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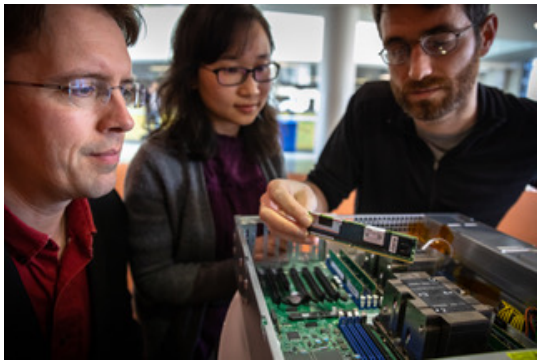
UC San Diego Researchers Find Strong Performance, Complexities, and Puzzles in Intel's Optane DIMMs



University of California San Diego computer scientists have completed the first comprehensive evaluation of Intel's new Intel Optane DC Persistent Memory Modules (Optane NVDIMMs).

They found that Optane DIMMs can make key storage applications 17 times faster, especially if system designers adapt their hardware and software to make the best use of the new technology. They also found that the DIMMs can significantly expand main memory capacity without sacrificing much performance and that they exhibit complex performance characteristics that designers must accommodate to fully exploit them.

Optane DIMMs aim to extend the memory capacity of servers while also preserving data across power failures—enabling order-of-magnitude increases in performance compared to conventional hard drives and solid-state drives (SSDs). The new memory (and similar technologies) have been in development for over a decade. The official release of the memory has been eagerly anticipated by researchers and potential customers like Google, Facebook, Amazon and other companies that require enormous memory capacity and storage performance.

UC San Diego's Non-Volatile Systems Laboratory (NVSL), led by Steven Swanson and Jishen Zhao, both computer scientists at the Jacobs School of Engineering at UC San Diego, worked with Intel to get early access to two high-performance servers equipped with multiple Optane DIMMs. Over the past several months, they, along with post-doctoral fellow Joe Izraelevitz, have put the Optane DIMMs through their paces and measured their basic performance characteristics and their overall impact on important software systems that power many of the cloud-based services that we all use every day.

“It’s been really exciting to finally have first-hand access to this memory. For a long time, researchers (including my group) have made predictions about how this technology would perform. We’ve proposed systems based on those predictions, and now we get to see how they really perform,” said Swanson.

The researchers used two machines provided by Intel to evaluate the Optane DIMMs’ performance. They measured basic performance numbers, including latency and bandwidth of reads and writes under a range of conditions. They uncovered a range of exciting results. “This memory is a new animal,” said Swanson, a professor in the UC San Diego Department of Computer Science and Engineering. “It is going to take a while for researchers, application developers, and system designers to understand its complexities and develop intuition about how it behaves.”

To understand how the underlying technology characteristics translate into application-level performance, researchers tested the memory on a wide range of applications used in cloud-based applications including MySQL, LMDB, RocksDB, MongoDB, Memcached, and Redis. One particularly exciting result is that Optane DIMMs can speed up some applications by up to 128 times compared to flash-based SSDs, the current workhorse of data center storage. Overall, the impact of the new memories varied between applications, and understanding the root cause of the differences will require more study.

“With a large variety of data-intensive applications—across big-data analytics, media processing, and computer vision domains—we also investigated the underlying software and hardware behaviors of computer systems with Optane DIMMs, traditional DRAMs, and DRAM-cached Optane DIMMs,” said Zhao, who is an assistant professor in the computer science department at UC San Diego.

Swanson and his research group have been studying emerging memory technologies like the Optane DIMMs for over a decade. The Non-Volatile Systems Laboratory developed some of the earliest software for managing and using such memories in 2011 and built a prototype SSD based on a precursor to the Optane memory chips in the same year. More recently the NVSL has released a high-performance file system called NOVA built specifically for Optane DIMM-like memories. Zhao has worked on computer architecture support for non-volatile memory systems at UC Santa Cruz and HP Labs and joined the group earlier this year.

Results of the study are available on the ArXiv preprint server: https://arxiv.org/abs/1903.05714

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