Advancements in DRAM-less SSDs

When solid state drives (SSD) were first introduced, dynamic random-access memory (DRAM) was routinely included as a cache for SSDs and to improve drive performance. The DRAM served as cache for writing data to the drive, and for storing the mapping tables that keep record of the location of the data on the SSD to allow access to the data. For years, it became the standard to continue to push the limits and gain better performance from SSDs using DRAM. However, there have been major improvements in the SSD interface, NAND technology, SSD controllers and firmware. Coupled with the desire to increase both performance and capacity cost efficiently, the conditions are ripe to challenge the need for DRAM in mainstream PC uses – enter Host Memory Buffer (HMB).

Host Memory Buffer (HMB)—What You Need to Know

HMB, which was enabled through NVMe 1.2 specifications, allows SSDs to utilize some of the DRAM attached to the host, or central processing unit (CPU), through the PCIe connection instead of requiring DRAM to support an SSD. The greatest utilization of host DRAM is to cache mapping information which often only requires tens of MBs of buffer size. While HMB is sufficient for most consumer applications such as working on local files (word documents, excel files) and rendering video files and photos, it may not be viable for all high-end applications or gaming environments. DRAM is still preferable for intensive workloads with random reading and writing of data such as downloading/playing a high-end video game, streaming game play, or executing multiple tasks simultaneously (downloading a program, working on large files and running computer updates).

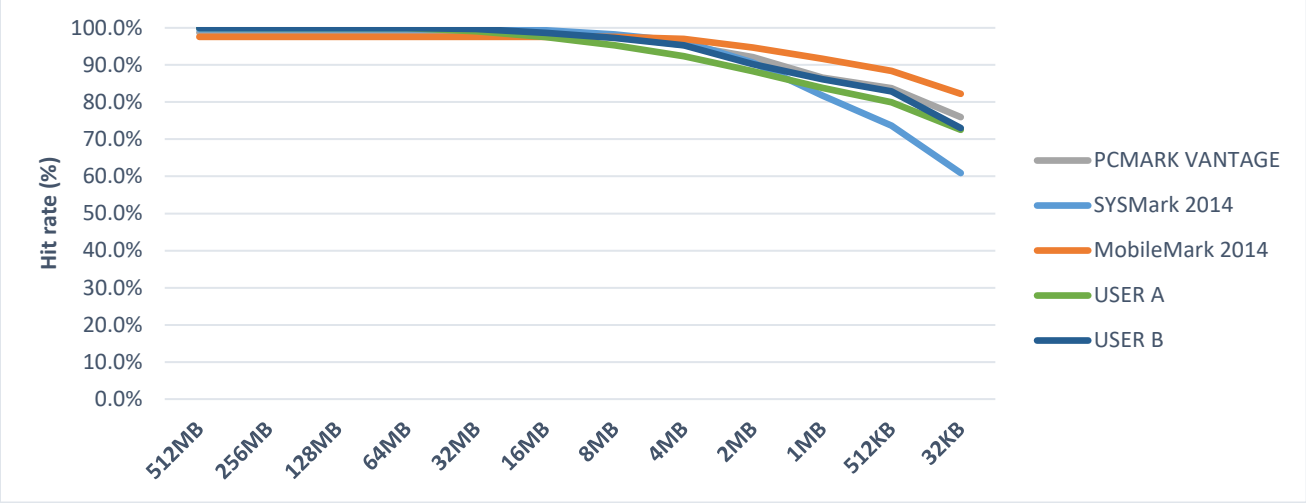
Testing with HMB—Does It Meet Our Expectations?

Western Digital conducted internal testing to determine the impact on performance using HMB, and how much was needed as an alternative to on-board DRAM. The goal was to determine how frequently delays occurred as a result of the drive requiring information to execute a command that was not in the HMB. Some of the key test cases include installing a popular office software suite, copying files, game play, as well as a few commonly accepted benchmarking test software. In order to determine the frequency and impact of the delays, the test specifically measured locality/hit rates when utilizing HMB with different amounts of

allocated RAM within the host. The hit rate is defined as the host memory having the required information the drive requires to execute a command or locate the data being stored in the drive. In other words, when there is a 'hit' there will be no observable delay experienced by the user.

The results were quite intriguing. When as little as 16MB of host RAM was allocated as HMB, the results showed that there was almost no impact on user experience. Specifically, for all workloads tested, 95% of all activities experienced no loss of performance. Additionally, 98% of most typical use cases such as installing software, copying files/folders, and general productivity for office users had no performance degradation whatsoever.

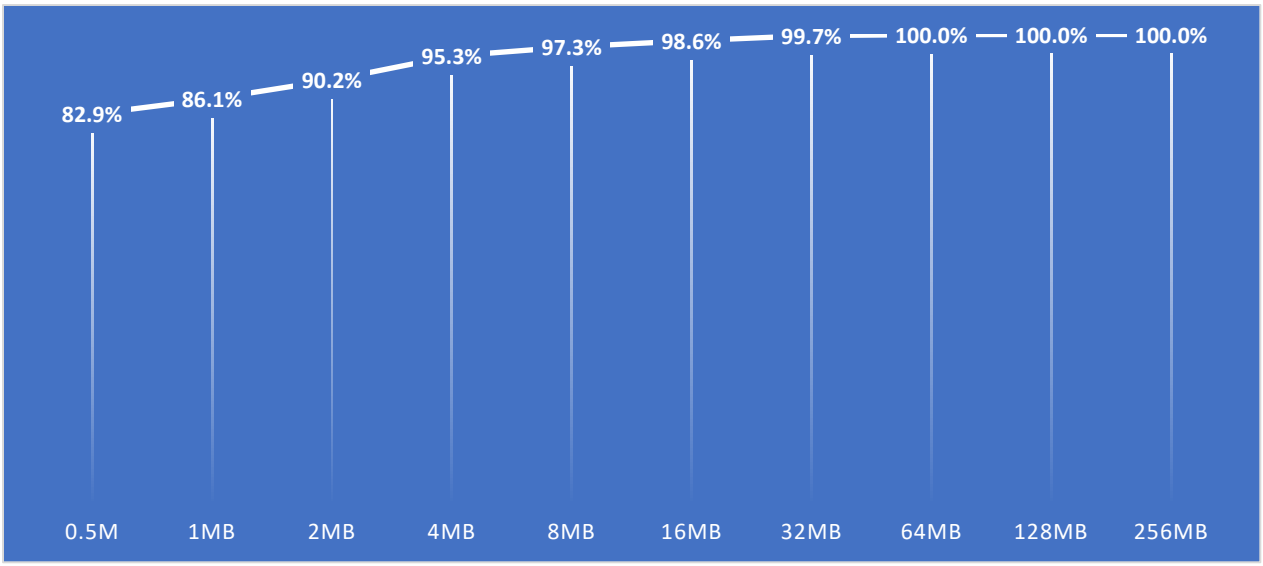
Exhibit 1: Locality of Various User Scenarios and Benchmarks



For all workloads, 16MB of DRAM (SSD FTL cache) yields hit rates >95%

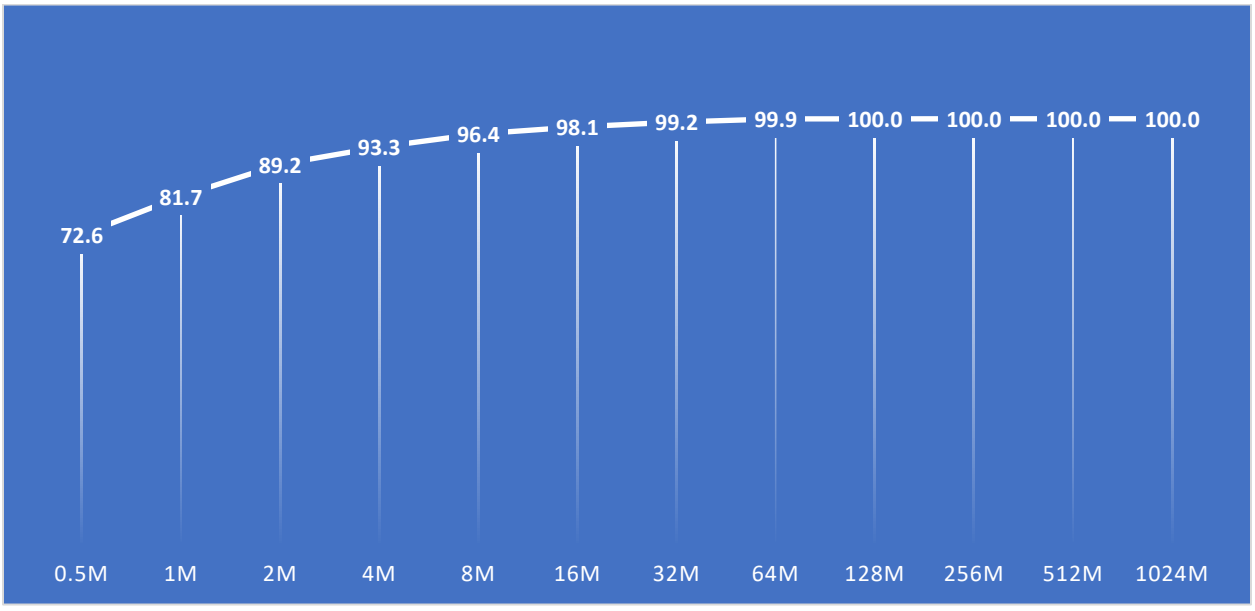
These results are seen in the charts below for two different users, which executed their typical workloads on their drives over the course of at least 10 business days. As expected, the more host RAM used by the drive, the greater the hits are. However, we want to limit the amount of RAM we use from the host, which is why Western Digital focused on the 16MB value where over 95% of the time a hit was achieved.

Exhibit 2: User RU10 average hit rates for various cache configurations



16 MB hit rates are >98% with no effect on user experience

Exhibit 3: User RU17 average hit rates for various cache configurations



16 MB hit rates are >98% with no effect on user experience

The users in this study conducted their day-to-day activities and while their behavior on the computer varied, the results were consistent - there was no noticeable change in performance. Western Digital is committed to providing high-quality and cost-efficient solutions to all PC users and used the findings from our research as we developed our recent WD Blue SN550 NVMe SSD. This drive provides exceptional performance and meets the needs of many users, whether it is in the home watching videos and casually playing games, or in the office working on large data files. Western Digital is committed to finding new features and pushing the limits of technology to meet the needs of our users and are proud to incorporate HMB in our portfolio of products.

5601 Great Oaks Parkway
San Jose, CA 95119, USA
US (Toll-Free): 800.801.4618
International: 408.717.6000

www.westerndigital.com