Executive summary

The Kaminario K2 All Flash Storage Array, powered by Intel® Xeon® processors, is a foundation component of the 21st century All Flash Data Center. K2 lets users scale business easily and efficiently without compromise. For customers across the board – healthcare, financial services, manufacturing, retail, government and utilities – simultaneously running a range of workloads including database, virtual desktop infrastructure (VDI), server virtualization, analytics and SaaS infrastructure, K2 delivers performance, scalability, resilience, simplicity more cost-efficiently than traditional storage solutions.

“Scale up and scale out with the K2 All Flash Array with Kaminario.”

-Kaminario
The Modern IT Infrastructure Challenge

The pace and intensity of doing business in the 21st century, fueled by rapid technological and social change, in the always-resource-constrained context of practical reality create a widening gap between the expectations of businesses' customers and owners and IT operations' ability to deliver to those expectations.

Business Expectations

More is more. A fundamental aspect of business today is that everything is growing. More users generate and consume more data on an ever-increasing number of devices. And they are doing it from more places, as mobility becomes the norm.

Experience the gap. Business users demand user experience improvements from their IT infrastructure, driven by improvements they experience in daily life, from phones and tablets to cars and refrigerators. Application performance must improve to support the improvements in user experience.

Agility. Keeping up with a dynamic business environment, with simultaneous changes in buyers, suppliers, and competitors, places never-before-seen requirements on IT to rapidly adapt to changes of all sorts.

IT's Ability to Deliver

Past is present. At the same time that the business world is changing, IT must contend with the legacy of preceding technologies. The legacy takes the form of installed-base hardware and software (often paid-for and/or depreciated), ingrained skillsets that accompany existing products and a mentality of 'what got me here will move me forward'.

Headhunting. People continue to be the largest single expense item in any IT budget. As other costs rise disproportionally the pressure increases on IT to meet business expectations with reduced headcount. And as ranks of IT staff shrink, the luxury of specialists disappears, giving rise to fewer, more generally skilled, IT staff.

Budget-busting. Do more, maybe with less. The business's expectation is that IT will support more projects and initiatives, with no more funding. The result is reduced spending in all IT areas, which can be amplified if overall spending is reduced, too. And the exponential rise in storage capacity puts the storage budget in the spotlight as spending is squeezed.

Kaminario K2 All Flash Array & Intel® Xeon® processors

The combination of flash storage and Kaminario's software-defined storage architecture running on advanced Intel® Xeon® processors enables users to efficiently and easily scale their business without compromise.

Flash elegance. Solid-state flash is the widely preferred medium for backend storage in an array. As a storage medium it has higher performance, lower power consumption and requires less data center cooling than a workload-equivalent amount of traditional disk storage. When integrated into a storage array, flash enables further benefits of less data center footprint, fewer host ports, consolidation of more servers and simpler management that a solution based on traditional storage arrays. Finally, flash density is increasing faster than Moore's Law, driving step function improvements in cost efficiency.

Architecture and execution. Kaminario's software-defined storage architecture is a framework that delivers key capabilities by leveraging the power of Intel® Xeon® Processors. Kaminario's software technology includes algorithms for flash-friendly I/O, array scaling, resiliency, distrib-
uted management, data protection and data reduction. Kaminario K2 processing is turbocharged in each K-Node with dual Intel® Xeon® E5 2600 series 8-core processors under the hood. Intel processor performance is key for software-defined capabilities including compression, deduplication, and RAID. Parallel and vector processing specifically enables RAID encoding and simultaneous handling of I/Os against multiple SSDs.

**K2 All Flash Storage Array**

The Kaminario K2 All Flash Storage Array is designed to harness the power of flash with the right storage efficiency features such as global inline selective deduplication, inline compression, thin-provisioning, efficient and robust Kaminario RAID scheme and highly efficient metadata management. The outcome is cost-effective All Flash Array (AFA) storage, with better cost than HDD storage. There is no compromise on enterprise resiliency, which is gained via native snapshot and replication features, high availability (HA) and non-disruptive upgrades (NDU).

K2’s unique scalability features of scale-out and scale-up drive business agility to the maximum, enabling independent linear growth of capacity and performance according to data center needs. Combined with a global adaptive block size algorithm, single management pane and full VMware® integration, K2 is able to sustain the performance of multiple environments and mixed workloads while keeping it simple and easy to manage.

The K2 All Flash Storage Array is built up from nodes called K-Blocks. The minimum system contains 2 K-Node processing units, interconnected via Infiniband and SAS-connected to a single 24-slot shelf of SSD storage. Each K-Node provides redundant Fibre Channel and Ethernet iSCSI ports for host connectivity as well as dual hot-swap power supply and battery back-up units. Volumes and metadata are automatically distributed between all solid state drives (SSDs) in the array and can be accessed from every K-Node in the array.

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![Figure 1: K-Block Diagram](image1)

![Figure 2: K-Block Scale Up Diagram](image2)
Scale up expansion is accomplished by adding a 24-slot expansion shelf to a K-Block. The expansion increases the capacity density and reduces the cost/GB of the array. The SAS-connected expansion shelf is added non-disruptively with no downtime or decrease in performance and existing volumes are automatically redistributed between all the SSDs in the array and can be accessed from every K-Node in the array.

Scale out increases the number of K-Blocks in the array, adding more capacity and compute power. Redundant InfiniBand switches interconnect all the K-Nodes in Multiple K-Block systems. The expansion linearly increases the capacity and performance of the array. Existing volumes are automatically redistributed between all the SSDs in the array.

From a software perspective, K2’s SPEAR (Scalable Performance and Resilience) architecture provides the Kaminario K2 AFA with a comprehensive set of storage efficiency features such as global inline selective deduplication, inline compression, thin-provisioning and K-RAID™ data protection. SPEAR also includes a complete software stack of enterprise resiliency features such as high availability (HA), non-disruptive upgrades (NDU), snapshots, replication and cloud-based HealthShield™ for enterprise serviceability. In addition, the Kaminario Management Service delivers ease of use and flexible management abilities. With scale-out and scale-up capabilities, the same ease of use and management simplicity is gained for any array size, with performance and capacity to suit the data center needs - driving business agility to the top.

Figure 3: K-Block Scale Out Diagram
**Key K2 Benefits**

The unique capabilities of the Kaminario K2 array provide key benefits to IT departments faced with closing the expectation gap in their businesses by implementing an all-flash data center.

**Cost Efficiency.** K2 requires that users purchase only one storage platform because the SPEAR architecture enables K2 to run all workloads, application and analytic, for all users, on one storage platform. K2 users can pay as they grow by purchasing a subset of storage, then licensing further amounts of capacity as required. Scale up and out lets users purchase the amount of capacity and/or performance required then easily scale. Kaminario Perpetual Array enables growth and Capacity Guarantee limits capital expenditure.

**Performance.** Kaminario’s workload agnostic software-defined architecture lets all workloads, application and analytic, for all users, run on one storage platform with consistent performance. Selective dedupe increases performance for online business database workloads, by disabling deduplication where there is no benefit. Adaptive block size algorithms optimize I/O for both transaction workloads – small block random – and analytic workloads – large block sequential, in a single K2 array.

**Resiliency.** Kaminario’s K-RAID advanced data protection algorithms enable continued process under several media failure conditions at a very low capacity cost. Perpetual Array supports non-disruptive expansion of K2 arrays keep business online while growing.

**Scalability.** K2 arrays scale up to lower cost/GB and increase density. K2 arrays scale out to lower cost/performance and increase capacity. Perpetual Array – K2 arrays minimize capital expenditure by protecting the investment in existing equipment and minimize opportunity cost through non-disruptive upgrades.

**Simplicity.** K2 arrays scale both up and out non-disruptively, requiring no capacity management or tuning. Kaminario Guaranteed Effective Capacity removes uncertainty from the data reduction portion of capacity planning. Perpetual Array delivers both investment protection and simple non-disruptive upgrades. HealthShield provides a platform for support analytics and management.

**Solution and Market Fit**

The K2 All-Flash storage array enables the all-flash data center for a wide variety of workloads and industries.

**Database.** K2’s ability to maintain consistent IOPS, throughput and low latencies even in the face of demanding mixed database workloads, along with native technologies like writeable snapshots and inline compression, make it cost-effective to deploy databases on an all-flash storage infrastructure. Consolidating databases can greatly reduce the required investment in server software and hardware. K2’s consistent performance and writeable snapshots allow long-running analytical and report workloads to share the same K2 array with time-critical transaction processing, further reducing costs. K2’s native compression can substantially reduce the physical capacity required for database volumes. Using K2’s native writeable snapshots to clone or backup databases saves time and prevents disruption to ongoing workloads. Snapshots also save up to 90% of the capacity needed for cloned databases and let analytics run against snapshots without risk to production service level agreements (SLAs).

**VDI.** K2’s consistent low latency and predictable high IOPS/throughput deliver responsive virtual desktops and ensures both IT and users can get their work done. K2’s global inline selective deduplication lowers virtual desktop storage physical capacity needs by up to 95%, or 20:1 in terms of data reduction ratios. Simultaneous startup and shutdown of large groups of virtual desktops typically create I/O storms that bring legacy storage to its knees, resulting in downtime and unhappy users. Benchmarks, run on a single K-Block K2 array holding 1,500 virtual desktops, measured only 8 minutes required to boot all desktops and only 3 minutes required to power them down, with array latency still remaining well below 1.0 ms. K2 supports leading desktop virtualization solutions from Citrix® and VMware.

**Server virtualization.** K2’s ability to efficiently scale up and out to handle demanding mixed workloads and blended I/O make it an ideal primary storage tier for virtual servers. K2’s intelligent design provides consistent low latency and high throughput/IOPS, across even the random blends of concurrent I/O requests typical in virtual server workloads. Virtualizing servers to eliminate redundant and over-provisioned server hardware and standardizing on K2 AFAs supports the same number of servers, applications and users with less hardware cost and fewer software licenses than legacy storage. Sandboxed virtual servers needed for internal development, QA...
testing and user training benefit from K2’s global inline selective deduplication, with their physical capacity requirements reduced by as much as 95%. Copying server VMs using K2’s native writeable snapshots is fast and saves up to 90% capacity compared to traditional VM copying. K2 integrates with VMware via a vCenter plug-in and support for VMware’s VAAI* hardware acceleration API enables K2 arrays to be easily integrated any VMware virtualized infrastructure.

**Analytics.** Moving data sets onto an all-flash Array infrastructure can cut the required time for data preparation and analysis by over 90%. Moving from legacy HDD-based storage to a K2 All-Flash Array improved the rate of extract-transform-load (ETL) updates by 10X. Even ongoing database update and maintenance tasks completed up to 3 times faster on a K2 AFA. K2’s native snapshots make it quick and simple to clone and process even large data sets with little overhead, delay or wasted storage capacity. K2’s native compression can save up to 2/3rd of the physical capacity required for data sets – equivalent to the best results from using the native database compression with no decrease in throughput and no extra load on the host server CPUs. K2’s inline deduplication can also reduce the effective capacity requirements of volumes storing data warehouses holding repeated sets of data from successive months. A single K2 array can grow with data sets, starting at 7TB and growing seamlessly to over 1PB of usable flash storage in just 20U.

**SaaS infrastructure.** K2 storage provides Software-as-a-Service (SaaS) application owners with cost efficiency, predictability and business agility to successfully operate and grow their subscription services. K2’s scale up and scale out architecture, with Perpetual Array capability, lets application owners spend less on storage and only when they need it. K2’s adaptive block size and selective data reduction algorithms let production and analytic workloads run side-by-side in the same array for predictable performance and the economic benefits of consolidation. K2’s advanced K-RAID data protection algorithms let SaaS businesses stay online under several media failure conditions at a very low capacity cost. And non-disruptive expansion of K2 arrays keeps business online while growing.

**Healthcare.** As the healthcare industry moves online, the IT infrastructure of all participants requires the speed, agility and flexibility of an all-flash infrastructure. Data processing in the form of electronic health records/electronic medical records (HER/EMR) and all forms of transactions and payments must be fast, reliable and scalable. Typical users include doctor/practitioner groups, hospitals, pharmacies, pharmaceutical companies and insurers.

**Financial services.** Financial services led the move to online transaction processing and advances in mobile connectivity and online social interaction increase both the speed and volume of those transactions. All forms of securities transactions from trading to settlement, online payments including credit cards and payment services and the ever-growing discipline of online fraud detection require performance, scale and the ability to handle multiple different workloads on a single storage infrastructure. Typical users include traditional business like banking, insurance and securities as well as 21st century businesses like online payments and micro-loans.

**Manufacturing.** Manufacturing has been a key participant as Software as a Service has evolved. Enterprise Resource Planning (ERP) got its start as Manufacturing Resource Planning (MRP). Most manufacturers today use a Customer Relationship Management (CRM) system as well. With the entire business moving online, IT systems are absolutely mission-critical in manufacturing not only from a reliability perspective but also from a growth and business agility perspective. Typical users include electronics, auto, aircraft and consumer goods manufacturers.

**Retail.** Retail businesses have seen both innovation and metamorphosis fueled by IT. In a direct customer-facing retail business, throughput, response time and predictability are the underpinnings of the most important business metric, customer satisfaction. IT advances clearly enabled all forms of retail innovation, from online bookstores to the sharing economy.

“... We selected Kaminario K2 v5 for our enterprise storage needs because it has one of the most efficient architectures we’ve seen on the market, allowing us to maximize our storage capacity of 300TB at a footprint of just 4U, keep pace with the demands of our customers, and simplify the management stack operations in different workload environments. In addition, K2 v5 enables us to reduce costs to under $2 per usable GB since we’re able to minimize the average amount of storage that is required for each VM. These cost savings are significant for our environment, where we test environments of thousands of virtual servers. We were able to deploy over 7,000 virtual servers on a single K-Block configuration of K2 v5, with a data reduction rate of 20:1.”

- Shai Toren, General Manager

*Intigra Kaminario K2 V5 Customer*
And IT has always been there for brick and mortar business, from Point of Sale processing to Big Data analysis of sales trends.

**Government.** Government users share many of the same characteristics as private industry, with a need for systems that are particularly cost-efficient and reliable, as well as systems with a long life and built in investment protection. Government users have a special requirement for all forms of lower cost – acquisition or capital cost and all forms of operational costs. Governments engage in healthcare, financial and retail activities, through agencies like revenue service/taxes and benefits/social security.

**Utilities.** Utilities business are built on reliability and require IT systems to match. Consumers want energy, communications and water to work all the time, regardless of natural or man-made occurrences. And like Government, Utilities engage in manufacturing, financial services and retail activities but within a tightly regulated environment which, among other things, controls pricing to put pressure on costs. Utility examples include oil and gasoline (with a special requirement for high performance computing for exploration), electric utilities and telephone/cable companies.

Intel® Xeon® processor E5-2600 v3 and v4 product families are at the heart of an agile, efficient storage solution. Intel® Xeon® Processors and chipsets have many advancements and optimizations for storage functions and workloads, from de-duplication and compression to thin provisioning and encryption. Intel’s Storage Group also produces optimized software libraries for implementing advanced storage functionality like erasure coding and optimized SSD protocols. Designed so that compute, storage, and networking work better together, the latest Intel® Xeon® processor can help you meet today’s challenges while laying the groundwork for tomorrow’s fully-orchestrated data center. The latest members of the Intel® Xeon® processor E5 family deliver the best combination of performance, built-in capabilities, and cost-effectiveness to address technical computing challenges, enable cloud deployments, accelerate processor performance for peak loads, deliver intelligent storage or power data analytics.

**Call to Action**
For more information visit [www.intel.com/storage](http://www.intel.com/storage)


**Kaminario At A Glance**
Kaminario transforms technology-driven businesses by simplifying data processing with optimized all-flash, enterprise storage. Redefining standards for scalability, ease of use, and cost efficiency, the Kaminario K2 all-flash array is the high-performance backbone of the modern enterprise. Leveraging the economics of commodity hardware with a highly efficient, software-defined architecture, the K2 delivers the performance benefits of flash at a disruptive price point below that of disk or hybrid storage.

“We saw the cost of everything coming down, but disk storage has always been an Achilles heel. We wanted more cost-effective and better-performing solutions. With the K2 shared array, this amount of throughput allows us to do things that we previously could not do with our measured queries. Access time to the disk in microseconds is orders of magnitude better.”

- George Herman, President, Distributed Systems Solutions, Inc. Kaminario Customer

“Scale, performance, resiliency, simplicity in Kaminario’s K2 All-Flash storage.”
Disclaimers

1 System configuration listed on page 13 of the following (download-only) document and supporting data listed on page 8 of said document: http://info.kaminario.com/performance_testing_vmware_view_vdi_kaminario_k2_storage

2 System configuration: K2 all flash storage array connected over typical IT network loading 1.5TB SQL Server database, as performed by K2 customer named ActiveTrail. Supporting data at http://kaminario.com/resources/files/CS-ActiveTrail.pdf

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at www.intel.com/storage.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.

Configurations: See endnotes 1 and 2 listed above.

For more information go to http://www.intel.com/performance.

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