SPC BENCHMARK 2™
EXECUTIVE SUMMARY

KAMINARIO, INC.
KAMINARIO K2
(K2F00000700)

SPC-2™ V1.5

Submitted for Review: November 20, 2013
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EXECUTIVE SUMMARY

Test Sponsor and Contact Information

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Revision Information and Key Dates

<table>
<thead>
<tr>
<th>Revision Information and Key Dates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC-2 Specification revision number</td>
<td>V1.5</td>
</tr>
<tr>
<td>SPC-2 Workload Generator revision number</td>
<td>V1.2</td>
</tr>
<tr>
<td>Date Results were first used publicly</td>
<td>November 20, 2013</td>
</tr>
<tr>
<td>Date FDR was submitted to the SPC</td>
<td>November 20, 2013</td>
</tr>
<tr>
<td>Date the TSC will be available for shipment to customers</td>
<td>currently available</td>
</tr>
<tr>
<td>Date the TSC completed audit certification</td>
<td>November 18, 2013</td>
</tr>
</tbody>
</table>

Tested Storage Product (TSP) Description

Kaminario K2 is an enterprise class general purpose MLC Flash array that eliminates I/O and throughput bottlenecks and dramatically reduces latency to accelerate applications. The K2 is consistently fast, highly available, cost effective, and easy to deploy storage. The K2 is a fundamentally better way to store performance sensitive data.
SPC-2 Reported Data

SPC-2 Reported Data consists of three groups of information:

- The following SPC-2 Primary Metrics, which characterize the overall benchmark result:
  - SPC-2 MBPS™
  - SPC-2 Price Performance
  - Application Storage Unit (ASU) Capacity
- Supplemental data to the SPC-2 Primary Metrics.
  - Total Price
  - Data Protection Level
- Reported Data for each SPC Test: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand Delivery (VOD) Test.

SPC-2 MBPS™ represents the aggregate data rate, in megabytes per second, of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video on Demand (VOD).

SPC-2 Price-Performance™ is the ratio of Total Price to SPC-2 MBPS™.

ASU (Application Storage Unit) Capacity represents the total storage capacity available to be read and written in the course of executing the SPC-2 benchmark.

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 8.

Data Protection Level of Protected 2 using K-RAID, which consists of RAID 10 during normal operation, where half of the SSD storage is allocated for data mirroring. During failures, the data is mirrored to the KMS storage capacity (HDDs).

Protected 1: The single point of failure of any component in the configuration will not result in permanent loss of access to or integrity of the SPC-2 Data Repository.

Currency Used is formal name for the currency used in calculating the Total Price and SPC-2 Price-Performance™. That currency may be the local currency of the Target Country or the currency of a difference country (non-local currency).

The Target Country is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.
SPC-2 Reported Data (continued)

<table>
<thead>
<tr>
<th>SPC-2 MBPS™</th>
<th>SPC-2 Price-Performance</th>
<th>ASU Capacity (GB)</th>
<th>Total Price</th>
<th>Data Protection Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>33,477.03</td>
<td>$29.79</td>
<td>60,129.54</td>
<td>$997,348.00</td>
<td>Protected 2 (K-RAID)</td>
</tr>
</tbody>
</table>

The above SPC-2 MBPS™ value represents the aggregate data rate of all three SPC-2 workloads: Large File Processing (LFP), Large Database Query (LDQ), and Video On Demand (VOD).

### SPC-2 Large File Processing (LFP) Reported Data

<table>
<thead>
<tr>
<th>Data Rate (MB/second)</th>
<th>Number of Streams</th>
<th>Data Rate per Stream</th>
<th>Price-Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFP Composite</td>
<td>31,884.08</td>
<td></td>
<td>$31.28</td>
</tr>
</tbody>
</table>

Write Only:

- 1024 KiB Transfer: 26,086.14 (85) 306.90
- 256 KiB Transfer: 26,363.90 (200) 131.82

Read-Write:

- 1024 KiB Transfer: 30,496.95 (160) 190.61
- 256 KiB Transfer: 32,081.35 (460) 69.74

Read Only:

- 1024 KiB Transfer: 34,591.57 (130) 266.09
- 256 KiB Transfer: 41,684.59 (475) 87.76

The above SPC-2 Data Rate value for LFP Composite represents the aggregate performance of all three LFP Test Phases: Write Only, Read-Write, and Read Only.

### SPC-2 Large Database Query (LDQ) Reported Data

<table>
<thead>
<tr>
<th>Data Rate (MB/second)</th>
<th>Number of Streams</th>
<th>Data Rate per Stream</th>
<th>Price-Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDQ Composite</td>
<td>37,089.66</td>
<td></td>
<td>$26.89</td>
</tr>
</tbody>
</table>

1024 KiB Transfer Size:

- 4 I/Os Outstanding: 30,131.38 (35) 860.90
- 1 I/O Outstanding: 34,692.16 (135) 256.98

64 KiB Transfer Size:

- 4 I/Os Outstanding: 42,855.61 (460) 93.16
- 1 I/O Outstanding: 40,679.48 (1,350) 30.13

The above SPC-2 Data Rate value for LDQ Composite represents the aggregate performance of the two LDQ Test Phases: 1024 KiB and 64 KiB Transfer Sizes.

### SPC-2 Video On Demand (VOD) Reported Data

<table>
<thead>
<tr>
<th>Data Rate (MB/second)</th>
<th>Number of Streams</th>
<th>Data Rate per Stream</th>
<th>Price-Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>31,457.36</td>
<td>40,000</td>
<td>0.79</td>
<td>$31.70</td>
</tr>
</tbody>
</table>
Storage Capacities and Relationships

The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.

![Pie chart showing storage capacities and relationships]
Configured Storage Capacity: 137,542 GB

- Overhead/Metadata: 7,560 5.26%
- Sparing: 15,994 GB 11.63%

Unused Data Capacity:
- 0 GB 0.00%

Addressable Storage Capacity:
- 60,130 GB 43.72%
- Data Protection Capacity (used): 60,130 GB 43.72%
- Data Protection Capacity (unused): 0 GB 0.00%

Addressable Storage Capacity: 60,130 GB

20 Logical Volumes, 3,006 GB per Logical Volume

Total ASU Capacity:
- 60,130 GB 100.00%

Unused Addressable Capacity:
- 0 GB 0.00%
**SPC-2 Storage Capacity Utilization**

<table>
<thead>
<tr>
<th></th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Utilization</td>
<td>30.60%</td>
</tr>
<tr>
<td>Protected Application Utilization</td>
<td>61.20%</td>
</tr>
<tr>
<td>Unused Storage Ratio</td>
<td>26.80%</td>
</tr>
</tbody>
</table>

**Application Utilization**: Total ASU Capacity (60,129,542 GB) divided by Physical Storage Capacity (196,491,768 GB).

**Protected Application Utilization**: Total ASU Capacity (60,129,542 GB) plus total Data Protection Capacity (60,129,542 GB) minus unused Data Protection Capacity (0.000 GB) divided by Physical Storage Capacity (196,491,768 GB).

**Unused Storage Ratio**: Total Unused Capacity (52,655,440 GB) divided by Physical Storage Capacity (196,491,768 GB) and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 25-26 in the Full Disclosure Report.
Priced Storage Configuration Pricing

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Description</th>
<th>Unit Price</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K2F000000700**</td>
<td>Kaminario K2 Flash 7 K-Blocks with 86.49TB total usable capacity</td>
<td>730,000.00</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Three years maintenance</td>
<td>4 hours mission critical</td>
<td>255,000.00</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>TS4-M11FF-10</td>
<td>WesternWire FC cable LC-LC 3m</td>
<td>8.00</td>
<td>448.00</td>
</tr>
<tr>
<td>28</td>
<td>QME2572</td>
<td>QLogic QME2572 8Gbps Fibre Channel I/O Card</td>
<td>425.00</td>
<td>11,900.00</td>
</tr>
</tbody>
</table>

Total System Price: 997,348.00

The following pricing includes the following:

- Acknowledgement of new and existing hardware and/or software problems within four hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration component.

K2F000000700** Line Item Components

The K2F line item in the above pricing includes the following components:

- **28 K-Nodes**: *SuperMicro SYS-1027R-72BRFTP1-E1007*:
  - Each K-Node includes eight 800 GB solid state storage devices (SSD), which provide the storage capacity for the primary and mirror SPC-1 ASUs.
  - Each K-node also runs an IO-director process responsible for exposing the data volumes to the Host Systems, connected via Fibre Channel.

- **2 K-Management Nodes, Storage System Management (SSM)
  *SuperMicro SYS-1027R-72BRFTP1-E1007.*

  The SSM modules provide storage installation, configuration and monitoring functionality. Each SSM module included eight 1 TB HDDs that serve as spare backup capacity for the system.

- **2 Dell Force10 S4810 10GB switches** - Interconnects all K-nodes for the purpose of sending Host System data between the K-nodes and for supporting management communication.

- **2 Cisco Catalyst 2960G 1 GB switches** - Interconnects all K-nodes to the K-management node for the purpose IPMI protocol control over the K-nodes.

- **1 Rack**: Used to house all of the above components.

Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

There were no differences between the TSC and the Priced Storage Configuration.
Priced Storage Configuration Diagram

Kaminario K2
(K2F0000700)

2 – SuperMicro K-Management Nodes
*Storage System Management (SSM)*
10 – 4 GiB DRAM modules per node
8 – 1 TB disk drives per node

56 ports used for FC connections

28 – dual-port 8Gb FC I/O cards
(56 ports total)

28 – SuperMicro K-Nodes
10 – 4 GiB DRAM Modules per node
8 – 800 GB Flash SSDs per node

2 – Dell Force10 S4810 10GB switches
interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication

2 – Cisco Catalyst 2960G 1 GB switches
interconnect between all K-Nodes and K-Management nodes for IPMI control
### Priced Storage Configuration Components

<table>
<thead>
<tr>
<th>Priced Storage Configuration</th>
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</thead>
<tbody>
<tr>
<td><strong>28 – dual port QLogic 8 Gb FC I/O Cards</strong> <em>(56 ports total, 56 ports used)</em></td>
</tr>
</tbody>
</table>

**Kaminario K2  (K2F00000700)**

- **28 – SuperMicro K-Nodes**
  - 8 – 800 GB SSDs per node
  - 10 – 4 GiB DRAM modules per node

- **2 – SuperMicro K-Management Nodes**
  - Storage System Management (SSM)
  - 10 – 4 GiB DRAM modules per node
  - 8 – 1 TB disk drives per node

- **2 – Dell Force10 S4810 10GB switches** *(interconnect between all K-Nodes and K-Management Nodes for Host System data and management communication)*

- **2 – Cisco Catalyst 2960G 1 GB switches** *(interconnect between all K-Nodes and K-Management nodes for IPMI control)*

- **1 – 42U rack and 4 PDUs**