Migration of Medical Image Data Stored through Mini-PACS to Full-PACS

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Abstract

This study evaluated the migration of medical image data stored thorough a mini-PACS to a full-PACS at the Yonsei University Medical Center. The 2.7 TB of stored image data was migrated through 4,500 CD archives at the Yongdong Severance hospital and 4.7 TB (2:1 image compression ratios) stored through the 196 DLT archives at the Severance hospital. Prior to carrying out the migration, the principles, methods and expected practical affairs were discussed and planned in order to optimize the migration. The CD image data of the 2.7 TB were estimated to require a total of about 94 days, but the practical migration work was completed within 3 months by using a maximum of 5 workstations. The DLT data of the 4.7 TB were estimated to require a total of 100 days by applying 16 man-hours per day with a single workstation. However, the practical migration work took 5 months. Migration plan should be carefully prepared by considering the individual hospital environments because the server system, archive media, the network, and the policy for data management may be unique.

Keywords:

PACS, Migration, Medical image data, DLT, CD

Introduction

Yonsei University Medical Center (YUMC) has recognized the importance of the medical digital image data and has stored image data through mini-PACS (Picture Archiving Communication System). The YUMC Yongdong Severance hospital had saved the CT (Computed Tomography), and MR (Magnetic Resonance) digital image data from early 1997. Meanwhile, the YUMC Severance hospital had saved the CT, MR, and DSA (Digital Substation Angiography) digital image data from 1998 and the ES (Endoscopy) image data and picture images acquired in the department of radiation oncology from 2000.

The storage media used were CDs (Compact Disk) in the Yongdong Severance hospital. Meanwhile, the storage medias used in the Severance hospital were a RAID (Redundant Arrays of Independent Disk) and DLT (Digital Linear Tape). Since the early 1980s, the development of computer technology and digital image detectors has led to the implementation of PACS. From 1994, the domestic PACS began with a partial PACS mainly in large-scale hospitals. Currently, high performance full-PACS is being introduced due to the developments of computer technology, network technology, storage media and convenient image viewing software. These developments require an upgrading of the mini-PACS or a replacement with a full- PACS. At this time, it is necessary to migrate the data stored through the old PACS to the new PACS, and the plan and preparation for the data migration should be thoroughly designed because of the lengthy time, manpower, and equipment needed [1-3].

YUMC signed a contract to implement the full-PACS with GE Medical Systems Korea in May 2001. The Yongdong Severance hospital began to reinforce the PACS network form July 2001, and completed it in December 2001. Meanwhile, the Severance hospital began to reinforce the PACS network from December 2001, and to implement the PACS server from May 2002, with final completion in August 2002, [Figure 1]. The Yongdong Severance hospital and the Severance hospital began to plan a methodology and prepare the required equipment for the migration of old digital image data from September 2001 and March 2002, respectively. Each data migration scenario was prepared before the full PACS operation and the migration work was begun with sequential data migrations of the old image data at the same time as storing the new image data. The CR and MR image data to be migrated in the Yongdong Severance hospital was estimated to be 2.7 TB stored in approximately 4,500 CDs. Meanwhile, the image data in the Severance hospital was 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 saved on 196 DLTs and RAID.

This study developed and, applied the principals and methods for migrating the digital image data stored on CD or DLT form a mini- PACS to a full-PACS, and the data migration results are introduced and evaluated.

Materials and Methods

1. Image Data Stored through Mini-PACS

Mini-PACS in the Yongdong Severance hospital was a workstation (W/S) (SiliconGraphics SGI, USA) implemented by Medical Interface

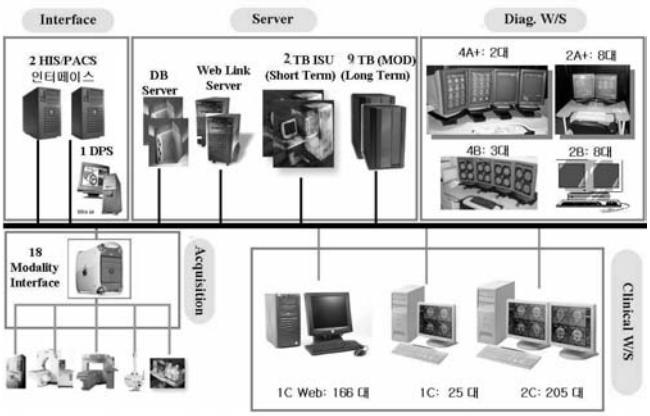

Figure 1. Schematic diagram of full-PACS at Severance hospital.

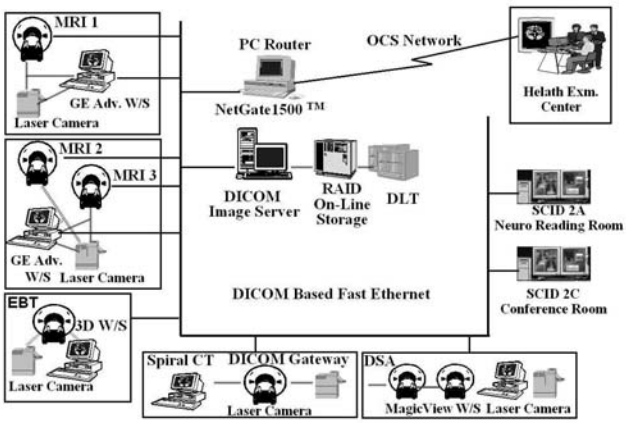

Figure 2. Schematic diagram of mini-PACS at Severance hospital.

(*former* Mediface Co., Ltd., Seoul, Korea) in 1996 and a PC grade W/S implemented by Mediface (*present* INFINITT, Co., Ltd., Seoul, Korea) in 1998. The acquired image data prior to 1998 did not constitute a database (DB) and after 1998, they were saved using DB with a CD backup method. CT and MR image data stored through two W/Ss were estimated to be 2.7 TB, which was stored in approximately 4,500 CDs (650 MB storage capacity).

The mini-PACS in the Severance hospital was composed of three Spectra PACS servers implemented by Mediface in 1997 and 2000. The CT, MT and DSA image data were saved using the Sun Ultra 10 Unix system (SPECTRA1; SUN Ultra Enterprise 2, USA) and the CR, ES image data were saved using the Sun Ultra 10 Window NT system (SPECTRA2, and 3; COMPAQ Proliant DL 380, 5500, USA, respectively) [Figure 2]. The operating system (OS) and storage method used were different from each other and 10/100 Mbps Ethernet connected to the PACS servers to a hospital backbone network. The CT and MR image data acquired from 1998 to 2002 were saved using a lossless 2:1 image compression ratios on 138 DLTs, which resulted in 2,484 GB and in the RAID resulted in 240 GB. The CR image data acquired from 2000 to 2002 were saved using lossless 2:1 image compression ratios in 58 DLTs resulting in 1,914 GB and in the RAID resulted in 240 GB. The ES image data of 2.1 GB were saved on a Hard Disk Drive (HDD). Therefore, the total original image data were 9,276 GB. The image data stored through the mini-PACS in the Severance hospital were classified to 313, 303 exams for CR, 124,712 exams for MR, 141,099 exams for CT and 27,067 exams for the others [Table 1]. If the total image data is migrated to the full-PACS using lossless 3:1 image compression ratios, a storage capacity of approximately 3 TB is required.

2. Principles and Methods for Data Migration

(1). Determination of the Migration Method

The PACS operation committee of the Severance hospital investigated following subjects

1). The decision to migrate all the image data or only the selected image data (i.e., the decision to migrate all the image data, the specified term, the specified imaging modality, or the necessary image data).

2). The decision of the migration order.

3). The decision of the manpower need in migration, an estimation of the required time, software development of the automatic procedures, and a consideration of the economical aspects.

Yongdong Severance hospital and Severance hospital established the principal to migrate all the digital image data. Moreover, the data migration priority order was concluded as first, the recent image data, second, the CT, MR, and DSA image data, third, the other image data requested by a radiologist or physician.

(2). Decision of the migration method

YUMC reviewed the following details as the expected migration methods while the migration work was performed.

1). Expected migration methods at Yongdong Severance hospital.

a. After constituting the migration gateway W/S, the CD data was retrieved and loaded into the mini-PACS server and the image data was sent to the full-PACs using the DICOM protocol through the hospital's internal network and the transmitted image data was saved in the full-PACS.

b. The CD data was directly retrieved, loaded and saved at the mini-PACS server.

Table 1. Number of order and study stored through the 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 angio)	-	4,461
DSA (others)	-	4,255
RF*	-	1,632
Others	-	200

*RF: Radiography and Fluoroscopy

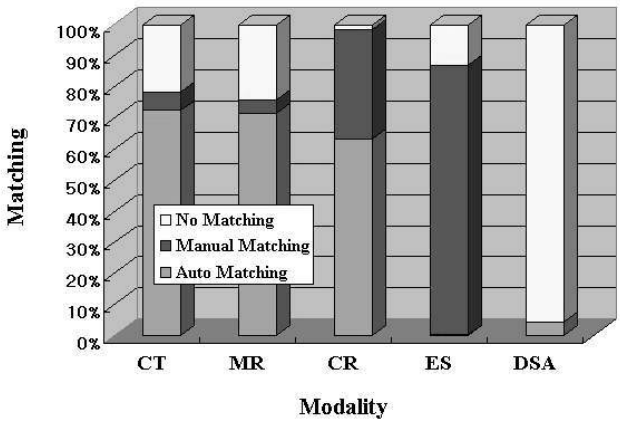

Figure 3. The result of simulation to match the image information of mini-PACS database and the patient information of OCS (Ordered Communication System) according to imaging modalities.

2). Expected migration methods at the Severance hospital

a. The DLT data was retrieved and loaded on the mini-PACS and the image data was sent to the full-PACS using the DICOM protocol through the hospital internal network and the transmitted image data was saved in the full-PACS.

b. The DLT data was retrieved and loaded at the mini-PACS, and the image data was fetched via the FTP at the full-PACS and the image data was then saved.

c. The DLT image data was retrieved in the DLT drive using the migration software developed with the specified object of migrating and directly sending the image data to the full-PACS and the image data was saved in the full-PACS.

d. The image data was directly retrieved on the full-PACS by means of converting the mini-PACS DB and fetching and saving the image data in the full-PACS.

Practically, the data migration method used was to retrieve and load the CD image data and send the image data to full-PACS using DICOM protocol and save the image data by matching it with the radiology exams of the hospital OCS (Ordered Communication System) [Fig. 3].

The full-PACS vendor constituted the gateway W/S (COMPAQ Evo W4000, Pentium IV 1.7 GHz, USA) and developed software for the migration. The DLT was loaded into the mini-PACS, and the image data was fetched and matched with the hospital OCS using the data migration software in the migration W/S, and these image data was sent to the full-PACS via FTP using the DICOM protocol. Finally, the image data was saved on the full-PACS [Figure 4].

(3). Practical considerations for the migration

YUMC reviewed the following details for the expected situations while the migration work was performed:

- Decision for matching with the old exam data.
- Decision for the migrated baseline date.
- Decision for the migrated image modality.

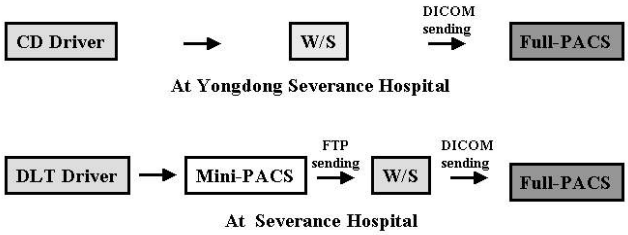

Figure 4. Schematic diagram of Migration procedures used in Yonsei University Medical Center.

- Decision for the migration subject.
- Preparation of the hardware tools and the development of software used for the data migration.
- Schedule. (Manpower and time)
- Economical valuation between the migrated data capacity and the cost of the storage media.
- Utilization rate of the migrated image data and the legal preservation period.

3. Matching Simulation

The expected problem prior to the migration in the Yongdong Severance hospital was to search for the patient information by analyzing the DICOM header information of an image file. The expected problems, in the Severance hospital was to match the patient information of the mini-PACS DB with the OCS connected to the full-PACS because the mini- PACS DB was not connected to the OCS. The first simulation was performed to extract the key information by matching the patient information in the image data DB with the patient information of the OCS. The data information required in the full-PACS was patient table, an exam table, an exam procedure table, a department table, a staff table, and a referring service table. 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. Again, the third matching simulation was performed according to the exam years for each modality based on the first and second simulations.

4. Data transmission scenario

A data transmission scenario was established as the following procedures by classifying a normal case, a case of one more orders, and a case of no order.

(1). 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 data to the migration W/S.

3). The data migration W/S temporarily saves the study data, lists the study information and sorts the information according to the patient ID, the study date/time, the modality code as well as the study description.

4). The data migration W/S searches all the orders of the patient and modality in an queue table (except already transmitted orders), and both lists and sorts the all orders according to the patient ID, the study date, and the order name.

5). Perform the simulation to match the study information and order with the study data or the order data.

6). At this time, if the duplicated order is detected more than once, move these studies to the duplicated order folder and add it to the list box queue of the separated duplicate ordered study.

7). Transmit the order of the matched information to the 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 the full-PACS transmits the study with transmitted order to the MIU (Modality Interface Unit).

9). Leave the information/image data for the non transmitted study and retransmit it later. This case corresponds to the no order information or non matched study.

(2). The case of one more orders

Match the most suitable order among these by searching for the corresponding order with the unit of order in the information separately listed in the migration W/S, with the information of the OCS.

(3). The case of no order

Register as an "Unspecified Exam" to the full-PACS.

5. Migration

In the Yongdong Severance hospital, the software was developed for the migration (Pvdata, Dada Hub Co., Ltd., Seoul, Korea) to recognize all the CD image data and the gateway W/S for the migration was constituted. The data migration software was classified into three configurations. The first module was coded to search for the patient ID, the patient name, the modality type, the exam date from the stored CD data and "Auto button" displayed on the screen is pushed. In second module, the data is transmitted to the full-PACS by searching the order connected to the OCS using the patient information acquired from the CD data and exam information, and the third module, to transmit the DICOM image data to the full-PACS after creating the order. The transmitted image data was compared and matched with the patient ID, the exam data, and the modality code with the order of the OCS transmitted image data, and saved in the full-PACS.

The same vendor implemented all the mini-PACS servers in the Severance hospital but the storing methods differed one from another. Therefore, in the case of the matching mini-PACS DB and the information of the OCS, the order was previously created in the OCS based on the information obtained from the matching simulation. This order was then sent to the full-PACS. The DLT image data was then transmitted to the full-PACS, connected to the OCS and saved in the full-PACS. The DLT image data not matched to the OCS was not transmitted to the full-PACS. The image data could be able accessed by a search using the patient ID and a manual connection was not attempted where possible.

In the migration of the CT, and the MR image data, the DICOM image data stored in the DLT were loaded onto the mini-PACS and transmitted via the FTP to the data migration W/S. The transmitted image data were decompressed and again transmitted and saved in the full-PACS. The data migration in the server system using Window NT OS was deigned to load the CR and ES image data to the mini-PACS server by using the DiskXtender software (OTG Software Inc., USA), and DICOM image data was accessed using the Window sharing folder, and to transmit to full-PACS server.

Results

In the Yongdong Severance hospital, the data migration work was manually performed for the cases of more than one order in the OCS for the same patient. No matching resulted from the misregistration of the patient ID, and no creation of the order in the OCS. Although the DB constructed after 1998 was damaged, all the image data were migrated and saved to the full-PACS because the storage method was a CD data backup. Therefore, all the image data was restored.

It required approximately 30 minutes to migrate the image data on CD. It was estimated to require 2,250 hours (≈ 94 days) to migrate all the image data of 2.7 TB using one gateway migration W/S. The data migration work to transmit all the CD image data required approximately 3 months using several gateway W/S (maximum 5 W/S employing) and more than 16 man-hours /day.

Table 2 shows the first simulation results to match the patient information of the mini-PACS DB with that of the OCS in the Severance hospital. The matching result of the first simulation was 94.67%. 1,203 orders among the unmatched orders were the CT, MR and DSA image data acquired prior to 1998, which had no DB because Severance hospital began to operate OCS after 1998. Fig. 3 shows the second simulation results performed by classifying the patient ID, the exam date, and the modality code for each image modality based on the first simulation results. For the CR and MR image data, the percentage of the auto-matched orders was high because a large part of the order was matched if the patient information of the OCS were matched with exam date of the image data. For the CR image data, the percentage of auto-matched orders was comparatively satisfactory at 63.3%. Meanwhile, the orders requiring manual matching were numerous because, although the patient information on the mini-PACS were in accord with the OCS order, the case required several exams on the same day was matched to each patient but was not matched to each exam. Therefore, many these cases were required to make a manual match.

It required approximately 4 hours to load the data from one DLT to the mini-PACS server, and it required 2 hours to transmit the loaded data to the migration W/S, and approximately 8 hours to transmit the image data to full-PACS. Therefore, if the data the migration work was optimized, two DLTs could be migrated using one gateway

Table 2. The result of first simulation to match the image information of mini-PACS database and the 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 value)	(42)	
Patient ID no matching (none numeric data)	(6,089)	
Exam data no matching (null value)	(439)	
Exam data no matching (Exam before 1998)	(1,203)	
Exam matched with OCS order	**138,187**	**94.67**
Total	**145,960**	**100.00**

W/S based on 16 man-hours per day. It was estimated to take 100 days to migrate all the image data of the 4.7 TB. The data migration took approximately 5 months to transmit all the image data using one or, in case of need, two gateway W/Ss by one migration operator.

Discussion and Conclusions

Because the Yongdong Severance hospital saved the raw image data using CD storage media, the number of CDs saved over seven years was approximately 4,500 and their custody and control were somewhat difficult to handle. In addition, if the inquiry of the CR data was requested, it takes a great deal of time to manually search the required data by loading the CD sequentially classified according to the exam data. Meanwhile, the Severance hospital saved the image data using the DLT. In addition, it was easy to search for the saved image data because the DB was constructed in the mini-PACS. At the time of the mini-PACS implementation, the DLT was selected as the storage media because the data backup of the image data acquired from each image modality was the main purpose. However, during operation, the frequent inquiry of the DLT resulted in aging or damage of the DLT. The Severance hospital constructed the DB in the mini-PACS and therefore, the data migration was performed by matching the information of the DB with the information of the OCS. Although few migration operators were required, it took relatively a great deal of time to migrate the data because of the DLT's intrinsic characteristics. In addition, if these data migration works were simultaneously performed at the peak time of the new image data acquisition, the data migration time zone should be considered because the network speed may be decelerated. The Severance hospital performed the data migration based on the principle to transfer all the old image data. However, a hospital planning a data migration needs to prepare appropriate migration plan according to each hospital's situation by evaluating the economic situation for occupying the storage space of the migrated image data and the benefits by considering the number of re-inquiries after the migration.

The expected results obtained through the migration are that an order number should be created during image data acquisition by connecting it with the hospital OCS for the case of considering the data migration, and 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, the 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. In addition, the baselines for deciding whether or not to migrate the data, for example, focusing on clinical practice or research, or economical efficiency, and hospital's policy as to who performs the migration (i.e., PACS vendor, or hospital institution), are important variables. In conclusion, it is important to appropriately prepare a migration plan and optimally perform the work by considering these technical and administrative details.

Acknowledgements

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