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Effects of Virtualization and High-Capacity Flash  
Memory on Electronic Medical Record and PACS Servers  
in the Era of Healthcare DX

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# Conflict of Interest declaration

- I have no conflict of interest related to the subject of this presentation.

# Purpose

- During the 2020 upgrade of the university hospital's EMR and PACS systems, [virtualization and high-capacity hybrid flash storage](#) were introduced to improve performance and cost efficiency.
- The [server infrastructure](#) was outsourced to [a local IT vendor](#).
- This study evaluated:
  - Cost efficiency
  - Performance improvement with all-flash storage
  - Centralized infrastructure management
  - Enhanced cybersecurity
- Challenges associated with these implementation.
  - Separation of the Oracle database server from other systems because Oracle licensing costs depend on the number of CPUs (processor-based licensing), unlike concurrent-user licensing
  - Effectiveness of PACS migration and VNA implementation

# Methods

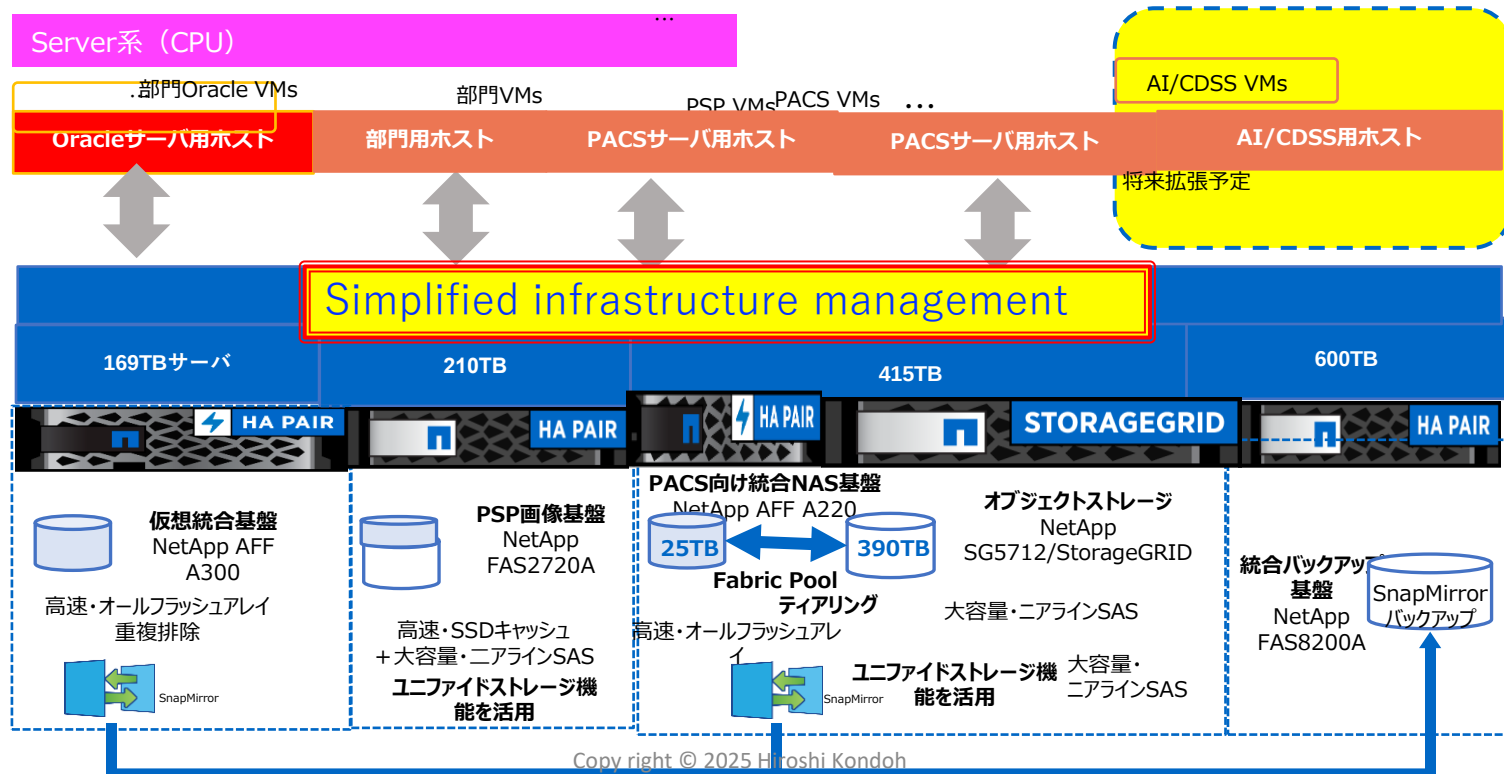
- Conducted two years of preliminary negotiations with our existing vendors
  - IBM transferred its server manufacturing business to Lenovo
  - GE HealthCare servers are currently sourced from Dell Technologies
  - Both vendors agreed to provide software-only support for the regional healthcare collaboration system.
- Existing EMR and PACS contracts were reorganized into separate software and hardware contracts
- Display times of the monitoring system were measured before and after infrastructure replacement.
- A hybrid storage architecture combining flash storage and object storage was implemented for two PACS systems
  - the departmental PACS for radiology
  - Hospital-wide PACS
- Due to technical issues, migration from Synapse to Synapse-VNA was performed during live operation
- Access times of two PACS viewers using WADO through the VNA were measured.

## Result 1 Infrastructure Modernization: Virtual servers and Storage configuration

- 1) Cost benefits
  - Total storage capacity increased from 400 TB to 1.9
  - Achieved fivefold storage expansion at approximately the same cost
  - Transitioned from 400 TB flash storage to an all-flash unified storage architecture
- 2) Scalability
  - Performance and storage capacity can be expanded by adding storage units
  - Unified storage architecture is well suited for medical imaging data
- 3) ONTAP :storage OS
  - Supports immutable backup for cybersecurity protection
- 4) Centralized management
  - Improved overall security level
  - Enabled future AI deployment using GPU-based edge deep learning
- The Oracle database server should be separated from other systems because licensing costs are processor-based

# Integrated Virtual infrastructure for EMR and PACSs (Updated 2020, Tottori University Hospital)

- ① Cost benefits → fivefold storage expansion with 400TB all-flash storage
- ② Scalable architecture → GPU-ready infrastructure for future edge AI application
- ③ Unified storage architecture → Optimized for medical image data
- ④ Oracle DB separation → Required for processor-based licensing.

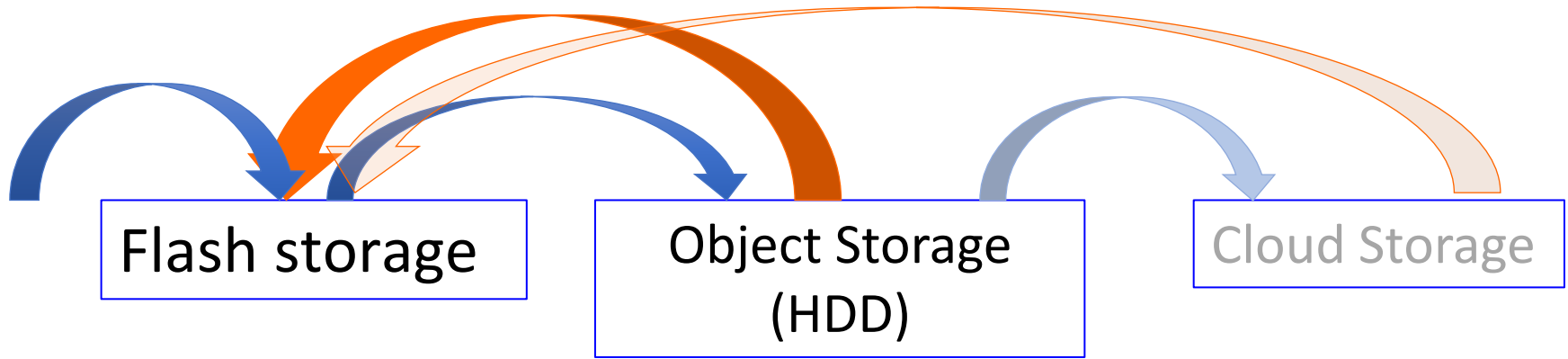


## Result 2 All-Flash Storage Reduced Display Time in the ICU Monitoring System

- Comparison of display times before and after migration to all-flash storage.
- Display time was reduced by approximately 60%.
- Faster image and waveform display improved clinical usability in the ICU environment

| Display time         | Before | After |
|----------------------|--------|-------|
| Initial Images       | 4.25s  | 4.31s |
| ECG                  | 7.06s  | 4,71s |
| Holter ECG           | 10.03s | 5.40s |
| exercise ECG         | 8.13s  | 5.17s |
| Respiratory function | 8.47s  | 5.15s |
| Blood Pressure Wave  | 7.90s  | 4.73s |

# Unified Storage



- Frequently accessed recent images were stored on high-speed flash storage  
Older images were automatically migrated to object storage

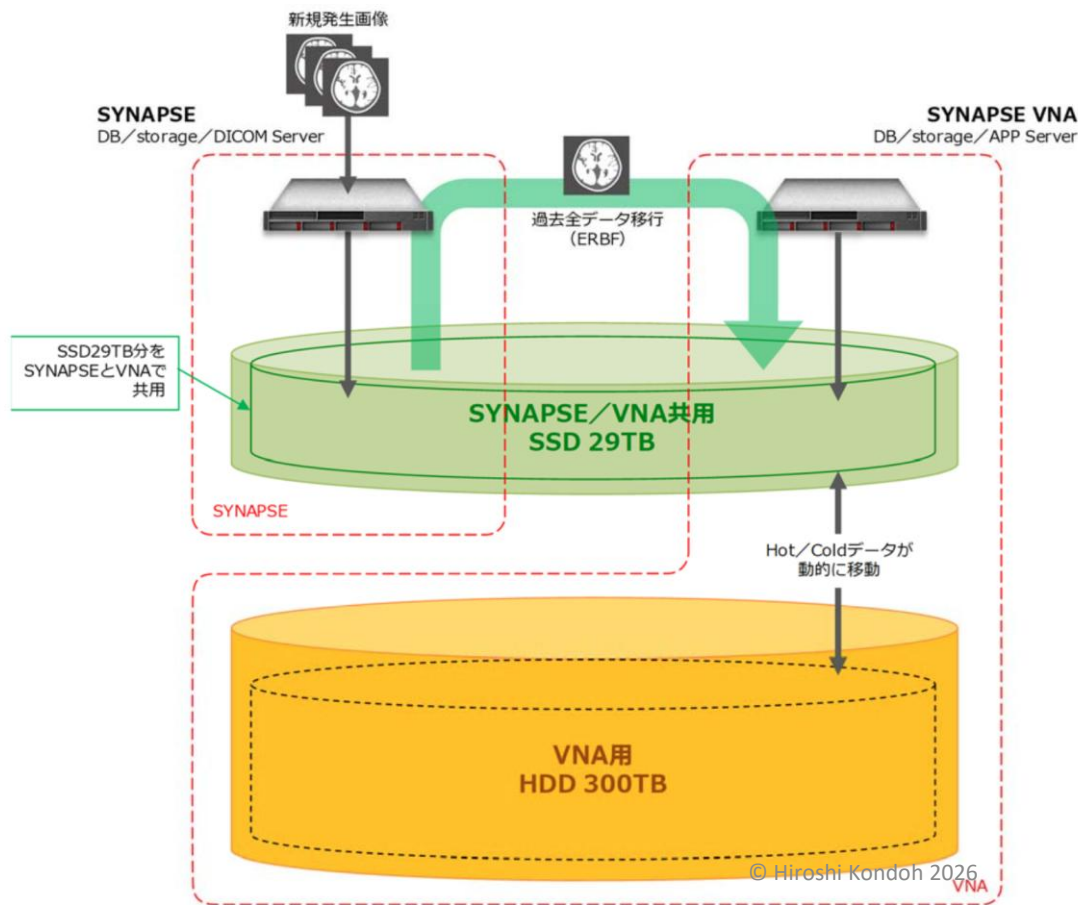
- **An ideal storage solution for a DICOM server**
- The image data itself remains unchanged, while the tag information is stored in a database (vendor-specific), enabling high-speed retrieval of new images. Once an older image has been retrieved once, it can be displayed quickly in subsequent searches.



## Result 3 PACS Migration and Vendor Independence

- Preventing vendor lock-in is essential for large-scale PACS environments
- As PACS data volumes increase, data migration between vendors requires substantial time and may not be completed before the start of operation after a bid award
- Because the hardware infrastructures was owned by the hospital, PACS migration could be performed while maintaining clinical operation
- All the input images from imaging modalities and external CDs were first transferred to the departmental PACS (PSP), and subsequently distributed to the hospital-wide PACS (GE)
- To support VNA and WADO-based image management, the PACS platform was migrated from Synapse (developed in Japan) to Synapse-VNA (developed in the United States)
- Unified storage and virtualization enabled flexible PACS replacement and long-term scalability

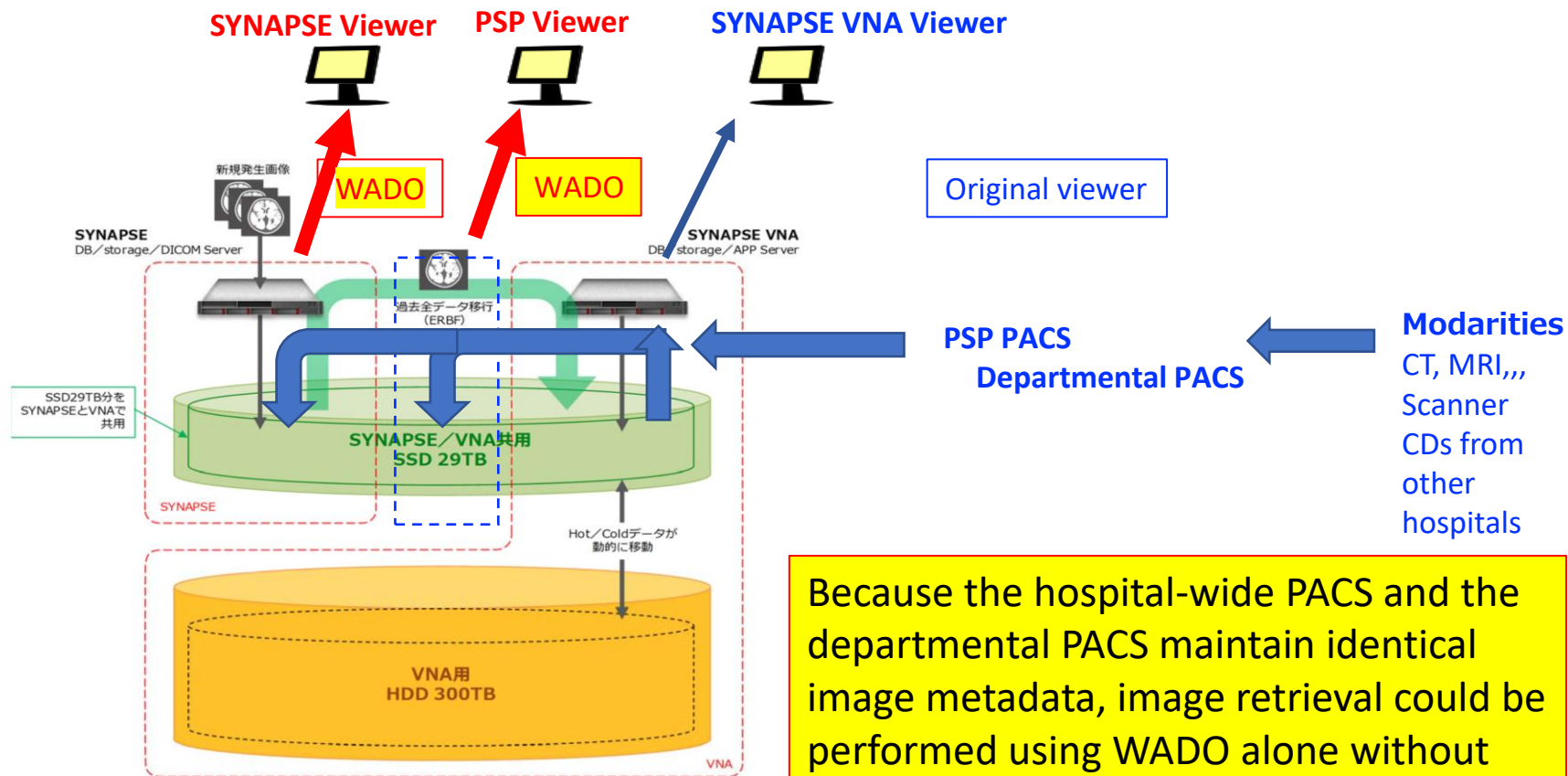
# Image Data Migration Between PACSs



Hospital-owned infrastructure enabled migration during live operation

Unified storage and virtualization enabled flexible PACS replacement and long-term scalability

# VNA on Unified storage



Because the hospital-wide PACS and the departmental PACS maintain identical image metadata, image retrieval could be performed using WADO alone without requiring QIDO.

## Result 4 VNA on Unified storage

- All PACS and VNA processes were virtualized and operated on unified flash-based infrastructure
- Multiple viewer environments were integrated in the same platform, including,
  - PSP PACS server via WADO
  - Synapse PACS via WADO
  - Synapse VNA PACS viewer
  - -> Integration of multiple viewer environments improved image-access performance compared with multiple independent systems
- Unified storage enabled seamless access to both recent and archived images through a single VNA environment
  - Frequently accessed recent images were stored on high-speed flash storage
  - Older images were automatically migrated to object storage (HDD-based archival tier)
- The architecture improved scalability, simplified management, and reduced storage costs while maintaining clinical performance

# Result 4 Access time of VNA on Unified storage

Example of measuring image loading speed in VNA Measurement Speed (seconds) from FMS

|           | CR/<br>CT | No. of<br>measure<br>ments | Total<br>Display<br>time | Display<br>image | Display<br>images<br>and list | No of<br>exam. | No of<br>series | No of<br>images |
|-----------|-----------|----------------------------|--------------------------|------------------|-------------------------------|----------------|-----------------|-----------------|
| Synapse 5 | CR        | 3                          | 3.83                     | 2.74             | 1.09                          | 100            | 1               | 4               |
|           | CT        | 3                          | 4.22                     | 2.96             | 1.25                          | 107            | 4               | 302             |
|           | CT        | 3                          | 3.94                     | 3.01             | 0.93                          | 95             | 8               | 1134            |
| SAI       | CR        | 3                          | 1.86                     | -                | 1.86                          | 100            | 1               | 4               |
|           | CT        | 3                          | 1.72                     | -                | 1.72                          | 107            | 4               | 302             |
|           | CT        | 3                          | 1.87                     | -                | 1.87                          | 95             | 8               | 1134            |

- \*1: Measurements were taken after clearing the browser cache and DICOM cache.
- \*2: Since SAIViewer displays images and the examination list almost simultaneously, the time taken to display the image was not measured.

From PSP “The access times were almost zero second.”

## Conclusions

- Virtualization and unified all-flash storage significantly improved the performance and scalability of the EMR and PACS infrastructure
- Storage capacity increased fivefold while maintaining similar overall costs
- Unified storage combining flash and object storage enabled efficient long-term management of large-scale medical imaging data
- Virtualization and hospital-owned infrastructure reduced vendor lock-in and enabled flexible PACS migration during live clinical operation
- VNA and WADO integration provided seamless image access across multiple PACS environments
- Centralized management improved operational efficiency, cybersecurity, and future scalability for AI applications
- Processor-based Oracle licensing remains an important consideration in virtualized environments



**Thank you for your attention!**