scale-out All-Flash Array. An XtremIO cluster is comprised of a number of X-Bricks, the common building blocks for the platform.

As customers add X-Bricks, the entire XtremIO cluster scales out, and all resources within the All-Flash Array are increased linearly (e.g., metadata cache, CPU, SSD, bandwidth, ports, performance, etc.). Additionally, the XtremIO cluster provides in-line Data services such as De-duplication, Compression, Encryption, and XtremIO Virtual Copies (XVCs).

PRODUCT FAMILY

The smallest XtremIO X-Brick system is a Half X-Brick system (5TB raw capacity), and the largest system can scale to 8 X-Bricks (as of 2016). Single X-Bricks come in a variety of raw capacities: 10TB, 20TB, and 40TB per single X-Brick (the Half X-Brick is half of a 10TB unit).

Customers simply add more X-Bricks into the cluster to scale out size/capacity that they need. Currently with XtremIO v4.x, X-Brick must be symmetrical in capacity throughout the cluster.



PERFORMANCE EVALUATION

For performance evaluation purposes, we have chosen a set of representative application workloads running on SAP ASE 16:

- **OLTP Benchmark** – a database management system (DBMS) test-bed framework for online transaction processing (OLTP) workloads. From the variety of tests available, we have chosen a "TPC-C like" workload. The workload simulates an environment where a population of users is simultaneously executing transactions against the database. There is a mix of five different types of transactions executing concurrently. The throughput is measured in transactions per minute (TPM).
- **Performance Comparisons**
    - The first test served as a baseline and was established with OLTP-Bench workload with SAP ASE built on physical disks (HDD).
    - A second test set was run with SAP ASE built on physical disks (HDD) and also with a non-volatile buffer cache enabled and built on the EMC XtremIO All-Flash Array.
    - A third test set was run with SAP ASE built entirely on the EMC XtremIO All-Flash Array.

SYSTEM LANDSCAPE

System Configurations

Table 1 reflects the machine configuration for our testing

Memory	Machine / Processor	CPU	FC Controller
1TB	Fujitsu Primequest 2800B	Intel Xeon E7-8800 6 Sockets x 10 cores, 60 cores total	Emulex HBA, 2 FC 8Gb ports

Table 2 reflects the HDD array details:

Model	Capacity	Front End Ports
Fujistu SAN, Eternus DX500 S3	43TB raw	• 8 FC 8Gb • 8 iSCSI

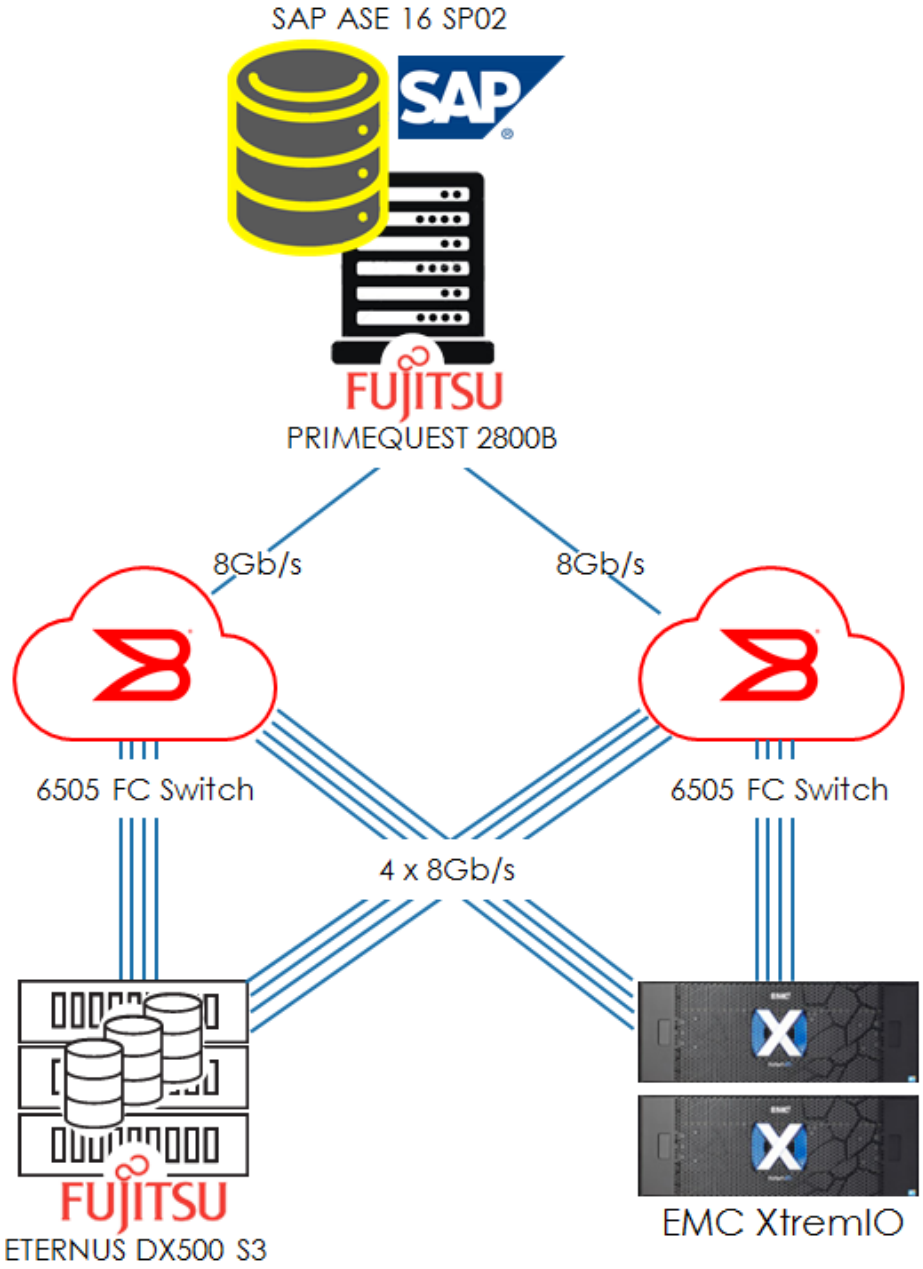
Table 3 reflects the All-Flash Array details:

Model	Capacity	Front End Ports
EMC XtremIO – Dual X-Brick All-Flash-Array	30 usable (40TB raw)	16 available: • 8 FC 8Gb • 8 iSCSI

Table 4 reflects the FC switches details/configuration:

Model	Front End Ports
2X Brocade 6505 24-port FC Switch	24 ports available: • 4 switch – storage connections per switch • 1 switch – server connection per switch

Overall System Architecture



Software Configuration

Table 3 shows the details of the software components used on the SAP ASE database server:

Software Component	Description	Version
Operating System	SuSe Linux Enterprise Server	SLES 12 SP1
DB Volumes	Raw Devices on Storage Arrays	Not applicable
SAP ASE	Database server	Version 16 SP02

DB and Software Configuration

DB consisting of 1 TB data, 0.5 TB log, allocation per test scenario:

- HDD – 1 TB data on HDD, 0.5 TB log on HDD
- NVC –1 TB data on HDD, 0.5 TB log on HDD, ~0.6 TB NV cache
- SSD –1 TB data on SSD, 0.5 TB log on SSD

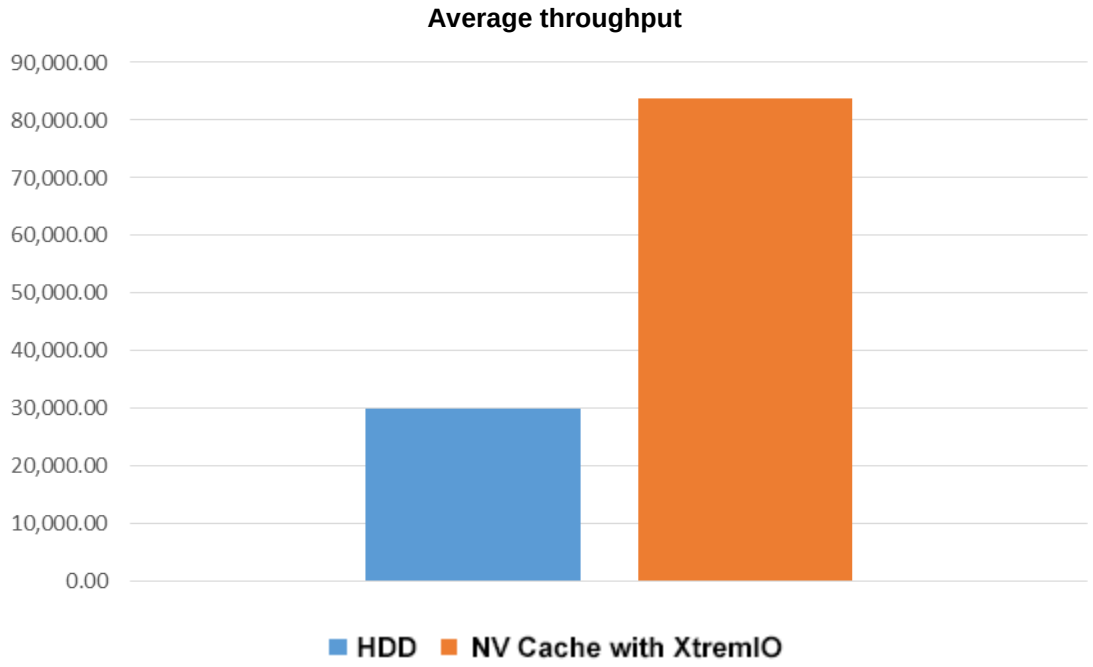
SAP ASE database configuration per all test scenarios:

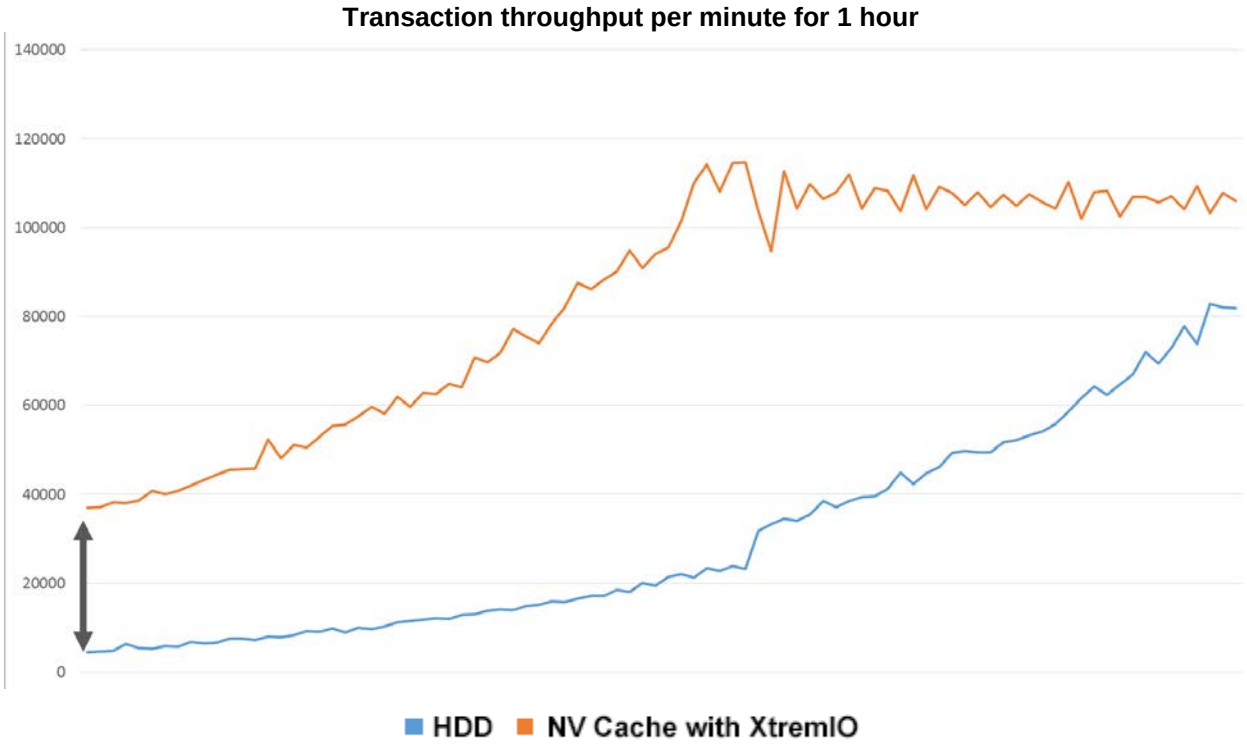
- Number of parallel engines or threads = 48
- Main memory cache size = 250 GB (note that main memory cache is not NV cache)

Workload configuration:

- Number of parallel clients = 100

HYBRID PERFORMANCE RESULTS AND ANALYSIS

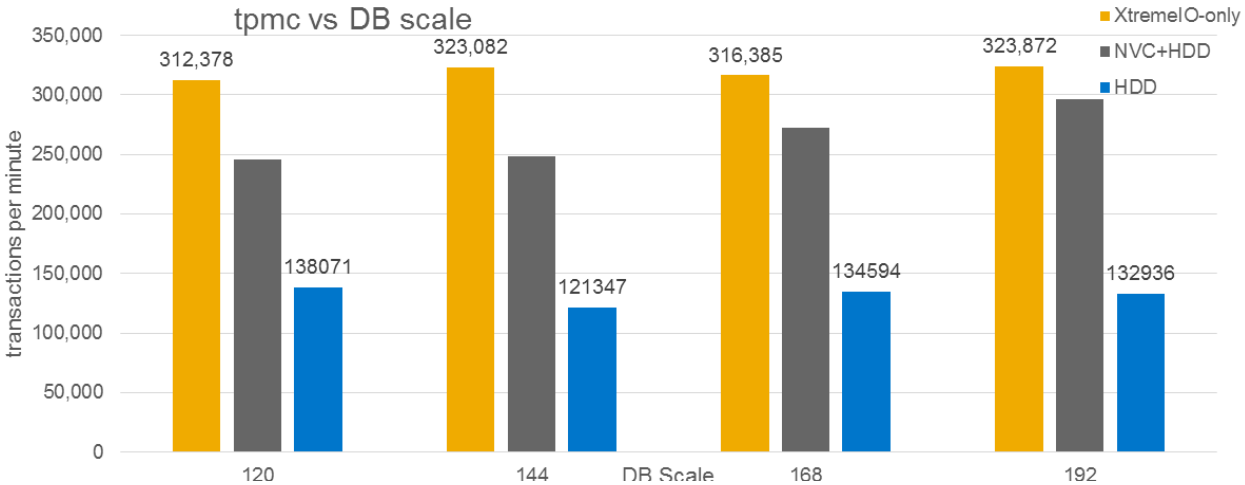




Transaction throughput over time					
HDD	HDD-Avg	NV Cache	NVC-Avg	NVC/HDD	
4,504	29,837.49	37,000	83,650.52	8.21492	

- The hybrid performance results show excellent SAP ASE speed improvements. On average, the SAP Co-Innovation Lab testing observed a 280% performance improvement in the SAP ASE database TPM rate.

ALL-FLASH PERFORMANCE RESULTS AND ANALYSIS



- The above All-flash performance results utilize an alternative configuration to the hybrid tests (as discussed in the "guidelines to interpreting the results" section, page 10). These results show excellent SAP ASE performance and TMP improvements across four different test scales. In order to compare the two testing models, the results must be normalized across all dimensions and then interpreted using the hybrid results as a core baseline. When this is done, the above all-flash results can be extrapolated to show a potential performance improvement of greater than 400% for the SAP ASE database.

SUMMARY

The extensive testing done by the joint SAP/EMC team demonstrates that significant performance gains achieved by the SAP ASE MemScale Option NV cache/XtremIO All-Flash solution. No matter what configuration or deployment architecture is chosen, customers using SAP ASE can expect to see significant improvement – in our test case, at least 280% – in SAP ASE database throughput/TPMs.

Going forward, other SAP ASE database architectures can benefit from this NV cache SSD flash solution, including those utilizing the SAP HANA accelerator for SAP ASE. This white paper will be updated in a future release to reflect testing on those additional solutions and use cases, as well as any additional updates to the test results.

CONTACT EMC

To learn more, contact us at these locations below.

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