Achieving Extraordinary Performance by Pairing Leading NVMe Flash Controllers and Data Acceleration Software

Summarized Results of Running Common Big Data Apps on Systems Using Microsemi's High-performance NVMe Controllers and Levyx Software

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Executive Summary

Levyx software harnesses the power of today's most advanced hardware. The company recently undertook the testing of one of the leading brands of enterprise-class, low-latency/high-throughput SSDs that incorporate Microsemi's Flashtec™ second-generation NVMe controllers. The test results highlight that end-users running popular Big Data applications using Levyx/Microsemi based solutions can get 300-400% more processing power from their SSDs in high-intensity Big Data environments when compared to applying conventional methods.

The performance testing involved using Levyx's software in conjunction with Microsemi's Flashtec NVMe2032 controllers to run the following open-source applications:

- Memcached - a general purpose distributed memory caching system that speeds up dynamic database-driven applications by caching data and objects in RAM; and

- Apache Spark - the de facto operating platform for Big Data that has been dubbed by pundits as the "Most Significant Open Source Project of the Next Decade"

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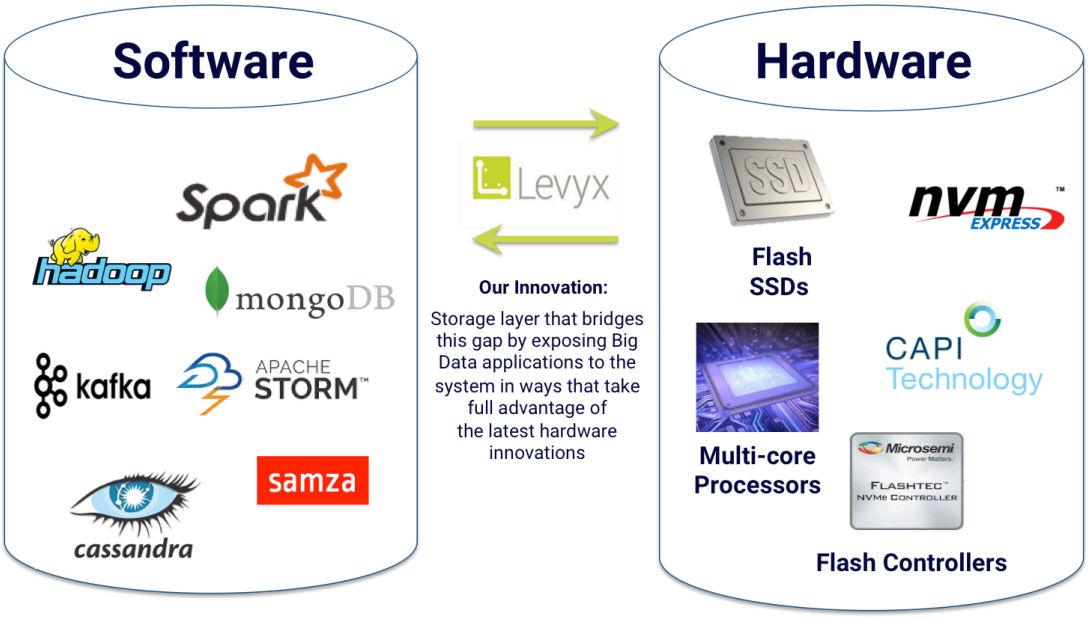
The value (i.e. performance enhancement) of Levyx's software paired with Microsemi's Flashtec controllers running these conventional open-source applications is measured not in terms of slight incremental improvement but rather in terms of "multiple times improvement":

- Up to 5X improvement for Memcached
- Up to 2X improvement for Apache Spark workloads

What Levyx Has Innovated and Why the Pairing Makes Sense

Levyx provides a software-only, high-performance key value storage engine (**Helium**^{TM}) and an analytics offload engine (**Xenon**^{TM}) that enable Big Data applications to interact seamlessly with enterprise SSDs—in particular, the memory-subsystem managed by Flash controllers. Today's enterprise-grade Flash controllers essentially act as CPUs on SSDs, which are actually their own small, self-contained "systems." Levyx's software exposes the higher-layer applications to the memory sub-system with a direct path for data to move between Flash (i.e. the SSDs) and the applications.



"Intelligent" Flash controllers, like Microsemi's Flashtec NVMe2032, are an excellent complement to Levyx's software. Leveraging the parallelisms of Flash and the horsepower of state-of-the-art Flash controllers, Levyx's software enables open-source Big Data applications to operate Faster, Simpler, and Cheaper. Built from scratch, Levyx's core engines accomplish these three efficiency goals through multi-core optimization, query offloading, and a highly parallelized IO architecture that substitutes Flash storage for RAM, while achieving equivalent or greater performance.

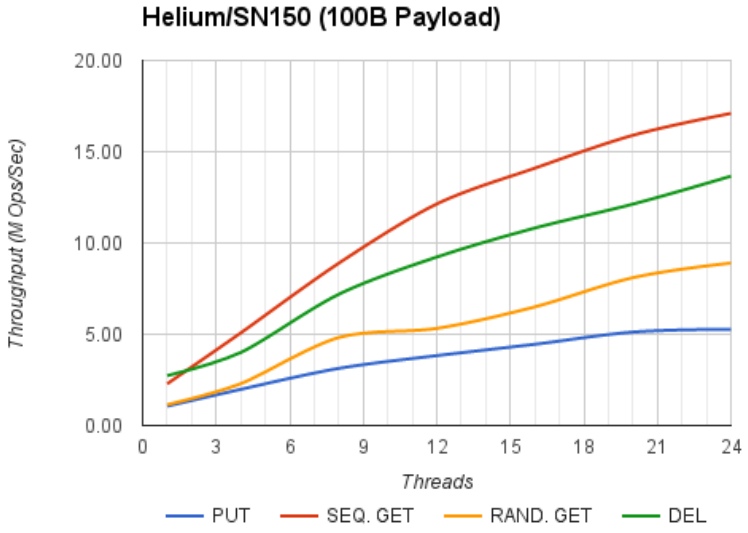
The market opportunity for a combined solution such as the one highlighted here is large and is derived from applications that require interactive (i.e. real-time) processing of large-scale datasets. The value proposition is substantial for customers in fields such as cybersecurity (fraud or threat detection), OLTP, real-time analysis of sensor data (Internet of Things), high-speed trading, low-latency messaging, and machine learning, and for customers in sectors like Financial Services, Government & Defense, Biotech & Healthcare, eCommerce, Social Networking, Digital Advertising, and Cloud Infrastructure (including Telcos).

Performance Measurement Process

Baseline Performance of Levyx's Helium using Microsemi's NVMe2032 Flash Controllers

We develop the baseline performance of Levyx's Helium on leading branded enterprise-class PCIe (NVMe) SSDs. This is done to establish the performance profile of the Levyx Helium key-value store as a Big Data processing engine, as well as ensure its compatibility with SSD controllers. As Levyx's initial product, Helium provides a very fast and scalable platform for storing and retrieving data objects. It is specifically designed for applications that manipulate a large amount of data (billions of data items) but which still require low latency/high responsive operations.

We summarize the results in the table below highlighting the I/O performance in terms of operations per second. Basic functions (puts, gets, deletes) are performed with latencies measured in the microseconds (i.e. sub-millisecond). Here, all values are in millions of operations per second. For each data point, a total of one million operations per thread were performed.



The characterization results in their totality firmly establish an extraordinary level of performance in terms of latency, as well as throughput. In particular, using Levyx's Helium as an object-oriented interface (one that has similar access patterns and requirements of Big Data applications), it is possible to harness the block-oriented capabilities of the enterprise-grade SSDs to the fullest extent possible. This is achieved, in turn, by using high-performance datapaths, modern data indexing, and lock-free data structures.

Running Memcached (Application-Level) using Microsemi's NVMe2032 Flash Controllers

Next, we set out to evaluate the performance characteristics of Levyx's engine, again paired with leading branded enterprise-class PCIe (NVMe) SSDs, in the context of real-world applications and Big Data benchmarks. Specifically, Levyx has released a version of Memcached that uses Levyx's Helium as a storage engine and provides flash-level caching capacities at memory-level performance with the added benefit of data persistence. With Levyx Memcached, we use the SSD as a second layer of persistence behind memory. However, it is vital that the second level persistence does not affect the throughput of applications using Memcached as a cache. This requires having a low latency, high throughput SSD backing—in this case, incorporating Microsemi's NVMe2032 Flash controllers.

Using the same system configuration as the first phase of testing, we compare the TPS (transactions per second) of conventional Memcached and Levyx Memcached. The table below demonstrates the benefits of a high performance flash-based key/value system running on SSDs by achieving 4-5X improvement (depending on the composition of the dataset) in total TPS over conventional Memcached:

Small: 100 byte x 100 Million total objects

Configuration	Conventional Memcached TPS	Levyx Memcached TPS
100% set	359 K	1.5 Million
90% get, 10% set	322 K	7.4 Million

Large: 1,000 byte x 10 Million total objects

Configuration	Conventional Memcached TPS	Levyx Memcached TPS
100% set	276 K	1.3 Million
90% get, 10% set	192 K	2.5 Million

Running Apache Spark (Application-Level) using Microsemi's NVMe2032 Flash Controllers and Xenon

Next, we used Xenon to perform an iterative join operation on a 256 GB input dataset. Apache Spark excels with iterative workloads because Resilient Distributed Datasets (RDDs) allow it to keep the results, or streamline the processing of the results, without going back and forth to/from Hadoop Distributed File System (HDFS).

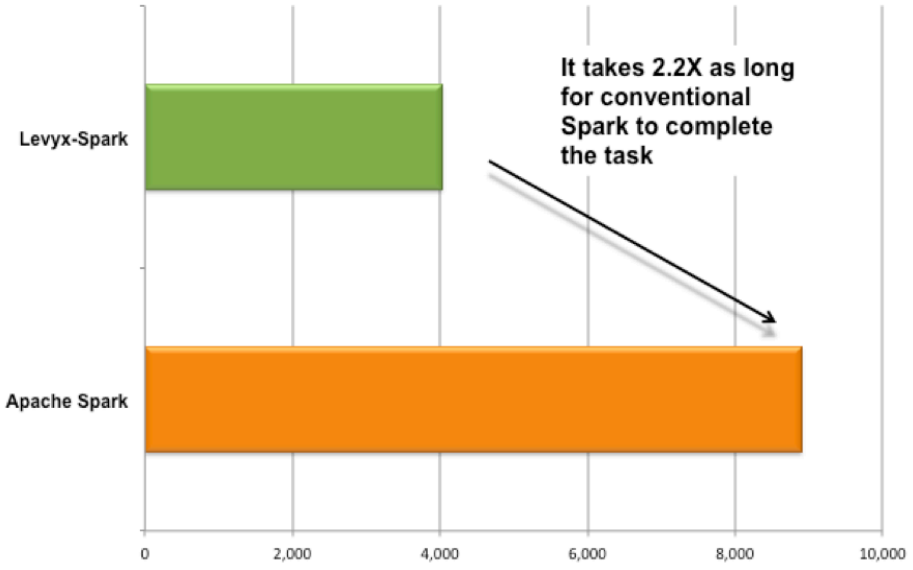
Xenon uses a combination of RAM and Flash to present a "storage class memory" RDD/DataFrame that is as performant as an Apache Spark normal RAM-only implementation and also persistent. This enables in-memory applications like Apache Spark to operate on large datasets that typically require a large cluster (to meet the memory capacity requirements) using far fewer, but very dense Flash-based nodes, in this case powered by Microsemi's Flash controllers.

This Spark comparison runs the application using Apache Spark 1.6.0 and Levyx's version of Spark (Levyx-Spark™) using its Levyx-Spark Connector™ (i.e. performance plug-in) for 10 iterations. As the following chart indicates, Levyx-Spark takes less than half as long to complete the iterations (some subsequent iterations take up to 4X longer using conventional Spark to complete compared to the Levyx-Spark solution):

Total Execution Time for All Iterations

(measured in seconds)

Conventional Apache Spark Vs. Levyx-Spark



Conclusion

By combining Microsemi's Flash controller technology and Levyx's software innovations, Flash-based SSDs are able to outperform in-memory solutions - at a fraction of the cost. In effect, the top-tier of performance in the memory hierarchy has been disrupted by combining software with hardware to create a better solution. In our view, this pairing of leading solutions to solve Big Data problems will become more common as end-customers will continue to demand high-performance solutions at more affordable price points.

Furthermore, the test data points exemplify the opportunity to deliver value-add to system OEMs, cloud providers, and system builders through a collaborative solution that harnesses the power and ubiquity of large-scale Big Data platforms as well as the performance innovations of the latest enterprise-class SSDs.

The Memcached opportunity represents a large deployment base involving users who store large amounts of data in RAM and who demand more cost-effective solutions. Apache Spark has a large and growing number of users and is currently being implemented by the world's largest web-scale enterprises. These two integrations, Memcached and Apache Spark, exemplify the potential of the combination of the Microsemi and Levyx solutions to improve a wide range of Big Data platforms - NoSQL, Kafka, HBase, Redis, to name a few. End-users that require low latency access to, and fast processing of, large-scale datasets, such as E-commerce, IoT, Cybersecurity, Social Networking, Cloud Infrastructure, Government & Defense, and Financial Services get extreme performance at a more attractive price point than highly-customized, memory-intensive closed solutions.

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