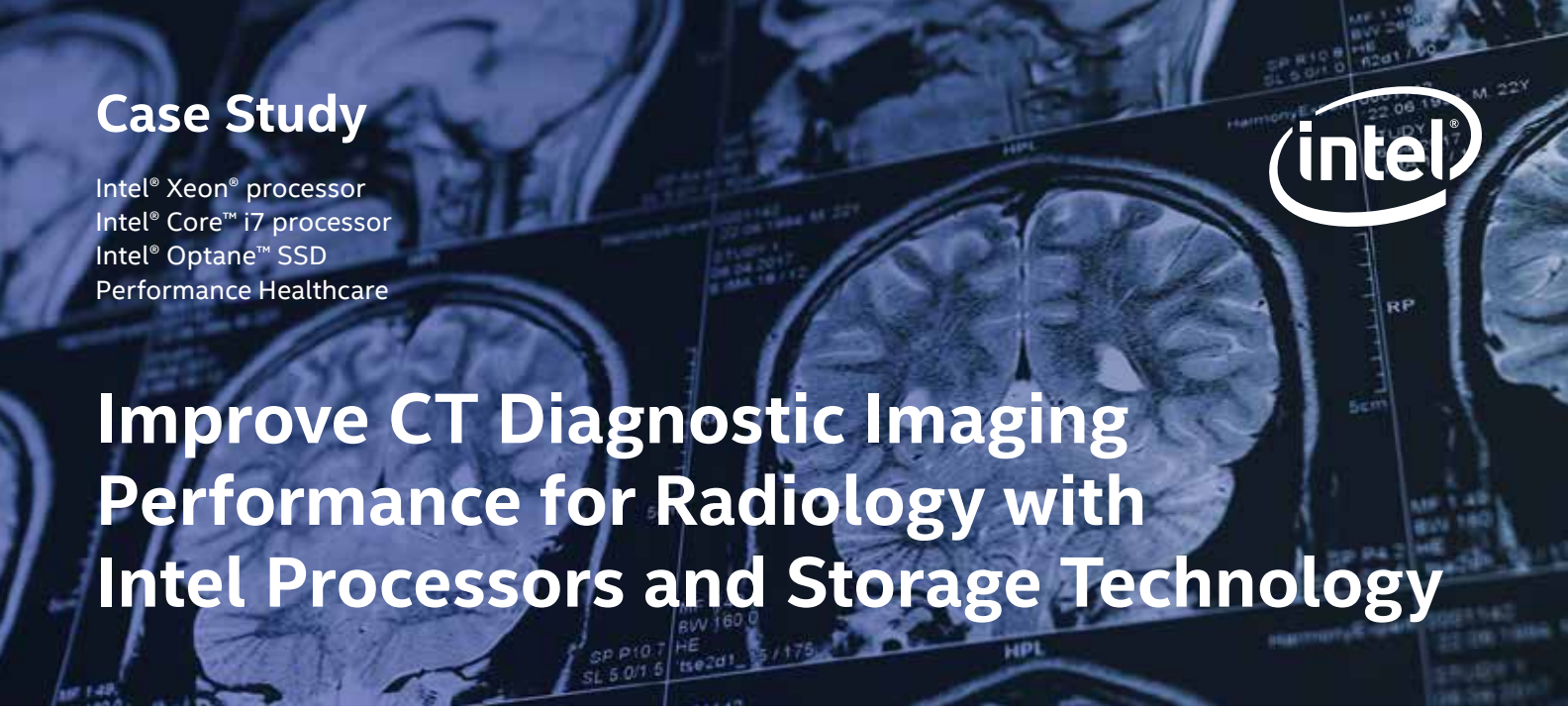

Case Study

Intel® Xeon® processor
Intel® Core™ i7 processor
Intel® Optane™ SSD
Performance Healthcare

Improve CT Diagnostic Imaging Performance for Radiology with Intel Processors and Storage Technology

Modernizing infrastructure resulted in faster image display in server and client workstations, and improved healthcare services

Fujifilm Medical Solutions Co., Ltd.
www.fujifilmusa.com

FUJIFILM
Value from Innovation

Challenge

- Radiologists must read and diagnose increasing numbers of images and caseloads each day
- Slow image display, communications throughput congestion, and application processing times delay diagnoses

Solution

- Upgrade Fujifilm Medical Solutions ShadeQuest Integrated Image Information Server with Intel® Xeon® Silver processors and Intel® Optane™ SSD DC P4800X drives
- Upgrade Fujifilm Medical Information Solutions ShadeQuest/ViewR-DG Image Diagnosis Workstation with Intel® Core™ i7 processors and Intel® Optane™ SSD 900P drives

Result

- Reduce file read and display times by 18x[1]
- Increase daily number of patients being diagnosed through accelerated image display
- Improve rates of early detection of diseases

Fujifilm Medical Solutions Co., Ltd. is a Japanese solutions provider of Picture Archiving and Communication System (PACS), Radiology Information System (RIS), and Therapy Radiology Information System (Therapy RIS) for medical image and diagnoses practices worldwide. Fujifilm Medical Solution offers comprehensive services ranging from healthcare IT consulting to system development, deployment, and maintenance.

Today's modern diagnostic medical imaging equipment, such as CT, MRI, and CR, offer high-resolution images, creating better tools for radiological diagnosis. Imaging provides effective non-invasive methods and is increasingly used by physicians, leading to rising numbers of images for radiologists to review.

CT or MRI scans can generate up to a few hundred images per exam on average and can be a few thousand to nearly ten thousand if the exam contains thin slice images. The higher the number of images, the heavier the burden on radiologists to read and diagnose them to support physicians and their patients in a timely manner.

"Radiologists are required to accurately detect any and all relevant lesions while efficiently reading massive amounts of CT images," said Mr. Hideki Matsuura of Fujifilm Medical Solutions.

To view an image, data is read from the server and displayed on the radiologist's client PC through an image diagnosis workstation. Latencies in reading data from the imaging server and processing it on the workstation can delay time to diagnosis. With thousands of images needing to be reviewed, response times impact radiologists' abilities to complete patient reviews in a timely manner.

To improve response times across the system, Fujifilm Medical Solutions adopted new technologies to improve performance and reduce latencies, such as parallel processing using multi-core processors and data read-ahead functions. Part of the solution lies in storage technologies, where latencies of hard drives are well known to result in data transfer bottlenecks. Fujifilm looked to Intel® Optane™ technology to improve data access performance. Through validation testing, they evaluated the performance benefit provided by Intel Optane technology compared to conventional HDDs and SSDs.

Up to 25x[1] faster server data read times with Intel® Optane™ SSDs

To evaluate the benefits of Intel Optane storage technology, Fujifilm engineers conducted two kinds of tests in May 2019:

1) a read-only test, in which CT images were read from the server, and

2) a viewer test of server and client workstation.

Test 1: Reading from the server
The first test read 1,000 CT images (525 kb per image, uncompressed) from the server. Latencies were measured and compared between using conventional SAS spinning hard disks and Intel® Optane™ SSD DC P4800X drives in the server (see Table 1). To exclude the influence of write performance, two patterns of tests were conducted: a test using the Linux cat command for reading and a test using actual image delivery protocol (YITL communications) for reading. The tests revealed the following (see Figure 1)[1]:

- Up to 25x faster read times using Intel Optane SSD DC P4800X drives with the cat command
- Up to 19x faster reading and image delivery using Intel Optane SSD DC P4800X drives
- Up to 2.3x faster reading and image delivery for two servers connected by a 1 GbE network (acceleration is limited compared to the first test above due to application bottlenecks)

Figure 1. Test 1: Reading from the server

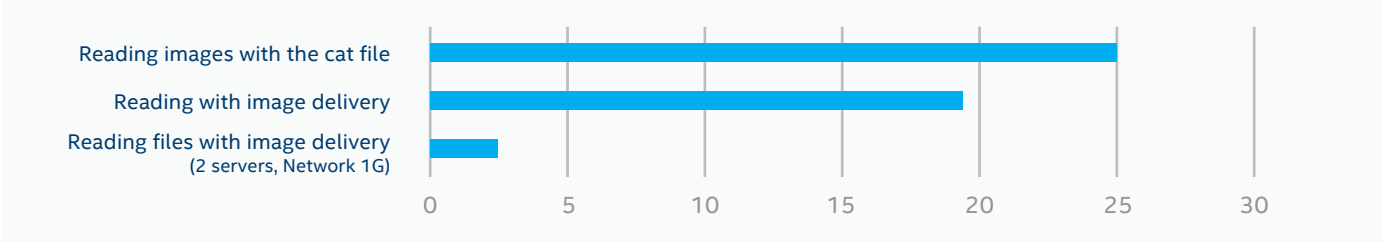

Table 1. System components for Test 1

Component	Server with HDDs	Server with Intel Optane SSD
CPU	Intel® Xeon® processor E5620 (12M Cache, 2.40 GHz) Memory: 8 GB	Intel® Xeon® Silver 4112 processor (8.25M Cache, 2.60 GHz) Memory: 16 GB
Storage	SAS 146 GB × 7	Intel® Optane™ SSD DC P4800X (750 GB) × 2
Application	ShadeQuest/Serv	ShadeQuest/Serv

Test 2: Server Viewer Test
The second test sequentially read and displayed 1,500 images (173 kb per image, compressed) on the client. Time was measured from initial call of the first image to the completion of the last image on the display. Several configurations were compared as follows, which included single- and multi-threaded versions of the server applications (see Table 2):

- Baseline configuration for both single- and multi-threaded comparisons comprised a server with legacy HDDs and client with conventional SSDs (metric 1.0)
- Single-threaded server baseline configuration with client workstation containing Intel® Optane™ SSD 900P drives
- Multi-threaded server baseline configuration with client workstation containing Intel Optane SSD 900P drives
- Single-threaded server with Intel Optane SSD DC P4800X drives and client workstation containing Intel Optane SSD 900P drives
- Multi-threaded server with Intel Optane SSD DC P4800X drives and client workstation containing Intel Optane SSD 900P drives

The testing revealed the following improvements[1]:

- Up to 1.2x faster time to completion for single-threaded baseline server with Intel Optane SSD 900P drives in the client
- Up to 7.5x faster time to completion for multi-threaded baseline server with Intel Optane SSD 900P drives in the client
- Up to 10.6x faster time to completion for single-threaded server with Intel Optane SSD DC P4800X drives and Intel Optane SSD 900P drives in the client
- Up to 18.9x faster time to completion for multi-threaded server with Intel Optane SSD DC P4800X drives and Intel Optane SSD 900P drives in the client
- With a baseline server configuration, time to completion was up to 1.42x faster when comparing the client SATA SSD configuration to client with Intel Optane SSD 900P drives (not shown in chart)

Figure 2. Test 2: Server viewer test (Fixing Intel® Optane™ SSD 900P on the client side)

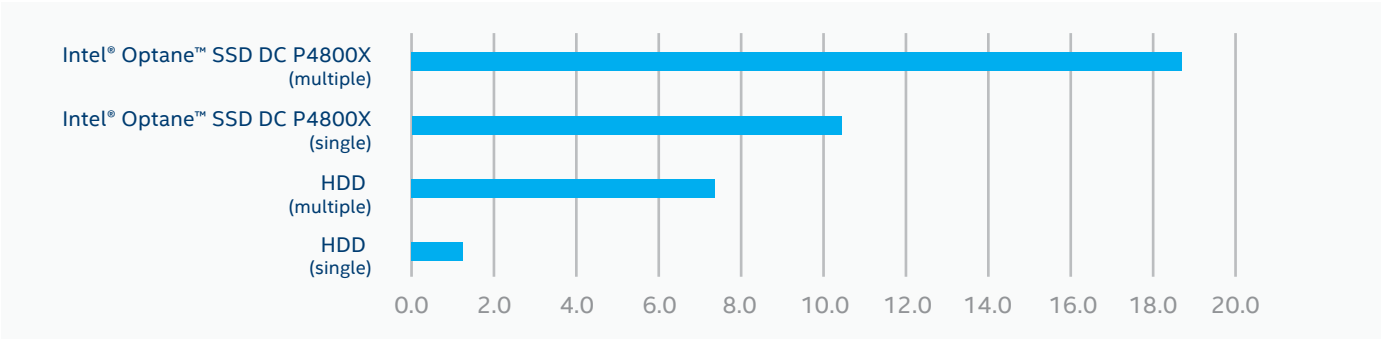

Table 2. System components for Test 2

Component	Client with Conventional SSDs	Client with Intel Optane SSDs
CPU	Intel® Xeon® W-2102 processor (8.25M cache, 2.90 GHz) Memory: 32 GB	Intel® Core™ i7-9700 processor (8 core/8T, 3.60 GHz) Memory: 16 GB
Storage	256 GB SATA Class20 SSDs + 1 TB SATA Class20 SSDs	Intel® Optane™ SSD 900P (480 GB)
Imaging GPU	Radeon Pro WX4100	GeForce GTX 1060 6 GB
Application	ShadeQuest/ViewR-DG	ShadeQuest/Serv

Reduction of image display times help deliver better healthcare services

The results from Test 1 and Test 2 show a significant improvement using Intel Optane SSDs.

"If we want to see quick results, using them on the client would be an option," stated Mr. Keishi Yoshimura of Fujifilm Medical Solutions. "But if we want to see bigger improvements, using them on the server would be more appropriate."

According to Mr. Yoshimura, the use of PACS means a huge volume of images. Thus, the realistic approach would be to use Intel Optane SSDs as a cache rather than server storage. How frequently images are accessed for PACS varies depending on the medical exam date, the patients' conditions, hospital admissions, and outpatient services. The solution needs additional embedded logic to store images in Intel Optane SSDs in advance to use them more efficiently in the application.

The test results illustrate that applications and networks are additional typical bottlenecks. Design engineers are considering code modifications to the application and migrating the solution to 10 GbE network for addition performance improvements.

"Using Intel Optane technology helped display each image accurately and improve response performance for radiologists' image analysis," added Mr. Matsuura. "Displaying images just five seconds faster per exam could increase the number of patients a doctor can see, which in turn would increase medical service fees for the hospital."

Following the above analysis, Fujifilm Medical Solutions is considering implementing a tiered storage architecture with a server cache for the application to PACS products and delivery.

"We expect to use Intel to optimize the entire system, including processors and networks," concluded Mr. Yoshimura. "We would love to see more varieties of products powered by Intel Optane SSDs so that we will have more choice."

Where to get more information

For more information on Intel® Optane™ technology, visit https://intel.com/optane.

1. Source: Fujifilm Medical Solutions Co., Ltd. internal testing.

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