SSDs: The Key to Maximizing Oracle® OLTP Per-CPU Licensing

Fast SATA Micron® SSDs Drive More from your Oracle Licenses

Overview

Online transaction processing (OLTP) database workloads are some of the most demanding—and most pervasive. In addition to online ordering, OLTP systems are broadly deployed—in banks, retail outlets, communication systems, manufacturing—anywhere users or systems conduct a massive number of short, nearly instant transactions.

When data sets are too large to fit into memory, storage performance is paramount. SSD storage like the Micron 5200 PRO enterprise SATA SSD enables fast access to immense, mission-critical data sets, enabling transaction processing with ultra-low and consistent latency where access delays can be extremely costly.

Of the many relational database management systems (RDBMS) in use, a March 2018 DB-Engines ranking showed Oracle Database as the most popular.

This technical brief discusses how we measured Oracle Database commits per minute (CPM) with enterprise SATA SSDs using standardized OLTP performance metrics and a data set that exceeded available system memory to test storage system I/O. We also included a legacy HDD configuration for reference.

We used the same base hardware (server, CPUs and DRAM) with both storage configurations:

- **5200 PRO Configuration:** 8x 1.9TB 5200 PRO SSD, Oracle Automatic Storage Management (ASM) Normal Redundancy.
- **Legacy Configuration:** 16x 300GB 15K RPM HDD configured RAID 10 (Oracle ASM External Redundancy). This configuration is included for comparison.

Fast Facts

Micron® 5200 PRO SATA SSDs deliver with Oracle and OLTP:

- Enormous commits per minute, faster and more consistent responses
- Lower overall CPU utilization with higher CPU-based licensing value[1]

8x 5200 PRO SSDs generated:

- 18X higher performance[1]
- 95% lower average response time 93% lower 90th percentile response time
- 15X better power efficiency[2] (compared to a legacy configuration)

We found that the 5200 PRO SSD configuration generated far higher CPM with lower and more consistent latency—as well as better power efficiency—than the baseline configuration to bring more value to OLTP workloads on Oracle Database 12c Enterprise Edition.

1. In this document, "performance" and "database commits per minute (CPM)" are used interchangeably. Higher CPU-based licensing value defined as more CPU resources (expressed as %CPU utilization) used for real application work for platforms with the same number of CPUs installed and the same licensing model. Actual results depend on licensing model, server configuration and other factors.
2. Power efficiency = CPM/watts consumed (see details later in this document).

5200 PRO Drives 18X More Commits per Minute (1.4 Million)

Enterprise SSDs like the 5200 PRO are a mainstay of high-performance, low-latency IT systems. High-capacity, high-performance enterprise SATA SSDs drive those systems farther and faster, processing more data and bringing more value.

This is especially true for high-performance, IO-intensive workloads like OLTP.

As more OLTP platforms have moved to SSDs, the reasons for doing so have become very clear: the differences between SSD capabilities and what we used to think of as a performance legacy configuration are greater than ever, with legacy configurations (like a 15K RPM HDD setup) being painfully slow in camparison. With Oracle Database OLTP, more commits can represent more value.

Figure 1a: 5200 PRO Configuration Commits per Minute

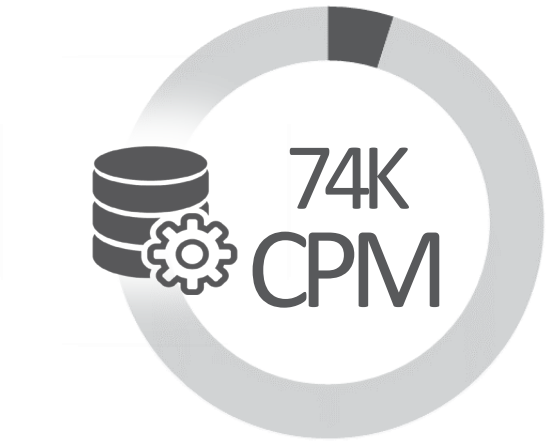

Figure 1b: Legacy Configuration Commits per Minute

The magnitude of the difference between enterprise SATA SSDs and a legacy configuration is evident in Figures 1a and 1b, which show each configuration's CPM: SSDs delivered 1.4 million CPM, or about 18X what the legacy configuration did.

(Figures 1a and 1b show values measured at a system load just before the test reached a stop condition. See the How We Tested section for stop condition details.)

More Value from Per-CPU Oracle Licensing: CPU Utilization

Oracle Database software is licensed in several ways including per-CPU[3] (details on licensing are beyond the scope of this document). When licensing Oracle Database software per CPU, getting more results—more real application work per CPU—is highly desirable.

Per CPU, one can evaluate how the storage system affects this by measuring the percentage of CPU resources being used (%CPU utilization) for real application work and comparing it to the percentage spent waiting for data or write completion (storage system response).

3 See http://www.oracle.com/us/corporate/pricing/technology-price-list-070617.pdf

Figures 2a and 2b compare %CPU utilization by task type for each configuration. In each figure, task types are shown in four categories by color: real application work (in green—the %CPU used to generate real workload value), kernel operations (purple), IO Wait (in dark grey, %CPU spent waiting on data or write complete acknowledgement – waiting for storage to respond) and unused (in light grey, indicating that the CPU was not the bottleneck for this test).

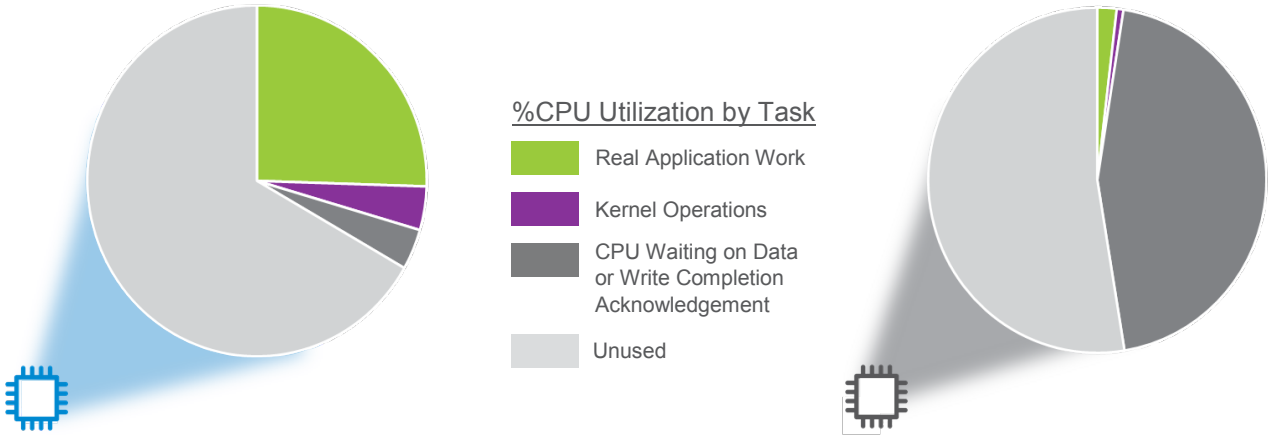

Figure 2a – 5200 PRO Configuration %CPU Utilization

Figure 2b – Legacy Configuration %CPU Utilization

The 5200 PRO configuration shows far higher %CPU utilization for real application work (13X that of the legacy configuration), while spending 90% less of its resources waiting for data or for write completion acknowledgement.

Fast, Consistent Responses

As shown in Figures 3a, 3b, 4a and 4b below, we calculated and compared the mean response time (latency) and the 90th percentile response time (a good indicator of latency consistency) at system load just before the test reached a stop condition for both the storage configurations (see the How We Tested section for stop condition details). We used the same metrics, database and test parameters for each configuration.

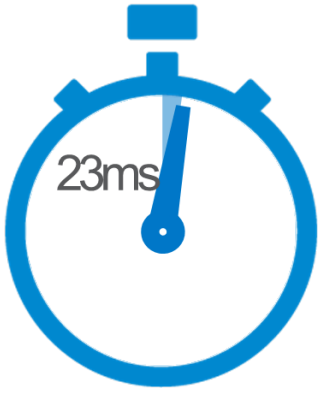

Figure 3a: 5200 PRO Configuration Mean Latency

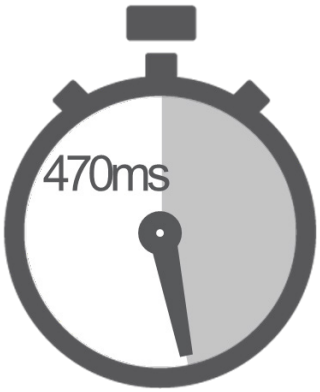

Figure 3b: Legacy Configuration Mean Latency

The SSD configuration responds much faster with a mean response time of just 23ms, 95% lower than the 470ms of the legacy configuration. Comparing 90th percentile latency shows similar results.

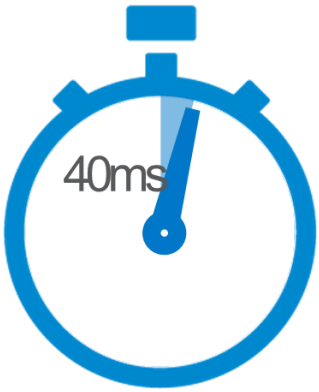

Figure 4a: 5200 PRO Configuration 90th Percentile Latency

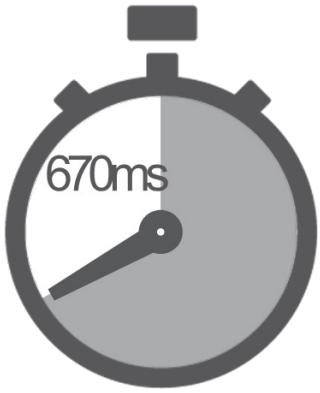

Figure 4b: Legacy Configuration 90th Percentile Latency

Figures 4a and 4b show that the SSD configuation has a 93% lower 90th percentile response time, indicating that 93% of its operations repond much, much faster than the legacy configuration.

Higher Power Efficiency

To evaluate power efficiency, we divided CPM by measured average instant power consumption for each configuration:

$$\text{Power Efficiency} = \frac{\text{CPM}}{\text{Power Consumption}}$$

Comparing the legacy configuration's CPM/watt to the same metric for the 5200 PRO configuration (Figures 5a and 5b) shows a dramatic power efficiency advantage (15X) for the 5200 configuration.

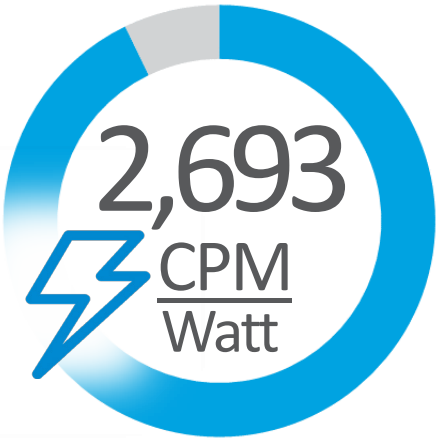

Figure 5a: 5200 PRO Configuration Power Efficiency

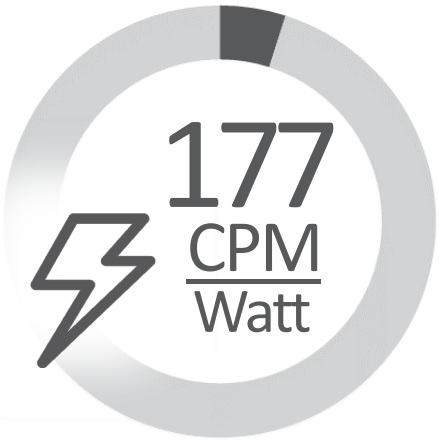

Figure 5b: Legacy Configuration Power Efficiency

The Bottom Line

Mission-critical data can't wait. Access delays or inconsistency can be extremely costly. Using enterprise SATA SSDs like the 5200 PRO can enable fast transaction processing and fast, consistent response times.

In our testing, these SSD configurations demonstrated tremendous benefits and new capabilities for one of the most popular database management systems and most challenging workloads — Oracle Database Server and OLTP. Supporting far greater CPM with lower and more consistent latency means more orders and more transactions completed faster and more consistently.

Learn more about our 5200 SATA SSD family and their transformative effect on your business at micron.com. Stay up to date on what's trending in storage by reading Micron's Storage Blog and following us on Twitter @MicronStorage.

How We Tested

To ensure a fair assessment of the expected maximum NOPM CPM of each configuration, we took a configuration-specific approach. We measured each configuration's CPM, latency and power efficiency at the maximum load the platform could reasonably support, as opposed to comparing them at an arbitrary load.

Prior to testing, we established stop conditions (Tables 1 and 2). As we tested, we increased the load until the test reached a stop condition, after which we stopped increasing the load and used the CPM, latency and power values recorded when we reached the stop condition.

We set the 90th percentile transaction response time to the values in Table 2, which each reflect common tolerance limits.

Limit	Stop Condition
CPU utilization	80%
90th percentile average transaction response time	See Table 2
CPM plateau	When CPM fails to increase with higher load

Table 1: Stop Conditions[3,4]

Transaction	90th Percentile Response Time
New order	5 seconds
Payment	5 seconds
Order status	5 seconds
Delivery	5 seconds
Stock level	20 seconds

Table 2: Threshold Limits

Determining Maximum Load by Configuration

For each drive configuration, we performed a one-run sweep across a range of loading values and Oracle SGA memory settings until we hit one or more stop conditions. After finding the rough value, we executed a large number of tests on the configurations around the stop condition to measure maximum performance. This section shows the test condition(s) that established each configuration's maximum load. The specific loading conditions are seeded based on past observations and iterated based on live results.

Legacy Configuration Stop Condition: CPM Plateau

Figure 6 shows the legacy configuration's CPM started to plateau at the system load shown on the far right.

As we increased system load, we observed peak performance as shown at far right. Above this loading level, we had to lower the SGA, which resulted in lower CPM.

Neither CPU utilization nor response times reached a stop condition.

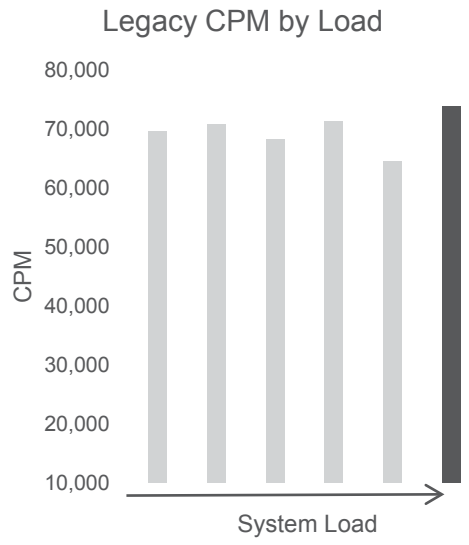

Figure 6: Legacy Configuration Stop Condition

3. We set the stop condition for CPU utilization at 80%. Many IT organizations plan for a platform upgrade when CPU utilization reaches 50% and implement that plan when it reaches 80%.
4. We sized the data set to ensure it was large enough to ensure storage I/O (data set size about 2X the memory size) but did not occupy more than 80% storage capacity.

5200 PRO Configuration Stop Condition: CPM Plateau

Figure 7 shows that the 5200 PRO configuration's CPM plateaus at the system load shown on the far right.

As we increased system load, CPM started to decrease.

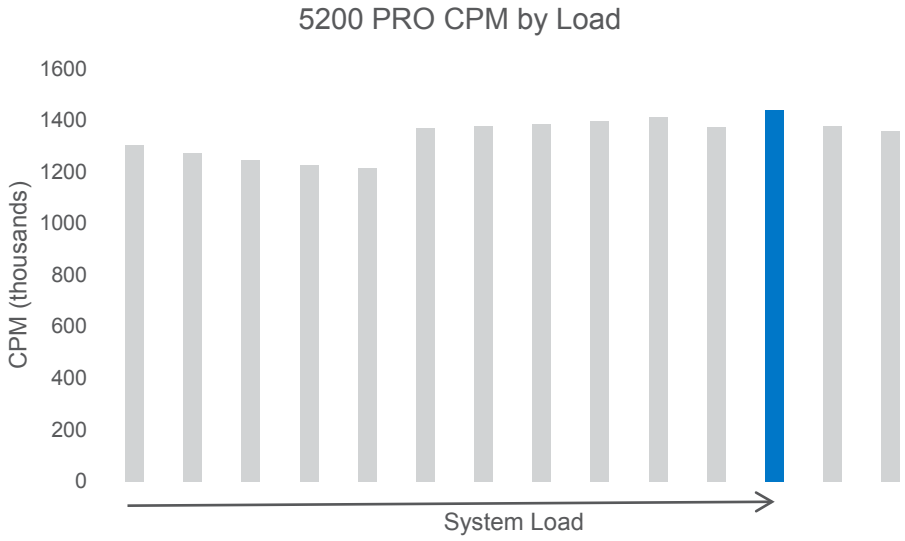

Figure 7: 5200 PRO Stop Condition

Oracle Server Settings

Table 3 shows specific Oracle Server configuration settings used for all testing.

The settings yielded the test results shown; other settings may yield different results.

Setting	Value	Setting	Value
threaded_execution	TRUE	2x Bigfile Tablespaces	ORDERTAB-order table partitioned in separate tablespace TPCCTAB-contains other tables in schema
lock_sga	TRUE		
sga_max_size	190G		
sga_target	190G	pga_aggregate_target	16G
pga_aggregate_limit	32G		
Redo Log Groups	10x 1GB groups	vm.min_free_kbytes	16,000,000

Table 3: Oracle Server Settings

Additional Configuration Details

Component	Description
Server	2U, 2-socket (Intel)
CPUs	Intel® Xeon® Platinum 816 based 8 24-core (x2)
Memory	384GB DDR4 2666 MHz DRAM
SSDs	Micron 5200 PRO 1.9TB (x8)
HDDs	15K RPM, 300GB (x16)
RAID Controller (HDD)	Dell PERC H740P (4GB cache)
HBA (SSD)	Dell HBA330

Component	Description
OS	Oracle Linux 7.4 (kernel 4.1.12-112.14.1.el7uek.x86_64)
Database S/W	Oracle Database 12c Enterprise Edition Release 12.2.0.1.0
Oracle ASM	HDD: RAID 10 SSD: Normal Redundancy

Table 4: Hardware Configuration

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