Micron Solid State Drive: Offer a Superior Solution for Accelerating MySQL Databases

Micron Technology, Inc.  
Technical Marketing Brief

Executive Summary

MySQL is a popular open source database widely used for enterprise and web applications. While hard disk drives (HDDs) could have trouble meeting the high I/O throughput and low latency demands of MySQL applications, Micron solid state drives (SSDs) can accelerate MySQL databases by providing dramatically faster random data access and higher I/O throughput.

Micron offers SSDs that are drop-in replacements for SAS or SATA HDDs and other SSD form factors that plug directly into system PCI buses for those applications that require the highest performance. The reliability and device lifetime of SSDs compare favorably to HDDs, and power consumption is a fraction of that of HDDs.

In an OLTP benchmark test, a single Micron PCIe SSD delivered better performance than a group of eight high-performance (15K) SAS HDDs:

- 13.6X greater transactions/sec
- 15.8X faster average response time
- Two orders of magnitude performance gain

Taking advantage of Micron’s storage solutions requires a properly designed database application and, most importantly, a balanced system where SSDs can be used to equalize the throughput performance of modern, multi-core processors and fast main memory.

MySQL Performance Challenges

MySQL, the world’s leading open source relational database, offers a strong feature set and a long history of development and usage. It is widely deployed in a variety of enterprise and web applications. In fact, social networking giant Facebook, social networking and microblogging service Twitter, image and video hosting web site Flickr, and crowd-sourced encyclopedia Wikipedia all employ MySQL databases.

Moore’s Law, the doubling of chip transistor count every 18 months or so, and the development of multi-core processors have rapidly advanced CPU and memory performance. HDDs, however, are limited by the physical characteristics of spinning magnetic media. As a result, advances in storage bandwidth and latency have lagged behind increases in CPU and memory performance, and this growing imbalance limits overall system execution.

MySQL applications may have high I/O throughput requirements, which will quickly highlight any storage-driven limitations. As the number of database users and transactions grow, MySQL performance can become constrained by storage I/O. Even those applications that demand low-latency queries can experience constraints due to HDD performance.

Database administrators can use a variety of utilities to determine if their MySQL system is suffering from a storage performance bottleneck. For example, MySQL Benchmark Suite comes with the original source distribution of the database platform. Other evaluation methods include the Super Smack stress-tester, SysBench, mybench, and MySQL Slap.

Traditionally, storage I/O has been improved by striping data across a large number of HDDs. However, this solution has drawbacks. For one thing, it is costly. It requires many drives, but only a small portion of the capacity of each drive is used, which wastes a significant amount of storage. Multiple drives also consume more power, demand more cooling, and occupy more data center floor space. Lastly, striping data across HDDs does not improve latency; disks operating in parallel do not respond any faster than a single disk does.
Micron SSDs Accelerate MySQL Databases

Micron SSDs are a superior alternative for accelerating storage performance in MySQL databases. Compared to HDDs and their spinning media, SSDs offer both cost and performance advantages for improving storage I/O.

First, SSDs are dramatically faster, especially for random reads and writes. A high-end HDD might fetch random data in just under 3ms. An SSD typically performs the same task in less than 100µs, which is more than 30 times faster.

Second, I/O operations costs are lower with SSDs versus HDDs. On a raw capacity basis, SSDs appear to cost more than HDDs. However, a more accurate cost comparison must take I/O performance into account. A high-performance spinning disk can perform up to 300 IOPS, while SSDs can reach 100,000 IOPS or more. Thus, a storage system or SAN using HDDs will require much more capacity and be correspondingly more expensive than one based on SSDs, if the two approaches are configured to achieve equivalent I/O throughput.

Micron SSDs are designed for enterprise-class reliability and endurance, with long device lifetimes equal to or better than what HDDs provide. SSDs also require only a fraction of the power demanded by HDDs, cutting electricity usage by as much as two-thirds, which is a major benefit for MySQL and other I/O-intensive applications operating in power-constrained data centers.

Other Micron SSD advantages include ease of use and flexible deployment. Most are drop-in replacements for HDDs, plugging directly into industry-standard SAS or SATA drive slots. They are easy upgrades when used to replace HDDs in RAID arrays. SSDs can also meet high-performance requirements with far fewer drives than HDDs.

Some Micron SSDs are designed to fit into server PCIe slots. Due to their architecture and direct system bus connection, PCIe SSDs deliver the lowest latency, highest throughput, and greatest concurrent I/O. These drives are suited for the most demanding applications, where the focus is on the number of queries satisfied per second.

No matter the configuration, Micron SSDs can boost the performance of single instances of a MySQL application on a server, multiple instances running in virtual machines, and databases spread across multiple nodes via sharding.

OLTP Benchmark Test

To demonstrate the performance advantages of SSDs for databases, an OLTP benchmark test using Percona SysBench compared the performance of a SQL Server database using 8 HDDs versus a single Micron® P320h PCIe SSD (see Table 1 below). SysBench was configured with 1 billion data items distributed among 100 tables of 10 million rows each. MySQL was configured with a 24GB buffer cache to force the InnoDB engine to access the disk. SysBench measured the number of transactions per second generated by 32 application threads and their corresponding response times and simulated up to 200 users issuing random read and write SQL transactions, similar to a high-performance transactional workload.

Table 1: Database, Server, and Benchmark Tool Configurations

<table>
<thead>
<tr>
<th>Database</th>
<th>Server</th>
<th>Benchmark Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percona MySQL 5.5.25a</td>
<td>Dell PowerEdge R720</td>
<td>SysBench</td>
</tr>
<tr>
<td>• 24GB buffer pool</td>
<td>• Dual Intel Xeon 8-core, 2.9 GHz</td>
<td>• 100 tables, 10 million rows/table</td>
</tr>
<tr>
<td>• 8GB log file size</td>
<td>• 96GB system memory</td>
<td>• 265GB database size</td>
</tr>
<tr>
<td>HDDs</td>
<td>SSD</td>
<td></td>
</tr>
<tr>
<td>• 8 15K SAS Seagate Sawvio 15K.3</td>
<td>• 1 Micron P320h PCIe SSD</td>
<td></td>
</tr>
<tr>
<td>• RAID 0</td>
<td>• No RAID</td>
<td></td>
</tr>
</tbody>
</table>
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The database was SQL Server 2008 running on Windows. To ensure that I/O requests bypassed cache and went to storage, the database memory setting was limited to 1GB. A Dell PowerEdge™ R720/R720xd with dual Intel® Xeon® processors hosted the storage for both tests: eight SAS 15K RPM HDDs in RAID 0 and a single Micron P320h PCIe SSD. Performance results were collected for each test.

As shown in Figure 1, the Micron P320h database delivered 4215 transactions per second compared to 310 transactions per second for the eight HDDs, which was a 13.6X improvement. The average 200-user response time for the PCIe SSD was 16ms compared to 253ms for the HDDs, which was a 15.8X improvement. On a per-drive basis, the P320h delivered 109X more transactions per second and 126X faster response times, which represents two orders of magnitude better performance.

Further Observations About MySQL Performance

Maximizing MySQL performance involves a series of design choices. If some general guidelines are followed, then SSDs can provide even greater acceleration. The first
fundamental guideline is to create a balanced system in which the performance of system resources—including CPU, memory, and storage—are considered to avoid any single resource becoming a persistent bottleneck. This will maximize the hardware asset return on investment.

The maximum benefit occurs when SSDs are used to equalize storage throughput with the performance of modern, multi-core processors and large amounts of DRAM memory. It is important to choose SSDs that meet workload performance requirements:

- SSDs are rated for a specific number of concurrent operations, typically between 32 and 256. Notably, multi-core processors with hyper-threading can drive a high number of simultaneous operations. If the number of concurrent operations is pushed beyond a drive’s rating, then latency will increase as I/Os are added to the queue.
- Write latency tends to have a disproportionate impact, even for read-heavy workloads because the write throughput of an SSD is typically less than the read throughput due to characteristics of NAND Flash media. This can create a situation where reads have to wait for writes to complete. Again, it is important to choose an SSD according to workload requirements.
- The performance of data stores, or tables, has a greater effect on the system than log files. Nevertheless, current best practice is to place both data stores and logs on SSD storage to ensure consistent performance.

Other design considerations that affect database performance include:

- The size of the buffer pool needs to be appropriate to the size of the data store.
- Sharding or breaking apart a MySQL database and running multiple instances in virtual machines on a single physical server can significantly increase IOPS. Beyond a certain point, software limitations within MySQL keep it from taking full advantage of additional memory and processor cores. While sharding is more complex, the tradeoff is better performance and resource utilization.

Conclusion

Micron SSDs accelerate MySQL databases by improving the I/O throughput and latency of the storage system. With drop-in replacements for SAS or SATA HDDs and the highest-performing PCIe SSDs, Micron SSDs offer the following significant benefits:

- Dramatically faster performance – As demonstrated by the OLTP benchmark, changing from HDDs to SSDs can improve storage throughput and latency by an order of magnitude or more.
- Balanced system performance – With better storage performance, an I/O bottleneck can be removed and MySQL applications can be liberated to take full advantage of modern multi-core CPUs and fast main memory.