SOLUTION BRIEF

Using Intel® SSD and Intel® CAS to Accelerate Medical Image Display

Delivering Superior Imaging Reading Experiences to Doctors, Featuring Smooth HD Medical Images with Very Low Latency and High FPS

Challenge

Yokogawa Medical Solutions Corporation (YMS) was founded in 1993 as a medical-business project reporting directly to the president of Yokogawa Electric Corporation, and split off as a wholly owned subsidiary of Yokogawa Electric in April 2010, YMS provides cloud-based medical imaging solutions including PACS (Picture Archiving and Communication System), RIS (Radiology Information System), and radiology therapy (Therapy RIS) with a strong foundation of technology and expertise. YMS is a total solution provider and provides medical institution customers with system development, deployment and maintenance.

Along with the prevalent adoption of medical imaging and diagnostic equipment such as CT (Computed Tomography), MRI (Magnetic Resonance Imaging), and PET (Positron Emission Tomography), the volume of medical images has dramatically increased in recent years. For most YMS clients, the number of images generated for each patient is 550 per exam on average. The quantity of high resolution slices (images) can be 2000-8000 for certain patients. In some cases, such as cancer patients, diagnostic imaging requires comparison review with image record history, so the large volume of high resolution images that must be delivered to doctors creates the need to transfer bulky data in very short time. When doctors compare current and past images, multiple diagnostic image streams are called from the server simultaneously and displayed on the screens side-by-side. The minimum speed at which images must be delivered is 30 frames per second with zero frame drop. The demands for image delivery are even higher when doctors perform multiple past image record comparison in parallel.

To fulfill these market requirements, YMS has optimized system performance by leveraging parallel processing with multi-core Intel® processors. However, given the 5-6 year typical usage for servers and clients, legacy systems have fallen below current system requirements. Server HDD (Hard Disk Drive) performance has become the bottleneck for image instant delivery, particularly in the case where multiple past image streams are compared. With new system deployments, such as PACS, the volume of radiographic images that a typical hospital stores can easily reach 100 to 500 TB every year. Traditional solutions, such as increasing storage, servers, or memory, add huge expense and complexity. The migration from HDD to high-speed Solid-State Drives (SSD) can drastically increase system performance and is effective, but can be very expensive. YMS and their medical institution clients have a crucial need to satisfy the 30 FPS performance demands for image transfer when managing the huge volume of high resolution images generated by modern medical imaging modalities.

Solution

To address the performance challenge, YMS turned its attention to a combination of Intel® Solid State Drives (SSD) and Intel® Cache Acceleration Software (CAS). Intel® CAS, combined with high-performance Solid State Drives (SSDs), increases system performance via intelligent caching. Intel® CAS uses the Intel® SSD as a server cache to reduce the I/O latency that is inherent in HDDs that are attached to a server, thereby improve overall system performance. Intel® CAS introduced seamless I/O acceleration for applications running on both virtual machines and physical servers. Deployment is very straightforward, and is accomplished by simply installing Intel® CAS software on existing servers. A key benefit of Intel® CAS is that there is no need to change application settings or storage configurations, so it is possible to optimize performance without a significant overheads. Intel® CAS is transparent to users and applications.

Intel® CAS interoperates with server memory to create a multilevel cache that optimizes the use of system memory and automatically determines the best cache level for active data, allowing applications to perform even faster than running on all-flash/SSDs alone. Intel® CAS performs detailed analytics, labels I/O based on predetermined classifications, and prioritizes the order in which items will be evicted from the cache. Intel® CAS works by retrieving data from storage on the initial access and copying it to the Intel® CAS cache. On the next reading, data is moved to system memory, and subsequent reads are accelerated through use of high-performance DRAM and SSDs. Several caching modes and capabilities for specific workloads and environment optimization are employed. All data is synchronized and written back to both storage and cache, and thereof data is not lost even if a fault occurs.

Intel® CAS can be used with data center SSDs that are compliant with the SATA or NVMe standards.

Test Details

To evaluate the performance of Intel® SSDs and Intel® CAS, YMS measured performance using actual diagnostic images. In the test, all image data was read and display latency was measured. After data was copied from the sever HDD to the SSD cache on the first access, the speed (FPS) was measured at which images were sent from the second access onward.

Two benchmark tests were conducted. In the first test, four groups of test content each containing images with 1,000 frames were sent simultaneously. In the second test, two groups of test content each containing images with 1,000 frames were sent simultaneously. The size of each image was approximately 500 KB (180 KB when stored on the server with lossless compression), and the time from the image initially started being displayed to the time when the entire image was displayed was measured.

The tests also factored in differences caused by SSD performance, so two types of SSD were used. The first was a high-speed SSD compliant with the NVMe standard and the second was a conventional SATA SSD. Intel® CAS was enabled on both SSDs, and the speed at which images were delivered to the display was measured with YMS's test scripts.

Test Environment

■ Server
OS: Red Hat* Enterprise Linux* Server 6.7 (Santiago)
CPU: Intel® Xeon® processor E3-1240 v3 (3.40GHz)
Memory: 4 GB
OS Space: 500 GB HDD (no RAID)
CAS Device 1: 1.6 TB SATA SSD
CAS Device 2: 1.2 TB NVMe SSD
Image Storage Space: 2TB HDD (no RAID)

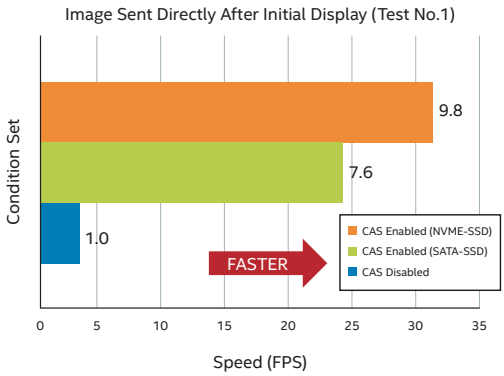
■ Client
OS: Windows* 7 Professional Service Pack 1 (64-bit version)
CPU: Intel® Xeon® processor E3-1225 v2 (3.20 GHz)
Disk: HDD
Memory: 4 GB
Monitor: 1 1280x1920 widescreen monitor

■ Product
Image Diagnosis Workstation ShadeQuest/ViewR V1.24.01 (Yokogawa Medical Solutions)
Integrated Image Information Server ShadeQuest/Serv V5.00 (Yokogawa Medical Solutions)

Test Results

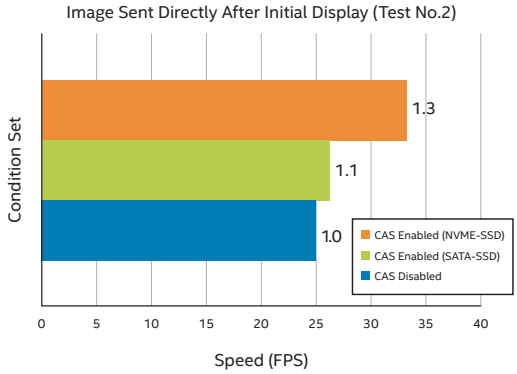
■ Measurement 1: Four concurrent image streams display Test (1,000frames × four images)
Displaying four test image streams concurrently creates a significant read load pressure on the server and storage system. The throughput for delivering images from the servers and storage with Intel® CAS disabled was 3.19 FPS. That is well below the 30 FPS requirement

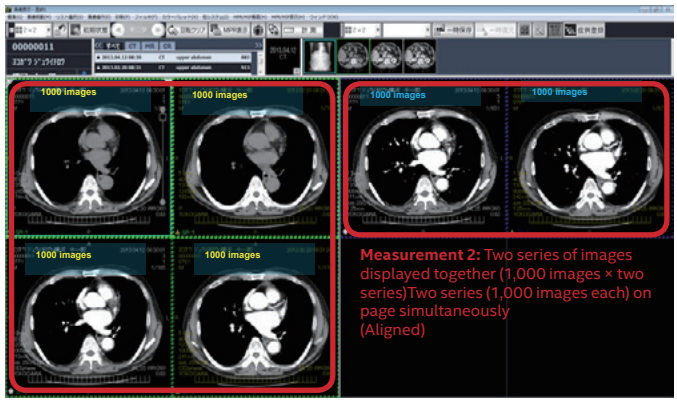
When Intel® CAS was enabled with the same test conditions, images were delivered at 24.20 FPS with the SATA-connected SSD and 31.36 FPS with the higher-speed NVMe SSD. This equated to an acceleration of 7.6 times and 9.8 times respectively.



■ Measurement 2: Two concurrent image stream display Test (1,000 frames × two images)
In Measurement 2, two test image streams were displayed concurrently, which was half the data required in Measurement 1. The frame rate at which images were delivered with Intel® CAS disabled was 24.88 FPS.

When Intel® CAS was enabled, images were sent at 26.39 FPS with the SATA SSD and 33.55 FPS with the higher-speed NVMe SSD. This equated to an acceleration of 1.1 times and 1.3 times respectively.





Measurement 1: Four series of images displayed together (1,000 images × four series)Four series (1,000 images each) on page simultaneously(Aligned)

Conclusions

As indicated by the test results, in demanding environments where large amounts of data are being simultaneously read from the servers (like four images being displayed concurrently), there was dramatic performance improvements when Intel® CAS was enabled on a server containing an Intel datacenter SSD. The results also imply that the more data (images) that are being examined (retrieved from the server) simultaneously, the greater the benefit of the combination of Intel® SSD and Intel® CAS. Although these tests results were derived in the scenario of simultaneously displaying multiple images for single doctor on one client PC, the results also apply to situations in which multiple doctors are simultaneously accessing the servers for the benefit of multiple patients. The doctors waiting time for image display is shortened by many times and image reading experience is greatly improved.

The combination of an Intel® SSD and Intel® CAS can be easily deployed on existing servers. Significant performance acceleration can be achieved simply by adding an Intel® SSD and Intel® CAS (minimal downtime needs to be scheduled for the installation of both the SSD and CAS). As the performance and data requirements arise in the medical environment, those servers with Intel® SSDs and Intel® CAS are ready to scale to meet the future demands.

YMS plans to integrate the solution into their imaging platform with further validation and offer the best experiences and affordable solutions to their customers.

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