

PACS Replacement :

Solving the Data Migration Problem

Today, data migration is one of healthcare IT's greatest challenges. In the United States, more than 50% of hospitals larger than 250 beds had PACS installed by 2005, and the majority of hospitals greater than 500 beds had PACS installed even earlier. Many of these large hospitals and healthcare systems are now in a position to renew their PACS contracts or replace their legacy systems. Having accumulated five or more years' of digital image data, these facilities must address the issue of data migration when looking at PACS replacement systems.

New imaging and visualization techniques and clinical applications have contributed to the vast accumulation of data, and these trends are expected to continue throughout the decade. With increased demands on networks, servers, archives, etc., legacy PACS have become unreliable, slow, and expensive to maintain. This creates even more pressure to migrate data because maintenance and support of the old system in addition to the new system cannot be economically justified.

Transfer and consolidation of data into a standards-based enterprise archiving solution can be expensive and requires extensive labor. However, successful PACS replacement and migration of previous data without any data loss or restriction is possible with INFINITT's Replacement & Migration Solution. At INFINITT G3 PACS customer sites, near instantaneous access to prior studies has been a significant factor in radiologists' productivity gains. Seamless access to images and reports, both current and prior, facilitates the implementation of an Electronic Health Record (EHR) system; it is a key element for reducing operational costs and improving the quality of patient care.

1. INFINITT REPLACEMENT & MIGRATION SOLUTION- OVERVIEW

INFINITT provides fast and accurate PACS replacement and migration services for transferring diagnostic images and related patient and report data between archives, and has replaced

more than 20 different PACS solutions for over 70 sites globally. Knowledge and experience migrating data from a variety of systems has allowed INFINITT to fine-tune its migration methodology, smoothing the way through all phases of migration and PACS upgrade.

In addition to its team of experienced migration specialists, INFINITT has developed its own migration tools that can be adapted to different hospital environments to support fast migration with minimal disruption to the hospital.

Distinguishing features of INFINITT Replacement & Migration Solution are:

- Fast and reliable migration methods and support tools
- Verification and validation of migrated data
- Matching of database information with image information
- 100% migration of images, reports and related data
- Configurable pre-fetch rules for various hospital environments
- Clean up of data

2. PRE-MIGRATION ANALYSIS

There is more to PACS replacement and data migration than simple movement of data from the legacy PACS to the new one. Three factors that must be assessed carefully are time to 'go live', migration accuracy and stability of the PACS during migration. Migration should be carefully planned to minimize the duration of the migration while optimizing migration accuracy and legacy system performance. (Data retention is also an important consideration, but federal, state and local statutes prevail when determining a healthcare institution's retention policy.)

Before studies are moved from one system to another, INFINITT analyzes the customer environment, with close attention to the following factors:

- The amount of data to be migrated (amount of primary active data and amount of secondary data in long-term storage)
- The type of primary active storage and secondary long-term storage
- Legacy PACS conformance with the DICOM standard
- Operational status of legacy PACS and its archive during migration
- Go-live date of new PACS

A complicating factor that must also be considered is that it's not sufficient to transfer the data that's stored in DICOM files. The information in the legacy PACS database should also be consulted for migration, and if the database includes text such as patient information, acquisition date, type of study, diagnostic report, etc., the information in the DICOM file must be updated to accurately reflect the information in the database files.

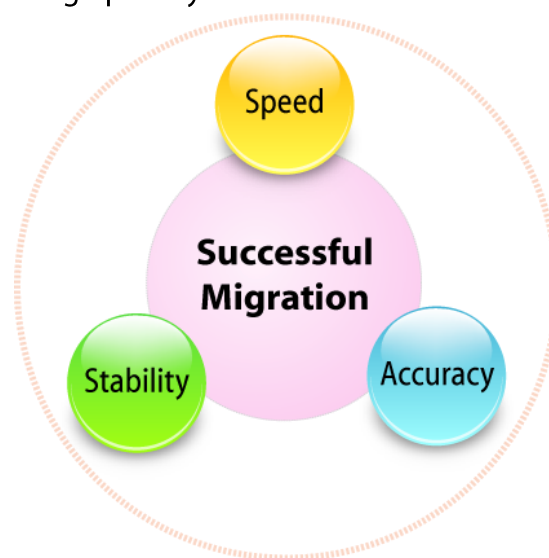
The major considerations are discussed in greater detail below.

2.1. Time to 'Go Live'

Once the contract is signed, PACS buyers want the new system up and running as soon as reasonably possible, including access to all previous data without restriction. Migration usually proceeds while the legacy PACS is in operation, prior to going live with the new PACS. With INFINITT Replacement & Migration Solution, it typically takes one to three months to migrate 10 TB of uncompressed image data; actual times vary depending on the migration method and environmental factors, such as network bandwidth, system load, etc.

When there are very large amounts of data to be migrated, the most recent 1-2 years of data can be migrated before the new PACS is launched. Then, after 'go live' the INFINITT PACS can pre-fetch priors on an 'as needed' basis from the older system while migration continues in the background.

INFINITT analyzes the PACS environment and system configuration to determine the best replacement method for the facility, and has the ability to expedite migration and shorten the time to "go live" when this is a high priority.



2.2 Accuracy of Migrated Data

The imaging studies on the legacy PACS should be migrated to the new PACS accurately, and without any loss of data. However, it is often not possible to migrate 100% of the data in the legacy PACS. Migrating the legacy PACS data accurately is difficult because:

- PACS data consists not only of images and related information conforming to DICOM standards, but also other proprietary information, such as gray scale window level, key image selections, etc.
- The data format of legacy PACS is different depending on the vendors and their program versions. It is not uncommon that the legacy PACS data is incompatible with the new PACS.
- There may be corrupted data in the legacy PACS.
- Legacy PACS vendors often resist giving information about their internal data format.

INFINITT migration specialists analyze the legacy PACS and its data prior to the migration. Based on the analysis, a consensus will be reached with the customer on the types and range of data to be migrated. If necessary, INFINITT migration tools are customized to satisfy migration requirements.

INFINITT migration tools can:

- Perform automatic migration according to predefined rules
- Compare legacy PACS data and INFINITT PACS data for verification
- Monitor the migration status of each study in the migration list

2.3 Stability of System During Migration

Data migration increases the load on the legacy system, making the transition from a legacy PACS to a new PACS even more difficult. A slow or unstable PACS could interfere with the daily operation of the hospital. The migration strategy must take this into consideration and minimize the load and downtime during the transition period. Often migration is only possible during off hours, which will extend the period of time required to complete data migration. INFINITT migration tools can be configured to run on pre-established days and times -- such as nights and weekends -- so the system load can be minimized.

3. INFINITT MIGRATION METHODS & TOOLS

During the planning stage INFINITT migration specialists assess the hospital or health system existing network and data storage environment. There are two types of data that must be migrated: image data and text data. Image data that has been stored in standard DICOM format is not difficult to transfer from the legacy PACS to the new PACS, but it is time consuming because the established DICOM protocol is slow. DICOM Standards specify formats for storing images and reports such as JPEG, JPEG 2000, MPEG2, SR (Structured Report) Documents, etc. Most PACS vendors today incorporate DICOM standards into their products.

Text data contains information about patients, studies, reports, and other data. The database structure for text and non-DICOM data remains proprietary for each vendor, requiring extra effort both for migration and for verification that the data was transferred successfully. INFINITT employs Direct Access Migration Service for data stored using known formats, and DICOM Query/Retrieve Migration method for data that is not recognized. It is also possible to use both Direct Access and DICOM Q/R services at the same time.

INFINITT is one of the few PACS vendors to develop its own migration tools to support its migration services. Most PACS vendors in the US use a third party migration service or toolkit that is less flexible and more expensive than INFINITT migration solutions.

As shown in Table 3.1 below, there are three methods INFINITT can choose from to optimize data migration. Direct Access Migration, using INFINITT Smart Converter, is appropriate for DICOM formatted data or other known formats that can be converted to DICOM. Simple DICOM Query/Retrieve method requires the INFINITT Smart Router to migrate non-DICOM data, and Corrective DICOM Q/R is used for error correction and verification functions. INFINITT Smart Converter and Smart Router are some of the most sophisticated and advanced migration tools on the market today.

Migration Services	Description	INFINITT HEALTHCARE Migration Tools
Direct Access Migration Service	<ul style="list-style-type: none"> Directly access the storage of the legacy PACS 	INFINITT Smart Converter
Simple DICOM Q/R Migration Service	<ul style="list-style-type: none"> Use DICOM standard query / retrieve operation Data is moved directly from the legacy PACS to the new PACS 	INFINITT Smart Router
Corrective DICOM Q/R Migration Service	<ul style="list-style-type: none"> Use DICOM standard query / retrieve operation Data is moved via INFINITT Smart Router. DICOM header information is modified if necessary 	INFINITT Smart Router

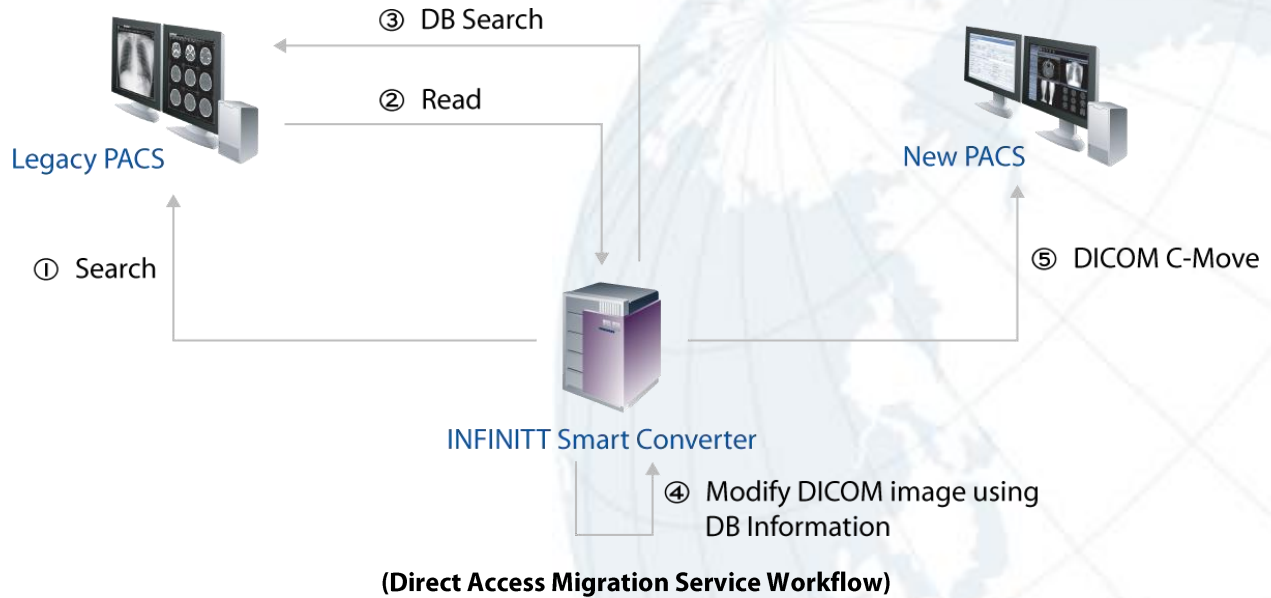
Table 3.1 INFINITT Data Migration Methods and Tools

3.1 Direct Access Migration Service

Direct Access Migration Service migrates data by direct access to the storage file system of the legacy PACS. It is the fastest method for migrating data from the legacy PACS to the new PACS. However, to use Direct Access Migration Service, the structure of the database and storage should be fully understood, and the image data should be in recognizable formats.

Direct Access Migration workflow is as follows:

- A complete analysis of data in the legacy PACS is performed prior to migration.
- A list of images to be migrated in the legacy PACS storage is prepared.
- INFINITT *Smart Converter* reads the images in the list.
- The images are converted to standard DICOM formatted images if necessary.
- The database is searched for the information corresponding to the current image.
- The information in the image's DICOM header is modified to match the information in the database based on pre-defined rules. The format of the image is also modified if necessary.
- INFINITT Smart Converter sends the images to the new PACS server by the DICOM C-Move operation.
- Upon receiving the images, the new PACS server registers and stores the images.



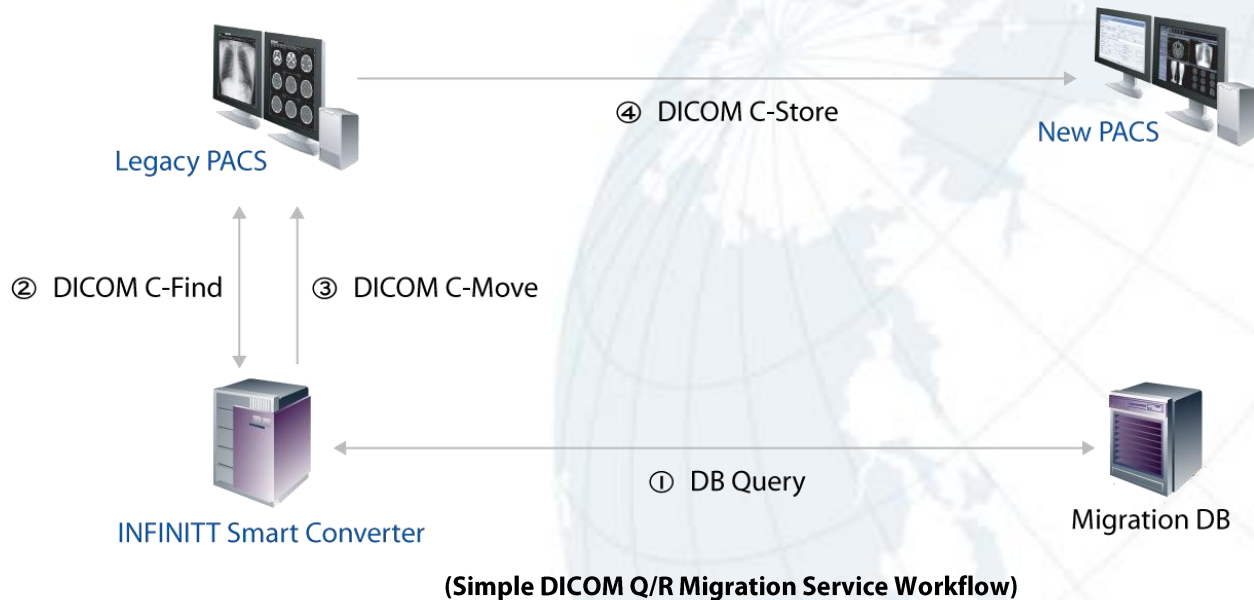
3.2 Simple DICOM Q/R Migration Service

In contrast to the previous scenario, INFINITT **Smart Router** is needed for DICOM Query/Retrieve Migration Service where the legacy PACS supports DICOM Q/R SCP. For some older legacy PACS that do not support DICOM Query/Retrieve operations, this migration service is not possible.

Simple DICOM Q/R Migration Service workflow is as follows:

- INFINITT Smart Router finds migration request(s) by sending DICOM C-Find to the Modality Worklist or querying the request queue periodically.
- INFINITT Smart Router requests DICOM C-Find to the legacy PACS to find the studies matching the request.
- Using the result from the above request, INFINITT Smart Router requests DICOM C-Move to the legacy PACS.
- Upon receiving DICOM C-Move request, the legacy PACS performs DICOM C-Store to transfer the matched study data to the new PACS.

INFINITT Smart Router can also be used after go-live of the new PACS, giving prior studies of scheduled patients high pre-fetch priority for immediate migration.



3.3 Corrective DICOM Q/R Migration Service

Simple DICOM Q/R Migration Service, however, also has limitations. It simply requests the legacy PACS to transmit the data to the new PACS. It cannot modify any information in the migrated data. Corrective DICOM Q/R Migration Service must be used to modify and correct data according to pre-defined rules by comparing information in the DICOM header to the information in the database. It can also change the format of images in the database if necessary.

Corrective DICOM Q/R Migration is used to support the following error correction and verification functions:

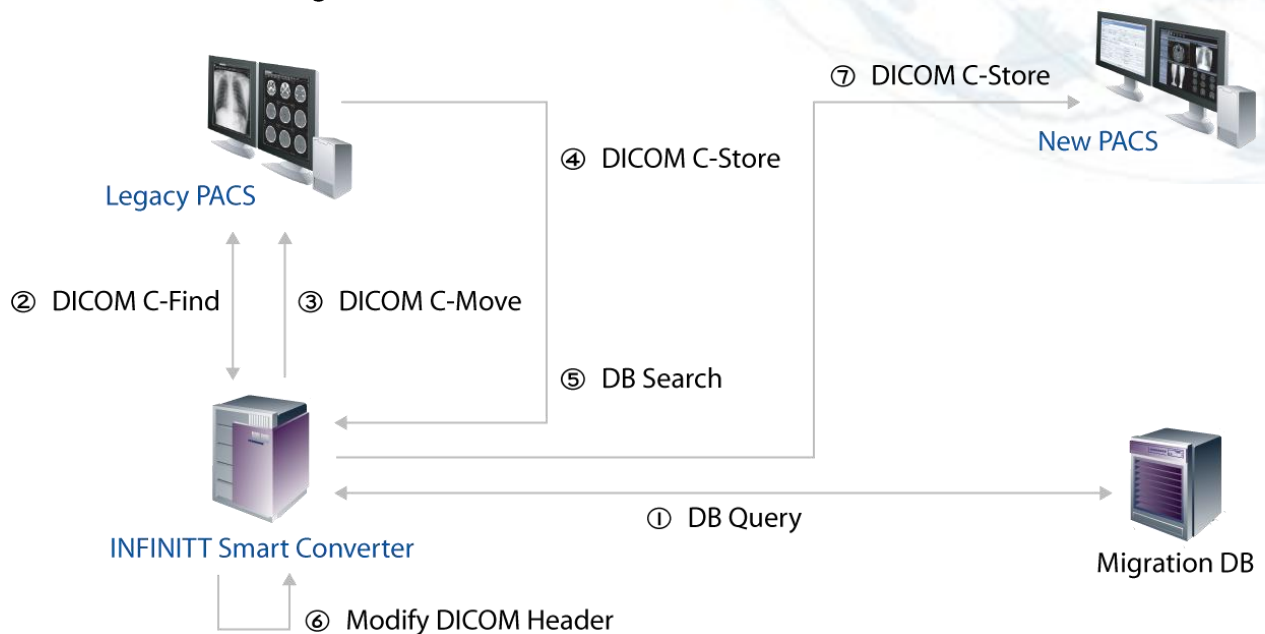
- The information in the DICOM header is compared to the information in the database. The information in the DICOM header is corrected if it is different from the information in the database.
- During the migration, there can be images which fail to be migrated for various reasons. INFINITT migration tools allow the failed data to be retried for migration automatically or manually at a later time.
- The list of the migrated data is compared to the data in the legacy PACS so that all the data is migrated completely.
- INFINITT migration tools support predefined rules to cleanse the data during the migration.

- The format of image data may have to be changed for better performance, accessibility, reduced storage requirement, etc.

INFINITT migration tools can also be customized to correct site-specific or unexpected errors in the legacy PACS data.

Corrective DICOM Q/R Migration Service workflow is as follows:

- INFINITT Smart Router finds migration request(s) by sending DICOM C-Find to the Modality Worklist or querying the request queue periodically.
- INFINITT Smart Router requests DICOM C-Find to the legacy PACS to find the studies matching the request.
- Using the result from the above request, INFINITT Smart Router requests DICOM C-Move to the legacy PACS to transfer the matched study data to INFINITT Smart Router.
- The legacy PACS transfers the data to INFINITT Smart Router according to the requests.
- The database is searched for the information corresponding to the current image. The information in the image's DICOM header is modified to match the information in the database.
- The image is transferred to the new PACS using DICOM C-Move.
- The new PACS registers and stores the transferred data.



(Corrective DICOM Q/R Migration Service Workflow)

Additional features & capabilities of INFINITT migration tools are:

- The data to be migrated can be prioritized by various filter conditions such as patient ID, study date, study instance ID, etc.
- Searches and migration can be done automatically by querying the PACS/RIS database or using DICOM queries.
- Migration can be performed in one or more legacy PACS at the same time.
- Migration status can easily be monitored, and failed studies can be retried either manually or automatically.
- Migration can be configured for off-hours to reduce the system load.

4. MIGRATION TIME

Migration time varies greatly depending on the amount of data to be migrated, format of the PACS data, compression method used for images, network bandwidth, system load, etc. Tables 4.1 and 4.2 show the average migration times for the migration services offered by INFINITT when running the migration tool in one station.

Amount of Data	Average Number of Studies	Average Migration Time
5TB Uncompressed	150,000	0.5 ~ 1 Month
5TB JPEG Lossless	500,000	2 Months
5TB JPEG Lossy	1,500,000	4 ~ 5 Months

Table 4.1 Migration Time for Direct Access Migration

Amount of Data	Average Number of Studies	Average Migration Time
5TB Uncompressed	150,000	1 ~ 2 Months
5TB JPEG Lossless	500,000	4 ~ 5 Months
5TB JPEG Lossy	1,500,000	10 ~ 12 Months

Table 4.2 Migration Time for DICOM Q/R Migration

Direct Access Migration is preferred to DICOM Q/R Migration if possible because DICOM Q/R Migration is much slower (two or more times slower) than Direct Access Migration. Migration time can also be shortened when the migration is performed at more than one station simultaneously. If the migration is performed at two stations simultaneously, the migration is usually 150% faster than in one station.

It is also possible to use Direct Access Migration Service and DICOM Q/R Migration Service simultaneously for different portions of data.

5. MIGRATION EXPERIENCE

INFINITT Healthcare has considerable experience migrating PACS data, having replaced more than 20 different PACS solutions in more than 70 sites globally. Many of these sites were very large university hospitals in Asia, such as Seoul National University Bundang Hospital where INFINITT migrated more than six million studies, comprised of approximately 200,000,000 images. The methods and tools that have been developed by INFINITT to facilitate migration are a direct result of this first-hand experience. Below is a representative list of INFINITT Data Migration projects.

Country	PACS Company	Hospitals	Data Amount
Korea	AF	Pohang St. Mary's Hospital	7 TB
	KC	Daejin Medical Center	28 TB
	AF	Bundang Seoul National University Hospital	46 TB
U.S.	Siemens	St. Joseph's Medical Center, NJ	30 TB
	GE	Medical Arts Radiology	25 TB
Japan	GP	Tokyo Woman Univ. Hospital	12 TB
China	MT	Zhejiang Women's Hospital	12 TB
Taiwan	MT	802 Hospital	10 TB
Singapore	KD	Parkway Group Mount Elizabeth Hospital	9 TB
Turkey	RG	Erciyes University Hospital	5 TB

Table 5.1 INFINITT's Major Migration Sites

6. CONCLUSION

PACS migration is a lengthy and labor-intensive process that can cause disruption to hospital operations if not planned and executed properly. Legacy PACS environments should be analyzed to determine an optimal migration strategy and to avoid possible migration pitfalls. Good planning and analysis may also shorten the migration period and expense. It is important that sufficient system and human resources be available throughout the migration period to ensure that migration can be performed smoothly.

Based on experience, INFINITT prefers a Direct Access Migration approach to an Indirect Migration approach when possible because Direct Access Migration Service shortens the migration period considerably compared to DICOM Q/R Migration approach, and the Direct Access Migration approach generates less load on the legacy PACS.

Sometimes, it is not possible to apply Direct Access Migration to all the legacy PACS data. But INFINITT migration specialists have always found a way to employ the Direct Access Migration method for some portion of the legacy PACS data. In cases where Direct Access is only possible for a portion of the data, a combination of Direct Access and DICOM Q/R Migration has proven to provide satisfactory migration performance in terms of time and cost.