IT@Intel Brief

Intel IT
Intel® Solid-State Drives
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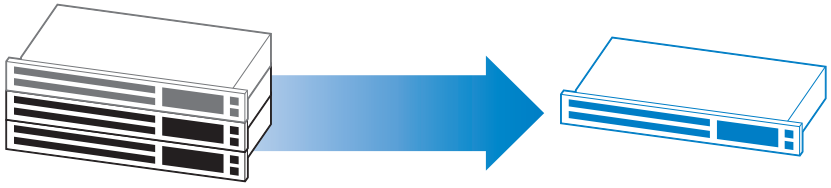
Improving Email Application Server Performance with Intel® Solid-State Drives

- Email application performance improved 6x
- The solid-state drive configuration takes up 60 percent less data center space
- Total power and cooling was reduced by 79 percent
- CPU headroom increased to improve user experience functions

With a goal to improve our email application server performance and lower costs to meet ongoing email demand, Intel IT conducted a proof-of-concept (PoC) evaluating the benefits of Intel Solid-State Drive (Intel® SSD) technology. Compared to our current email application server configuration with hard disk drives (HDDs), our study results showed the performance, power, and endurance characteristics of the Intel SSD DC S3700 Series significantly improves the user experience by reducing the outgoing email delivery times, while also reducing our data center footprint, system complexity, and infrastructure costs per system user.

For the PoC, we replaced 40 SAS HDDs in our email application server configuration with 16 Intel SSD DC S3700 Series (see Figure 1). We found that the Intel SSDs improved performance by reducing email submission times by 84 percent. In addition, the Intel SSD-based solution required 60 percent less data center space and 79 percent less power and cooling. It reduced overall complexity for simpler system management and lowered the annual per-user infrastructure costs. These savings offset the higher initial cost of the solid-state drives (SSDs) as compared to the HDDs.



Baseline — HDDs
- Intel® Xeon® processor 5670 based server
  - 16x 10K 2.5-inch SAS HDDs
- 2x External 12-disk JBOD
  - 24x 7.2K 3.5-inch SAS HDDs

Target — 100% SSDs
- Intel® Xeon® processor 5670 based server
  - 16x Intel® Solid-State Drive DC S3700 series

Figure 1. Intel replaced 40 hard disk drives (HDDs) with 16 solid-state drives (SSDs) to improve performance and lower the cost per user on an email application server.

The benefits of using SSDs instead of HDDs include higher IOPS, lower and consistent access times, high reliability, low power consumption, and a smaller space footprint.

Background

Like other IT organizations, Intel IT seeks to improve user experience while at the same time reduce overall costs. We recognized that users were experiencing inconsistent outgoing email delivery times because of heavy utilization of the email application server's HDD and CPU configuration. After running load tests and re-evaluating our current HDD configuration, we found that our existing storage framework was creating a bottleneck to system performance. We determined that faster storage access and increased I/O operations per second (IOPS) could provide users with a more consistent experience and simultaneously reduce costs in the process.

We decided the most effective way to speed up disk access would be to replace existing HDDs with new Intel SSDs. Solid-state drive (SSD) technology offers lower latency and provides higher IOPS to enable fast and consistent performance.

The benefits of using SSDs instead of HDDs include higher IOPS, lower and consistent access times, high reliability, low power consumption, and a smaller space footprint. Intel SSD technology offers up to 100x lower cost per IOPS than typical 15K SAS HDDs and has lower failure rates than HDD technology, providing two-million hours mean-time-between-failure (MTBF). As we look to deploy SSDs in data centers, we expect them to deliver better performance than HDDs.

Despite these benefits, SSDs have been criticized for their expense and perceived lack of reliability. We knew we needed to show more than just performance enhancements as a result of deploying SSDs; we also needed to illustrate a convincing total cost of ownership (TCO) business case and alleviate any reliability concerns.

More Options for Increased Storage Space and Write Endurance

Intel IT chose high write endurance drives to manage I/O requirements for our proof of concept's highly consolidated email workload. However, workloads and capacity requirements vary widely by email platform and user need. The newest Intel®-based two rack-unit (2U) server platforms offer more options to extend an inside-the-server storage solution with high write endurance Intel® Solid-State Drive (Intel® SSD) DC S3700 Series or the new standard write endurance Intel SSD DC S3500 Series.

Intel®-based 2U servers can include 24 2.5-inch drive bays, up to 800-gigabyte drive sizes, and up to 19.2 terabytes of available storage for the following:

- Maximum I/O spreading
- Greater write endurance drive options
- Simpler management, space, power, and workload consolidation

When we doubled the workload of an HDD on an SSD (see Figure 2), we found that the SSD configuration achieved efficiencies in CPU utilization, interrupts, and page file usage, which resulted in more efficient I/O, increased CPU headroom to free up user experience functions, and a more effective memory subsystem.

This indicates that larger drives—for the Intel SSD DC S3700 Series or the Intel SSD DC S3500 Series—could support many more users while continuing to provide improved quality of service.

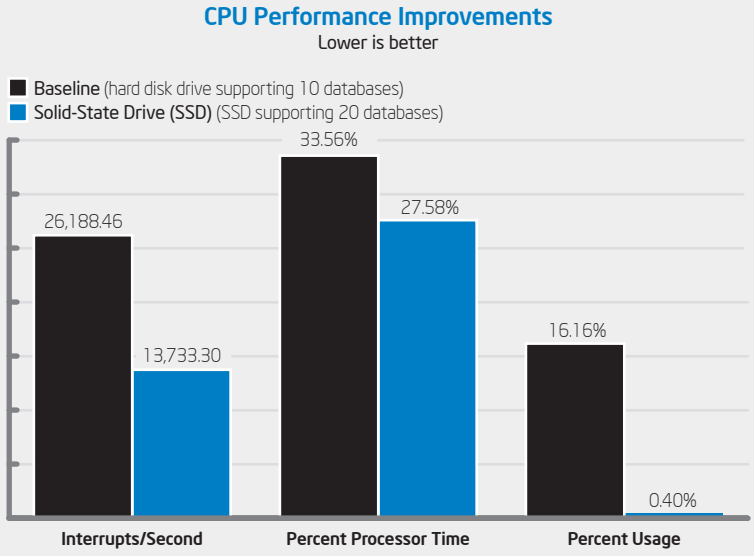


Figure 2. The CPU performance improvements in a solid-state drive when undergoing twice the workload of a hard disk drive.

Solution

We conducted our initial PoC on an email application server configuration that relied on a baseline configuration of 16 2.5-inch SAS HDDs as well as two external sets of 12 3.5-inch SAS HDDs to meet IOPS requirements (a total of 40 HDDs). But this configuration left only 20-percent CPU headroom, supported only 6,000 users, took up six rack units of space, and still did not solve the I/O bottleneck issue.

As data increased, the HDD arrays were being over-provisioned to improve performance at the expense of under utilization of capacity, a practice also known as short stroking. We anticipate that our data growth is going to continue unabated, and HDD storage will not able to keep pace with the performance demands.

By replacing our email application server's HDD configuration with SSDs, we sought to eliminate any frustration users experienced due to inconsistent outgoing email delivery times. Typically, the under 100 microsecond (µsec) average access latency of SSDs provides 100x faster performance than high-performance hard drives that average under 10,000 µsec. Through dramatic access latency improvements and IOPS scale performance per drive, we open the I/O bottleneck and balance the server performance that will scale to future data demands and provide server consolidation opportunities as well.

In the PoC, we replaced the 40 HDDs in our email application server with 16 new Intel SSD DC S3700 Series. These Intel SSDs contain several new features that improve reliability, including high write endurance, end-to-end data protection, power loss protection, error-correcting code (ECC) protected memory, and meeting the Joint Electron Device Engineering Council (JEDEC) endurance standard.

Results

Compared to our email application server configuration with HDDs where we are I/O constrained, the results from our PoC showed the Intel SSD DC S3700 Series removed I/O constraints and provided these benefits:

- Six times faster email transaction rates
- Increased CPU headroom by 50 percent
- Reduced power needed for cooling
- Reduced rack space

Reducing the I/O Bottleneck in Data Centers

Like other enterprise IT departments, Intel IT is experiencing exponential data growth within our data centers, as data continues to increase in importance as a corporate asset. Many IT departments are using more virtualized applications to support this growth and the increasing user demand for content and real-time access. High latencies and slow I/O storage devices are becoming a significant performance bottleneck.

In looking at ways to reduce the I/O bottleneck in our data centers, we studied several options. Solid-state drive technology is only one method to deal with the growth in virtualized applications as well as volume and variety of data that are causing I/O bottleneck and limits a data center performance.

Other methods include short stroking a hard drive disk. We found that while this can improve performance, the process sacrifices capacity, which makes scalability a challenge. More HDDs can also be added to manage the data growth, but we discovered that neither option delivers the IOPS, power, or cost benefits available in SSD technology.

In the case of the Intel® Solid-State Drive data center family, we anticipate that the high IOPS and low latencies will enable our data centers to keep up with increasing demand for content and real-time data access. The table below illustrates potential use cases where we would see the most dramatic impact.

Use Case	Recommended Intel® Solid-State Drive (Intel® SSD) Data Center Family
Mail server. I/O bottleneck caused by high disk queuing and OS paging on the OS system drive.	Intel SSD DC S3700 Series and Intel SSD DC S3500 Series. 75K IOPS 4K random read performance frees the CPU from the storage bottleneck for improved efficiency.
Data center virtualization. Storage access from multiple virtual machines (VMs) causes a high random access demand on the storage framework.	Intel SSD DC S3500 Series. A high quality of service provides consistent read performance for random access from multiple VMs.
High-performance computing. CPU utilization is currently bound by storage I/O when solving exascale problems.	Intel SSD DC S3700 Series. 500 megabytes-per-second sustained sequential reads with consistent 75K 4K random read IOPS and high write endurance increase CPU utilization in computing cores.
Big data. Edge servers require high-performance storage to collect and analyze large volumes of structured and unstructured data.	Intel SSD DC S3700 Series. Use in edge servers as low latency proximity storage. The 32K IOPS 4K rand write performance allows for analysis of massive amounts of data.
Cloud computing. Multiple VM access results in high random I/Os for which disk-drive storage is not able to keep up with virtual application storage.	Intel SSD DC S3500 Series. Maximum latencies of <500 microseconds 99.9 percent of the time and standard write endurance optimize the Intel SSD DC S3500 Series as primary performance storage in VMs.

Table 1. Performance advantages of the 400-gigabyte Intel® Solid-State Drive DC S3700 Series configuration versus the hard disk drive proof-of-concept configuration when supporting 6,000 email users.

Parameter	Baseline Configuration	Solid-State Drive (SSD) Configuration	Difference
Sign-In Look Up (LDAP)	Baseline	2x	2x faster authentication
Mail Submission Time[Δ]	Baseline	6x	6x faster outbox
CPU Headroom	Baseline	2x workload produced less CPU overhead	Predictable performance and still under 50-percent CPU utilization
Capacity Configuration	Server plus 40 HDD JBOD	Server plus 16 SSDs	Less management and complexity
Size	6U rack space	2U rack space	60-percent data center space savings
Total Power and Cooling[¥] (Server plus 1.25 x Server)	1780 watts	370 watts	79-percent power reduction
Annual Savings Per User	Baseline	6 percent	6-percent cost savings

[Δ] Mail submission time equals the time it takes beginning from when a user clicks the Send button to when the system determines where to send it.

[¥] Power based on actual measurements under load and 1.25 watts, per watt cooled for HVAC.

Table 1 contains a more comprehensive analysis on the data from improving email application server performance using SSDs. These findings confirm that the Intel SSD solution provides a better user experience and a 6-percent cost-per-user savings.

Future Plans

Now that we have designed a successful blueprint of improving email application server performance using SSDs, we plan to deploy Intel SSD DC S3700 Series in more high random I/O applications. We also plan to pursue an even lower-cost, blended SSD blueprint featuring the new Intel® SSD DC S3500 Series and a tiered-user approach. The Intel SSD DC S3500 Series is standard endurance and read-intensive compared to the Intel SSD DC S3700's high endurance and write-intensive, providing an even more cost-efficient option to balance varying work loads.

A tiered-user approach is based on the fact that approximately 50 percent of users in many enterprises need only about 5 percent of allocated capacity. If we tier the users such that the low-capacity users are combined in high density on fewer SSDs—while maintaining the improved quality of service (QoS)—we can support two to four times more users on each SSD, depending on the balance of the rest of the drive, such as CPU, memory, and network. Based on extrapolations from data in this PoC, we calculated that even at only twice the capacity—12,000 users instead of 6,000 users—we would see a 53 percent annual savings per user.

We also plan to begin to identify other I/O intensive applications where upgrading to SSD performance makes the most return-on-investment sense. For example, our IM and videoconferencing platform is a prime target as it continuously monitors 16 kilobyte blocks at 550 IOPS with spikes over 10K IOPS.

Conclusion

We found that the Intel SSD Data Center Series is ideal for handling high random I/O applications such as email application servers in our environment. It allows us to improve service delivery capacity and quality within a flat budget. Performance improvements create a more satisfying user experience for our users. Capacity efficiencies allow fewer devices to support more mailboxes, which equates to cost savings in the number of devices that need to be purchased, power, and rack space. Configuration simplicity and reliability lowers the administration overhead.

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