

# Kaminario and Broadcom Providing Solution to Meet the Extreme Demands of Cloud Data Centers

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## Executive Summary

Cloud applications, both in the public and private clouds, place increased demands on infrastructure over the traditional monolithic application stacks from data centers of the past. These new environments must support the consolidation of multiple workloads into a single, virtualized environment, while allowing for rapid and often unpredictable, scalability. International Data Corporation (IDC), in its Worldwide Quarterly IT Infrastructure Tracker, reports that infrastructure product sales for cloud data centers grew 25.5% year over year in the third quarter of 2017 and now represents over 30% of worldwide IT infrastructure spending. Further, IDC reports that storage infrastructure grew 45.1% in that same period and accounts for 42% of IT spending in cloud data centers. This tremendous growth in storage for high-demand data center environments requires a storage and networking infrastructure that can meet performance, scalability and reliability needs.

Broadcom and Kaminario provide a solution designed to meet the extreme demands of these cloud data centers, built around Kaminario's K2 Gen 6 all-flash array, Broadcom's Emulex Gen 6 Fibre Channel (FC) host bus adapters (HBAs), and Brocade Gen 6 FC storage networking switches. This paper will show that the solution performs at high levels in mixed workload environments and under high-volume transactions. Customers who are building cloud infrastructures can feel confident that the solution provides the performance, reliability and scalability they need to meet the demands of today and tomorrow.

### KEY FINDINGS

- The solution seamlessly supports the transition from 16GFC to 32GFC as application workload demands increase
- Running mixed workloads, the Kaminario K2 with 32GFC target HBA delivered twice the throughput with 1/2 to 1/3 of the latency; significantly faster than 16GFC
- Database query execution times were over 3x faster with 32GFC
- Bootstorms completed up to 3x faster
- Storage Migration times were almost 4x faster with 32GFC
- The Kaminario K2 array fully consumed the available network bandwidth with maximum throughput of 3140MB/sec with the 32GFC target HBA

## Solution Components

### Brocade Fibre Channel Switches

To take full advantage of flash-based storage, innovation for the storage network is required. As companies redefine application performance with flash storage, they require networks that deliver ultra-low latency, higher capacity bandwidth, and greater reliability. In fact, an aging network will bottleneck the performance of an all-flash data center. Brocade Gen 6 Fibre Channel with Brocade Fabric Vision technology is the network innovation required for the virtualized, all-flash data center.

Brocade Gen 6 Fibre Channel combines innovative hardware, software, and integrated network sensors, ensuring the industry's highest level of operational stability that redefines application performance. Brocade Fabric Vision technology enhances visibility into the health of storage environments, delivering greater control and insight to quickly identify problems and achieve critical Service Level Agreements (SLAs). Breakthrough 32 Gbps performance accelerates application response time eliminating IO bottlenecks and unleashes the full performance of today's flash and next-generation NVMe-based storage.

New server and storage technology advancements like flash-based storage are driving up storage network bandwidth demand well beyond current capabilities. In addition, requirements for higher-density server virtualization, new latency-sensitive applications, mixed/dynamic workloads, and overall application growth all are placing unprecedented demands on the network. Flash-based storage is driving exponential advances in storage, enabling faster storage performance for high-density virtualized workloads and traditional mission-critical applications. As a result, many enterprises are implementing all-flash cloud data centers to eliminate performance issues and scalability challenges

### Brocade Fabric Vision

Enable operations to simplify end-to-end management of large-scale environments by automating monitoring and diagnostics with the following:

- Automatically detect degraded application performance through integrated network sensors for device latency and IOPS metrics.
- Optimize application performance and availability through IO Insight intelligence. Increase resiliency by automatically discovering and recovering from device or network errors.
- Validate and benchmark the physical infrastructure to help ensure predictable application performance prior to deployment.

All critical capabilities when managing an all-flash cloud data center with mixed workloads and high-volume transactions for mission-critical applications.

## Emulex HBAs by Broadcom

An essential element to the performance of applications and all-flash storage is the selection of the Fibre Channel Host Bus Adapter (HBA). Because HBAs provide the connectivity for data transfer between devices in the SAN, from host servers to switches and flash storage, their performance and reliability is pivotal to the performance of the entire SAN.

The HBAs key role in talking to both servers and storage, means that HBA innovation must be in lock-step with innovation in both storage and server design. On the server side, multi-core processors, new memory technologies, higher VM loads and the latest PCIe3.0 bus have placed increased demands on the network. On the storage side, new all-flash arrays such as the Kaminario K2 have solved storage performance bottlenecks. Installing the latest Emulex Gen 6 HBAs in both the Kaminario K2 and in the servers it's connected to enables the network with the highest horsepower, industry-leading reliability, and the latest innovations required to meet the needs of the most demanding all-flash environments.

### Emulex Gen 6 Fibre Channel HBAs

- **Optimizes Flash & Application Performance** - 2.5x more IOPS in active-standby mode than others thanks to Emulex's exclusive Dynamic Multicore Architecture which can dynamically apply all ASIC resources to any port that needs it- either to a single active port or across both active ports in a dual-port configuration, as demanded by the workload. This ensures that performance is delivered when and where needed, to meet service level agreements (SLAs). Real workload testing shows that Emulex HBAs significantly boost application performance, delivering up to 46% greater OLTP transactions per minute (TPC-C order entry dataset) simply by upgrading to an Emulex Gen 6 HBA.
- **Alleviates SAN Congestion** - The exclusive Emulex congestion management feature throttles outstanding IO via queue depth assignment to avoid over subscription (slow drain). Emulex's queue depth changes require no reboots. The BB Credit recovery feature enables lost credit recovery via periodic synch-up.
- **Improves Security** - The exclusive rogue firmware protection feature uses digital signature verification prior to HBA firmware download to prevent security breaches caused by malicious firmware.
- **Future-proofs Data Center Investments** - Emulex leads the industry with the first shipping NVMe over Fibre Channel solutions on multiple Operating Systems. Concurrent support for NVMe over Fibre Channel and traditional SCSI over Fibre Channel, means there is no rip-and-replace required for existing 16 & 32GFC networks which provides datacenters with an easy transition path to NVMe all-flash storage.
- **Simplifies SAN Management** - Emulex supports Brocade Fabric Vision to maximize uptime, simplify management and provide unprecedented visibility.

## Kaminario K2 All-Flash Array

All-flash arrays have become synonymous with performance. However, they have also been regarded as expensive and lacking the full set of enterprise features, and are better used as a solution for a specific pain point or a single application.

Flash prices have gone down considerably over the last few years and flash as a storage media has gained maturity. Customers are looking for all-flash arrays to replace traditional spinning arrays or hybrid arrays, however the market is crowded with all-flash products that are based on legacy architectures not engineered for flash media, or products that are capable of servicing only a single application, not an entire datacenter.

In its sixth generation, the Kaminario K2 all-flash array manages to realize Kaminario's vision of an all-flash datacenter, and makes the K2 the right choice for IT departments of the on-demand world, supporting applications such as relational databases, virtual environments, private-cloud implementations, NoSQL databases, containerized applications and more.

The K2 all-flash array combines prescribed hardware with tested and enterprise ready software and services. K2's Gen6 hardware platform is based on leading off-the-shelf enterprise components that enable K2's software-defined architecture and software stack. The K2 runs the Kaminario Composable Data Platform, the next-generation flash operating system stack that provides the core software and advanced data services framework.

The Composable Data Platform consists of Kaminario VisionOS, Kaminario Clarity, and Kaminario Flex. These software pillars power Kaminario K2, K2.N and Cloud Fabric.

### kaminario. VisionOS

The next-generation flash operating system stack that provides the core software and advanced data services framework. VisionOS enables modular components and services that demonstrate a superior value proposition across a real scale-out storage platform, both in innovation and in ease of use. VisionOS delivers world class data services such as data reduction, data management and data protection.

### kaminario. CLARITY

Kaminario Clarity is a cloud-based analytics platform that includes a comprehensive set of management and monitoring functionalities, including a unique capability to leverage application-level intelligence, machine learning and big data analytics - all of which enable customers to automate their storage environment and deliver higher performance for business-critical applications.

### kaminario. FLEX

Flex™ is Kaminario's Dynamically Composable Orchestration Layer. Flex is designed to provide deeper flexibility to Kaminario K2.N resources. Since K2.N's building blocks (controllers and drive shelves) are all connected via NVMeF, discrete K2 virtual private arrays (VPAs) can be carved out from a mesh of K2.N resources. Flex is then able to dynamically reallocate resources between VPAs with no actual physical movement or re-cabling - everything is done via the network. Multiple VPAs can share resources and Flex can automatically schedule resource placement according to business units' needs - end of month, annual holidays, and so on. With a comprehensive set of APIs, Flex integrates with any REST-based control platform to achieve seamless automation within the data center.

## Performance Testing

Two sets of tests were conducted by Broadcom’s Emulex labs. The first set of tests were designed to measure the effectiveness of the Kaminario K2 running demanding mixed workloads at near maximum bandwidth limits of 32GFC and 16GFC respectively, and measured the impact to latency in high-throughput scenarios.

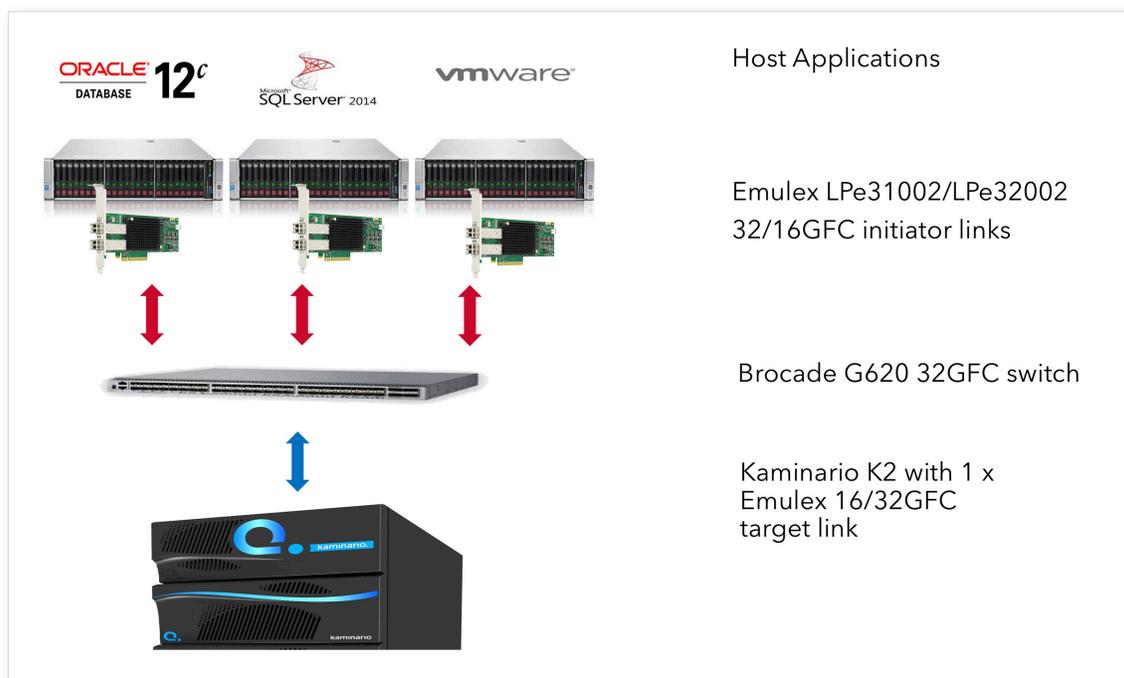
The second set of tests were designed to measure the impact that upgrading the SAN had on the performance of the Kaminario K2 array. The high-throughput tests were designed to saturate the host links running at 8GFC, 16GFC and 32GFC, connected to the K2 array and measured how the different networks impacted the workload completion times.

### TEST 1: Storage Performance Testing of the Kaminario K2 All-Flash Array with 32GFC Target HBAs

To demonstrate the performance advantages of the Kaminario K2 array with a 32GFC target HBA, Emulex labs ran an identical series of mixed workloads tests to compare the K2 with a 32GFC target HBA versus the K2 with a 16GFC target HBA.

The mixed workload testing consisted of Oracle Database 12c OLTP, Microsoft SQLServer 2014 OLTP and VMware 6.0 boot storm. The configuration for the tests was identical except for swapping the target HBA in the K2 array from an Emulex 32GFC HBA to an Emulex 16GFC HBA. A Brocade G620 32GFC switch was used. Emulex labs found the analytics on the K2 array to be very accurate and matched the throughput statistics captured on the hosts perfectly. For both 16GFC & 32GFC testing, throughput fairness was achieved without the need for setting QoS on the K2 array with the throughput being allocated evenly between all three applications.

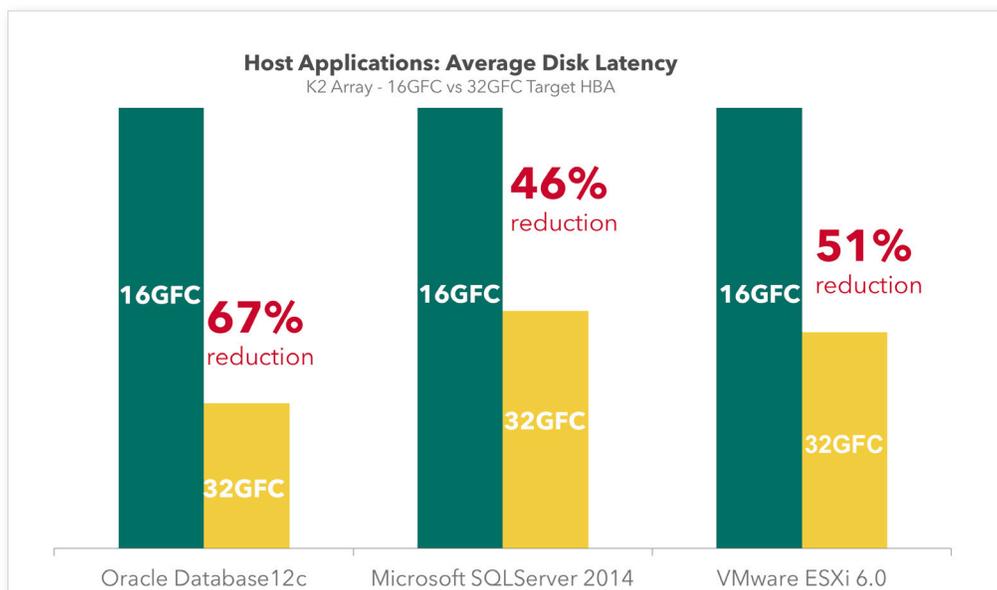
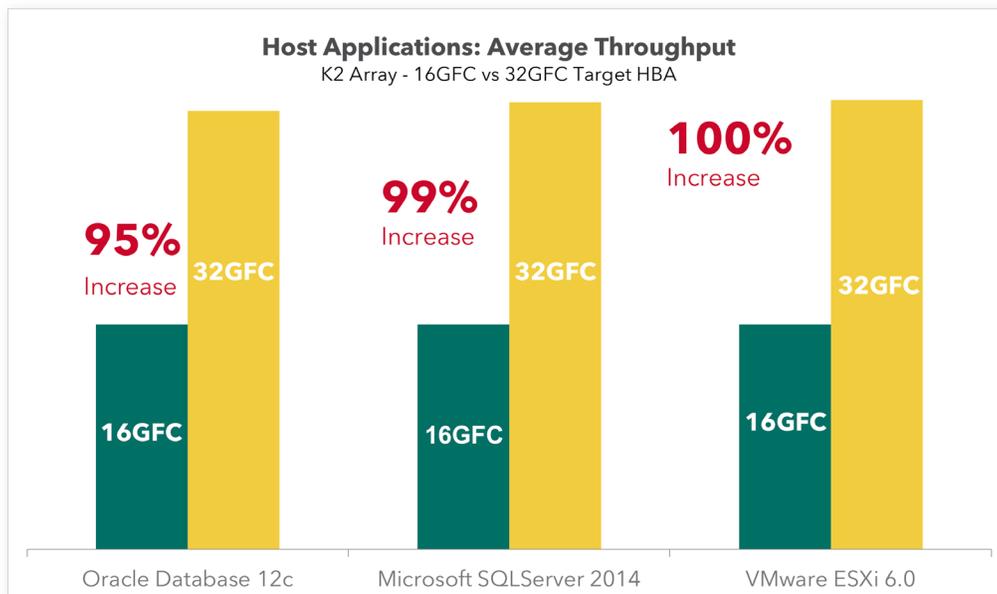
#### Target HBA Performance Test Topology



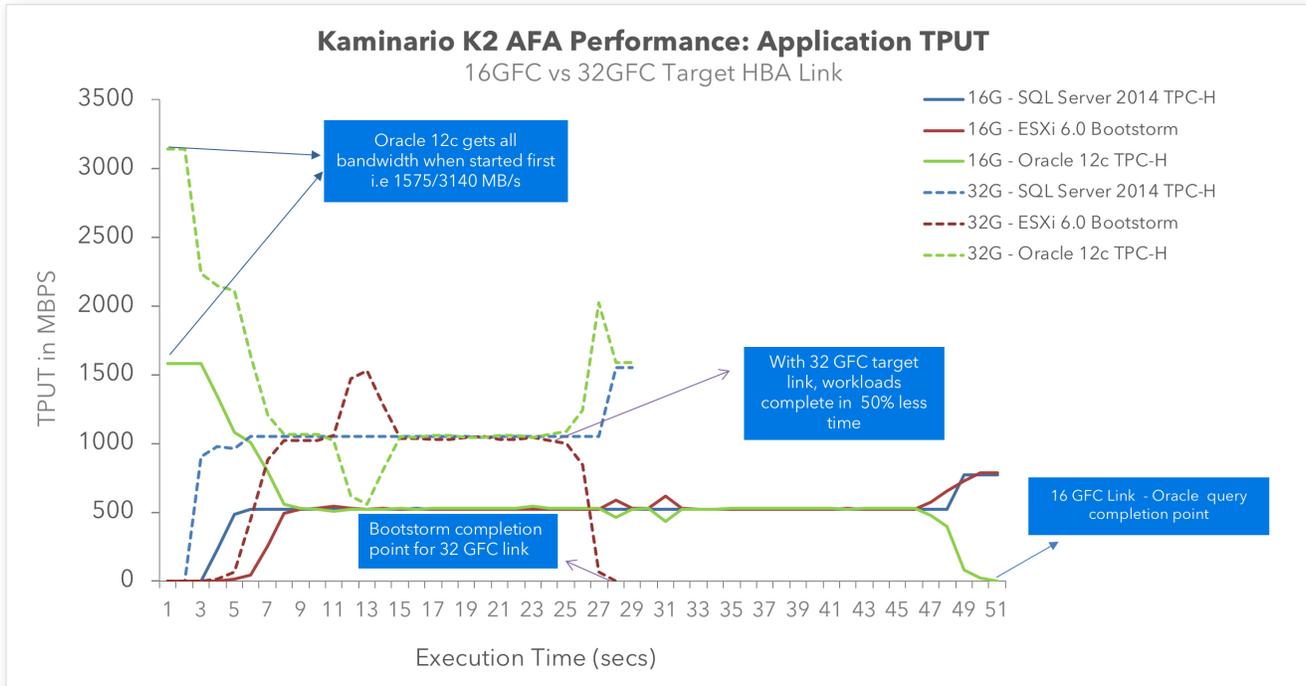
## Results

For the host applications, the Kaminario K2 with a 32GFC target HBA delivered impressive performance results versus the K2 with a 16GFC target HBA.

Throughput *was almost double for all workloads* and at the same time *latency was reduced to between 1/3 to 1/2*, depending on the workload. During testing, the K2 array fully consumed the available network bandwidth with maximum throughput of 3140 MB/sec with the 32GFC target HBA and 1575 MB/sec for the 16GFC target HBA.



The following chart shows the results of mixed workload testing with all three applications starting at the same time. For all applications running on the Kaminario K2 with an Emulex 32GFC target HBA (represented by the dotted lines), the end time (execution time) is reduced by half when compared to the K2 with a 16GFC target HBA (represented by the solid lines). Execution time was reduced to 27 seconds from 51 seconds.



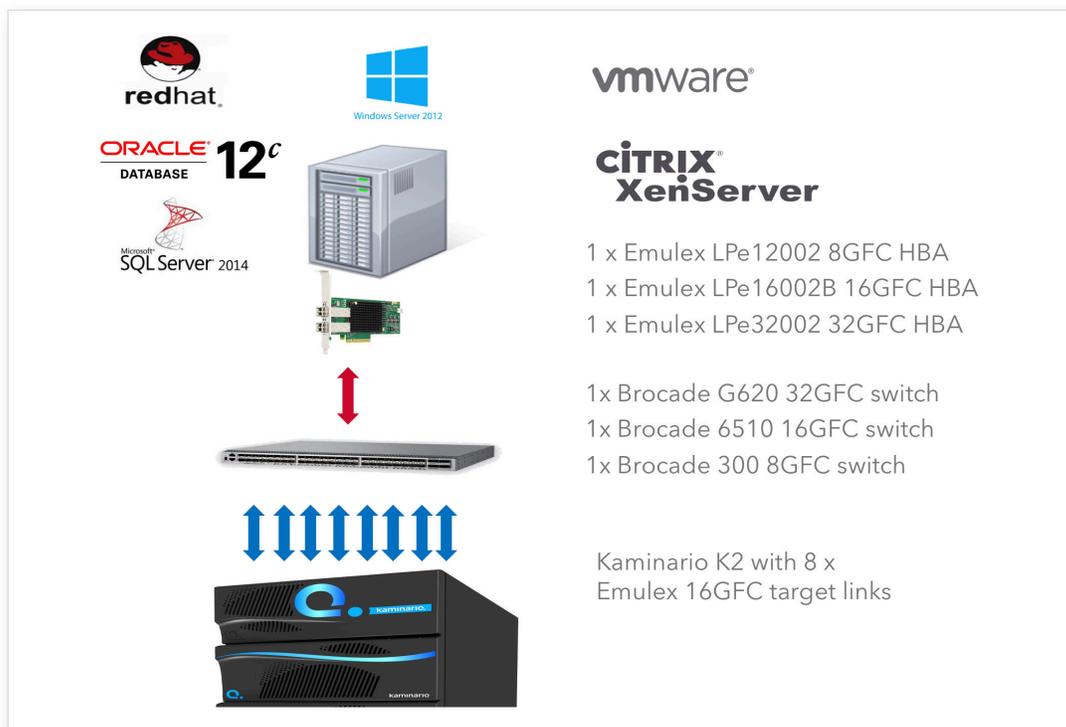
## Test 2: Application Performance Testing of a 32GFC Network Compared to 16GFC/8GFC Networks

To demonstrate the performance advantages that network and server admins can expect to see by upgrading to a 32GFC network versus a 16GFC or 8GFC network, a series of workload testing was performed by Emulex labs. Testing consisted of database applications and virtualization workloads. The tests performed were identical with the exception of swapping out the Emulex 32GFC, 16GFC and 8GFC HBAs in the servers, and swapping out the Brocade 32GFC, 16GFC and 8GFC switches.

The database workload consisted of TPC-H DSS query execution for Oracle 12c and Microsoft SQL Server 2014. The Virtualization workload consisted of boot storm and storage migration for VMware ESXi 6.0, Microsoft Hyper-V 2012r2 and Citrix XenServer 7.0.

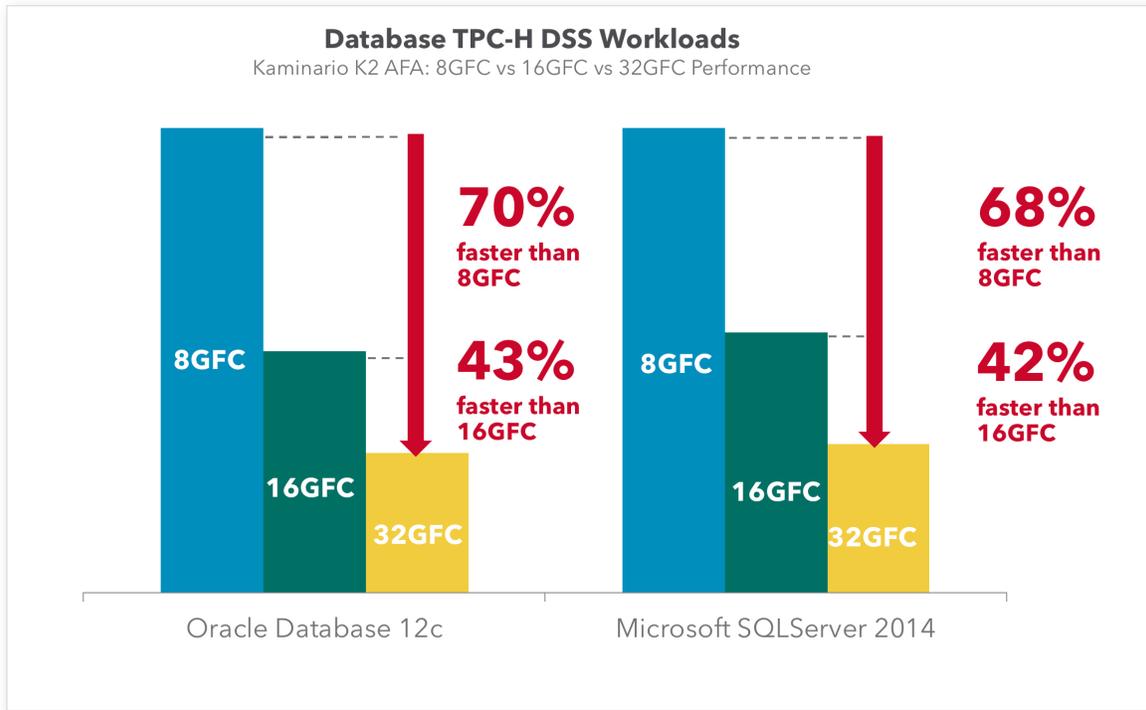
- For all the applications, upgrading the network to 32GFC from 16GFC boosted the performance of the array by approximately 2x.
- For all the applications, upgrading the network to 32GFC from 8GFC boosted the performance of the array by approximately 3x.

### Application Performance Tests-Topology



### Results: Database Application Testing

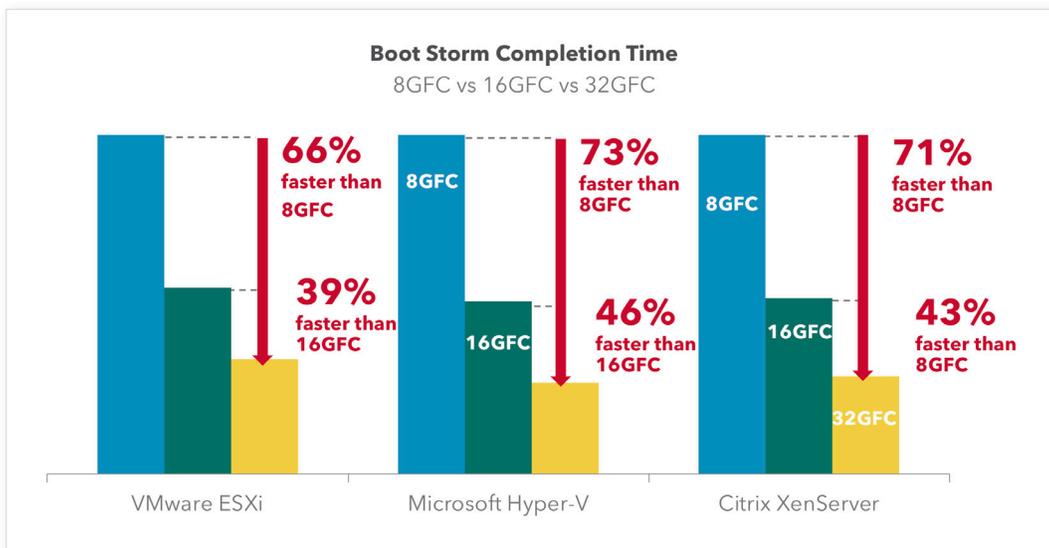
Decision Support Systems (DSS) analyze large volumes of data and complex queries to provide answers to business questions that often have a significant impact to revenue. Examples include sales figures over time, projected revenue figures, and the modelling of different business decisions. TPC-H-like tests simulate queries that are commonly used in the industry to provide performance metrics. The TPC-H-like tests used in this report consisted of 22 ad-hoc queries to a database. The query execution time was then measured. The chart below shows a performance gain of **over 3x faster query execution times** using a 32GFC network versus an 8GFC network (70% and 68% reduced execution time). Compared to a 16GFC network, the performance improvement delivered by the 32GFC network was **almost 2x faster** (43% and 42% reduction in execution time).



**Results: Boot Storm Testing**

The boot storm workload testing was designed to mimic a real world scenario of multiple Guest OSES booting simultaneously and hosting critical applications. As part of the Guest OS boot up, a service is added that reads a 25G file. Many enterprise databases load data into memory as a cache (in-memory databases). The startup of the OS is determined to have completed once the IP address is visible to the hypervisor management tools through the integration services/tools.

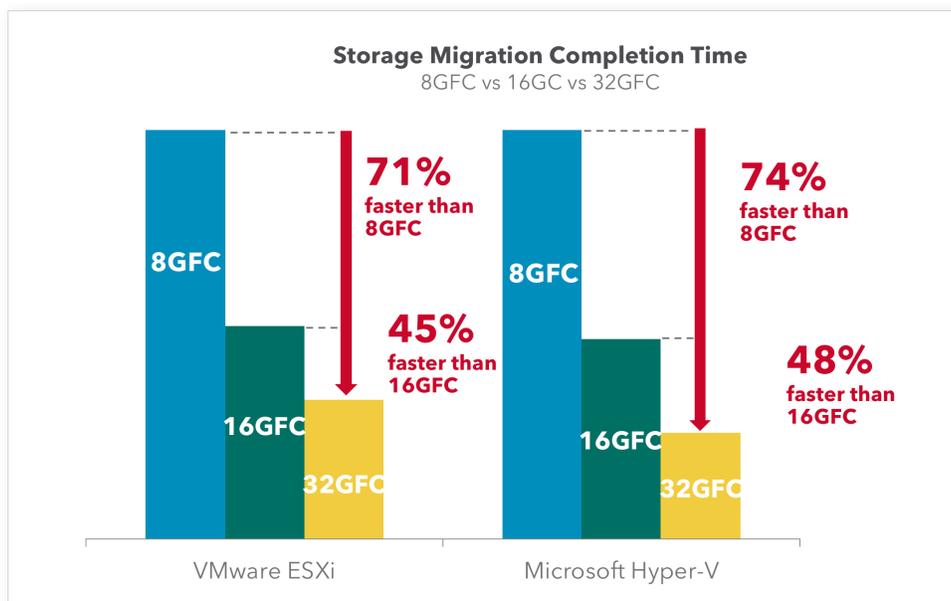
In each of the hypervisors tested, boot storms completed approximately **3x faster with a 32GFC network** versus an 8GFC network (73% to 66% reduction in completion time). Boot storms completed approximately **2x faster with 32GFC than the 16GFC network** (46% to 39% reduction).



**Results: Storage Migration**

Virtual Machine Storage Migration moves the virtual disk files of a running VM from one data store to another, with minimal disruption to the VM or the user. Data stores can be on different SANs or on the local storage of a server. Storage migration is used when the SAN has reached capacity, for load balancing reasons, to replace a SAN or take a SAN down for maintenance, or to move virtual disks from local server storage to a SAN.

In the chart below, VM migration times were **almost 4x faster for Hyper-V using a 32GFC network** versus an 8GFC network. Migration times were **almost 2x faster** with the 32GFC network compared to the 16GFC network (48% and 45% reduction in completion time).



## Summary

Testing has shown that the Kaminario K2 with a Gen 6 Fibre Channel network is very effective in delivering the performance needed to accelerate demanding mixed workloads as well as providing the performance and scalability required to support next-generation applications. In these tests, the K2 with a 32GFC target HBA running a mixed workload comprised of Microsoft SQL Server, VMware EXSi 6.0 and Oracle 12c saw double the throughput and at the same time displayed significantly reduced latency -- ½ to 1/3 the latency of a K2 with a 16GFC target HBA. Network testing showed the 32GFC network consisting of Emulex 32GFC HBAs installed in servers and connected to a Brocade 32GFC switch delivered over 3x faster database query execution times, 3x faster bootstorm times and almost 4x faster storage migration times than a 8GFC network. The solution was easy to upgrade from 8GFC to 32GFC, enabling datacenters to scale for future workload requirements while protecting investments in all-flash arrays and the Fibre Channel networking infrastructure.



### Contact

Contact a business development representative to answer any questions you may have.



### Schedule a Demo

Schedule a demo with an engineer and learn if Kaminario's solution works for you.



### Request a Quote

Request a quote for your application from our business development team.

## About Kaminario

Kaminario, the leading all-flash storage company, is redefining the future of modern data centers. Its unique solution enables organizations to succeed in today's on-demand world and prepares them to seamlessly handle tomorrow's innovations. Only Kaminario K2 delivers the agility, scalability, performance and economics a data center requires to deal with today's cloud-first, dynamic world and provide real-time data access -- anywhere, anytime. Hundreds of customers rely on the Kaminario K2 all-flash array to power their mission critical applications and safeguard their digital ecosystem. Headquartered in Needham, MA, Kaminario works with an extensive network of resellers and distributors, globally.

For more information, visit [www.kaminario.com](http://www.kaminario.com)

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