# Instant Prior Imaging Retrieval mPlexus®

*Efficiency in Imaging at Eastern Radiologists Incorporated*

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## Executive Summary

The mammographers at Eastern Radiologists Incorporated wanted to find a way to view mammograms more efficiently using the equipment they had. mPlexus provided the facility with software that would instantly, automatically, and accurately retrieve comparison films and prepare them for viewing in such a manner as would work with the facility's existing, otherwise highly optimized mammography viewing workstations.

## Introduction

In order to attempt to achieve greater economies of scale and introduce efficiency into their workflow, many radiology groups today are merging into larger groups. With these mergers, however, can come unanticipated challenges.

Large radiology facilities may find themselves wasting both time and money due to unexpected inefficiency that results from merging the various information systems of the component radiology groups. Oftentimes, these great inefficiencies can be reversed with small, targeted changes, particularly in the field of radiology. Due to the high salaries radiologists typically earn, finding a 10% more efficient working method for a six-figure salary means much greater savings for the group than it would for a lower cost asset.

Eastern Radiologists Incorporated (ERI) in Greenville, North Carolina has experienced this first-hand in their busy mammography practice. Achieving the efficiency necessary to eliminate even a fraction of an FTE radiologist mammographer could save tens or hundreds of thousands of dollars per year. Or, rather than using fewer radiologists to do the same amount of work, ERI would have the option to take on more work. Either way, ERI would make more money and provide better service to their mammography patients. Applied over the whole group of 50 radiologists in addition to the mammography group, this savings would be quite significant.

Groups responsible for imaging at multiple facilities including private imaging facilities, hospitals and the increasingly common regional health care delivery networks typically find themselves working within multiple disparate PACS and RIS systems. Navigating the multiple systems for primary reads and for viewing of comparison studies is a throughput killer. In addition to the time wasted hunting for priors on one or more independent archives, radiologists are often unaware of the existence of many prior studies leading to potential lost opportunities to optimize care by having prior images. The most obvious but most costly solution is to replace the disparate PACS systems so they are all on a common platform. Given that large deployments of PACS systems can cost upwards of 6 million dollars, this is often an impractical or downright impossible solution.

ERI set out to find a solution to the efficiency challenges they faced and to improve the quality and speed of mammography readings.

## The Initial Status at Eastern Radiologists Incorporated

Eastern Radiologists Incorporated is the 28th largest radiology group in the United States. Located in Greenville, North Carolina, they read an average of 733,000 studies a year. Dr. Schroeder, a senior partner and the head of mammography, saw an opportunity for improvement in the efficiency of the mammography section.

The mammography section of ERI reads at least 50,000 mammograms a year stored on two independent PACS and utilizing multiple different RIS systems from 14 facilities. Given the current environment, in which resources are limited, Dr. Schroeder understood the need to maximize efficiency and accuracy by utilizing dedicated personnel and technology. He checked with a few large vendors and well-known names in medical imaging, but all of them told him that the greater efficiency he was looking for simply was not possible with the vendors' current systems.

However, upon attending RSNA 2010, Dr. Schroeder discovered that one company had developed software that could meet the core of his needs: the mPlexus Relevant Prior Engine (RPE). mPlexus began to work with Dr. Schroeder and his team at ERI to build a system centered on the RPE functionality that would address their efficiency concerns. Working closely with Dr. Schroeder to understand his specific needs, mPlexus was able to take the project from concept to full clinical implementation relatively quickly.

## Assessing the Current System

mPlexus' existing software platform could meet the needs of the mammography department with a few adjustments indicated by Dr. Schroeder's unique understanding of his department's operations. The only question was: how could it be integrated with their existing system? The implementation would be complex, given that the mammography imaging hub receives images from 14 different facilities with various different information systems. So, mPlexus began with the existing workflow system at the hub itself.

*The Mammography Viewing Stations*

The mammography imaging department has four General Electric Seno Advantage (General Electric, Waukesha, WI) workstations designed with hanging protocols highly optimized for mammography viewing. The mammographer assessing the studies can open any number of mammography images all as part of the hanging protocol workflow, including films from two years ago, four years ago, and comparisons of different views all with a push of a button.

ERI's viewing systems were extremely efficient for the first several years after their 2004 digital mammography conversion. However, as more and more of ERI's affiliates moved to digital and the number of digital priors increased, the efficiencies began to disintegrate. This workflow includes the computer automated detection (CAD) images provided by R2 Technology (Grand Rapids, Michigan) integrated into the hanging protocol. These CAD images electronically detect signs of cancer and compare all areas of different images that appear to be cancerous. The workstations are designed so that it can take an expert mammographer less than a minute to view a screening mammogram with all of its comparison studies – about as optimized as the process can get!

*Problem 1: Naming Conventions*

The mammography viewing workstations do not always work as they should, however. When certain things occur, the system encounters errors. Inconsistencies in data entry (e.g. misspellings, inconsistent use of middle initials/names, omitting gender) and unavoidable name changes led to increasing instances in which the prior images, even if correctly routed to the workstations, would not be recognized by the system as belonging to the same patient. The viewing stations require that multiple factors from the set of name, medical record number, date of birth, and gender on the comparison film must match the current study exactly for the priors to be presented.

The largest concern with this dependency on exact file names is that the 14 hospitals that send images to the hub have various independent information systems. Each of ERI's affiliate facilities has an independent patient ID numbering scheme, and one multi-site hospital system even made an RIS change resulting in an alteration to their existing scheme.

It is also common for patients to be seen at multiple unrelated facilities in the region over the course of a single imaging cycle or over the years, resulting in several different medical record numbers (MRNs) being assigned to one patient, making it impossible for the mammogram viewing workstation to load all of the prior images even if they already exist on the workstation.

When related images having mismatched data are present on the workstation, the radiologist may or may not be aware of their presence. If aware, the radiologist can manually "merge" the two or more patient records so they are viewed correctly within the hanging protocol. However, if the radiologist is not aware of the presence of the images on the workstation, or if there are images in one or more of the PACS archives, those images are never compared. Once a manual "merge" is selected it is retained only until the next case is launched. This means that even if desired, they cannot have clerical support staff "pre-merge" the cases for a subsequent reading session.

The power of the workstation is compromised by any of these situations, and a mammographer who must manually find the films, retrieve them, and identify them as matches so that the workstation will open them together dramatically increases the time spent reading one mammogram.

*Problem 2: File Types*

When a mammography study is performed, the workstation produces two types of files. Those files are designated in the DICOM header as "for presentation" or "processed" (intended to be viewed by the mammographer) and "for processing" ("RAW" data intended to be processed by the CAD workstation or one of their other image processing systems). The "for processing" images are sent to the CAD system, which produces two file types: Radio-Therapy Structured Set Storage (RTSS) and Mammography CAD Structured Report (SR). Some of ERI's older workstations can view the RTSS and others the SR. Sending both file types to all workstations would cause difficulty in the workstations that are not designed to handle both file types. The very large SR files, for example, can cause severe slowdowns and potential crashing on some workstations.

*Problem 3: The Scramble to Find Images*

In order to be as efficient as possible, studies must be delivered for viewing "just in time," without delays.

The mammography interpretation task is generally considered to be divided into two types of tasks: routine screening and diagnostics. The routine reading of screening mammograms can be performed within 24 to 48 hours of when the mammogram is taken.

A diagnostic mammogram, however, must be interpreted within minutes of being performed since this is often a dynamic, iterative process requiring real-time decision making. In addition, the ERI mammography facility must provide immediate results to the patient for diagnostic exams. Therefore, the diagnostic mammogram cases are treated as "STAT" cases. Because of this, the image routing system must prioritize real-time cases ahead of screening cases, which are typically "batch-read" at a later time.

Since mammograms are relatively large file sizes, a week's worth of mammograms plus five comparison studies per mammogram can fill up a large amount of drive space on a viewing workstation. Consequently, maintenance procedures must be performed regularly to clean off hard drive space. This also means that a year's worth of images cannot simply be stored on the workstations to save retrieval time.

Therefore, any system to optimize mammography viewing must deliver images "just in time."

The DICOM standard of image transfer relies on forming associations between computers. That means that before anything is sent, one location must ask the other if the transaction is authorized. If the other location verifies, then the association is formed. However, if the association limit has been reached for any DICOM destination, such as the viewing workstations, then other association attempts are rejected.

While extremely efficient for viewing mammograms, the GE Seno Advantage workstations originally had a limit of four DICOM associations per workstation, which was adequate for a typical facility at the time they were developed. These workstations were not optimized for the extremely high volume, multi-site environment that ERI has become. The CAD workstations alone, send out seven files, each file with its own association. Consequently, each reading workstation's viewer association limit is saturated by the CAD workstations alone.

## Constructing a Solution

When Dr. Schroeder and the Information Technology team of Eastern Radiologists Incorporated came to mPlexus for a solution to the mammography department's problem, mPlexus was able to tell them that we had already developed software that would do most of what they needed. It was just a matter of integrating it into the mammography imaging center's existing workflow and taking into account the specific workflow at each of the outlying sites.

mPlexus' Relevant Prior Engine (RPE) software is designed to automatically, accurately, immediately, and intelligently retrieve relevant images from any DICOM image database, such as a facility's PACS. mPlexus also programmed it to only send along the appropriate file types, and to automatically search each of the 14 imaging centers' image files and correct any irregularities in the identifiers on images from the same patient so that all prior studies would be named and labeled identically for the mammography viewers.

## How RPE Works

*Part 1: Query*

Before a mammographer even sits down to view a study, RPE has already done most of its job and has the studies ready for immediate delivery. mPlexus' software identifies the current study by either of two triggers depending on what facilities the images are coming from.

The first trigger: the software receives an HL7 message from the RIS which triggers the RPE functionality.

The second trigger: if the software receives a mammogram but no HL7 message, the receiving DICOM router sends an HL7 message automatically to the RPE.

As soon as the RPE is triggered, the first thing it does is reference a Master Patient Index (MPI) which mPlexus has developed based on the existing billing indexes of all 14 facilities. The MPI is a cross reference for any given patient that pairs all of their MRNs with the facility that assigned them so that every different MRN convention is represented.

Referring to the MPI, the software identifies the patient no matter what MRNs they have been assigned. RPE then connects to the PACS that is storing each facility's images, searches under each different MRN, and retrieves all of the images.

Next, the software sorts through all of the images to determine relevance to the current study the mammographer will view and fetches the five most relevant studies (note: this number was chosen by the mammographers. RPE can be programmed to fetch more or less as need requires).

*Part 2: Association and Delivery*

After querying the PACS and identifying the relevant images, RPE then pulls the studies it has identified, sending them along to the mammography viewer. Identifying the files remotely before accessing them saves a great deal of time and avoids fetching unnecessary studies.

With the relevant prior studies accessed, RPE then compares each study for header information against the current study the mammographer is expected to view. By normalizing the header information on the comparison studies the RPE ensures that all the prior studies match the current one.

Once the files are all properly identified and pulled, however, there is one final step before actual delivery. Recall that DICOM systems operate by forming associations with each other, and that the viewing workstations are limited in the number of associations they can form at one time.

Originally, mPlexus software was designed to transfer studies as quickly as possible; RPE is capable of forming thousands of associations at once. However, in order to work with existing systems, mPlexus redesigned the software to send studies in a preconfigured number of associations at a time per DICOM destination. Acting as a central transfer system, mPlexus' solution can receive unlimited simultaneous associations and hand off images at the fastest pace allowed by the receiving destination

## The Central Transfer System

In order to accommodate the workstations, mPlexus built a central transfer system to modulate the flow of images to the workstations. The central transfer system receives all of the data, holds it, and hands it off bit by bit to the workstations, a relatively complex programming task involving changing the way computers involved in this workflow actually communicate with each other. The result of this programming and implementation was so effective, that mPlexus has developed it further. It is now known as RadiX.

This central image transfer engine runs on a single computer and has been extremely reliable. It receives more than 50 GB of mammogram and breast MRI data per day and then parcels it out to the four workstations and two test workstations. The CAD reports are handled in the same way. Between these two functions the system handles more than 200 GB of imaging data every day and more than 1 TB of data per week.

The deliveries to the workstations are customized, as well, since each workstation has slightly different needs. Some of the workstations require slower transfer speeds, while others need different files stripped out so that they can work properly. Some files need the MRNs adjusted to match the digit requirement of the reporting system (IE, adding zeroes to the beginning of 5-digit MRNs to meet a 6-digit protocol).

The central transfer system and the RPE meet each of these requirements automatically, accurately, and reliably. In addition to delivering the appropriate images every time, the system is very stable with greater than 99% uptime

The whole process - from the trigger to the delivery - takes very little time. The priors are fetched ahead of the current case being completed and can, if necessary, meet the STAT needs of diagnostic cases. In most non-STAT cases, the comparisons are ready for viewing on the workstation either before the current mammography is complete, or within a couple of minutes of completion. When a mammographer sits down to read any case, all of the relevant studies are there, every time: no hunting, no workstation crashes, no angry mammographers, no wasted time, no frustration.

## mPlexus for Any Medical Facility

This study has shown how mPlexus works for a large, complex mammography system. However, the software is designed to work with any medical facility dealing with image transfers, no matter how small. According to Dr. Schroeder, "Our system is about as complex as you can find. If mPlexus can work in our environment it should be able to handle anything you throw at it."

mPlexus software is designed to work between unrelated, even competitive or unfriendly facilities as long as they have the desire to serve the patient and share the patient's images in a timely, intelligent, pain free fashion.

With a system like this, radiologists can be more efficient, saving the organization wasted time of their most expensive asset. A system like this could even eventually eliminate unnecessary repeat imaging, which will become more important in a healthcare system run by Accountable Care Organizations (ACOs). mPlexus is proud to be part of a solution that helps medical organizations save time, money, and lives.