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Migration of Medical Image Data Archived Using Mini-PACS to Full-PACS

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This study evaluated the migration to full-PACS of medical image data archived using mini-PACS at two hospitals of the Yonsei University Medical Center, Seoul, Korea. A major concern in the migration of medical data is to match the image data from the mini-PACS with the hospital OCS (Ordered Communication System). Prior to carrying out the actual migration process, the principles, methods, and anticipated results for the migration with respect to both cost and effectiveness were evaluated. Migration gateway workstations were established and a migration software tool was developed. The actual migration process was performed based on the results of several migration simulations. Our conclusions were that a migration plan should be carefully prepared and tailored to the individual hospital environment because the server system, archive media, network, OCS, and policy for data management may be unique.

KEY WORDS: PACS, migration, medical image data, DLT, CD

YONSEI UNIVERSITY MEDICAL CENTER (YUMC) has long recognized the importance of the medical digital image data acquired in the department of diagnostic radiology and has stored these image data using mini-PACS (Picture Archiving Communication System) while continuing to use printed film to interpret imaging studies and treat patients. YUMC Yongdong Severance Hospital (a 747-bed teaching hospital) began archiving CT (computed tomography), and MR (magnetic resonance) digital image data in early 1997. Meanwhile, YUMC Severance Hospital (a 1554-bed teaching hospital) archived CT, MR, and DSA (digital subtraction angiography) digital image data beginning in January 1998. Endoscopy (ES) image data and images acquired in the department of radiation oncology and converted to Digital Imaging and Communication in Medicine (DICOM) format had been stored since August 2000. The storage media used were compact disks (CDs) in Yongdong Severance Hospital while Severance Hospital's mini-PACS used Redundant Array of Independent Disk (RAID) short-term storage and Digital Linear Tape (DLT) for long-term storage. In order to access the archived image data, the CDs or DLTs were manually loaded into mini-PACS and the retrieved im-

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ages were displayed on a display device using DICOM image viewing software (πView™, INFINITT Co., Ltd., Seoul, Korea) or printed on film.

Beginning in late 1994, the Korea PACS was installed mainly in large-scale hospitals. Currently, many medium-size hospitals have either implemented or plan to implement PACS. Initially, PACS was limited to mini-PACS installations, featuring only archive and retrieval functions. However, with the recent developments of computer and network technology, increased capacity and decreased cost of storage media, and convenient DICOM image viewing software, high-performance full-PACS is being introduced. These developments require the upgrading of the prior mini-PACS or replacement with a new PACS. When it becomes necessary to migrate the data stored in the existing mini-PACS to the new PACS, the planning and preparation for effective and economical data migration should be thoroughly investigated to optimize the use of time, manpower, and equipment resources.[1-4]

YUMC signed a contract to implement PACS with GE Medical Systems (GEMS, Milwaukee, WI, USA) in May 2000, Yongdong Severance Hospital implemented the PACS servers and upgraded the PACS network between July and December 2001. Meanwhile, Severance Hospital began to upgrade the PACS network in December 2001 and to implement the PACS servers in May 2002, with final completion in August 2002. Since then, PACS has been used in diagnostic and clinical practice (Fig. 1). Yongdong Severance and Severance Hospitals began to plan the methodology and prepare the required equipment for the migration of old digital image data archived from mini-PACS to full-PACS in September 2001 and March 2002, respectively. Each data migration scenario was simulated before the full-PACS installation was completed. The migration work commenced with sequential migrations of the old image data simultaneous with storage of the new image data. The CR and MR image data volume to be migrated in Yongdong Severance Hospital were estimated to be 2.7 TB stored in approximately 4,500 CDs. The image data volume to be migrated in Severance Hospital were estimated to be 5.5 TB for the CT, MR, and DSA images and 4.7 TB for the CR and ES images, which were archived on 196 DLTs and RAID connected to the mini-PACS server.

In this study, the strategies and methods for migrating the digital image data stored on CD or DLT from mini-PACS to full-PACS were developed and applied, and the migration results were introduced and evaluated.

MATERALS AND METHODS

Image Data Archived Using Mini-PACS

Mini-PACS in Yongdong Severance Hospital consisted of a workstation (Silicon Graphics SGI, USA) implemented by Medical Interface (*formerly* Mediface Co., Ltd., Seoul, Korea) in 1996 and a PC workstation implemented by Mediface (*presently* INFINITT Co., Ltd., Seoul, Korea) in 1998. The archived image data prior to 1998 did not include a database, although after 1998 data were archived using a database with a CD backup method. The original image data were stored archived in DICOM format without image compression. CT and MR image data volume stored through the two workstations was estimated to be 2.7 TB and used approximately 4,500 CDs with a storage capacity of 650 MB each.

Mini-PACS in Severance Hospital was composed of three Spectra PACS servers implemented by Mediface in two stages in July 1997 and August 2000 (Fig. 2). The CT, MR, and DSA image data were archived using the Sun Ultra 10 UNIX operating system (SPECTRA1 server; SUN Ultra Enterprise 2, USA). The CR and ES image data were archived using the Windows NT operating system (SPECTRA2 and SPECTRA3 servers; Compaq Proliant DL 380 and 5500, USA; respectively). Each mini-PACS featured a different operating system (OS) and storage method. A 10/100 Mbps Ethernet connected the PACS servers on the hospital backbone network.

To calculate the storage capacity required to hold the data to be migrated at the Severance Hospital, an analysis of the stored data volume was performed. CT and MR image data acquired from January 1998 to August 2002 were archived using a lossless, 2:1 image compression ratio on 138 DLTs of 20-GB storage capacity each (with 26 DLTs online in a DLT jukebox and 112 DLTs offline). Accounting for disk overhead, this produced a total of 2,484 GB of compressed data, or 4,968 GB of uncompressed data. Two hundred forty gigabytes of data were stored in RAID resulting in a total data storage requirement of 5,208 GB or 5.208 TB. The CR image data acquired from August 2000 to August 2002 were archived using a lossless, 2:1 image compression ratio on 58 DLTs holding a total of 1,914 GB or 3,828 GB of uncompressed data, which when combined with 240 GB of data stored in RAID resulted in a total of 4,068 GB or 4.068 TB. The ES image data of 2.1 GB were archived on a hard disk drive (HDD). Therefore, the total volume of image data in the 196 DLTs, RAID, and HDD stored at the Severance Hospital was just over 9 TB and consisted of 313, 303 CR studies, 124, 712 MR studies, 141,099 CT studies, and 27,067 other studies. For the total

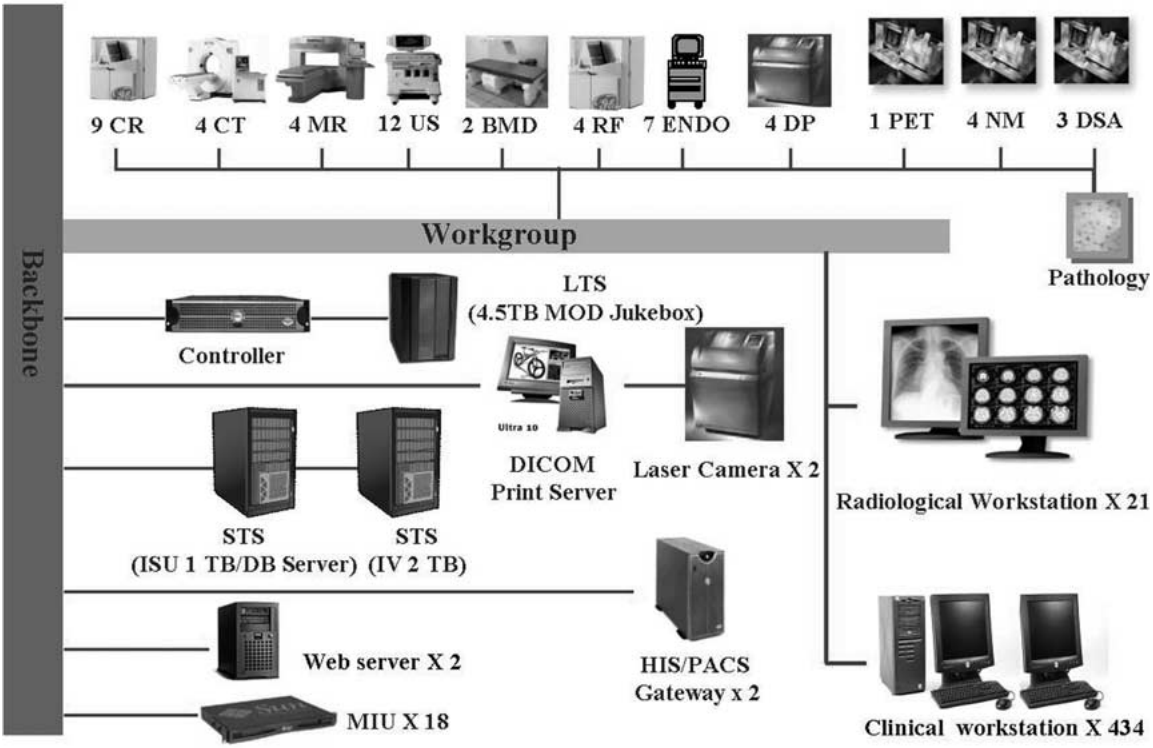

Fig 1. Schematic diagram of full-PACS at Severance Hospital.

image data archived using mini-PACS to be migrated to short-term storage of the full-PACS using a lossless, 3:1 image compression ratio, a storage capacity of approximately 3 TB was required.

Methods for Data Migration

Determination of the Migration Strategies. The PACS operation committee of Severance Hospital considered the following issues when evaluating migration strategies:

1. To migrate all or only selected image data (ie, the decision to migrate all image data, the specified term, the specified imaging modality, or the necessary image data).
2. The migration order (ie, which data to migrate first).
3. Estimations of the manpower, required time, software development of automatic procedures, and the cost of the overall migration process. The decision of both hospitals was to migrate all image data in the following order: recent CT, MR, and DSA data first followed by the rest. Any studies requested by a radiologists or physicians were migrated immediately.

Migration Methods. YUMC considered the following options as migration methods for studies on CDs:

1. The CD image data would be loaded into the mini-PACS server and, after identifying exams using the existing DB, if possible, the retrieved image data would be sent to full-PACS using the DICOM protocol through the hospital's internal network and the transmitted image data would be saved in full-PACS.
2. After developing a migration gateway workstation separate from the mini-PACS, the CD image data would be sent directly from this gateway to full-PACS using the DICOM protocol.

The following options were considered as migration methods for studies on DLTs:

1. The DLT data would be retrieved and loaded on mini-PACS and sent to full-PACS using the DICOM protocol.
2. The DLT data would be retrieved and loaded on mini-PACS, and the DICOM-formatted image data would be transmitted to full-PACS via FTP (file transfer protocol).
3. The DLT image data would be retrieved using a DLT and migration software specifically developed for this project to send directly to full-PACS.
4. The image data were directly retrieved on the full-PACS by first converting mini-PACS DB, then fetching and saving the image data in full-PACS.

The Yongdong Severance Hospital PACS operations committee concluded that direct retrieval of the CD image data in full-PACS would introduce a technical problem because the CD data were archived using the data storage method supported by the mini-PACS vendor. The migration method chosen was to retrieve and load the CD image data, then

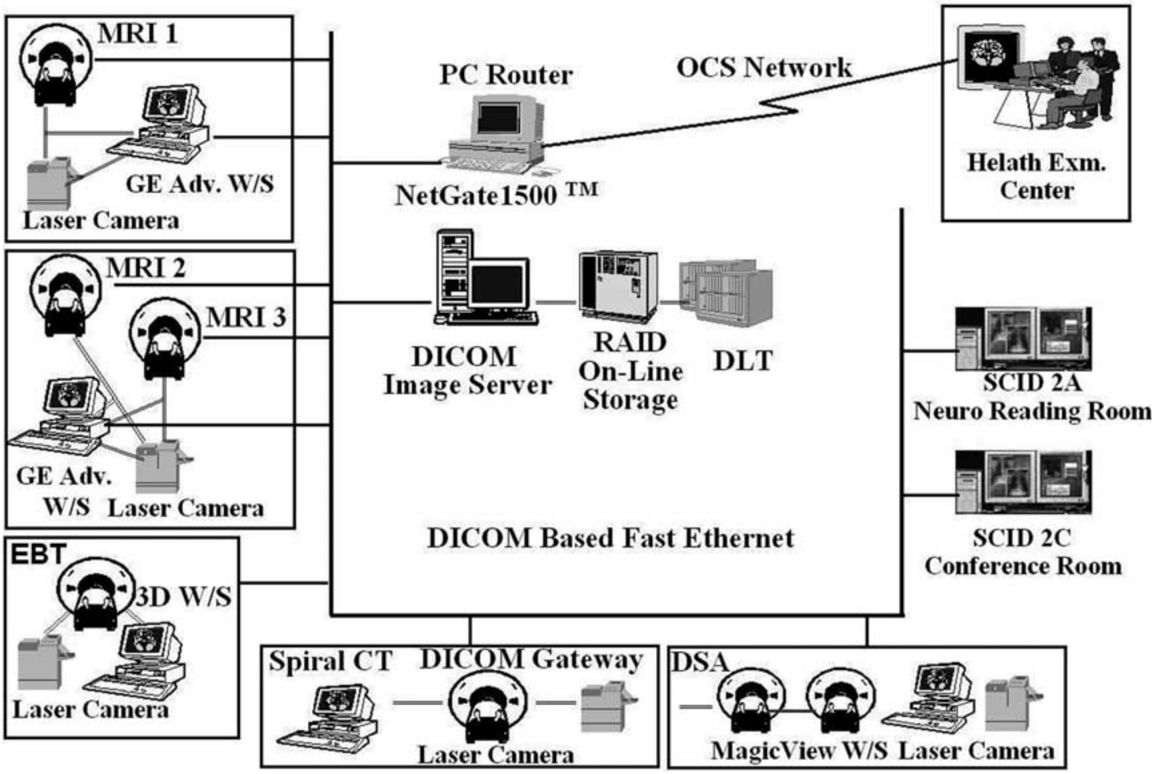

Fig 2. Schematic diagram of mini-PACS at Severance Hospital.

send them to full-PACS using DICOM protocol and save them by matching with the radiology exams of the hospital OCS (Ordered Communication System), which was ready to interface with the full-PACS user software (Fig. 3).

In order to migrate the DLT data, it was decided the optimal solution would be to develop migration software that could read the DLT, use the mini-PACS DB to identify studies, decompress the studies, then send them to the full-PACS. However, this process was not possible due to the cost and time schedule. Therefore, the following procedures were used for the data migration. The full-PACS vendor developed a gateway workstation (Compaq Evo W4000, Pentium IV 1.7 GHz/256 KB cache, 512 MB RAM) with software for the migration with the help of the mini-PACS vendor. Studies from the DLTs were loaded into mini-PACS, were matched with the exams of the hospital, and the DICOM-formatted studies were sent to full-PACS via FTP where they were stored in short-term storage (Fig. 4). FTP was used because its performance was so much faster than DICOM transfers.

Practical Considerations for the Migration. YUMC considered the following as migration progressed:

1. Whether to match with the old exam data (a consideration of only the PACS environment or film images).
2. The migration baseline date (related to the migration data capacity).

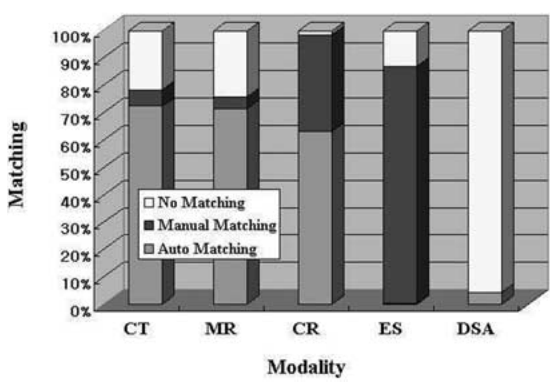

Fig 3. Result of the simulation to match the image information of the mini-PACS database and the patient information of the OCS according to the imaging modalities.

3. The migration image modality (related to the migration data capacity).
4. The migration subject.
5. Preparation of the hardware tools and the software development necessary for the migration (consideration of the hospital specialty and automation rate).
6. Schedule (manpower and time).
7. Economical valuation between the migration data capacity and the cost of storage media.

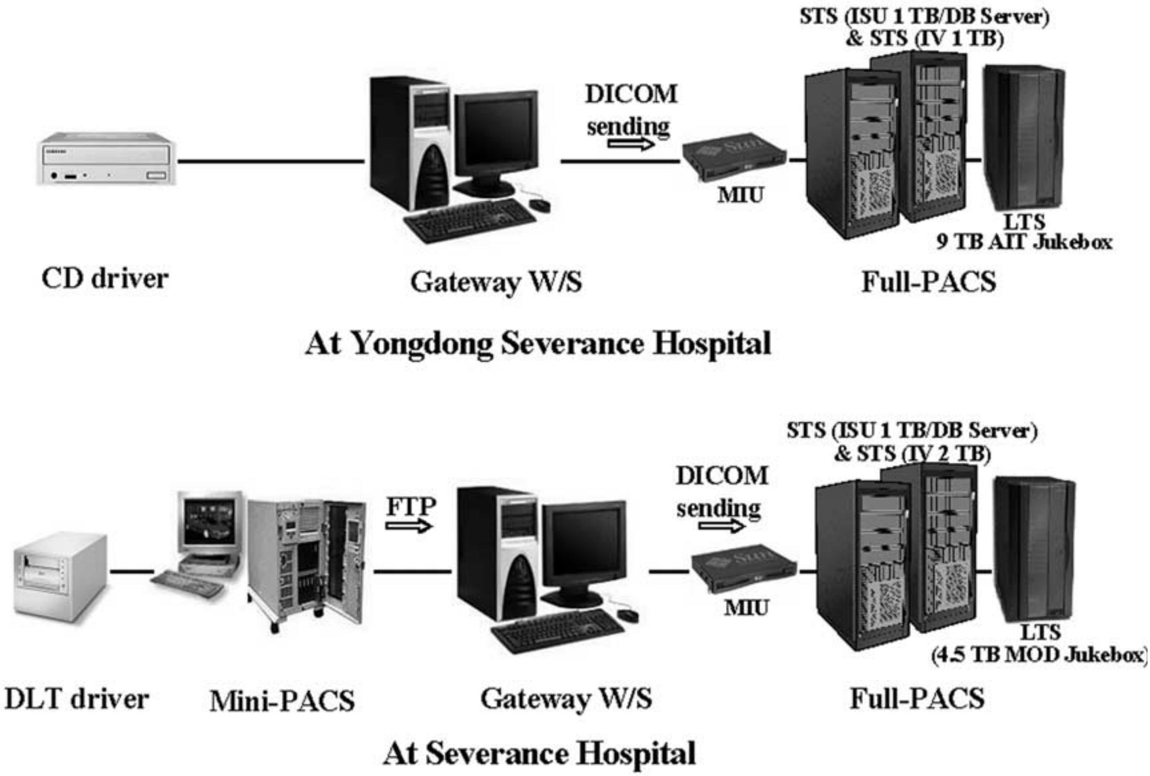

Fig 4. Schematic diagram of the migration procedures used at the Yonsei University Medical Center.

8. Utilization rate of the migration image data and the legal preservation period.

Matching Simulation

One anticipated problem prior to performing the migration in Yongdong Severance Hospital was the necessity to search for the patient information by analyzing the DICOM header information of an image file from each CD because there was no DB index for the image data stored prior to 1998. The anticipated problem in Severance Hospital was the difficulty in matching the patient information from the mini-PACS DB with full-PACS interfaced to the OCS because the mini-PACS DB was not interfaced to the OCS. If the image data were not consistent with the OCS, their clinical value was reduced because the information needed in the clinical treatment was simultaneously reviewed. In order to prevent inconsistencies, the first simulation was performed to extract the key information by matching the patient information in the image data DB with that of the OCS. The data information required in the GE full-PACS was the following tables: patient, exam (exam/order/report information), exam procedure (exam code), department (department code), staff (user information), and referring service (ordered clinical information). First, a matching simulation was tested to match the patient identification (ID), the exam date, and the modality code with the patient information of the OCS. The second matching simulation was performed after profiling the patient ID, the exam date, and the modality code for each image modality based on the first matching simulation. Finally, the third matching simulation was performed according to the exam years for each modality based on the first and second simulations.

Data Transmission Scenario

A data transmission scenario was established for the following cases: the normal case where each study matches with exactly one order, the case where a study matches with multiple orders, and the case where a study matches with no orders. Table 1 shows the number of orders and the number of studies stored at Severance Hospital and illustrates some of the problems one might expect when attempting to match order information and study information from two nonintegrated systems.

Normal Case.

1. Sort the mini-PACS DB data according to the patient ID and exam date in the legacy image data storage.
2. Transmit the data from one study to the migration workstation.

Table 1. Order and Study Numbers Archived Using Mini-PACS at Severance Hospital

Modality	Order (number)	Study (number)
DSA (Angio)	2,004	14,724
CT	111,175	141,099
MR	56,966	124,172
ES	157,033	1,795
CR	992,719	313,303
DSA (X-ray)	—	4,461
DSA (others)	—	4,255
RF	—	1,632
Others	—	200

[a] RF: Radiography and Fluoroscopy.

3. The migration workstation temporarily saves the study data, lists the study information, and sorts the information according to the patient ID, study date/time, modality code, and study description.
4. The migration workstation searches all the orders for the patient and modality in a queue table (except the already transmitted orders) and sorts all the orders according to the patient ID, study date, and order name.
5. Perform a simulation to match the study information and order with the queue table data.
6. At this time, if the simulation produces duplicate matches, the matches are added to a duplicate queue for manual matching.
7. Transmit the studies and orders that matched correctly to full-PACS. At this time, the accession number, which was created in order queue table, is updated to the header of the image data.
8. The DICOM gateway server in full-PACS transmits the studies with their associated orders to the Modality Interface Unit (MIU).
9. The information/image data for the nontransmitted studies are kept to be handled as a study with no matching orders.

The Case of a Study Matching with Multiple Orders (Manual Matching). After visually verifing the image data, match it with the exact order among those generated in the normal-case scenario with the information of the OCS by searching for the corresponding order with the unit of order in the information separately listed in the migration workstation.

The Case of a Study Matching with No Order. Register as an "Unspecified Exam" to full-PACS.

Migration Work

In order to optimize the migration work in Yongdong Severance Hospital, the software Pvdata (a subcontract vendor: Dada Hub Co., Ltd., Seoul, Korea) was developed to recognize all the CD image formats. The migration software was classified into three modules. The first module was coded to search for the patient ID, patient name, modality type, and exam date from a CD. The second module queried the OCS using the data from the first module and transmitted the results to full-PACS. The third model moved the study information from the CD to full-PACS to be matched with the corresponding OCS order. Each step of the migration work was performed manually and the software was designed to be triggered by one click of the button.

Studies stored on DLT at Severance Hospital were transmitted to full-PACS, connected to the OCS, and saved in full-PACS. The DLT image data not matched to the OCS were not transmitted to full-PACS. This image data could be accessed by searching with the patient ID and a manual matching was not attempted when not necessary.

CT and MR studies stored in DLT were loaded onto the mini-PACS server and transmitted via FTP to the migration workstation. The transmitted image data were decompressed in the migration workstation and again transmitted and saved in the full-PACS short-term storage. On this occasion, the old image data of mini-PAC were indicated as "Reference Only" in the GE full-PACS user viewing software (PathSpeed or RadWorks, GE Medical Systems, Milwaukee, WI, USA) and thereby distinguished from the recent image data. In addition, the migrated studies were set to preferentially move from short-term to long-term storage. The data migration in the server system using Windows NT OS was designed to load the CR and ES image data stored in DLT to the mini-PACS server by using the DiskXtender software (OTG Software Inc., USA), and DICOM image data were accessed using the Windows sharing folder and were transmited to the full-PACS server.

RESULTS

In Yongdong Severance Hospital, studies acquired after 1998 were preferentially migrated because there was no DB for the studies prior to 1998. The migration work was manually performed for cases with more than one order in the OCS for the same patient, no matching orders resulting from the misregistration of the patient ID, and no matching order at all in the OCS. Although the DB constructed after 1998 was damaged, all the image data were successfully migrated and saved to full-PACS because the storage method was a CD data backup using the DICOM format.

It took approximately 30 min to migrate the studies stored on one CD, producing an estimate of 2,250 h (approximately 94 days) to migrate all the CDs using one gateway migration workstation. The data migration work to transmit all the CD image data required approximately 3 months using up to five gateway workstations and more than 16 man-hours/day.

Table 2. Result of the First Simulation to Match the Image Information of the Mini-PACS Database and Patient Information of the OCS

Details	No. of Exam	%
Exam not matched with OCS order	7,773	5.33
Patient ID no matching (null/space)	(42)	
Patient ID no matching (none)	(6,089)	
Exam data no matching (null value)	(439)	
Exam data no matching (exam)	(1,203)	
Exam matched with OCS order	138,187	94.67
Total	145,960	100.00

Table 2 shows the first simulation results matching the patient information of the mini-PACS DB with that of the OCS in Severance Hospital. The matching result of the first simulation was 94.67%. Among the unmatched orders, 1.203 were the CT, MR, and DSA image data acquired prior to 1998, which had no DB because Severance Hospital began to operate the OCS after 1998. Figure 3 shows the second simulation results performed by classifying the patient ID, exam date, and modality code for each image modality based on the first simulation results. For the CR and MR image data, the percentage of the automatched orders was high because a large part of the order was matched if the patient information of the OCS was matched with the exam date of the image data. For the CR image data, the percentage of automatched orders was comparatively satisfactory at 63.3%. Nevertheless, the orders requiring manual matching were numerous because although the patient information on mini-PACS was in accord with the OCS order, when a patient had several exams in one day it was not possible to identify a specific order to match with an exam. Therefore, many of these cases required a manual match. Table 3 shows the results of the simulation to match the DLT study information with the OCS patient information for the exam year and modality. “Matched” and “Manual match” indicate automatching and manual matching, respectively, between the mini-PACS DB and the OCS exam name. “Patient level failed” indicates no match between the OCS exam name and the patient ID. “Exam level failed” indicates that the order was created in full-PACS because the OCS order name and patient ID were matched, but a specific order could not be matched with the study from the mini-PACS.

It took approximately 4 h to load the data from one DLT to the mini-PACS server, 2 h to transmit the loaded data to the migration workstation, and 8 h to transmit the image data to full-PACS. Therefore, if the migration work was optimized, two DLTs could be migrated using one gateway workstation based on 16 man-hours/day, producing an estimate of approximately 100 days to migrate all the studies stored on DLTs. The data migration took approximately 5 months to migrate all the studies using one or, when needed, two gateway workstations by one migration operator.

DISCUSSION AND CONCLUSION

In the early 1980s, the development of computer technology and digital imaging detectors initiated implementation of PACS in the medical environment. Korean PACS implementation began in 1994 and has expanded continuously since. In the early stage of PACS introduction, its main purpose was digital image data backup, which was quite useful in diagnostics, clinical practice, and research. The improvements in computers, networks, and storage of media technology, as well as the development of effective and convenient user interface software, resulted in a high-performance PACS. These innovations have facilitated the upgrade or replacement of PACS, for which hospitals should plan thoroughly and prepare carefully in order to migrate the data of the existing PACS to the new PACS while optimizing the performance and minimizing the cost required for the migration. A data migration plan should depend on the hospital’s individual characteristics because data migration requires a great deal of time, manpower, and accompanying equipment and because the configuration of PACS, storage media, hospital circumstance, and the OS used may all differ from one another.

The main purpose of data storage in mini-PACS was data backup for digital image data. In contrast, the role of the advanced data storage system in full-PACS is to allow complete archiving and retrieval of digital image data using a data management system, anytime and anywhere in the hospital. In the full-PACS archive for

Table 3. Result of the Second Simulation to Match the Image Information of the Mini-PACS Database and Patient Information of the OCS According to the Imaging Modalities and Storage Years

Modality	Matching	Before 1998	1998	1999	2000	2001	2002
CR	Exam level	—	—	8	784	2,844	383
	Patient level	20	—	18	167	520	168
	Manual match	—	—	16	7,811	70,891	30,947
	Match	—	—	32	21,112	126,62	50,961
MR	Exam level	210	3,790	3,396	1,526	1,050	242
	Patient level	1,152	16,762	8,560	1,912	934	250
	Manual match	4	346	802	1,358	1,562	406
	Match	216	5,746	15,966	22,044	27,626	8,312
CT	Exam level	244	5,530	7,222	3,230	652	124
	Patient level	345	6,884	4,050	1,444	640	198
	Manual match	4	508	1,464	1,944	3,128	1,074
	Match	38	4,186	14,380	24,442	43,691	15,676
DSA	Exam level	14	80	62	208	544	34
	Patient level	935	5,222	3,548	3,486	3,484	48
	Manual match	—	—	—	—	4	4
	Match	—	—	—	—	328	1,184
ES	Exam level	—	—	—	5	46	13
	Patient level	—	—	—	61	93	13
	Manual match	—	—	—	215	1,069	275
	Match	—	—	—	2	2	1

YUMC, the short-term storage capacity is 3 TB of direct attached RAID storage at Severance and 2.5 TB direct attached RAID storage at Yongdong Severance hospital. The long-term storage is 9 TB AIT (advanced intelligent tape), featuring the advantage of cost for unit storage capacity, at Yongdong Severance Hospital and 4.5 TB MOD (magneto-optical disk), featuring the advantage of rapid response for retrieving data, at Severance Hospital. These storage capacities were planned to allow for image data storage of only 1–2 years at both hospitals with a plan for future upgrade of storage capacity because the unit price of storage capacity is expected to drop continuously with the ongoing rapid development in storage technologies.

Because Yongdong Severance Hospital archived the raw image data in DICOM format using the 650-MB CD storage media, approximately 4,500 CDs had been accumulated over the 7 years and their custody and control were somewhat awkward. In addition, when the image data stored on the CDs were requested, a great deal of time was needed to manually search for the required data by loading the CDs sequentially classified according to the exam data. Although the DB was constructed after 1998, it was damaged during migration and the 4,500 CDs were too numerous. The CD data backup at Yongdong Severance Hospital was achieved by using the DICOM storage function on the DICOM viewer program of πView instead of the special DB programs. This performance log was used with the DB lists but was easily damaged. Consequently, although part of the migration was performed using the performance log, most of the migration work was performed by manually archiving the backup CD image data by utilizing the record on the CD label according to the acquired date. Nevertheless, the 2.7 TB of image data was fully migrated within 3 months using several gateway workstations and migration operators.

Meanwhile, Severance Hospital archived the image data using 20-GB DLTs and a lossless, 2:1 image compression ratio. In addition, it was easy to search for the archived image data because the DB was constructed in mini-PACS. At the time of mini-PACS implementation, DLT was selected as the storage media because the main purpose was to provide data backup for the image data acquired from each image modality. However, during operation, frequent DLT queries resulted in rapid aging or damage to the DLTs. Large numbers of the connecting parts of the DLTs were cut off or lengthened. Although it may have been possible to recover some or all of the data of these DLTs, they were excluded from the data migration because of the required time and expenses. Consequently, 20% of the DLT image data could not be migrated because frequent access had partially damaged the DLTs. Nevertheless, in the case of the image data for the damaged DLTs being requested, the stored film for the requested image was digitized using a film digitizer and migrated to full-PACS although the image quality was somewhat degraded. Severance Hospital constructed the DB in mini-PACS and, therefore, the migration was performed by matching the information of the DB with that of the OCS using software specially developed for this purpose. Although few migration operators were required, it did take a great deal of time to migrate the data because of the DLT's intrinsic characteristics. In addition, if such migration work was simultaneously performed at the peak time of the new image data acquisition, the migration time zone should be considered because the network performance may be adversely affected. The OCS patient information and the matching mini-PACS study information were sent to the database of full-PACS.

In the cases presented here, the mini-PACS vendor readily converted the mini-PACS DB of Severance Hospital to the general format of the DB for the fields required by the full-PACS vendor. However, the role of the mini-PACS vendor at Yongdong Severance Hospital was not significant because the storage method using CD media was simple and data retrieval was feasible without the DB. Meanwhile, the full-PACS vendor performed most of the preparation and migration work, including the preparation of hardware and software, and the management of the manpower required for the migration.

It is essential to match the order in the OCS with that of the exams in mini-PACS because if this is not achieved it is impossible to obtain OCS information through the PACS program or to examine image data through the OCS program. A practical problem was the case of a study not matching with a single order, when no order resulted from a manual match, or an exam was acquired before the Severance OCS operation. When these cases occurred, a new order had to be created using the DICOM header information of the exams. These no-matching exams resulted in the manual migration procedure and ultimately required extra manpower and long working hours. The expected results obtained through the migration are that an order number should be created during image data acquisition by connecting the order number with the hospital OCS for the case of considering the data migration, and that the image data should be acquired using an image modality supporting a DICOM modality worklist. If these functions are not supported and a connection with the OCS is not possible, then correct registration of the patient name or ID is necessary at the time of the exam in order to reduce the amount of data loss. YUMC performed the migration based on the principle of migrating all the old image data. However, for the migration strategy, an appropriate migration plan needs to be prepared according to each hospital's situation by evaluating the cost of storage space required for the migration image data versus the benefits relative to the number of future reinquiries after completion of the migration. In addition, the bases for deciding whether or not to migrate the data are important variables for the migration process. These may include, for example, a focus on clinical practice, research, or economical efficiency, and a decision between the PACS vendor and the hospital as to who performs the migration.

In conclusion, it is essential to appropriately prepare a migration plan and optimally migrate the data by fully considering the technical and administrative details discussed in this article.

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REFERENCES

1. Behlen, F: A DICOM document-oriented approach to PACS infrastructure. J Digital Imaging 11(3 Suppl 1):35-38, 1998

2. Behlen, FM, Sayre, RE, Weldy, JB, et al: "Permanent" records: experience with data migration in radiology information system and picture archiving and communication system replacement. J Digital Imaging 13(2 Suppl 1):171-174, 2000

3. Blado, ME: Management of the picture archiving and communications system archive at Texas children's hospital. J Digital Imaging 14(2 Suppl 1):84-88, 2001

4. Maass, M, Kosonen, M, Kormano, M: Radiological image data migration. Acta Radiol 42(4):426-429, 2001