Advantages of Solid-State Drives for Design Computing

- SSDs used as swap space for large silicon design workloads
- 1.63x performance-normalized cost advantage due to lower cost of SSDs
- Up to 88 percent of the performance compared with running workloads entirely in RAM

In Intel IT tests with large silicon design workloads, substituting lower-cost solid-state drives (SSDs) for part of a server’s physical memory resulted in a 1.63x performance-normalized cost advantage, as shown in Figure 1.

We conducted tests to evaluate the use of SSDs as application swap drives. We ran electronic design automation (EDA) workloads on servers configured with enough RAM—512 GB—to load the entire workload into physical memory. Then we configured the servers with only half as much RAM, 256 GB, forcing the applications to use swap drives based on multi-level cell (MLC) SSDs or hard disk drives (HDDs).

When swapping to a 400-GB Intel® Solid-State Drive (Intel® SSD) DC S3700 Series SATA, an enterprise-class MLC drive, the server completed the workloads 12 percent less quickly than when the workloads were entirely loaded in RAM. However, because SSDs cost much less than RAM, server cost was greatly reduced; this resulted in a substantial performance-normalized cost advantage. Performance with the Intel SSD DC S3700 swap drive was 38 percent faster than with the HDD swap drive. Our tests show that a server with an SSD swap drive is a cost-effective, high-performance server platform for EDA applications.

![Performance-Normalized Cost Advantage](image)

Figure 1. Performance-normalized cost advantage with solid-state drives. Using Intel® Solid-State Drive (Intel® SSD) DC S3700 SATA as swap space delivered a 1.63x performance-normalized cost advantage. Electronic Design Automation performance was only 12 percent lower than a full RAM configuration, but server cost was greatly reduced. (Intel IT internal measurements, DELL server list prices, www.dell.com, and Intel SSD list prices, www.intel.com, August 2013.)
Business Challenge

Silicon chip design engineers at Intel face the challenges of integrating more features into ever-shrinking silicon chips, resulting in more complex designs.

The increasing design complexity creates large design workloads that have considerable memory and compute requirements. We typically run the workloads on servers that need to be configured to meet these requirements in the most cost-effective way.

Traditionally, we have had two options for configuring servers to support these large design workloads:

- We can install a large amount of RAM, enabling the workloads to run entirely in physical memory. This maximizes performance, but is an expensive solution due to the relatively high cost of the high-density 32-GB RAM modules required.

- We can use less RAM, using low-cost 16-GB RAM modules, so that application workloads whose memory requirements exceed the physically installed RAM swap to HDDs as necessary. This reduces cost because HDDs are much less expensive than 32-GB RAM modules, but it also substantially reduces performance.

SSDs offer a promising new approach. These storage devices use solid-state memory to store persistent data; they emulate HDDs and can replace HDDs in many applications.

Because of this, we now have a third server configuration option:

- We can use SSDs as swap drives instead of HDDs. Because SSDs are faster than HDDs but much less expensive than RAM, this option has the potential to deliver good performance at relatively low cost. An additional benefit is that SSDs consume significantly less power than HDDs, reducing total system power requirements.

Both high-endurance data center and data center MLC SSDs are available, which are compared in Table 1.

To evaluate the potential of SSDs as swap drives in design computing, we conducted tests to compare performance and cost when using each of these server configuration options to support actual Intel silicon design workloads. Our tests included both high-endurance data center SSDs and data center SSDs.

Performance Tests

We conducted performance tests using Intel silicon design workloads on a current two-socket server platform based on Intel® Xeon® processor E5-2600 product family.

Depending on the test, we configured the server so that the workloads were loaded entirely in RAM or used an HDD, a high-endurance data center SSD, or a data center SSD as a swap drive. Specifications of the server and swap drives are shown in Tables 2 and 3.
EDA WORKLOADS AND SWAP CONFIGURATIONS

Each test case consisted of one or more EDA applications operating on an actual Intel silicon design workload, as shown in Table 4. Test case memory requirements ranged from 343 GB to 476 GB.

We tested the following system configurations:

• 512 GB of RAM; no swap space allocated.
  We used the more expensive 32-GB RAM modules since the server had only 16 memory slots. The entire application workload was loaded into physical RAM.

• 256 GB of RAM; HDD used as swap space.
  We used the less expensive 16-GB RAM modules in all 16 memory slots.

• 256 GB of RAM; MLC-based Intel SSD DC S3700 high-endurance data center SSD used as swap space. We used 16-GB RAM modules in all 16 slots.

• 256 GB of RAM; MLC-based Intel SSD DC S3500 data center SSD used as swap space. We used 16-GB RAM modules in all 16 slots.

RESULTS

When using the Intel SSD DC S3700 as a swap drive, average performance was 38 percent faster than with the HDD swap drives and only 12 percent slower than using the full 512-GB RAM configuration with no swap space.

With the Intel SSD DC S3500, average performance was 25 percent faster than using HDD swap drives and 20 percent slower than using the full 512-GB RAM configuration with no swap space.

The results are shown in Table 5.

Cost Comparison

Based on our performance test results and typical server list prices, we compared the cost for the two highest-performance alternative configurations:

• A server with 512 GB of RAM
• A server with 256 GB of RAM and a 400-GB MLC Intel SSD DC S3700 used as a swap drive

To do this, we calculated a performance-normalized cost by adjusting the cost of each configuration based on its relative performance in our tests, as shown in Table 6.

We then compared these performance-normalized costs. The Intel SSD DC S3700 swap disk resulted in a 1.63x performance-normalized cost advantage.
Conclusion

Using SSDs as swap drives enables us to substitute lower-cost solid-state storage for higher-cost RAM, with only a small performance impact.

In our tests, servers with SSDs provided a 1.63x performance-normalized cost advantage, delivering up to 88 percent of the performance compared with running workloads entirely in RAM.

Servers with SSD swap drives are a cost-effective, high-performance server platform for EDA applications.

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