

Medical Imaging needs a next generation, sophisticated Enterprise Workflow Application

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Executive Summary

The current generation of department PACS were designed over tens years ago. That applies to the workflow and worklist components of the solution as well as the system architecture. The workflow was designed to assemble images for interpretation by a single physician group working in a single department, working with a single department PACS. The concept of prioritization was placing a STAT icon next to a study ordered by an Emergency Room physician, and perhaps applying a background color to that line item in the list. Today, even mid-sized healthcare organizations are commonly made up of several amalgamated radiology groups (some owned, some affiliated). They have multiple EMRs and PACS solutions. These organizations have to manage complex cross-site credentialing issues while trying to deliver a common standard of care across the new integrated enterprise. In addition to this, the organization has to hold each physician group to similar performance goals. The worklist of each individual physician absolutely has to consider such input as: physician availability (schedule, locations, etc.), turn around time, physician RVU loading, sub-specialty reading, credentialing, critical results reporting, and peer review. None of the current generation department PACS have a workflow application that addresses today's issues much less future issues we can barely imagine. A new generation of workflow application that is applicable to the enterprise is clearly needed.

There have been improvements over the last ten years in the features and functions of the diagnostic display application, and yet most imaging departments have had to augment their core PACS application with a number of third-party specialty display applications. The physicians have to work through a pull down list of these applications in order to find the one that is the most suited to use in the interpretation the study they have pulled off their worklist. Similar to the way the enterprise workflow solution needs to provide a federated view of available studies to read, the enterprise workflow needs to provide federated access to all the available diagnostic display resources within a site or across a multi-site enterprise.

An enterprise workflow/worklist application is also one of the key components of the next generation of PACS. The PACS 3.0 configuration is based on a Vendor Neutral Archive. The various diagnostic display applications are simply plug-ins to the VNA. As the brain of the PACS 3.0 configuration, the enterprise workflow/worklist application is the entry point of all of the interpreting physicians in all of the imaging departments. The individual physician worklist presents the highly specific list of studies to be read and the underlying workflow launches the most appropriate diagnostic display application based on the pre-defined choices of the physician and the specific type of study selected from the list. Now is the time for a single workflow/worklist application for the enterprise.

Introduction

Some key words are immediately understood, providing the reader with a base point from which to leap into whatever subtleties of the subject lay ahead. A Picture Archiving and Communication System or “PACS” is one such word, or acronym, that needs little introduction. The words workflow and worklist are a little more ambiguous, their meanings being somewhat dependent on the user’s experience. Therefore it is important to begin this paper with a basic description of these two terms in the context of the current generation of department PACS.

The following summary description of workflow applies to any imaging department in the healthcare organization. Those without a PACS simply have more manual than automated components.

Workflow is the term that refers to the series of processes involved in an imaging study, starting with the referring physician’s decision to order a study and ending with the delivery of the report to that same physician. From the moment the patient shows up for the study to the moment the resulting data is displayed for interpretation, all of the intervening processes involved in preparing the data for interpretation constitute the pre-interpretation phase of workflow. In the current generation of department PACS, that includes the physicians and department staff working together to determine the correct protocol for the imaging study, and the staff populating one or more digital forms with patient and study-specific information and /or scanning one or more documents associated with the study. It involves one or more individuals performing the study including any associated measurements, matching the imaging data to an order, verifying the patient and study ID, editing the data (merges, splits, and deletions), and closing the study in the appropriate information system.

The middle phase of workflow involves providing the interpreting physician (i.e. radiologist, cardiologist, etc.) with access to whatever non-structured data associated with the patient or the study might be available in the Electronic Medical Record system. Highly customized “hanging protocols” featured in the actual diagnostic display application might be considered a component of this phase of the workflow. Launching the reporting solution in patient/study context is part of this workflow. The final phase of workflow is comprised of all of the processes involved in providing the referring physician access to the actual image data and final report. If an Emergency Department physician ordered the study, the workflow would include a process known as discrepancy reporting...a communication loop between the ED physician and the interpreting physician.

Worklist in the broadest sense is the term that refers to the department-specific list of completed imaging studies that are ready for interpretation. In a more practical sense, worklists are created for each individual interpreting physician in the department, so the workload can be divided across the group of physicians. Perhaps the most important aspect of the worklist application is how the individual studies are actually distributed across the group...assigned to the individual physicians. In an imaging department that is

organized by its PACS, once the individual physician worklists are created, the studies in an individual list can be prioritized according to the order in which the studies should be interpreted. This prioritization is usually tied to several pre-defined parameters, the most important of which is the urgency of the result as it pertains to the patient's care.

Business issues may also drive this prioritization. The priority may be determined by the Service Level Agreement, in which the healthcare organization guarantees the referring physician/organization a specific turn around time (TAT) between the completion of the study and the delivery of the report. The processes involved in the creation of the individual physician worklists and the prioritization of studies within each list require a complex workflow. The prioritization in the current generation of worklist is managed manually by the physicians themselves and is non-existent in the worklist application.

The workflow processes that determine the individual physician worklist should consider such input as: physician availability (schedule, locations, etc.), turn around time, physician RVU loading, sub-specialty reading, credentialing, critical results reporting, and peer review. The workflow behind the worklist should also allow for user-specific logic to determine the relevant priors associated with the new study, because not all interpreting physicians have the same criteria for priors. The worklist effectively launches the display of the images for the selected study, both new images and relevant priors, according to the individual physician's pre-defined hanging protocol. The workflow behind the worklist should also enable the physician to access all of the available unstructured data associated with the patient and the study (lab results, prescriptions, care summaries, etc.).

Many current department PACS are only able to create a worklist by applying pre-defined but static filters to the complete list of studies ready to be interpreted. Using this approach, the filter may produce a list of all neurological CT studies, all STAT studies, all studies ordered by a specific outside referral group, etc. In imaging departments without a PACS, the worklist may simply be prioritized by the order in which the study was completed. Even simple worklists created by a PACS are updated with the status of the study such as "study in process", "QC in process", "study on hold awaiting additional information", etc. and the worklist would prevent two physicians from simultaneously interpreting the same study.

The workflow component of the worklist application presents additional challenges if there are multiple physician groups in the healthcare organization that are responsible for the interpretations, a specific imaging department is spread over multiple facilities, or there are disparate PACS being used in the same department.

In a way, all of the above described functionality falls under the purview of "Workflow" and the individual physician "Worklist" is simply a product of that workflow.

Looking at this subject from a historical perspective...

We have already experienced two generations of workflow applications. First Generation covers the workflow and resulting worklists of the 90's. These worklists were primarily image-based, i.e. the worklist was driven by the generation of an imaging study. To the extent that HL7 interfaces existed, those interfaces were primarily used to deliver

accurate demographics, and prior reports. Those early worklists effectively had no knowledge of the imaging exam until it occurred, and workflow played a minimal role in the creation of these worklists.

Then in the 2000's the advent of Exam- or RIS-driven workflow occurred. This Second Generation workflow enabled a level of preparation that preceded the arrival of a new study, i.e. pre-fetching/staging priors, characterization of the study type with a higher degree of granularity than is typically available in the DICOM header. This degree of workflow supported protocoling, and provided the technologist with the tools required to complete the studies (DICOM has always had an inherent weakness in specifying the end of a study).

Today we are entering the domain of the Third Generation...the age of Enterprise Workflow, where IDNs are emerging as the dominant delivery model and there is a focus on the value of radiology as part of a multi-discipline care delivery. The Third Generation introduces the concept of an Enterprise Workflow that produces a set of Enterprise Worklists.

IDNs have fundamentally different needs.

- They are commonly made up of many amalgamated radiology groups (some owned, some affiliated).
- They have multiple EMRs and PACS solutions. While there will be a strategic effort to centralize and normalize on one PACS per department, the nature of continuous expansion, and the complexity of other systems will mean that there will always be some level of heterogeneity across the enterprise.
- They have to manage complex cross-site credentialing issues while trying to deliver a common standard of care across the new integrated enterprise.
- Additionally, the IDNs have to hold the radiology providers to similar performance goals.

The IDNs require a physician worklist that is based on a much more sophisticated understanding of the entire enterprise. This worklist must be able to handle multiple patient, physician and exam code descriptions, while simultaneously meeting requirements for contracted turn around times, sub-specialization, and fair work distribution across the enterprise.

The IDN scenario will only become more complex. It is anticipated, that the aggregation of providers into mega IDNs will continue into the next decade, resulting in the total number of healthcare systems counting in the low 3 figures. At that point, the concept of an independent hospital or imaging group will be a distant memory.

Problems and Solutions

Most of the current generation department PACS are deficient in one or more areas of workflow and worklist as described above. The need for a next generation of sophisticated workflow/worklist application is driven by major problems experienced in many healthcare organizations today. This section will introduce the major issues (problems) with existing PACS or RIS-driven worklist/workflow solutions and the corresponding solutions.

Workflow

1. As the next generation of workflow application, the Third Generation should include a simple but effective method of communicating additional clinical information related to the patient or the study between the individual(s) performing the study (technologist, sonographer, etc.) and the physician who will ultimately interpret the data created by the study. A wide variety of information falls into this category including consent forms, patient history, requisitions, drawings, and technologist/sonographer worksheets. There is patient care information as well as specific information that can be collected about the patient during the exam. Most PACS support a methodology for associating scanned documents with the study's image data, but recording the information in a document and then scanning that document is labor intensive and time consuming.

A far better approach would be a customized Forms Application built into or at least associated with the department PACS. This approach would allow the individual performing the study (technologist) to fill in customizable clinical forms to capture specific information about the patient during that specific study. Forms could be prepopulated with unstructured data provided through HL7 interfaces with the EMR or other information systems. This process would allow for the communication of valuable clinical information about the patient to the interpreting physician, information that cannot be collected from other sources. All of the information captured and conveyed in these custom forms would then be uploaded to the host EMRs as a CDA, which is then make the information available to the remote interpreting physician in their personal EMR worklist as part of their Patient Summary. Radiology information cannot be treated in isolation of the integrated view of the EMRs.

2. The Third Generation workflow application should include a methodology for discovering, accessing and delivering to the diagnostic workstation relevant prior imaging study data from other imaging department data repositories in the healthcare organization. Unfortunately most current generation department PACS do not have the ability to do this. Their relevant prior algorithms do not include study descriptors and exam codes used in other departments. If the PACS solution actually supports a pre-fetch and autoroute function, it typically does not search foreign data repositories, the principal reason being that PACS are not equipped to reconcile the idiosyncrasies in the DICOM data format created by other PACS.

Even if the PACS retrieved image data from another PACS, it may not be able to properly display that data. Furthermore, retrieving relevant priors from other imaging departments should not be limited to those departments that have PACS solutions. Images being managed in other departments by standalone specialty workstations, and images captured on digital cameras and mobile devices could be just as relevant to the new study as those imaging studies previously acquired in the same department. What is needed is a workflow application that is capable of aggregating across all of the imaging departments in the healthcare organization all of the relevant prior study information related to the patient and the current study just completed, and resolving any of the idiosyncrasies in the study data files that might prevent the proper display of the images in the destination diagnostic workstation.

The situation gets even more complicated when dissimilar PACS are involved in the image capture and interpretation process. The nature of an IDN easily creates the potential for the interpreting physician to be working at a site other than where the patient is being treated, creating the situation where the interpreting physician may be reading from a PACS other than the one that originally acquired the study. In order to deliver the DICOM studies with appropriate presentation states and reports back to the point of patient care, back to the originating PACS, the workflow application will need the original definition of exam codes in order to perform the appropriate bi-directional transcoding.

3. While the Forms application mentioned above is an excellent approach to collecting clinical information when and where the study is being performed, there is a wealth of information about the patient and the current episode of care in the Electronic Medical Record system. The Third Generation workflow application should provide whatever internal infrastructure is required to enable the interpreting physician to launch the EMR in patient context and display the appropriate clinical content on the control screen associated with his diagnostic workstation. This would allow the interpreting physician to easily and quickly access the patient summary and any other clinical information related to the patient and study about to be interpreted. Most of the current generation of department PACS cannot launch the EMR in patient context. As previously mentioned, any new indications, issues or observations collected during the course of the imaging exam and interpretation needs to be added back to the host EMR, problem list, etc. Just sending the final report back to the EMR is not sufficient.

4. The typical current generation PACS operates as an island unto itself. It can ingest and manage data forwarded to it from imaging modalities located in one or many facilities that comprise that imaging department. In some cases it can autoroute new studies and relevant priors to specific pre-defined diagnostic workstations, but there is limited granularity in the auto-routing logic. For example it might be possible to route all STAT studies after 6:00 PM to a pre-determined remote reading station, but the routing scheme may not be able to take into account the specifics related to sub-specialty reading and credentialing. In general, the vendors of current generation PACS have given up trying to build sophisticated routing algorithms. Their PACS solutions primarily operate in an “on-demand” mode, delivering the imaging study data to the diagnostic workstation only

in response to the physician actually selecting the study from that PACS system's reading list. For many PACS vendors, the concept of "Enterprise" PACS seems to assume that the IDN simply requires a bigger PACS instance. That's inherently wrong. The nature of rapid expansion over the next 10 years, creation of affiliate sites, sub-networks created in the form of ACOs for certain population groups, direct provider contracts with individual SLAs is demanding a much richer patient / payer / criticality to the routing requirements. There is a lot more to meeting the requirements of the Enterprise than simply building a bigger PACS.

The Third Generation workflow application needs to address the needs of the healthcare organization where an individual imaging department, for example radiology, is scattered across multiple hospitals each using a different PACS. In this case, the physicians logged into one PACS should not be limited to reading only those studies acquired by that PACS. The next generation of workflow application should be able to route new studies and related priors to whichever department PACS the physician chooses to use, regardless which PACS was used to acquire the new studies. In this use case, the workflow application needs to be able to transform the exam codes and the physician and patient ID codes to operate within each of the PACS...the PACS that acquired the study and the PACS used to read the study. The same codes need to be transcoded when the image and report data is sent back to the VNA, or to whatever system is being used at the patient's care giver site.

Considering the physician's perspective, the next generation of workflow application also needs to address the more complicated scenario where there are multiple physician groups working across multiple healthcare organizations. The evolving future reality of healthcare is that there are multiple physician groups, working across multiple EMR/RIS/PACS that are being held to complex SLA around turn around times and sub-specialization in the delivery of critical results. The next generation of workflow must provide the infrastructure required to help these physician groups manage their own governance for RVU reimbursement, deal with concerns about load balancing, while ensuring that the appropriately credentialed physician is reading the right studies.

5. In today's complex diagnostic imaging environment, it is common for a given imaging department to depend on more than one diagnostic display application. The case of multiple department PACS has already been mentioned. It is also quite common for an imaging department to have one or more specialty diagnostic display applications to supplement their core PACS solution. Radiologists may turn to separate specialty applications to interpret Mammography and Nuclear Medicine studies, and yet another specialty application to perform complex 3D modeling and multi-modality image fusion. Cardiologists may turn to a separate display application to interpret EKG studies and another for Nuclear Cardiology studies.

Current generation PACS support third-party plug-in applications to provide these specialized tools to the interpreting physicians, but the workflow process is tied to the core PACS, requiring the physician to go to the core PACS to access the pull down list of the third-party applications. Moreover, the core PACS has to pre-stage the image data for

third-party application. In the on-demand PACS, the image data is not made available to the third-party application until the physician launches the application, and priors quite often have to be manually selected. This workflow is not efficient.

The Third Generation workflow application should not only determine which physician or physician group is best suited to interpret a specific imaging study, but also pre-determine the diagnostic display application that would be the most suitable for interpreting that study. By the time a specific study is placed on a worklist, and before that study is actually selected by the interpreting physician, the workflow application will have already pre-staged the new study data and the relevant priors on the appropriate display server's cache. When the interpreting physician selects the study, the most appropriate diagnostic display application is launched and the new study data and the proper priors are immediately displayed without delay.

In this sense, the Third Generation workflow application takes responsibility for moving study data around the enterprise from PACS systems that acquired the data to diagnostic display servers that are most likely going to support the interpretation of the study. The Third Generation workflow application now supports what is effectively an Enterprise Workflow/Worklist that would span multiple imaging departments and multiple PACS, allowing the physicians to work from a list of studies assigned specifically to them and based on all of the complex criteria mentioned above.

This is an example of federation. Similar to the way enterprise workflow solutions provide a federated view of available studies to read, the enterprise workflow would provide federated access to all the available diagnostic display resources within a site or across a multi-site enterprise.

The concept of a workflow application pre-staging data, and the worklist launching the most appropriate diagnostic display application based on study descriptor has been referred to as Determinant-Based Launch. Additional detail on this key concept will be provided later in this paper.

Worklist

1. The Third Generation worklist application should effectively be an Enterprise Worklist that spans all of the imaging departments in the healthcare organization. The enterprise worklist will manage access to multiple disparate diagnostic display applications while optimizing turnaround times, physician RVU loading, sub-specialty reading, credentialing, critical results reporting and peer review. In short the enterprise worklist application crosses multiple imaging departments to build individual physician worklists that distribute each department's workload over all of the physicians in one or more groups responsible for the interpretations. Not only do radiologists read radiology studies and cardiologist read cardiology studies, but individual department worklists reflect the appropriateness of the physician taking into account sub-specialization, turn around time, credentialing and quality auditing. All of the imaging departments in the healthcare organization would use the same worklist application, especially those

departments that do not have a formal PACS solution to organize their workflow (i.e. endoscopy, ophthalmology, dermatology, etc.).

2. The Third Generation worklist application should dynamically prioritize the studies in each worklist to make certain that complex SLA turn around times are being met. This would include shifting studies from one physician's list to another's list, if the initial physician is suddenly unavailable, or has fallen behind in the workload.

Productivity

The next generation of sophisticated workflow/worklist application should effectively improve the productivity of each of the imaging departments in the healthcare organization. Load balancing across the physician group(s) in each department, with the appropriate attention to sub-specialization and credentialing, should produce an immediate improvement in productivity. The workflow/worklist application suite must optimize the delivery of all of the organization's imaging services in an environment where physician groups are aggregating to become mega groups, or being acquired into providers, hospitals are merging into ever-larger networks and population financial risk is beginning to shift to providers. This will require the providers to optimize across three dimensions: quality, productivity and utilization. They must strive to improve productivity in the face of declining payer reimbursement while maintaining high quality to sustain or improve market share in a more competitive and transparent world.

The utilization of the Third Generation workflow/worklist application in a mixed PACS, multi-site distributed environment can be expected to increase physician productivity by 15 to 30%, reduce turn around times by 30% and increase sub-specialty reads by 50%, while managing to capture all the compliance information for Joint Commission reviews.

The Future

I have been emphasizing that the new generation of workflow and worklist applications must function as an Enterprise application suite, coordinating imaging operations in all of imaging departments, and building individual worklists for all of the interpreting physicians associated with the healthcare organization.

Ideally the application suite would be built on an integrated architectural platform that is designed to address the future state of clinical and financial integration as providers consolidate and take on financial risk. The application suite should be designed as a modular platform that can work with any existing department PACS, as well as the standalone workstations that are being used to organize data in the non-PACS departments. This modularity would facilitate targeted deployments that would meet today's immediate needs, while providing a platform that will meet tomorrow's needs. As the provider community evolves, individual workflow/worklist modules could be seamlessly added to the base application to work in harmony with the enterprise EMR. In short, the Third Generation workflow/worklist application suite must be flexible enough to easily adapt to the future.

The best example can be found in radiology. With all the radiology groups either being acquired or merging with each other, and the IDNs building closed networks and expanding their reach, what used to be 5,000-plus radiology groups are now less than 2,000. The evolving future reality is that there will continue to be multiple groups struggling to distribute the imaging department's workload, trusting that their dynamic worklists have taken into account the ever-increasing complexity of study assignments and prioritization. These are the new table stakes for the future of a radiology practice, and none of the existing PACS solutions or RIS driven solutions can support the new workflow paradigms. That which is occurring in radiology is also occurring in every other imaging department. If one adds the need for physicians to be part of an integrated care team, demonstrating their value in an "At Risk" environment, driving an integrated Medical Management program around imaging utilization, then the situation and the corresponding workflow/worklist application gets even more complex.

The takeaway here is that the key use cases of the future are not well known today, so a more sophisticated, modular, and nimble workflow/worklist application suite is a requirement, and this application suite should be applicable to all the imaging departments in the enterprise.

Deployment Strategies

What are the deployment options for a Third Generation Enterprise Workflow/Worklist application suite? Economic realities being what they are, one option has to be interfacing the standalone application suite with existing department PACS. In this scenario, the primary workflow and worklist applications provided by the PACS, the department's information system, or the EMR are overlaid with the workflow and worklist functionality of the Third Generation enterprise application already described in this paper.

The department PACS would still be responsible for image acquisition, reconciliation of the new study with the order, and study QC, but the more sophisticated functions of workflow would be provided by the enterprise workflow application. The enterprise workflow would create the individual physician worklists. Selecting a study from an individual physician's enterprise worklist would automatically launch the diagnostic display application that is the most appropriate for the specific study. The Third Generation enterprise workflow/worklist application suite is now sitting at the center of imaging operations as illustrated in Figure 1 on the next page.

The enterprise workflow/worklist application suite could also be specified and deployed with a replacement PACS project, the same way that a VNA or a universal clinical viewer are sometimes included in a replacement PACS project. When including the enterprise workflow/worklist application suite in a PACS replacement project, it is important to carefully specify the workflow and worklist requirements, to make sure that the PACS vendor understands that you are considering a standalone Third Generation enterprise workflow/worklist application that will have to be interfaced to their replacement PACS. It would also be prudent to ask for a complete description of the

interface options that will be available for connecting the Third Generation application to the replacement PACS.

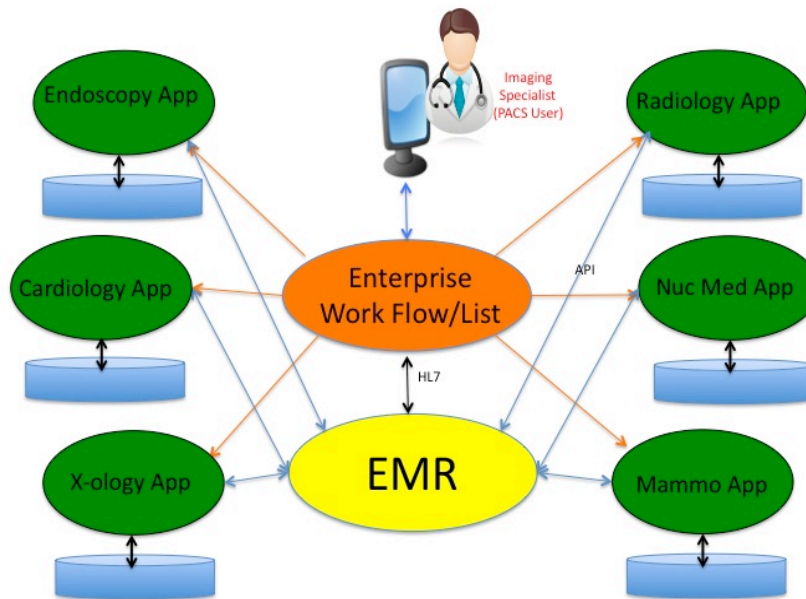


Figure 1

The replacement PACS could be another conventional department PACS, one of a generation whose architecture goes back at least ten years and referred to as PACS 2.0, or it could be a new generation PACS referred to as PACS 3.0. This new generation of PACS is based on the Vendor Neutral Archive functioning as an enterprise data management system and individual diagnostic display applications functioning as “plug-ins” to the VNA. The concept of PACS 3.0 and the role of the enterprise workflow/worklist application suite in that concept are presented in the next section.

PACS 3.0

The current generation of Radiology PACS has come to be known as R-PACS 2.0. The roots of this generation stretch back at least ten years. The most significant characteristic is a software application package that runs on the display platform, requiring the transfer of the complete set of images over the network to the display in order to view and manipulate the images. In an era of zero or near-zero clients and server-side rendering display applications being used to image-enable the EMR, R-PACS 2.0 solutions are seriously outdated.

The 2.0 designation and all of the negative implications is equally applicable to the current generation of Cardiology PACS. Figure 2 on the next page illustrates the current composition of R-PACS 2.0, including the various third-party specialty applications that are typically required to meet requirements.

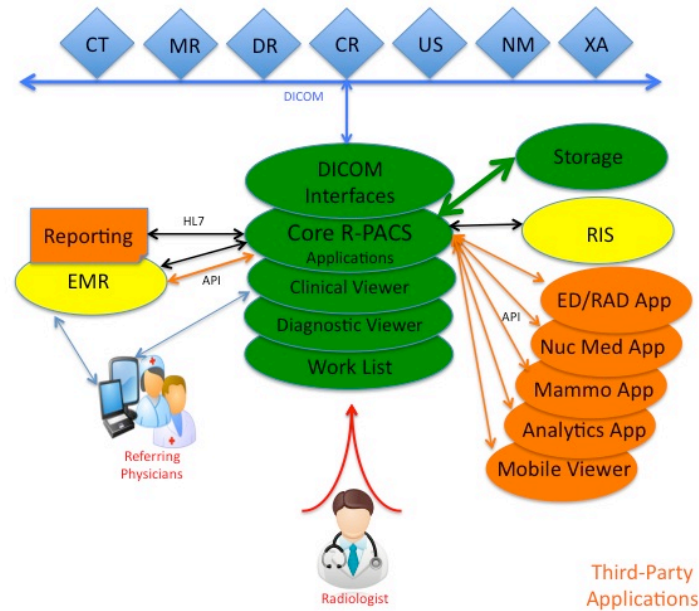


Figure 2

R-PACS 2.0 is comprised of the following major subsystems:

- Image Acquisition, which includes the reconciliation (matching) of the study to the order, and the technologist toolset for study QC functions.
- Workflow, which is everything related to preparing the study for interpretation, including identifying and accessing the related priors.
- Worklist, which as previously described is the creation of individual reading lists for the radiologists through the application of static filters to the list of new study data. Some R-PACS 2.0 worklists can be created by an independent radiology information system (RIS) or the RIS component of the EMR.
- Diagnostic Display, including user-defined hanging protocols and study-specific image manipulation, image processing, measurements, etc.
- Reporting, which is usually a third-party application launched in patient context through the display application.
- Data Archiving, which includes one or more tiers of storage for the primary copy of the data and a separate Disaster Recovery tier for the secondary copy of the data. Note that storage is included in the PACS configuration, because the PACS tightly controls the storage solution and the images stored there cannot be directly accessed by another application.
- Distribution, which is the clinical viewing application used by the referring physicians to access and display the images and the report. In some configurations the clinical viewer is an embedded thin-client application, in other configurations it could be a new generation zero-client (Mobile Viewer) application interfaced to the Core PACS application.

As illustrated in Figure 2, a significant aspect of the R-PACS 2.0 configuration is that all of the third-party specialty applications are connected directly to the Core R-PACS

application via an API interface, meaning the radiologist would be accessing those applications through the Core PACS application. Another negative that is more difficult to appreciate is that the image data itself is being managed by the Core PACS application, which is not only imposing all of its idiosyncrasies on the data format, but delaying the transfer of the image data to the third-party application until the radiologist opens the application. Both of these issues present significant performance limitations.

The growing list of limitations to the R-PACS 2.0 configuration is the principal reason for replacing key functions of this generation of PACS with newer and superior solutions.

- The severely limited data archiving functionality of R-PACS 2.0 gave birth to the Vendor Neutral Archive.
- The limitations of a thin-client clinical viewing application gave birth to the zero-client, server-side rendering UniViewer solution.
- The limitations of a radiologist worklist created by a simple static filter gave birth to the Third Generation worklist application.
- The limitations of the workflow component of the Core R-PACS application gave birth to the Third Generation workflow application.
- The VNA with its routing and compression capabilities is actually better than the PACS at performing image acquisition, especially in multi-facility organizations

If all of the weaknesses of the R-PACS 2.0 configuration are resolved with each of the above listed solutions, this current generation of R-PACS has effectively been reduced to little more than a core diagnostic display application, and without those third-party specialty applications, the core application is effectively limited to interpreting only the basic radiology studies. This circumstance suggests that is time for a major paradigm shift in department PACS.

In the new PACS paradigm, referred to as PACS 3.0, it is no longer appropriate or necessary to preface PACS with a department identifier. The new PACS paradigm applies equally to any department that creates medical images. The PACS 3.0 configuration is based on four major subsystems:

1. Vendor Neutral Archive (VNA) and its standards-based enterprise services bus (ESB).
2. Individual Display Applications that simply “plug into” the VNA services bus. These can be older fat- or thin-client display applications (i.e. an R-PACS 2.0 diagnostic display application), but most will probably be new generation zero-client, server-side display applications. The number and variety of such display plug-ins is unlimited (Radiology, Nuclear Medicine, Mammography, Cardiology, Endoscopy, etc.), effectively creating a diagnostic display solution for each imaging department in the enterprise.
3. UniViewer, the universal zero-client server-side rendering clinical display application that would image-enable the EMR.
4. The Third Generation enterprise workflow/worklist application suite that would also plug directly into the VNA services bus.

Figure 3 illustrates the concept of PACS 3.0

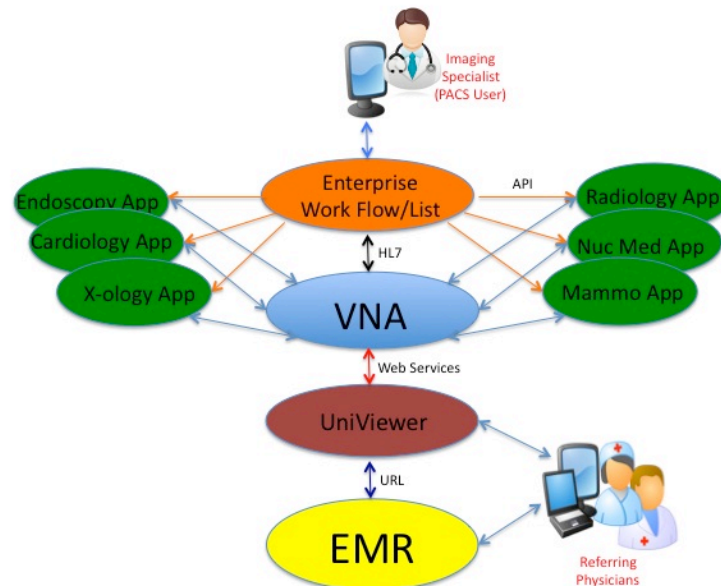


Figure 3

In this configuration, the VNA is at the center of enterprise data management, not any individual department PACS. The Third Generation enterprise workflow/worklist application is the entry point for all of the interpreting physicians. The referring physicians can access images and reports by directly accessing the UniViewer, or through their EMR portal.

Perhaps the most significant feature of the PACS 3.0 configuration is the functionality of the Third Generation enterprise workflow/worklist application suite that connects the interpreting physician directly with the most appropriate display application based on the characteristics of the study, and that user's specific preferences. I have referred to this important functionality as Determinant-Based Launch. In my opinion, this new application is what defines the Third Generation workflow/worklist and what makes it applicable to the enterprise.

The following is an excerpt from a three-part white paper that I recently wrote titled PACS Paradigm Shift – Moving control of the data from display applications to an enterprise access infrastructure. The paper can be downloaded from my web site¹.

Determinant-Based Launch is Key

“Whether the enterprise worklist is the function of a freestanding application or a function of the organization's EMR, the key to making PACS 3.0 work seamlessly and

¹ <http://www.graycons.com>

efficiently for users is the concept of determinant-based launch (DBL). DBL is the feature of the enterprise worklist that launches the right diagnostic display application based on pre-defined determinants such as study descriptor, ICD 9 code, imaging department, facility identifier, physician profile, etc.

“When the user selects a study from the enterprise worklist, DBL logic notes all of the various metadata details that describe the study and checks a series of internal specialty study descriptor codes for a match that will determine the most suitable diagnostic application that should be launched for that study. For example, if the study descriptor codes identify mammography and mammography-related ultrasound studies, the enterprise worklist would launch the appropriate mammography diagnostic display application.

“An automated, multi-application, enterprise worklist that determines the appropriate application to launch based on study parameters saves time. In a highly specialized radiology environment, manual selection of the most appropriate application from a worklist pull down menu is an outdated paradigm.

The concept of DBL is the keystone of the Third Generation enterprise worklist application. It is the application that unifies all imaging operations across the enterprise in a VNA-centric data management solution. The enterprise worklist with DBL technology is yet another application that can be more suitably performed outside of the conventional PACS 2.0 solutions. The PACS 3.0 concept represents the step-by-step removal of traditional PACS applications including long-term data management, clinical viewing, specialty diagnostics, advanced visualization, workflow and worklist.”

Enterprise Reach

The implication of an enterprise workflow/worklist application suite is its application to any imaging department in the enterprise. This would certainly include cardiology and the Determinant-Based Launch would make it possible for the cardiologist to directly access whichever of the specialty diagnostic display applications are being used in cardiology: EKG, Echo, Nuclear Cardiology, etc. It would also bring PACS-like functionality to other departments like endoscopy, ophthalmology, dermatology, surgery, etc. With the VNA supporting image acquisition and the other PACS functions for these departments, the Third Generation enterprise workflow application works in partnership with the VNA to pre-stage the image data on the appropriate display application server, and the worklist application builds the physician worklist. Once again, the DBT application then links the interpreting physician to the most appropriate display application for the interpretation process. In some of these scenarios, the most appropriate display application may turn out to be the UniViewer.

Rationale

There are numerous reasons why the sophisticated Third Generation enterprise workflow/worklist application is an absolute requirement for radiology as well as the

other imaging departments. The features and functionality that today's radiology groups need to increase their productivity are simply not provided in the current generation of department PACS, whether the worklist application itself is being provided by the PACS, the RIS or the RIS component of the EMR.

- The static filtered worklist can provide a measure of load balancing, but it cannot take into account, physician availability, sub-specialization and credentialing.
- The worklist doesn't include studies acquired in other facilities using another PACS, or allow the physician to use his preferred PACS to read a study managed by a disparate system.
- The PACS cannot identify and display relevant priors from other imaging departments.
- The R-PACS 2.0 model, being ten years old, is inherently inefficient. Thick and thin-client display technology severely compromises remote off-campus interpretation and reporting.

There is an urgent need to address the changes that are already impacting the healthcare organization's imaging departments and the various physician groups that are interpreting the studies. There is also an urgent need for a new generation of workflow/worklist application that is modular enough to be easily upgraded to meet the future challenges of medical imaging that we can only speculate about today. The present application suite needs to offer flexible deployment strategies including working with today's PACS 2.0 configurations, as well as being a key component of the emerging PACS 3.0 solution.

Conclusion

We have seen numerous reasons why the relatively simplistic workflow and worklist applications embedded in the current generation of department PACS are completely inadequate in today's healthcare environment and completely incapable of meeting the rigorous demands of tomorrow. Today we are entering the domain of the Third Generation Workflow/Worklist...the age of enterprise workflow, where IDNs are emerging as the dominant delivery model and there is a focus on the value of medical imaging as part of a multi-discipline care delivery. This is the beginning of the generation of enterprise worklists.

The nature of today's IDN easily creates the potential for the interpreting physician to be working at a site other than where the patient is being treated, creating the situation where the interpreting physician is reading from a PACS other than the one that originally acquired the study. The workflow application must be able to effectively and efficiently move image data around the enterprise, between disparate PACS. It is also quite common for an imaging department to have one or more specialty diagnostic display applications to supplement their core PACS solution. In this case, the workflow application must be capable of pre-staging the new and relevant prior image data on the

caches associated with the diagnostic or specialty application that is the most appropriate for the study type. These are actually the easiest requirements of a next generation workflow/ worklist application that was referred to in this paper as the Third Generation.

By far the more complex and difficult aspect of workflow is the creation of the individual physician worklist. The worklist must consider such input as: physician availability (schedule, locations, etc.), turn around time, physician RVU loading, sub-specialty reading, credentialing, critical results reporting, and peer review. Prioritization of the studies in the list must be dynamically adjusted in real-time to assure the contractually promised Turn around time.

The evolving future reality is that there will continue to be multiple groups struggling to distribute each imaging department's workload, trusting that their dynamic worklists have taken into account the ever-increasing complexity of study assignments and prioritization. These are the new table stakes for the future of medical imaging and the physician practice groups. None of the existing PACS solutions or RIS driven solutions can support the new workflow paradigms.

A standalone enterprise workflow / worklist application is not only a quick fix for the current generation of department PACS, it is also an essential component of the new PACS 3.0 configuration, where the Vendor Neutral Archive is at the center of data management and the various diagnostic display applications across all the imaging departments are simply "plug ins" to the VNA. In this PACS model, the Third Generation enterprise workflow/worklist application represents the brains of the operation.

When you consider all of the issues raised in this paper, it becomes abundantly clear that the time for a Third Generation enterprise workflow and worklist application is now.

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Michael Gray is principal of Gray Consulting, a consulting practice established in 1991 that has provided services to more than 100 healthcare organizations. Mike's areas of expertise include radiology and cardiology PACS, vendor neutral archives and clinical viewers that image-enable the EMR. He routinely publishes articles on his weblog at <http://www.graycons.com>. Mike has a BS in biology and chemistry from Washington University in St. Louis. He has been awarded three U.S. patents and has an extensive bibliography in medical image display and electronic information management systems. Mike and his family reside in Novato, California.