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Information Technologies for the Healthcare Delivery System

Gary Scialdone

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Information Technologies for the Healthcare Delivery System

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Master of Science in Information Technology

Information Technologies for the Health Care Delivery System

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Signature of Author:
Dedication

This degree is dedicated to Angela Scialdone, who gave me life and toughness,
to my teachers at PS #21 who taught me to reason,
to the friends of my youth who gave me community and a sense of belonging,
to Maureen McAndrews who helped me learn to live, and
to Alexander and Zachary Scialdone, two truly wonderful young men who provided me
with the privilege of being their father.
Thank you all.
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1. Purpose

That modern healthcare requires information technology to be efficient and fully effective is evident if one spends any time observing the delivery of institutional healthcare. Consider the observation of a practitioner of the discipline, David M. Eddy, MD, PhD, voiced in Clinical Decision Making, JAMA 263:1265-75, 1990,

“...All confirm what would be expected from common sense: The complexity of modern medicine exceeds the inherent limitations of the unaided human mind.”

The goal of this thesis is to identify the technological factors that are required to enable a fully sufficient application of information technology (IT) to the modern institutional practice of medicine. Perhaps the epitome of healthcare IT is the fully integrated, fully electronic patient medical record. Although, in 1991 the Institute of Medicine called for such a record to be standard technology by 2001, it has still not materialized. The author will argue that some of the technology and standards that are pre-requisite for this achievement have now arrived, while others are still evolving to fully sufficient levels.

The paper will concentrate primarily on the health care system in the United States, although much of what is contained is applicable to a large degree, around the world.

The paper will illustrate certain of these pre-requisite IT factors by discussing the actual installation of a major health care computer system at the University of Rochester Medical Center (URMC) in Rochester, New York. This system is a Picture Archiving and Communications System (PACS). As the name implies, PACS is a system of
capturing health care images in digital format, storing them and communicating them to users throughout the enterprise.

2. **Author’s qualifications**

The author has twenty-eight years of experience in health related organizations. Many of those years have been in senior management positions. The past three years have been in an IT management position, specifically responsible for the installation of a large enterprise PACS and other systems that affect patient care.

Invited members of the thesis committee are Rochester Institute of Technology, B. Thomas Golisano College of Computing and Information Sciences faculty members, Doctors Rayno Niemi and Anne Haake, and surgeon and Chief Medical Information Officer at the Strong Health System, University of Rochester Medical Center, David Krusch.
3. Introduction

3.1 Why optimizing the potential IT benefit to health care is important

Driving the need for realizing the full measure of benefit that can be derived from the application of IT to health care are two primary factors, patient safety and the cost of care.

Patient safety is compromised by the lack of effective, automated processes. Of course, health care decisions and actions can be of a critical nature. The difference between a transaction concluded in an accurate and timely manner and one concluded erroneously or delayed can be disability or death. To illustrate this point, consider the following:

- In November 1999, the Institute of Medicine (IOM), an advisory group associated with the National Academy of Sciences, estimated that 98,000 patients die each year through preventable medical errors. (Hagland, 2003)

- Because decisions are not always based upon scientific evidence, services are sometimes given to those who will not benefit from them, and are sometimes withheld from those who will. According to the Institute of Medicine, only 55% of Americans receive recommended medical care consistent with evidence based practice guidelines. (Hagland, 2003)

- Again from the IOM, more then 50% of those patients with chronic conditions have three or more providers, report often receiving conflicting information from these providers, undergo duplicate tests and procedures, and do not receive recommended care.
- The New England Journal of Medicine, in June 26 2003 stated that only little more than half of 7,528 adults surveyed for quality of care indicators had received the care that had been recommended by clinicians. (Marietti, 2003)

The cost of health care is a universal concern, and in some ways is a particularly acute problem in the United States economy. In September 1993, Lawrence Bell stated that:

- The United States spends the largest percentage of gross domestic product (GDP), nearly 14%, and has the highest per-capita annual cost for medical care of any advanced economy, while some 40 million citizens are without health insurance.

- Costa Rican and Cuban men outlive Americans, as do men and women in Japan, France, Italy, Singapore and Canada, all of which spend less than 10% of GDP on health care.

- A recent study published in the New England Journal of Medicine by Dr. Steffie Woolhandler at Harvard Medical School showed that the United States spends about $300 billion on health care administration, $1059 annually per person, versus $307 per person in Canada.

- In the U.S., $0.31 of every dollar spent on health care goes not to providers for the provision of services vs. $0.17 in Canada. This difference of $752 per year, per person, times each American, means that $213 billion each year could be available for spending on improved outcomes and accessibility, plus the saved time of clinical personnel freed from administrative tasks, all without increasing the percentage of GDP going to health care.
When discussing IT and healthcare today, one must also include mention of patient privacy and information security. Although these considerations are essentially matters of work process when handling patient health information (PHI), the advent of computer networks has provided vastly increased communication opportunities of PHI and therefore increased opportunities for a breach of confidentiality. The Federal government has addressed this issue with provisions of the Health Insurance Portability and Accountability Act of 1996 (HIPAA).

3.2 The Electronic Medical Record

Perhaps the epitome of the attainment of the full application of modern IT to the health care enterprise is what is known as the fully realized, electronic medical record (EMR). The literature references this concept under several different names that include electronic patient record (EPR), electronic health record (EHR), computerized patient record (CPR), etc. To date, realization of this goal has largely eluded healthcare. In 2003, Sensmeier wrote:

“More than a decade ago, the Committee on Improving the Patient Record, convened by the Institute of Medicine (IOM), set a goal to make the computer-based patient record (CPR) a standard technology in healthcare by 2001. The committee defined the CPR as, “an electronic patient record that resides in a system specifically designed to support users by providing accessibility to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids.”” (Sensmeier, 80, 2003)
In a recent New York Times article it was reported that only about 300 of the nation's 4,900 non-government hospitals have a computerized patient safety system, but only 40 have fully met the standards of the Leapfrog Group, a national organization of 150 employers and unions which was formed largely in response to the report by the IOM. “For a hospital to win its approval, Leapfrog - whose members provide health care for 34 million consumers - requires that 75 percent of doctors use an online system to order prescriptions and tests. Claire Turner, a Leapfrog spokeswoman, said that 118 more hospitals were expected to qualify this year, which would increase the total to just 3 percent of the nation's hospitals.” (Freudenheim, 2004)

Stated as an information technology and business rules goal, the purposes of an EMR might be written as:

We must facilitate and improve the efficient delivery and effective outcomes of healthcare by:

- Creating a rapid means of digitizing all patient data including
  - Encounter and admission information,
  - Practitioner order entry,
  - Diagnostic procedure results and interpretations, and
  - Progress recording,
- And by communicating this data as information, via a single computer user interface, to provide
  - Rapid access to all, complete and accurate patient data, for all authorized health care practitioners,
  - Cues and alerts to ensure that practitioners:
- Take appropriate actions in response to illness in a timely fashion, and
- Address situations that present health risks as they occur
  - Computer aided decision support to reduce errors of omission and false diagnostic and treatment conclusions, and
  - Practitioners with integrated access to current medical knowledge and protocols.

It must be noted that such an electronic patient record must have interfaces with supply chain management and billing processes in order to attain the full measure of efficiency. This paper will speak only briefly of these latter aspects as they are more like the IT processes common to every industry, as opposed to like those that are more unique to the delivery of healthcare.

### 3.3 Components of an Electronic Medical Record

In 2003, the Institute of Medicine was asked by the United States Department of Health and Human Services to provide key capabilities that could guide the IT industry in the development of a standards-based electronic health record (EHR). The IOM developed the following description.

An electronic health record contains the health records of hospitals, nursing homes, ambulatory clinics and individual practitioners. It is comprised of:

- A longitudinal collection of electronic health information for and about persons,
- Immediate electronic access to person and population level information by authorized users,
• The provision of knowledge and decision support that enhance safety and care, and
• Support of efficient processes for care delivery.

The IOM went on to define eight capabilities of the electronic health record as:

1. Health information and data
   - The EHR must provide immediate access to key information at the point of care, in multiple settings, to improve sound and timely decisions.
   - The user interface must not overwhelm the practitioner with too much data, but convert voluminous data to useful information.

2. Result management
   - The EHR must provide access to new and past test results.
   - Electronic results may deliver displays that enable better interpretation and easier detection of abnormalities.

3. Order management
   - The EHR must enable the entering and storage of physician orders with accuracy and speed. This function is usually known as Computer Physician Order Entry (CPOE).
   - The author would note here that order management should include electronic means to ensure that drug and other therapies are delivered as ordered without error.

4. Decision support
o The EHR must present reminders, prompts and alerts to improve compliance with the best clinical practices, identify drug interactions, and facilitate diagnosis and treatment decisions.

5. Electronic communication and connectivity

o The EHR must provide secure and timely communication among all authorized providers for the continuity of timely care.

o This may include e-mail, messaging and immediate, automatic notification of abnormal results.

6. Patient support

o The EHR must provide access to patients for education, at home monitoring and self-testing.

7. Administrative processes

o The EHR must provide functionality such as scheduling for tests and appointments with physicians.

o The author would add that the EHR must provide efficient interfaces with electronic supply chain management and billing systems.

8. Reporting

o The EHR must contain data standards for population health reporting and analysis.

3.4 Progress on the Electronic Medical Record To Date

As already noted, progress has been much slower than expected. To date, achievement of an electronic medical record has eluded most of the healthcare system.
• In 1991 the IOM stated that the electronic patient record was critical for patient safety and that it would be in place in the U.S. within ten years. In 2003 they again estimated implementation to occur within ten years.

• “A decade-long study of integration in leading integrated delivery networks (IDNs) across the nation, reports that information systems continue to be inadequate in the critical function of physician and clinical integration… information systems in many organizations are a ‘patchwork’ of applications on disparate platforms that have evolved over time, not a single, seamless, integrated application.” (Sensmeier, 80, 2003)

• “Only 7 to 10 percent of U.S. hospitals have made serious progress toward developing a CPR to support inpatient care. For those with a true CPOE, which is the touchstone, probably it’s more like 1 to 2 percent.” (Baldwin, 34, 2003)

• In response to the Healthcare Information and Management Society 13th annual leadership survey, Chief Information Officers of hospitals in the United States described the penetration of the CPR as shown on the following graph:

![Use of Computerized Patient Record in U.S. Hospitals](image)
When components of an electronic medical record are in place, results have confirmed the potential to improve healthcare.

- Hagland (2003) sites that implementation of CPOE alone at Maimonides Medical Center in Brooklyn, New York resulted in a 48% reduction in lab tests because physicians can determine what’s already been done at the point of care. It also resulted in a 20% reduction in other tests, a 58% reduction in medication discrepancies in which a physician or pharmacist intervenes in response to a perceived problem in the initial order, and a 55% reduction in transcription errors.

- Douglas Page reports that a study in the Journal of the American Medical Informatics Association (2002; 9[5]: 529-539) showed that implementations of CPOE eliminated errors due to handwritten prescriptions, cut turnaround time for x-rays from 7.5 hours to 4.3 hours (43%), reduced medication turnaround times, and reduced lab test times by 25%.

3.5 Why Progress Has Been Slow

Sensmeir (2003) has postulated several reasons for the failure of the electronic medical record to materialize. These include:

- A lack of integrated systems,

- Islands of data exist within specialties such as radiology, cardiology and pharmacy, each with their unique requirements that are difficult to connect. For example, radiology is dependent on imaging as a diagnostic tool, and typical healthcare information systems cannot support integration between digital images and other structured data formats. Cardiology data includes three-dimensional
waveforms, which are accessible only via stand-alone systems. Pharmacy systems are being connected with medication management systems, but the implications for work flow and the lack of standardization for this type of documentation makes integration a difficult challenge. (Sensmeier, 80, 2003)

- A lack of standardization,
- The complexity and cost of healthcare systems,
- The challenges of demonstrating return on investment, and
- A limited amount of capital. “The typical healthcare organization spends approximately 2% of its capital budget on IT, as compared with an average of 10% in other industries.” (Sensmeier, 82, 2003)

One should note that in late 2003, the healthcare information technology market was identified as recognizing its need to invest. In fact it was identified as out-performing all other segments of the technology industry according to Sheldon I. Dorenfest & Associates, a provider of health care market data. This growth is led by PACS and CPOE buying, as well as computerized patient record, document management and clinical department systems. (Peterson, 1, 2003) Available capital, however, may be lacking.

“President Bush asked Congress for $100 million in next year's budget to finance demonstration projects promoting the use of information technology to improve health care quality. He recently called a group of purchasers and providers of health care to the White House to follow up on the proposal. Senator Kerry, for his part, is calling for enhanced federal reimbursements to help install computerized patient safety systems in every hospital by the end of the decade.
But no one has proposed spending the $20 billion or more it would cost to meet that goal... The initial cost for an average-size hospital to install a system was estimated at $7.9 million, including hardware, software licenses and other expenses, in a study last year for the American Hospital Association and the Federation of American Hospitals by the First Consulting Group of Long Beach, Calif. Continuing costs average $1.34 million a year.” (Freudenheimer, 2004)

To the list of barriers to the realization of the full benefit of IT in healthcare, the author would add the idea that a number of information technologies and technological factors needed to emerge, evolve and converge before the objectives of healthcare IT could be achieved.

3.6 Prognosis for the Future

Progress going forward will depend upon:

- The will of providers to restructure and succeed,
- Systemic changes,

  - Hagland (2003) expresses that “The main problem isn’t technology. It’s the system-which requires transformation of work flow and care processes.” He goes on to explain that, in one key application, “E-prescribing is really the tip of the iceberg in knowledge based medication management. Once you begin to e-prescribe you see that you are not just digitizing a prescription pad, but rather entering patient’s recent history, recalls, interaction and allergy checks, perhaps other indications such as patient weight, co-morbid conditions and such. You’re actually spending
time and effort creating better input. So you are fundamentally changing what docs do.” The author contends that this is true for all major clinical IT systems.

The ability of health care providers to invest,

- In 2004, Ernst & Young described health care’s access to capital as severely limited. At the same time they have stated that in order for health care to succeed, significant investments are required to compete for scarce labor and to fulfill IT needs. Ernst and Young opines that although historically an under investor in technology, health care companies are for the first time making major commitments to information systems. In fact, compared to other industries, healthcare is expected to show the strongest IT spending growth in the coming year. Leading drivers include patient safety improvement, reduced cost of care delivery, and integration of systems so that clinical information flows seamlessly across the continuum of care. Over 60% of CEOs interviewed plan to invest in some type of clinical/CPOE system in next two years. Additionally, supply chain performance is moving rapidly onto the agenda of hospital’s executive management.

And the evolution of affordable, efficient technologies,

It is this last requirement that is the primary topic for this paper.
4. Technological Factors

So what technological factors are required? The author suggests that all of the factors may be categorized into the following groups.

- Sufficient, affordable hardware and software systems and components,
- Standards,
- Proven interfaces that must not be uniquely written between every clinical information system,
- A common user interface that delivers all information for the desired patient context, and
- Work flow engineering.

4.1 Sufficient, affordable hardware and software components

In order for healthcare to realize the full benefit of IT, certain hardware and software needed to become sufficiently available at affordable price points to allow the expansion of their use throughout the industry. Recent years have seen the development of many of these and the author believes that they will soon be sufficiently available to support a significant emergence of the EMR within the decade. This paper intends only to highlight some of the factors that make healthcare somewhat unique among other industries. These include:

- Monitors
- Workstations
- Storage
- Wireless Devices
- Transmission technologies
- Databases
- High availability, and
- Web-based systems

4.1.1 Monitors

Factors that need to be considered to make an effective choice of monitors include:

- Resolution, luminance, refresh rate and other technical factors,
- Gray-scale vs. color,
- Total cost of ownership, and
- Portability.

Radiology imaging presents the largest challenge for health care information display. Until recently, sufficient monitors were thought to be at a resolution of three mega pixels or higher, and at least 20 inches in diagonal measure. At a cost anywhere near affordable on a large scale, they were, until recently, CRT monitors as well. As such they were heavy, hot, expensive to buy, difficult to keep calibrated, and had short lives. LCD monitors are now becoming competitive in purchase price and certainly in total cost of ownership to CRT monitors. They offer longer lives, automated calibration systems, increased brightness and other advantages.
As radiologists gained experience with the ability of digital workstations to manipulate an image as to window and level (similar to brightness and contrast on a television screen), magnification, panning and other aspects, they learned that two or even one mega pixel monitors were sufficient for most diagnostic reading, with the primary exception of digital mammography. (Herron, Bender, Campbell, Sumkin, Rockette, & Gur, 2000) Digital mammography requires detection of extremely small and subtle abnormalities. Monitors of approximately five mega pixels are currently thought to be necessary for diagnostic reading of mammograms.

Initially radiologists wanted banks of at least four diagnostic quality monitors per workstation to provide sufficient screen area to read and compare current and prior studies. Today, most radiologists are satisfied with a bank of two diagnostic quality monitors per workstation. Increasingly a third, smaller, lower resolution, color monitor is used to display color as needed, and to display other applications, such as the radiology information system, report writing application, etc. during a work session.

Something that has not changed is that most higher native resolution radiographic images are thought to be of diagnostic quality only on gray scale monitors. This is because the human eye can discern finer differences in the gray scale than it can among colors. (http://www.sh.lsuhsc.edu/radiology/Downloads/040105%20Display%20Characteristics.ppt) Having said this, some modalities, ultrasound, nuclear medicine, fluoroscopy and angiography for example, make diagnostic use of color images. As 3D imaging and other advances progress, the use of color for clinical purposes is likely to increase.
In 2003, IBM released the first color, flat panel, LCD monitor that meets or exceeds all of the capabilities expected from diagnostic quality, grayscale displays. More are likely close behind. There are no binding regulations that specify capabilities that diagnostic quality monitors must have, although several health care bodies have made recommendations. (http://www.acr.org/departments/stand_accred/standards/pdf/teleradiology.pdf) To illustrate, the IBM monitor promotional materials site the following qualifications for diagnostic monitors:

- High resolution, up to 5 mega pixels per image, (the IBM unit can display at up to 9 mega pixels)

- Display low contrast features at a minimum of 50 foot-Lamberts (the IBM monitor luminance is rated at 70 foot-Lamberts)

- Can be calibrated to a standard grayscale display function (GSDF) with a high degree of accuracy and based upon the display’s minimum and maximum luminance. This may be accomplished by generating thousands of shades of gray. Although typically only 256 shades are used, this allows choosing the best 256 to shades to fit the GSDF curve. Previous commercial-grade, color, LCD monitors could only offer 256 shades. This resulted in an average calibration error of up to 2.0 just noticeable differences (JND) versus the recommended medical grade of 0.3 JND (the IBM monitor delivers 0.4 JND)

- Pixel density of native radiography is about 145 pixels per inch (ppi). Most commercial monitors display only 100 ppi, so a radiological image must be
minified. Conversely, to see the image at full resolution it must be viewed at a size larger than life size. (The IBM monitor displays 200 ppi)

Diagnostic monitors are not direct substitutes for images on film. Monitors for the display of images that must have consistent meaning, require regular calibration to a common standard. Grayscale standards have been developed over the years. Physicians have learned to assign meaning to images under the assumption that these standards are maintained and that deviations may signal abnormality. Volatile displays for images that can be processed on-line have been set adrift somewhat from these standards. Also, maximum brightness of a monitor is about one order of magnitude less than a typical view box. Monitor variants also include contrast ratio across a large area of screen, detail contrast ratio, color of light, phosphor decay, pixel halo, monitor size and aspect. (Arenson, Chakraborty, Dev, Seshadri & Kundel, 2003)

Diagnostic quality monitors are accepted as an absolute necessity for radiologists. Most referring physicians begin their thinking about monitors by assuming that they want exactly what the radiologists have. Experience has shown that this may not always be necessary. Many referring physicians may not require high-resolution, large, grayscale monitors for their medical management decisions and other purposes. Because most referring physicians rely on a combination of radiologist reports of findings, as well as the images themselves, they can often make their decisions using monitors that provide clear anatomical features as opposed to the full resolution detail required for diagnosis. Having said this, there are indeed non-radiologists who are very image-dependant for their decision-making. The choice of monitor characteristics must be a case-by-case, or at least a sub-specialty-by-sub-specialty, physician decision.
Purchase cost is a very real consideration given that a large medical center may have from 40 to 120 diagnostic monitors, and many more monitors used to display images to one thousand or more referring physicians, and tens of thousands of patients. Smaller institutions have a need for fewer monitors, but have smaller capital and IT support budgets as well. To illustrate today’s monitor costs, consider a bid that was obtained from a leading PACS manufacturer during 2004. Recognize that monitor costs have been coming down rapidly in recent months. A three-mega pixel, flat panel, LCD, diagnostic, grayscale monitor was quoted at the vendor’s cost of $5,000 if purchased with the PACS. Similar monitors cost as much as $14,000 in 2003.

Location of monitors is another limiting consideration. Radiologists typically work in suites that, to a greater or lesser extent, are designed with some consideration as to ambient lighting and the workflow that resulted from generations of reading studies on film. These suites are slowly being retrofitted to the workflow that results from digital reading. Throughout the rest of the healthcare enterprise, monitors are best located wherever the physicians are that use them. Physicians, of course, move about during their workday, and they require information wherever they are. These locations include each patient bedside, or other point of care delivery locations. Ideally then, the enterprise would benefit from portable monitors that, although small and light weight, would be capable of delivering at least key images in sufficient resolution and with lighting adequate to describe salient points of a radiologist’s findings. Such portable displays are still disappointing for most health images.
4.1.2 Workstations

Physician workstations that are flexible in that they can be used for multiple applications, and have interfaces that are designed from the users' requirements, have yet to become widely available in healthcare. From the perspectives of user interfaces that facilitate optimal physician productivity and physical design for the ergonomic considerations of spending hours each day at a workstation, much still needs to be done.

Until recently, little consideration was given to building workstations that could be run on standard PCs and that could run a variety of clinical and business applications simultaneously. Too often workstations are built as proprietary platforms with high performance requirements and high, per seat licensing costs.

Complicating the evolution of flexible workstations is the increasing complexity of radiology imaging. The size of files is growing at alarmingly rapid rate. (Siegel & Reiner, 2003) Today’s cross-sectional imaging can be processed accurately to yield an “infinite” number of static images and 3D renditions of body organs and systems. This is requiring rapid redesign of viewing systems and increased processing power at diagnostic workstations. This development will also increase the demand for computer aided diagnostic programs to be integrated on the desktop to assist radiologists in confronting a tsunami of digital data and information heading their way.

4.1.3 Storage

In a busy hospital, the amount of information generated for storage, led of course by imaging, is very large. On average, sizes of some health images is displayed on the following chart:
<table>
<thead>
<tr>
<th>Digital image</th>
<th>Number of images</th>
<th>Size of image file (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>20 - 230</td>
<td>16-180</td>
</tr>
<tr>
<td>Computer tomography (Unprocessed)</td>
<td>40-2000+</td>
<td>20-2000</td>
</tr>
<tr>
<td>Digital mammography (processed)</td>
<td>4</td>
<td>500</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>2</td>
<td>16</td>
</tr>
</tbody>
</table>

These numbers are quickly becoming obsolete as health care moves to sophisticated, volumetric imaging in which an ""infinite"" number of images can be produced from cross-sectional scans that can produce accurate images in any plane in 3D renderings.

Typically institutions are storing all data at approximately 2:1, lossless compression. Although there is research that supports the position that certain image types are of equal diagnostic value at lossy compressions of as great as 10:1 and greater, the legal-medical establishment has not yet come to widely accept this practice. (Erikson, Bradley J, 2000) When that does come to pass, storage archives will likely be required to intelligently compress various image types at levels of irreversible compression at various times in their shelf life. In New York State, all radiology images must be kept for at least seven years. Pediatric images must be kept for at least seven years, and until the age of majority of the patient.

The University of Rochester Medical Center is currently producing about 12 TB of image data, uncompressed, annually. The existing image store is over 35 TB. In 2001, the Mayo Foundation Department of Informatics estimated their five-year data storage requirement at 800 TB uncompressed for their multi-hospital system. These numbers are not complete. There are still image capture devices that are not yet converted to digital.
Nor are visible light images yet being stored digitally. When Mayo figures in all of the new digital imaging that they expect to introduce over the five-year period, their estimated need goes well into the Petabyte ($10^{15}$) range. To this must be added the requirement to replicate data in some fashion for disaster recovery, or preferably continuation of business purposes. (Erikson et al., 2001)

To compare healthcare to other industries, consider the data warehouse of AT&T labs. That warehouse, split between two data centers, holds two years of detailed records of long-distance phone calls that traverse the AT&T network. In its raw form the data would amount to 96 TB. Compressed to 26.3 TB, this database is considered to be one of the largest in the world. (McGee, 2004)

Storing this data for many years (typically seven years in the case of adults, to the age of majority in children and indefinitely in mammography) is a daunting task. Managing access to it in the manner required by the vision of the EMR is another. At Mayo, Erikson describes the performance requirements of an image archive as having to: (Erikson et al., 2001)

- Handle all daily incoming volume without impeding operation of busy image capture devices as images are generated,
- Handle at least 300 imaging devices with up to 100 simultaneous incoming archive associations active at a given time, regardless of the number of retrieve associations that may be active,
- Manage incoming transactions for all image types, while providing a successful storage commitment message to the image capture devices, and handling text interfaces for patient demographic information transfer,
• Manage retrieval volume up to at least 1229 transactions per hour, from at least 300 retrieve devices, with up to 100 simultaneous retrieve associations at a given time, regardless of the number of incoming storage associations that may be active,

• Provide a retrieval rate to the user workstation that is “reasonable” at the busiest hour, and that allows the user to be set at prioritization levels of high, medium and low, (typically the expectation is for the first image in a series to display in full resolution in less than 3 seconds)

• Once retrieval is begun, send data at a mean rate of 5 MB/sec,

• Provide data compression and decompression at variable rates of lossless and lossy, by image type and date of study,

• Allow legacy data to be migrated in and out,

• Provide security as to what devices can store to it, who can access it and who can change data,

• Perform reliably with no single point of failure, employ fail-over technology, bit-by-bit confirmation of what goes in is what comes out, multiple time-stamped copies to protect against errant software, and in case of multi-site disaster, restore studies that are less than two years old in 24 hours, and all older studies in seventy-two hours,

• Keep correct, most up to date demographic data attached to the study with all changes recorded,
• Keep the radiology information system synchronized with what stage the procedure is in and what has been stored,

• Store graphical information, annotations, and key images sent by users at all workstations,

• Maintain re-archiving parameters for data integrity when a study is received a second time, but in an altered state,

• Provide administrative access to remove and change studies, etc.

• Provide automatic monitoring for performance and maintain service logs.

Of course storage in healthcare has not yet performed fully at these levels.

Historically in healthcare as in many other industries, each individual computer system has had its own isolated storage environment. (Butler, 2000) Typically this has been direct attached storage (DAS) to an application specific server. This makes the content of an electronic patient record difficult to manage, protect and share.

For storage to meet the needs of healthcare, data from multiple sources, in multiple file formats, must be securely stored and repeatedly distributed quickly. The previous high volume storage standards of other industries, like digital linear tape (DLT) jukeboxes in banking, proved poorly suited for the large data sets, like imaging and the sharing of the information that results from a very large number of patient transactions. Retrieval time was much too slow and device downtime too high.

For these reasons, network attached storage banks (NAS) and storage area networks (SAN) are filling a void in healthcare IT infrastructure. These technologies
address the coordination and management of systems data, management of multiple connections, and rational, centralized backup that the electronic health record requires.

Of particular interest is the SAN. A SAN is a high-speed, special-purpose network that connects different kinds of data storage devices (disc, tape, CD-Rom, DVD, etc.) with associated data servers. The disc arrays are their own component within the configuration, and the data can be shared across multiple servers and across multiple applications. SANs use a dedicated high-speed network such as fibre channel. Vendors are creating highly reliable, sophisticated systems with fast continuation of business capability. Through approaches such as SAN, healthcare can now realize the storage of many terabytes of new data annually online, including large image files, coupled with real-time access to years of historical, fixed content information. (Seabolt, Long, & Hall, 2003)

While new storage strategies have been developing, the cost and capacity of spinning disk has been dropping and compression technologies improving, making high performance storage more affordable.

4.1.4 Wireless devices

As with the discussion of monitors above, wireless technology is of interest in its ability to follow the healthcare practitioner as their physical location changes throughout their workday, including to the patient bedside and other points of care delivery.

The use of personal digital assistants, tablet PCs, etc. with wide area network capability is still quite new in a hospital environment.
• In one study of wireless (802.11b) enabled PDAs and portable computers, issues that have been encountered and must be overcome include: (Siddiqui, Scopelliti, & Emge, 2003)

• Average network speed of 2 Mbps,

• Limited portability of tablets and even PDAs with WLAN expansion pack/antenna and extra or extended batteries,

• Short battery life,

• Physician preference for voice recognition to handwriting for navigation,

• Images good mostly only to assess adequacy of study completion on PDA,

• Integration of all applications including image viewer,

• Pen-based image navigation difficult,

• And of course security of patient specific information. 4.1.5 Transmission technologies

4.1.5 Transmission technologies

In 1989, a paper in the International Journal of Optical Engineering described a kind of cycle of demands on a clinical network within the healthcare setting:(Mun et al., 1989)

• Demands that physicians place on purveyors of diagnostic information

• Consultation (dialogue) with specialists about what diagnostic techniques may be helpful
- Scheduling the procedures
- Reporting status of procedures
- Reporting of findings and diagnoses
- More consultation

Throughout this process the author stressed that person to person contact must be maintained between physicians in real time. Delays adversely affect quality of care.

Comparing the requirements with the capabilities of the network available to them in 1989, the authors concluded that there needed to be a three to ten times improvement in transmission technologies before the needs could begin to be satisfied. These authors were working with fiber optic cable network backbones at 40 Mbps and were attempting teleradiology practice to remote sites via a T1 line at 1.5 Mbps.

Using radiology as the extreme case for IT demands, a radiologist in 1989 was reading, annually, 50,000 images in 1500 hours of film reading time out of a total of 2200 hours of work. The radiologist was reading 33 images per hour at a rate of thirty seconds for each film, and under tremendous pressure to get to the next case. Until network speeds (100 Mbps Ethernet, Gbps Ethernet) and other transmission technologies (streaming algorithms, JPEG 2000 compression) became facile enough, healthcare attempted to accomplish this task by pre-fetching current studies and associated prior studies needed for clinical comparison to workstations or work group servers where the radiologists were expected to be. Although this worked with varying degrees of effectiveness for radiologists, it could not work for all of the practitioners within the enterprise whose location and time of need are much less predictable.
4.1.6 Database

Again, the healthcare enterprise is a hodgepodge of different applications using different database management systems.

Commercial acceptance and wide deployment of relational databases using Structured Query Language (SQL) was not achieved until the 1980s. (Hoeffer, Prescott & McFadden, 26, 2002) This was required to provide some ease of access to large sets of data to non-computer-programmers. During the 90s client/server architecture, data warehousing and Internet applications grew in capability to deal with large, increasingly complex data sets such as those found in health care. In 2000 the concept of object oriented, relational databases takes healthcare a further step toward better mastery of complex, multi-media databases.

The nature of healthcare is highly distributed so the database solution must operate at least to some degree on a distributed basis as well. For the EMR to be realized however, databases need to be able to be rapidly integrated regardless of their physical location. Distributed solutions need to be scalable linearly with the growth of volume stored and the number of concurrent and serial requests received. Goals for the database can be measured in transaction response times, data availability, and data concurrency as it is acted upon in multiple locations simultaneously. (Cheung, Barker, Camorlinga, & Rueda, 2003) The development of working, distributed databases sufficient to the requirements of an EMR is a work in progress.
4.1.7 High Availability

Healthcare requires an IT system that is characterized by high availability of services. As with everything that is healthcare and IT, it must be deliverable within affordable costs. This cost restraint makes it difficult to obtain a system that attains high availability solely through the availability of dual or redundant, replacement critical components alone, essentially doubling all hardware costs.

This topic serves as a good illustration of the computing power and sophistication that needs to become affordably available in order for healthcare to realize a full measure of the benefit of information technology.

High availability in healthcare has been able to take advantage of the growing performance in technologies that cluster switches, servers and software processes to provide not only some assistance in the event of a failure within a device, but:

- Rapid fail-over that is reasonably transparent to a user of the system, and
- Performance enhancement by network traffic load balancing among clustered devices.

As with many of the terms that come into vogue for describing rapidly evolving information technologies, there is no standard definition of high availability. The opposite of availability is downtime. For the purposes of this discussion, we will define downtime as the percentage of time that a system is unavailable at acceptable performance levels, including all downtime, whether as a result of unplanned technical malfunctions, planned maintenance and upgrades, or disasters.
The author has heard discussions among colleagues in which it was stated that healthcare organizations must have 99.999% of reliability for mission critical systems. In practice, however, an organization must finally define for itself:

- The outcomes that it considers to be mission critical,
- The percentage of time that the organization can tolerate the absence of these outcomes, and
- The processes, both manual and electronic, that must be kept available in order to maintain those outcomes.

In order to define what mission critical means to an organization, one must ask, “What is the cost of downtime?” Health care operations may sometimes measure downtime in lives. Adding availability however may require financial cost that may be beyond the organization’s ability to pay. The organization may also consider that it may tolerate a period of downtime by substituting a manual process for a failed electronic one, even if the speed of mission critical transactions may be slower.

To provide some context for the downtime decision, in October 2001 the following data was reported on the availability of some American web sites. (Windows & .net magazine)

<table>
<thead>
<tr>
<th>Web Site</th>
<th>Percent availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBI</td>
<td>99.24</td>
</tr>
<tr>
<td>Library of Congress</td>
<td>99.96</td>
</tr>
<tr>
<td>Supreme Court</td>
<td>99.62</td>
</tr>
<tr>
<td>Top 10 shopping sites, e.g. Nordstrom, Neiman Marcus, Saks</td>
<td>99.5</td>
</tr>
<tr>
<td>Fifth Avenue</td>
<td></td>
</tr>
</tbody>
</table>
In the table below, consider what the percent of system availability means in terms of interruptions to operations in time, if downtime were evenly distributed over a one-year period.

<table>
<thead>
<tr>
<th>Percent available</th>
<th>Time per month</th>
<th>Time per year</th>
<th>Web site examples</th>
<th>Cost of downtime</th>
<th>Cost of ensuring desired availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>98%</td>
<td>14 hr. 36 min.</td>
<td>175 hr. 12 min.</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>99%</td>
<td>7 hr. 18 min.</td>
<td>87 hr. 36 min.</td>
<td>FBI</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>99.5%</td>
<td>3 hr. 39 min.</td>
<td>43 hr. 48 min.</td>
<td>Nordstrom</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>99.9%</td>
<td>43 min.</td>
<td>8 hr. 46 min.</td>
<td>Supreme Court</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>99.99%</td>
<td>4 min.</td>
<td>53 min.</td>
<td>Library of Congress</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>99.999%</td>
<td>26 sec.</td>
<td>5 min.</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

The organization-specific computations of cost in the table above are critical to determine the value of downtime to the organization and a cost for acquiring the systems that will ensure the desired percentage availability. Decision makers must realize that the downtimes in the table above may not be distributed evenly over the course of a month or year. Also, downtime of critical sub-components of a system each have their own distribution pattern and characteristics that may relate in ways that is difficult to predict.

To completely estimate a period of downtime, one must recognize that following any technical outage, there results a period of restoration. (Windows & .net magazine) This may viewed in phases as:

- Diagnosis
- Procurement if replacement hardware or software is necessary to restoration of service
- Configuration
- Restoration of files and data from media
- Verification of data integrity and production level performance

The times that each of these phases takes to complete contributes to the total downtime.

To address the need to streamline these processes, a continuum of high availability technologies have evolved. (Connor, 2003) These include:

- Availability of cold and hot redundant devices,
- Data partitioning, in which segments of data are stored across more than one server. The user sees a single file directory. Time is saved because only a portion of the data needs to be restored if a server fails,
- Snapshot backup and restore, in which faster storage technology, such as Storage Area Networks (SAN) with fibre channel connectivity are employed to save time in data restoration,
- Fault tolerant systems, in which fault tolerant and redundant components such as servers, network cards, storage, uninterruptible power supplies, switches, power units; all with fail-over capability, are combined,
- Data replication over several physical locations with single logical view of the data,
- Redundant servers that contain the entire database through file replication processes,
- RAID 1 mirroring and RAID 5 stripping,
- Server clustering with short delay fail-over while applications sessions reconnect to a new server,
- Network Load Balancing for mirrored/clustered servers,
- Network Load Balancing and fail-over through the use of content switches.

The last three bullets in the continuum are technologies that need to reach a level of maturity before the EMR could be fully realized. The intended result of these technologies is to take the time required by all of the restoration phases out of the downtime calculation entirely. The section below describes the complexity of this technology and the computing power that was required before this could be done well and affordably.

Windows Cluster Service is a form of software-based fail over. Other operating systems have comparable services. Windows provides fail-over capability through a rather complex system of software-based device communication and replication processes. Clustered resources can include physical hardware such as disk drives and network cards, and logical items such as IP addresses, applications and application databases. The collection of like resources into a cluster creates a single logical resource with fail over capability. Upon failure of a clustered device, the user might experience a temporary degradation in service, but would not lose access. (Windows 2000 Clustering Technologies)
Windows Network Load Balancing (NLB) is a software-based load balancing technology. It was designed to scale services across multiple server nodes in a cluster. NLB uses statistical mapping to look at the source IP addresses and source ports of incoming packets of data and match them to a destination based upon how busy each node in the system is. All of the nodes in a system perform this process in parallel. The node identification that matches will accept the packet, while all others drop it. The mapping may also be set to look only at the source IP, thus enabling the direction of all packets from a single source to certain nodes in the cluster. Node ID priorities and fail over IDs are set by the administrator. (Network Load Balancing)
Content switching is a form of hardware controlled fail over and load balancing. It uses devices that perform forwarding of packets based upon information typically from OSI layer numbers 2,3, and 4 through 7. (Appendix 1) The intent of content switching is to scale server capacity dynamically to match aggregate client demand, while ensuring continuous service availability. (Microsoft Corporation) Load balancing switches provide the infrastructure to:

- Scale application-processing power,
- Maximize server efficiency, and
- Ensure high application availability.

Content switching performs its load balancing and fail over functions with hardware as opposed to earlier generation technology that are PC based software products.
with limited performance, flexibility and connectivity for the rapid growth that we are
experiencing in our reliance on mission critical hardware and applications.

Content rules specify what packet patterns are to be matched and what actions are
to be applied. Variables may be either header fields, sub-strings inside the content, XML
tag sequences, or supported string functions. Clusters of servers may be running a
common, or several common applications.

In addition to server load balancing and multi-layer switching, content switching
seeks to consolidate multiple functions. Examples are redirecting traffic to caches, load
balancing traffic across multiple firewalls, packet filtering and bandwidth management.
The functions of a content switch can be many and flexible: (The Next Step in Server
Load Balancing, 1999) (Chow, Godavari & Xie, 2002)

- A content switch may assign a session to a real server and then recognize all
  subsequent packets associated with that session for the duration of the session.

- Special mechanisms can be invoked to send subsequent sessions to the same
  physical server.

- The switch also monitors the health of physical devices and will route to alternate
devices upon failure. Real server health monitoring will ensure that connections
are bound only to healthy servers. When a piece of hardware or a software
process fails, all existing sessions are removed from that device so that users
experience minimal delay.

- When a server recovers it is brought back on line slowly so as not to overwhelm
it.
Different server types, Unix, Windows, etc. can be combined within a cluster to host the same application.

Traffic can be routed to the least utilized server, or to the server best configured to handle particular types of requests.

Preferred customers and mission critical applications traffic can be given higher priority.

Bandwidth management can also be configured to provide predictable quality of service to priority users and applications. Such traffic management can also be controlled in a variable fashion over different time periods.

To allow database servers to keep up with aggregate requests from multiple application servers, back-end servers can connect to a higher speed switch port than the application servers. The same content switch platform allows clients to access application servers through layer 4 switching, while allowing application servers to access the database server through layer 2 or 3 switching.

Multiple content switches can operate in an active-active configuration to ensure usable performance and capacity. Should one switch fail, only half of the user sessions to the system are effected.

The content switch is really a front-end processor to clusters of real servers that are connected to each other directly or indirectly, in close proximity or in geographically dispersed locations. Load balancing thousands or tens of thousands of connections per second, over dozens of real servers, requires a vast amount of processing capacity and memory. To address this computational need for content switching, sufficiently powerful
and affordable microprocessors needed to be developed. Typically, multiple specialized processors are required within a content switch to manage the computations required quickly. (The Next Step in Server Load Balancing, 1999)

As high availability technologies have evolved, healthcare has been able to take advantage of the growth in processing power and reduction in processing cost to achieve reliability goals. The evolution has proceeded from cold redundancy of devices to active-active, redundant front end intelligence in the form of content switches that mine each packet for the information required to deliver granular networked services.

Whether performed by devices such as content switches or by specialized, application specific software, healthcare applications and their internal software processes must be automatically monitored to ensure that failures or precursors to failures such as slowed processing or inordinately large queues of transactions are detected and corrected in real-time. This capability has also grown in recent years and is essential to realization of the effective EMR.

4.1.8 Web based systems

The healthcare enterprise is a highly distributed process across both time and space. While client-server technology was a great boon to distributing information, it was inadequately scalable and affordable for the full measure of healthcare information transactions and exchanges. The advent of the World Wide Web brought a ubiquitous platform that was truly scalable to all healthcare information users, where and when information is needed. The growth of the Internet and improvements in efficient and secure transmission means such as Secure Socket Layer, public-private security key certificates and Virtual Private Networks led to a rush to create browser-based user
interfaces for all prevalent healthcare applications. That work continues today as personal computers have grown affordably powerful enough to support even image viewing applications on a browser with only minimal downloads of ActiveX controls or JAVA applets to create a sufficiently able, thin-client platform.
4.2 Business Process Fusion

Business process fusion (BPF) describes an effort to improve the joint performance of disparate information systems within an enterprise. A real-time, enterprise-wide, seemingly singular information system can only be fully achieved if local, partial processes are streamlined and linked into end-to-end business processes. (Flint, 2003) If this is done among real-world business processes, as documented by valid workflow analysis, then BPF can provide the technical means to integrate processes, mapping those processes to information systems effectively.

Successful BPF requires adherence to four principles of change:

- Focus on end-to-end business processes. Do not tolerate a silo-based culture that defers to the power of departmental managerial practices and governance. Failure to eliminate such practices will continue to produce fractured processes.

- IT managers must communicate effectively regarding the specific business vision, refraining from generalities and techno-speak.

- Establish enterprise-wide, collaborative governance mechanisms to mitigate the narrow views that can result from departmental differences.

- Enable IT to select and support emerging technologies that further systems integration.

When one begins to address any problem, it may help to know how you got into this trouble to begin with. And, for fractured departmental practices and information systems, consider the following passage from Genesis 11:4-9:
“And they said, "Go to, let us build a city and a tower, whose top may reach unto heaven; and let us make us a name, lest we be scattered abroad upon the face of the whole earth." And the Lord came down to see the city and the tower, which the children of men builded. And the Lord said, "Behold, the people is one, and they have all one language; and this they begin to do: and now nothing will be restrained from them, which they have imagined to do. Go to, let us go down, and there confound their language, that they may not understand one another’s speech." So the Lord scattered them abroad from thence upon the face of the earth: and they left off to build the city. Therefore is the name of it called Babel; because the Lord did there confound the language of all the earth: and from thence did the Lord scatter them abroad upon the face of all the earth”

Business process fusion can serve the goals of commercial organizations by seeking to achieve systems integration. Its focus is on achieving and maintaining information unification in the face of applications that are constantly changing. It can be thought of as comprised of standards and standardizing efforts such as:

- Standards that establish common ground regarding information exchange between applications and organizations,
- Proven interfaces that ideally, do not need to be uniquely written between every clinical information system,
- A common user interface that delivers to the user’s desktop, all information for the desired customer, task or patient centered context.

In the past, achieving BPF required high expense, high risk, and relied upon highly skilled people writing customized solutions between applications and processes.
Only now are products emerging to enable achieving this end with lower cost, lower risk and increased ease. (Phifer, Hayward & Flint, 2003) This is being made possible through some key IT concepts:

- System integration must achieve the scope of managing end-to-end processes within an organization or industry,

- New system integration products must include a focus on explicitly representing processes within an industry and across as many industries as possible. No longer should integration mechanisms for applications be developed independently with a focus solely on heterogeneous information models. The content of the business processes within like organizations must be described independently from the applications. We will see this approach exemplified for healthcare in this section by an effort called Integrating the Healthcare Enterprise (IHE), and reflected in other healthcare standards and standardizing efforts as well.

- Integration mechanisms must display back-end data, to users in a way that is pertinent to the user’s intended context. For example, in this section we will discuss the Health Level 7, Clinical Context Object Working Group standard that is intended to bring all patient data that is pertinent to that patient’s current healthcare encounter and user’s purpose, to the user’s desktop.

- Applications must be made mutable to accommodate organizational changes. One could say that maximum flexibility is achieved by developing application interfaces from scratch, but as we have observed, this is also a most difficult, expensive and time-consuming way to achieve this end. Instead organizations have sought to use packaged integration software called integration engines to
bring together established systems. Today, web services using service-oriented architecture, and design-time service assembly and orchestration efforts using re-usable, industry specific principles, such as Integrating the Healthcare Enterprise are vying to replace uniquely customized interfaces.

4.2.1 Workflow Engineering

The start of any IT-related design effort aimed at increasing efficiency and productivity must be to review business rules, involved people’s expectations and existing work processes. (Whitten & Bently 42-47, 1998) A simple but true axiom is that automated inefficiency is still inefficiency.

There exists a persistent and growing work process problem within healthcare organizations. Complicated by inadequately integrated installations of segregated IT systems, work process is often tangled and plagued by redundancies. As new systems are added, care must be taken to avoid further deterioration of work processes. Significant emphasis must be placed on simplifying and improving workflow parallel to application selection and deployment. (Peterson, 2, 2003) Institutional healthcare is also plagued by a high degree of departmental compartmentalization, or a culture of semi-independent silos, apt not to function as a whole with maximum effort of all staff devoted to common goals.

Studies of radiology workflow at the Veterans Hospital in Baltimore resulted in the conclusion that, “The most important lesson has undoubtedly been that the purchase of a PACS provides an opportunity to re-engineer and streamline the inefficient manual workflow found in most conventional imaging departments.” (Siegel & Reiner, 2003) (A PACS is a digital radiology imaging system known as Picture Archiving and
Communication System). Their analysis showed that there existed 59, pre-PACS work steps required to request, obtain, report and transcribe a radiographic study. Through careful workflow redesign they were able to eliminate most of those steps. The results were increases in technologist efficiency by 20% to 65%, clerical efficiency by more than 50% and radiologist efficiency by more than 40%.

This author believes that a thorough workflow analysis followed by committed management follow through to effect change in real-life processes is most often lacking as a prerequisite for IT efficiency efforts.

The balance of this section will discuss some healthcare specific, IT efforts to enable business process fusion in the highly fragmented healthcare delivery system.

4.2.3 Health Level 7 (HL7)

Founded in 1987, Health Level Seven (HL7) has set the crucial foundation of data communication among healthcare organizations. (http://hl7.org/about/hl7about.htm) Health Level Seven is an American National Standards Institute (ANSI) accredited Standards Developing Organization (SDO) operating in the healthcare arena. Most SDOs produce standards for a particular healthcare domain such as pharmacy, medical devices, imaging or insurance claims processing transactions. Health Level Seven’s domain is the overarching realm of clinical and administrative data. HL7 focuses on the interface requirements of the entire health care organization instead of the unique requirements of particular medical disciplines or departments.

The stated mission of HL7 is, "To provide standards for the exchange, management and integration of data that support clinical patient care and the management, delivery and evaluation of healthcare services. Specifically, to create
flexible, cost effective approaches, standards, guidelines, methodologies, and related services for interoperability between healthcare information systems." The group seeks to coordinate its efforts with other American and International standards development activities. Argentina, Australia, Canada, China, The Czech Republic, Finland, Germany, India, Japan, Korea, Lithuania, The Netherlands, New Zealand, Southern Africa, Switzerland, Taiwan, Turkey and The United Kingdom are part of HL7 initiatives.

HL7 includes several specifications; the most widely used being a messaging standard that enables disparate healthcare applications to exchange key sets of clinical and administrative data by expressing the binary data in a common format. Level seven refers to the highest level, the application level, of the International Standards Organization (ISO) Open Systems Communication (OSI) model. The OSI model establishes a hierarchy of roles to be played at seven different levels to enable communications to occur between information systems. The application level addresses definition of the data to be exchanged, the timing of the interchange, and the communication of certain errors to the application. It supports functions such as security checks, participant identification, availability checks, exchange mechanism negotiations and, most importantly, data exchange structuring.

The general structure of HL7 is meant to model real world events, as shown in the diagram below. Each message is composed of groups and segments where: (HL7 Desktop Reference)

- Groups contain segments or groups
- Segments contain fields
- Fields contain components, and
Components contain sub-components

There are four primary HL7 message types:

- Patient administration (ADT)
- Orders (ORM)
- Results (ORU), and
- Charges (DFT)

HL7 can be implemented in different ways, thus making different applications that all claim to be “HL7 compliant”, not necessarily able to communicate effectively without user effort. This de facto standard is a comprehensive, complex and yet loose framework. HL7 defines different sorts of messages to be sent and received such as patient tracking, orders, results, etc., and the segment order of information contained within each message type. There are required and also optional message ingredients for
every HL7 message. The result is a sort of cookbook or catalog of rules from which application vendors can choose. Vendors may interpret the rules differently and may choose slightly different ingredients to send the in same message type. In order to communicate effectively among applications, these differences must be negotiated or messages must be translated in an interface between and among different systems.

The logical diagram below describes one example of a facility’s communications that requires such effort to achieve integration.

In this typical example, the Health Information System (HIS) acts as the facility’s master system for tracking patient status from admission to discharge. It is the authority
for patient demographic information and is responsible for receiving status information from ancillary systems and ensuring that all systems are kept synchronized with timely, accurate information of changes. Without a standard such as HL7, this integration would be extremely difficult, expensive and maybe even impossible.

As we have observed, different “flavors” of HL7 are used by different applications. Some healthcare applications are also generating messages in other standards and in proprietary formats. To address this Tower of Babel phenomenon, the HL7 Interface Analyst position exists in many healthcare organizations. The primary tool of this person in facilities of any size is the interface engine. The engine receives HL7 and other message formats, transforms the messages into specifically formatted messages for each ancillary system, modifying fields as necessary based upon the rules that are configured by the facility. Interface engines can also provide centralized monitoring and alert capabilities, and store and forward functionality.
4.2.4 Digital Imaging and Communications in Medicine (DICOM)

DICOM is a prime example of a necessary healthcare communication standard outside of HL7 that must coexist in the information integration effort. In 1983, the introduction of digital medical image sources and the use of computers in processing these images led the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) to form a joint committee in order to create a standard for the transmission of medical images and their associated information. In 1993, this body released version 3.0 of their standard and named it Digital Imaging and Communications in Medicine (DICOM).

The Standard enables what is known as a picture archiving and communication systems (PACS). Its stated goals are: (DICOM Strategic Document, 2003)

“…to achieve compatibility and to improve workflow efficiency between imaging systems and other information systems in healthcare environments worldwide. DICOM is a cooperative standard. Therefore, connectivity works because vendors cooperate in testing via scheduled public demonstration, over the Internet, and during private test sessions. Every major diagnostic medical imaging vendor in the world has incorporated the standard into their product design and most are actively participating in the enhancement of the Standard. Most of the professional societies throughout the world have supported and are participating in the enhancement of the standard as well.”

DICOM is used or will soon be used by virtually every medical profession that utilizes images within the healthcare industry. These include cardiology, dentistry, endoscopy, mammography, ophthalmology, orthopedics, pathology, dermatology,
pediatrics, radiation therapy, radiology, surgery, etc. DICOM is even used in veterinary medical imaging applications. (DICOM Strategic Document 1) To accommodate some bio-signal and bio-numerical data such as electrocardiogram, DICOM also developed a waveform standard in 2000. (Cho, Leon, Choi, Chin & Kim, 2003)

The DICOM standard promoted efficient communication of digital image information regardless of device manufacturer by the following means:

- Specifying a network protocol utilizing TCP/IP,
- Defining the operation of Service Classes beyond the simple transfer of data, such as storage, query, printing, etc.,
- Creating a mechanism for uniquely identifying Information Objects, not only for images but also for waveforms, patients, studies, reports and other data groupings, as they are acted upon across a network,
- Specifying a hardware interface, a minimum set of software commands, and a consistent set of data formats,
- Describing how an implementer must structure a Conformance Statement to specify minimum levels of conformance.

The DICOM standard does not specify:

- The implementation details of any features of the Standard on a device claiming conformance,
- The overall set of features to be expected from a system implemented by integrating a group of devices each claiming DICOM conformance,
• A testing/validation procedure to assess an implementation’s conformance to the Standard. (NEMA)

A DICOM file contains a “header” comprised of groups of various elements. The header in total contains patient demographics, scan type, image attributes used to accurately display the data, and the image itself. (The DICOM Standard)

DICOM continues to evolve. Health imaging is increasingly moving to using raw acquisition imaging data sets such as metabolic images like nuclear medicine and PET scanning, and anatomic images like CT scanning and MRI scanning, and then creating, dynamic, interactive images from processing, and sometimes fusion of data sets. The display may include 3D reconstructions, movies, text and graphical overlays, all linked and interactive. The number of views that can be created has become ““infinite”“ as advanced imaging techniques enable voxels (three dimensional pixels) to be oriented in any plane to produce an accurate image. Integrating these images into PACS presents another challenge. A problem arises when one considers having to store the ““infinite”“ number of images that can be created by such processing. Furthermore image appearance is also dependant upon the sometimes-proprietary software and hardware configurations of the electronic image data processor and viewer being used. Current DICOM proposals for handling these issues assume image softcopy presentation state functions that can store the processing steps taken so that the retrieval of these digitally stored steps can be used to a recreate a specific image from the raw data when necessary. DICOM grayscale display functions can ensure that the image on one workstation looks clinically the same when viewed on another. The goal is that with such protocols, users would be able to place any object from a desired location on a display and recreate screen order,
transparency, movie speed and links needed to synchronize the different objects. (Gould, 2003)

4.2.5 The Health Insurance Portability and Accountability Act (HIPAA)

Even with the common adoption of de facto development of standards such as HL7 and DICOM, that provided healthcare with common languages for information integration among applications, additional actions were thought to be required by the United States government to bring order across the industry, and to encourage organizations to invest in effective IT systems. The sentiment that even more federal action to enforce standardization and motivate increased IT investment persists among some legislators and regulators today. (Freudenheim, 2004)

In 1996, Congress passed the Health Insurance Portability and Accountability Act (HIPAA). In part it was passed in an effort to simplify processes, and thus reduce American health care costs that were escalating at a rate feared to make American industry non-competitive in a global marketplace,

"The Administrative Simplification provisions, Title II, Subtitle F, of the Health Insurance Portability and Accountability Act of 1996 (HIPAA) require the Secretary of Health and Human Services (HHS) to adopt standards for the electronic transmission of administrative and financial health care transactions, including data elements and code sets for those transactions; for unique health identifiers for health care providers, health plans, employers, and individuals for use in the health care system; and for security standards to protect individually identifiable health information. The law also requires the Secretary to submit recommendations for Federal health privacy legislation to the Congress within
one year. Additionally, these provisions gave special responsibilities to the NCVHS to advise the Secretary on establishing privacy standards.

The purposes of these provisions are to improve the Medicare and Medicaid programs in particular and the efficiency and effectiveness of the health care system in general by encouraging the use of electronic methods for transmission of health information through the establishment of standards and requirements for covered electronic transmissions.” (Administrative Simplification in Health Care 9)

The minimum standards required under the law include: (Administrative Simplification in Health Care 9)

- Transactions for

  o Health claims or equivalent encounter information,
  
  o Enrollment and disenrollment in a health plan,
  
  o Eligibility for a health plan,
  
  o Health care payment and remittance advice,
  
  o Health plan premium payments,
  
  o First report of injury,
  
  o Health claim status,
  
  o Referral certification and authorization,

- Claims attachments,

- Code sets and classification systems for the data elements of the transactions,
• Unique identifiers for health plans, health care providers, employers, and individuals for use in the health care system,

• Security and electronic signature standards and safeguards to protect health information during transmission and while stored in health information systems, to ensure the integrity of the information, and to protect against unauthorized use and disclosure,

• Coordination of benefits and sequential processing of claims, and

• Privacy and security regulations to protect individually identifiable health information.

HIPAA's value is not only in the potential savings to be realized from the reduction of overhead caused by disparate transmissions. It also seeks to build incentives for healthcare to build IT infrastructure. It may also add a network-effect value that can result from a functioning national network on a like standard.

Much has been written about the possible deleterious effects that the HIPAA privacy and security provisions may have upon healthcare costs. Certainly, however, such provisions must be in place for the vision of the EMR to be realized. Interconnected healthcare providers sharing medical data must have a means of combating unauthorized access, eavesdropping, masquerading, intrusion and attacks against data integrity. There must be a structure in place, either inherent in the EMR, or perhaps using middleware among organizations, that will provide fine-grained access control, policy management, demographics filtering, log maintenance and auditing. This must all be done without a degradation of system performance.
This effort is not uniquely American. In Manitoba, Canada the Canadian-Manitoban Personal Health Information Act (PHIA) serves a similar role to HIPAA. (Kallepalli, Ehikioya, Camorlinga, & Rudea, 2003) The goal of this effort in Manitoba is to link access to DICOM images among all hospitals, walk in clinics, labs and research organizations. While DICOM provides mechanisms for integrity checks, secure authorization, and secure transfer of data, it defers access control, log maintenance and auditing for future consideration. In Manitoba they have used middleware to accomplish these security goals. Their system functions include: (Kallepalli, Ehikioya, Camorlinga, & Rudea, 2003)

- An authentication engine in which the user presents credentials and in return gets access according to the set of roles to which they have been assigned,

- An authorization engine that establishes a patient-team-based and group-role-based authorization to a set of DICOM operations. The engine identifies roles and checks to see if a user is on a particular patient’s team. The engine also performs:
  
  o Policy management, checking for conflicts to policy when processing external requests,

  o Filtering, replacing demographics imbedded in the DICOM file as necessary, and

  o Log maintenance, maintaining logs of every attempt to access data.

The system acts as a gateway between image capture modalities, work stations and data stores. Each remote location must have at least one security node, or a small site may use a node of a larger site. Security nodes across sites must list each other as trusted
sources. If a security node receives a request for information to which it has access, it processes the request. Otherwise it dispatches the request in XML to the node where the data resides. SSL is used internally and externally for encryption.

4.2.6 Integrating the Health Care Enterprise

As we have seen, both HL7 and DICOM are complex standards and yet contain enough optional characteristics and are sufficiently open to interpretation to result in a need to build customized interfaces between applications. Such a situation is not unusual when a standard must gain the voluntary support of a critical mass of vendors in order to become a de facto industry market standard.

So in the face of this lack of exact consensus on how to use existing standards among vendors of myriad systems, some see a place for other voluntary solutions that may reduce the repetitive, customized interface development that is still necessary. In the healthcare industry, such an initiative is Integrating the Healthcare Enterprise. (IHE)

In 1998, a joint effort of the Radiological Society of North America (RSNA) and the Healthcare Information Management Systems Society (HIMSS) began the IHE initiative as an effort to clearly define, as a start, how two standards; HL7 and DICOM should be used to resolve common information system communication tasks in radiology.

The intent of Integrating the Healthcare Enterprise (IHE) is to provide an incentive for vendors to demonstrate that their systems can operate efficiently in standards-based, multi-vendor environments, with the functionality of existing hospital information systems. By participating in IHE, vendors can direct product development resources toward building increased functionality, rather than redundant interfaces.
IHE uses established standards including HL7, DICOM and generic information technology standards. It seeks to agree upon implementation profiles for the transactions used to communicate patient data within the enterprise.

The IHE working group states that, “IHE will help healthcare enterprises achieve a high level of systems integration efficiently, enabling secure access to vital information for optimal patient care.” (Integrating the Healthcare Enterprise 1) The core tasks in radiology are largely analogous to the core tasks in other healthcare departments. The intention of IHE is to expand across the whole enterprise and to encompass more that the HL7 and DICOM standards as required to do so. Lab and cardiology profiles are already under development.

To accomplish this end, vendors and healthcare providers voluntarily come together to demonstrate successful use of the IHE models to integrate disparate systems. (Siegel & Channin, 2001) Rigorous testing is required at these “Connect-a-thons” to establish working integration to IHE models. As of October 2003 (Gould, 2003), IHE has expanded its presence into Japan and a number of European countries as well. Vendors report increasing frequency of IHE references in requests for proposals for their products.

The IHE is about detailed definition of common processes and workflow. IHE uses an information model and Integration Profiles to accomplish processes through automated means. It defines a precise, common language to assist humans in unambiguously discussing how to integrate heterogeneous information systems. These models do not seek to address every detailed task in the healthcare workflow. Instead they seek to identify the fundamental subset of necessary core processes required for success. Healthcare is not the only industry that is making an effort to describe business
processes and then integrate them. RosettaNet is an industry-wide value chain process standards initiative; launched in 1998 for computer distributors and manufacturers, software developers, resellers, shippers, and end customers. Members agree on a shared set of processes from part numbers, to what constitutes a return. (Tapscott, Ticoli, & Lowy, 2000)

The IHE information model defines a set of Actors that must interact with each other to complete a given process successfully. The Actors interact according to well-defined Transactions based upon established standards such as HL7 and DICOM.

IHE has defined several Integration Profiles to date that reflect core processes. As of 2004, these include (IHE Working Group):

- **Scheduled Work Flow** to establish seamless flow of information to support efficient patient care in a typical imaging encounter. It specifies transactions that maintain consistency of information from registering through ordering, scheduling, image acquisition, storage and viewing. It also forms the foundation for subsequent transactions such as results reporting. Typically the IT systems involved are the:
  - Enterprise wide Health Information System (HIS) (contains patient registration, ADT, etc.)
  - Radiology Information System (RIS) (contains examination scheduling and study specific data)
  - PACS (image management, archiving and communication), and
  - Image capture modalities.
• **Patient Information Reconciliation** to establish a means to match images acquired prior to a patient being unambiguously identified with that patient’s registration and order history. Systems typically involved are:
  - Enterprise wide HIS
  - RIS, and
  - Image captures modalities.

• **Consistent Presentation of Images** to specify the transactions that maintain consistency of presentation of images and presentation state information such as user notations, shutters, flip/rotate functions, display area and zoom capabilities. It also defines a standard contrast curve/display function against which different types of display and hardcopy output devices can be calibrated. Systems typically involved include:
  - Review or diagnostic image softcopy display stations
  - PACS
  - Hardcopy printers on film and paper
  - Image capture modalities.

• **Presentation of Grouped Procedures** to address the complex information management problems encountered when information for multiple procedures is obtained in a single acquisition step. (e.g. the CT scan of a chest, abdomen and pelvis in a single step) This provides the ability to view image subsets and relate
each image subset to a different requested procedure. It allows the generation of reports that match billing policies. Systems typically involved include:

- Images capture modalities.
- PACS
- RIS
- Diagnostic softcopy display stations

- **Post Processing Workflow** to address the need to schedule and track the status of steps of the typical post processing such as Computer Automated Detection (CAD), or image processing. Work lists for these tasks can be generated and queried, work items selected and status returned from the system performing the work to the system managing the work. Systems typically involved include:
  - PACS
  - RIS
  - Diagnostic softcopy display stations including specialized post processing units

- **Reporting Workflow** to address the need to schedule, distribute and track status of key reporting tasks such as interpretation, transcription and verification. Work lists of tasks can be generated and queried, work items selected and status messages returned from the systems performing the work to the systems managing the work. Systems typically involved include:
  - PACS
• RIS

• Diagnostic reporting work stations

• **Evidence Documents** to allow detailed, non-image information generated by acquisition systems and work stations to be stored and managed by archival systems and retrieved and presented by display and reporting systems as input to the decision process. (e.g. observations, measurements, CAD results, procedure details). Systems typically involved include:

  - Images capture modalities.
  - PACS
  - Diagnostic reporting stations

• **Key Image Note** to enable a user to flag as significant, one or more images in a study. The note will include a title stating the purpose and a user comments field. Notes will be stored, archived and displayed as images move among systems and image users. Systems typically involved include:

  - View stations
  - PACS
  - Images capture modalities.

• **Simple Image and Numeric Report** to facilitate the growing use of digital dictation, voice recognition and specialized reporting packages by separating the functions of reporting into discrete Transactions and Actors for creation, management, storage and viewing. Reports will have a title, observation context,
and one or more sections with a heading, image references, and optionally coded measurements. Systems typically involved include:

- Review or diagnostic work stations
- Reporting work stations
- Report management systems
- Report repositories

- **Charge Posting** to specify the exchange of information related to charges among departmental and enterprise information systems, and billing systems. Department systems provide precise information regarding the procedures performed. Enterprise systems provide patient demographics, account and insurance information, and guarantors. All of the information needs to be present for submitting a claim. Systems typically involved include:

  - HIS
  - RIS
  - Billing systems

- **Basic Security** to establish measures that help to protect confidentiality of patient health information. This consolidates audit trail events on user activity across several systems. Systems typically involved include:

  - Imaging systems
  - Departmental and enterprise information systems
• **Access to Radiology Information** to specify support for query transactions providing access to images and related reports. Systems typically involved include:
  
  o Review or diagnostic stations
  
  o Reporting stations
  
  o PACS
  
  o Report repositories

The vendor requirements for establishing IHE compliant interfaces are not trivial. Although complex and time consuming however, they are slight compared to constant customization, if the resulting IHE components are reusable processes that can be replicated and easily understood in subsequent integration efforts.

Consider the work required of one effort to integrate only a single model of General Electric (GE) CT scanner, with a single version of a McKesson PACS, for only the single, Presentation of Grouped Procedures (PGP), IHE integration profile. (Wendt) The PGP integration profile is for cross sectional imaging when multiple requested procedures are performed in one grouped acquisition, or pass of the scanner. This profile is essential for speedy and cost effective softcopy enterprise distribution, reading and retrieval. It is not technically trivial.

CT studies may consist of several thousand images covering a number of body parts. A single study, or pass of the body through the CT scanner from shoulder to pelvis may be comprised of several requested procedures in the RIS. Without some IT intervention, in the PACS there is only one study listed. Several reports must be
generated from that single PACS study. When a radiologist marks the first study viewed as “Read”, that entire study no longer appears in the PACS, “Unread Studies” work lists. Later, to find the truly unread portions of the study, users must search for relevant images in a large data set, if they can actually retrieve the correct study by searching for the body part that concerns them.

Vendor actions that were required to address this issue included modification of the CT scanner hardware and software. The vendors also needed to build in support of the Scheduled Workflow, and Consistent Display of Images integration profiles that serve as a basis for the PGP profile. GE had to develop two software applications to support these profiles, a monitor calibration tool and a post acquisition application designed to subgroup images, and create grayscale presentation states. McKesson had to modify software to support the PGP information passed from the scanner. The PACS now implements virtual image splits by receiving PGP information as grayscale presentation state (GSPS) objects from the scanner to the PACS. Now PACS users are presented with only the relevant images for the body part that they select from the PACS work list. While PACS needs to store only one data set that contains all acquired images.

IHE requires vendors to cooperate and implement lab-to-lab testing to ensure proper functioning before clinical implementation. In the case of a single health-imaging vendor, GE, consider their following outline of IHE documentation as an illustration of the scope of the vendor IHE effort for only the GE imaging capture devices listed, and the GE, Centricity PACS.

IHE Integration Statements for GE Medical Systems Products
An IHE Integration Statement specifies the specific IHE Actors and corresponding IHE Integration Profiles each product version implements. Such IHE Integration Statements are intended for GE customers to know precisely the IHE Integration capabilities currently offered by GE Medical Systems products, both GE imaging equipment and GEMS-Information Technology systems.

Bone Densitometry

enCORE v7.0
enCORE v8.0

Computed Tomography (CT)

HiSpeed QX/i
LightSpeed QX/i
LightSpeed Plus
LightSpeed Ultra
LightSpeed16
LightSpeed Pro 16
LightSpeed RT

Magnetic Resonance Imaging (MRI)

Signa 3T vVH2
Signa 3T vVH3
Signa Excite 1.5T v11.0
Signa Excite 3.0T v10.0
Signa Excite Open Speed vHFO4
Signa Excite Ovation vMFO4
Signa Fiesta vCNV3
Signa Infinity v9.0
Signa Infinity v9.1
Signa Infinity with Excite v10.0
Signa Lx ASP1 v8.3.7
Signa Lx ASP2 v8.3.8
Signa OpenSpeed vHFO2
Signa OpenSpeed vHFO3
Signa Ovation vMFO2
Signa OpenSpeed vHFO3
Signa Pulsar v8.4ACGD
Signa Supernova vCNV4
Signa TwinSpeed v9.0
Signa TwinSpeed v9.1
Radiology PACS, Workstations and RIS

Advantage Windows Workstation v4.1
Advantage Windows Workstation v4.2
Centricity PACS v2.1
Centricity RA600 v6.0
Centricity RA600 v6.1

Ultrasound

Logic 3 v2.0.2
Logic 5 v3.0.0
Logic 7 v2.1.0
Logic 7 v3.0.2
Logic 9 v2.1.0
Logic 9 v3.0.2
LOGIObook v1.2.5
Vivid 7 v1,v2,v3


IMPORTANT REMARKS
The use of these IHE Integration Statements, by itself, it is not sufficient to ensure that inter-operation will be successful. The user needs to proceed with caution and ensure that a qualified systems’ integration (such as GE's IT Professional Services) address at least four issues:

Integration The integration of any system into an integrated department or enterprise requires an analysis of the applications requirements. The design of a solution that integrates GE systems with non–GE systems is the user's responsibility and should not be underestimated. Special care should be exercised in defining the expected workflow, the special conditions, and the clinical practice to be supported to ensure a safe and effective operation.

Validation - Testing the complete range of possible interactions between any GE system and non–GE system, before the integration is declared operational, should not be overlooked. Therefore, the user should ensure that any non–GE provider accepts full responsibility for all validation required for their connection with GE systems. This includes the accuracy of the data once it has crossed the interface and the stability of the data for the intended applications. Such a validation is required before any clinical use (diagnosis and/or treatment) is performed.

Future Evolution - GE understands that the IHE Technical Framework and the underlying communication standards will evolve to meet the user's growing requirements. GE is actively involved in the development of the IHE Technical Framework and the underlying standards. Such evolutions may require changes to already installed systems. In addition, GE reserves the right to discontinue or make changes to the support of communications features (on its products)
reflected on by these IHE Integration Statements. The user should ensure that any non-GE system that connects with GE systems also plans for the future evolution of IHE. Failure to do so will likely result in the loss of function and/or connectivity as the IHE Integration profiles evolve and GE Products are enhanced to support these changes.

As indicated in the GE material above, IHE also represents a significant investment by the healthcare service provider. There is significant preparation that must be completed to ensure a successful IHE implementation. Northwestern Memorial Hospital has 270,000 radiology procedures per year. (Makori & Channin, 2003) It has a GE PACS, sixty image capture devices from 11 vendors, a Cerner order entry system and a Cerner RIS. Not all systems are IHE compliant. In order to prepare for implementation of IHE integration profiles, the enterprise has worked to develop a radiology “playbook”. This is comprised of a list of orderable studies that are mapped to procedures according to department clinical protocols. Each procedure is has a protocol consisting of performed procedure steps. This process needs to take into account that the exam may need to be tailored to a specific patient’s needs, or specific request of the attending physician. The Assistant Acquisition Protocol Setting Integration Profile, planned for IHE year four, will include a mechanism for communicating the above protocols directly to the image capture device with each step. This will then be mapped to each specific machine’s protocols that the technologist can then accept, modify or override. These steps must also be mapped to Common Procedure Terminology (CPT) billing codes. Northwestern believes that this “playbook” is a necessary step for their IHE implementation because it will enable them to re-examine processes as they proceed, system by system, to integrate while improving performance and reducing variance and
complexity. Without such a well-organized representation of the Northwestern real world, the benefits of the IHE structure could be realized to a less than optimal degree.

In closing this discussion of IHE, let the following real memos exchanged among IT staff, regarding the effort to share meaningful information with PACS at the University of Rochester Medical Center serve to illustrate the complexity of, and time and skill required for application integration in the absence of something like the IHE effort.

"Several times over the past months we've encountered problems with PACS and the ImageCast image web distribution system with regards to data storage and query functionality due to inconsistent patient data, including differences in last names and medical record number (MRN) formats. This is becoming more and more prevalent as we attempt to expand the PACS functionality across the enterprise.

An example of inconsistent patient data with regards to MRN format is demonstrated by some systems stripping leading zeros from MRN's, while our PACS and RIS use a fixed 7-digit MRN, including leading zeros. Data for the same patient will not be stored in the same "electronic folder" if any variation in the MRN's exist, and queries based on the MRN will not return all stored data for that patient. As an example, while attempting to use the obstetrics PACS Broker (an interface engine among RIS, PACS and image capture devices) to automate our orthopedics pre-fetch, we found that they strip all leading zeros from the MRN for their Acuson PACS, while we require the leading zeros."

"Thank you for your diligence in solving the leading zero problem. It seems that this problem isn't limited to our orthopedics study pre-fetch issue. Inconsistency exists across the enterprise with respect to the MRN data field. As an example, IDXsched (the ambulatory clinic information system) drops leading zeros. Allscripts (a CPOE system) does not use leading zeros. IDXrad (a RIS) uses leading zeros. Omega (a HIS) uses 12 digits including leading zeros. Our Kodak PACS uses seven digits including leading zeros. The Acuson mini-PACS for obstetrics does not use a forced seven-digit format with leading zeros. Therefore, to keep from messing up their database we need to continue sending all of their exams without the leading zeros while sending those designated with resource_name = ORTHO containing the leading zeros to seven digits. Can you do this? If the studies are to be stored centrally, a study for pt # 795472 would not match in a search for the same patient # 0795472."

In addition, look at examples using the following names:
Inconsistent patient last name data is a reoccurring problem. Originally, the archives had problems with patients having last names that contained apostrophes, hyphens, or other punctuation. The archive databases were stripped of all occurrences of these, and punctuation is no longer allowed. Additionally, it was determined that there should be no spaces in the last name. As an example, a patient with the last name of "McDonald" should be entered into the database as "MCDONALD". However, when the patient last name is entered "upstream" in Omega, IDXrad, etc., in what can be considered a non-standard format for PACS, the archives do accept this data. Inconsistent last name data format can result in problems with patient queries and storing patient studies in an inappropriate electronic folder.

IDXrad receives patient data from Omega. If the information is incorrect when received, and radiology personnel don’t correct it, then every system that IDXrad interfaces with, including PACS, will potentially have this same flawed data format. Who should we speak with to assure that data is being entered into Omega in the proper format? Is there a policy in place to govern this?

Please refer to the DICOM patient name format below.

- **Name Field:** Required field. The patient’s name must be entered accurately and completely. The last name should be entered as a single word without any punctuation. The first name should be the patient’s legal name, not a nickname. Only the middle initial is entered. The suffix is entered after the middle initial with a space separating them. Appropriate suffixes are Jr, Sr, and generational indicators such as II, III, and IV. Reference policy and procedure pages 67 & 85 for further information.

**Examples:**

- Dan O’Brien
- Susan Smith-Wesson
- James Joseph Colelli Jr
- Steven Andriola, MD
- Mark Allen III
- Lastname, Baby Boy

**IDX Standard**

- OBRIEN,DANIEL
- SMITHWESSON,SUSAN
- COLELLI,JAMES J JR
- ANDRIOLA,STEVEN
- ALLEN,MARK III
- LASTNAME,BOY

Patient Name, DICOM Value Representation, PN ~ Person name, DICOM Standards
“A character string encoded using a 5 component convention. The backslash shall not be present, as it is used as the delimiter between values in multiple valued data elements. The string may be padded with trailing spaces. The five components in their order of occurrence are: family name complex, given name complex, middle name, name prefix, name suffix. Any of the fine components may be an empty string. The component delimiter shall be the caret character. Delimiters are required for interior null components. Trailing null components and their delimiters may be omitted.

Examples:

[one family name; three given names; no middle name; one prefix; two suffixes.]

Susan Morrison-Jones, PhD., Chief Executive Officer
Morrison-Jones^Susan^^Ph.D, Chief Executive Officer
[Two family names; one given name; no middle name; no prefix; two suffixes]...

As one can infer from the communication above, integration of applications requires the time of skilled staff in a seemingly never ending effort to yield usable information to the varied application users throughout the enterprise.

4.2.7 Clinical Context Object Working Group (CCOW) - A common user interface that delivers all information for the desired patient context

The Clinical Context Object Working Group (CCOW) is responsible for a subset of the HL7 standard, called Context Management Architecture (CMA). This architecture is intended to enable multiple applications to be automatically coordinated and synchronized in clinically meaningful ways at the user interface. The clinical user’s experience should be one of interacting with a single system when, in fact they may be using multiple, independent applications from many different systems. (Seliger, 2002) An example is a radiologist sitting at a single workstation while seamlessly accessing the
diagnostic quality image viewer, RIS, EMR, and voice recognition report dictation applications. Applications should provide a highly secure single sign-on. Logging into one of these applications as an authorized user should authenticate and open the user account, with the specified access privileges, in every other application. Each application should be accessible by an intuitive user interface interaction. Each application should automatically open to the patient, date of service and clinical context that provides the user with access to just the information pertinent to the user’s current interest.

Examples of clinical context include but are not limited to:

- The identity of a patient whose data the user wants to view or update via the applications,
- The identity of the user who wants to access the applications,
- A moment in time around which temporal data displays should be centered by the applications, and
- A particular patient encounter that the user wants to review via the applications.

Healthcare application developers often implement a common clinical context capability for their own applications. However, there are currently no widely deployed standards that enable independently developed applications to share a common clinical context. Further, with the diversity of application programming technologies currently available, a common context solution should strive to be applicable to at least several of the dominant and emerging technologies in healthcare.

The underlying principle of CCOW is that common context can be established by identifying things such as patient, user, and clinical encounter in a way that different
applications can recognize. The core architecture is comprised of three main types of components. (Seliger, 2002) These are:

- Applications,

- A context manager that coordinates and synchronizes applications, and

- Mapping agents that represent identifiers used for patients, users, etc.

CMA defines the roles and responsibilities for these components and the interfaces that enable them to communicate. It does not dictate the implementation of them. In general the first application accessed sets the context by selecting, for example, a patient of interest. The context manager receives the context identifier, perhaps a medical record number, from the application and informs other applications of the context. Each application adjusts its internal state and display accordingly. In the absence of uniform context identifiers among all applications, third party mapping agents can work with the context manager to map application-specific context identifiers to each other among applications.

To further describe the scope of CCOW, consider the following features that have been released from its ratification in 2000 to version 1.5 in 2002.

- Version 1.0

  o General architecture for linking of applications to a context subject

  o The context manager and mapping agents

  o End-to-end security

  o The Patient subject
• The User subject

• Microsoft Component Object Model specifications for CCOW message encapsulation

• Version 1.1

  • Dependent context subjects that can be set only when the parent subject is set

  • The Encounter subject

  • Custom subjects whose data definition is not published by CCOW

  • Formal conformance statements

• Version 1.2

  • Web technologies specifications utilizing URL-encoded HTTP for CCOW messages

  • Capability to deploy over private and public networks using the Secure Socket Layer for all CCOW communication

• Version 1.3

  • The Annotation subject (dependant) composed of data elements that describe something as opposed to defining something

  • The Annotation agent used to set the Annotation subject

  • The Observation request subject for calling for the display of the results of a particular procedure
- The Certificate subject for keying into the same digital security certificate

- Version 1.4

  - Secure, multiple context sessions on the same point-of-use device

  - The Action subject that allows an application to request another application to perform a task

  - A context filer that enables applications to specify context subjects about which they will always be notified whenever that context is set

  - A set of definitions for linking applications based upon DICOM studies

- Version 1.5

  - Specifications for mapping to the Simple Object Access Protocol that enables XML to encode messages

4.2.8 Web services

Web services is a technology that has promise to remove the sort of middleware that has been required to integrate information from the many separate and diverse applications that must feed into an EMR. Instead it proposes to use web-based standards to create a sort of Internet middleware. (Sun, 2003)

Gartner (2003) predicts web services are likely the most important technology deployment through 2008 – “Web services will impact every enterprise using Internet-based technologies and applications to reach internal knowledge workers, customers, trading partners and other stakeholders.” They go on to say that, “2003 is the year for even cautious enterprises to begin Web services pilots.” (Sun, 2003)
Web services are not software run over the web. It is the reuse of business functions that are represented in software and consumed via applications. (Hotle, Gartner, 2003)

”Web services allow for seamless integration of disparate applications representing different and, at times, competing standards. A Web service is a collection of objects and operations that are accessible through standardized Internet protocols and services. A Web service can be invoked on demand pervasively by business processes, applications or people to fulfill a particular function as simple as a small calculation or as complex as processing an entire business transaction.” (Laroia, 2002)

To illustrate, before computerization, each department in an organization handled date calculations independently and by hand. The development that replaced this method was the computer application. An application is a tightly coupled group of business processes; a set of transactions bundled together. Applications often still mirror organizational structure within a department rather then the enterprise business processes. With applications alone, each department can still have its own discrete date calculators and calculations that can differ. In the 1980s, early precursors of customer relationship management software, termed middleware, was used to integrate information from varied department applications to, for instance, “make a client a client” in terms of creating a single bill. Customized interfaces needed to be written within the middleware or Interface Engine to bring data from different applications together.

Web services uses a browser, a common transport protocol and a more common data description technology to more effectively break down application walls. This can
happen within an organization’s software portfolio or among organizations. Within an organization, candidate artifacts for services in legacy software may be examined, finding tens of date routines, for example, each with its own idiosyncrasies. All except one may be eliminated. The single survivor may be able to handle messages or requests from each enterprise application wherever it resides. As standards for web services grow more rigorous and service level agreements are forged, this may extend to outside, trusted environments. Perhaps third party, web services utilities, may be established to sell highly generic services over the web, thus establishing a “phone book of common services”. Of course this will be an evolving process that will require effort and investment. It will require re-architecting existing application structures to suit a granular, distributed, best of breed approach.

Key components of the Web services model include: (Laroia, 2002)

• Extensible Markup Language (XML) is a format for structured documents and data on the Web. It uses readable tags to indicate the purpose of information in the document. The tags and their context are definable by the document authors. As Hypertext Markup Language (HTML) tags define the layout characteristics of a web page, XML can identify procedures, date, time, description, quantity, etc. In this way XML documents can be exchanged among and understood by dissimilar applications. What is still required for reusable integration elements (documents) is agreement on content design and interpretation among user communities.

Without this there are mismatched or competing libraries of XML documents of various types, for example, lab or radiology examination orders or results reports,
and components of documents like dates, addresses, anatomy parts, etc. (Tapscott, Ticoli & Lowy, 2000)

- XML Schema is the recipe for how a specific XML document should be built and for what data goes into the document. It provides a means of defining the structure, content and underlying foundation of an XML document. In the face of an "infinite" number of author definable tags, it specifies what tags are allowed in a specific document. It avoids so much flexibility that the standard for a particular document becomes unclear.

- Web Services Flow language (WSFL) is a specification that represents the workflow among Web services that is required to implement a specific business process. In Web services as in IHE, business processes among participants must be described and aligned. (Tapscott, Ticoli & Lowy, 2000)

- Universal Description, Discovery and Integration (UDDI) is a specification for registering network accessible web service providers offering web services. This is analogous to the white pages of a telephone directory. A Web Services provider may be a commercial firm on the Web or a repository of Web services made or purchased within an organization’s own network. UDDI also specifies the Web services available. This is analogous to the yellow pages of a telephone directory. Last it specifies what specific protocols, document types and transaction sets are supported.

- Web Services Description Language (WSDL) is a specification for representing the programmatic details of a Web service. It allows a web service provider to
specify the messages and operations supported, data formatting, network protocol, and network address and port of a specific installed web service.

- Simple Object Access Protocol (SOAP or the XML protocol [XMLP]) allows systems to communicate using XML. It is a messaging system framework that specifies the message envelope format and the method of data serialization. Soap can use Hyper Text Transport Protocol (HTTP), Simple Mail Transport Protocol (SMTP) and many other protocols for message transport. HTTP is most often used to transport SOAP messages.

- Multipurpose Internet Mail Extensions (MIME) is a multipart envelope that is standard for Internet mail messages using SMTP and can be used instead of SOAP when the XML document is to be e-mailed.

By combining the standards above, the service requester application and service provider application can integrate to automate workflow, discover complementary Web services, or bind and invoke a particular Web service, all without any knowledge about the implementation details of each other.

As an example of a web-based healthcare function that might be enabled through web services, consider an electronic physician order entry document for a radiology examination or one of the myriad specialty consultations that may arise from patient care. (Rosenthal) Today the process is a series of telephone calls and paper that involve the referring physician, physician’s office staff, specialty department clerical staff, specialist, patient and a great deal of time. The request for an examination must accurately and unambiguously identify the patient, the responsible physician, the procedure being requested, and provide enough information for the specialist to accurately protocol and
interpret the service to be provided. The time for a response to the request must be within the parameters of the needs of the imaging department, the clinical need and the patient’s needs. Information must be provided in a form that can be translated into standard International Classification of Diseases, 9th Revision (ICD-9) codes for billing and reimbursement, and the other, increasing complex and mutable rules that govern billing.

Now consider a Web services application comprised of reusable operations that make up a scheduling application that serves as the referring physician’s interface. It assembles its required operations using common web service standards to enable a consultation to be scheduled from any physician’s office, to any department in the enterprise, using only a browser. Specialty departments such as radiology, dermatology, etc., could reserve blocks of time available for appointments of varying length. Without consideration of the functionality of the applications being used at either end of the transaction to perform the actual inner-department scheduling, billing, etc., physicians could be forced, through the use of required fields and drop down menus, to provide all necessary information that is required. At the same time, as the patient is identified, information pertinent to the referral and contained in the EMR could populate the document automatically through calls to the information systems that serve as the source of this information within each organization. Once the prerequisite information is complete, the specialty office could immediately produce appointment confirmations for the physician and for the patient. The patient could also immediately receive instructions by e-mail as to how to prepare for the service to be rendered and be given directions to the office.
4.3 Summary of Business Process Fusion

All of the complex efforts at BPF in healthcare that have been discussed above share some common goals. They all aim to establish an IT enabled value chain of applications within health care that will result in:

- Decreased complexity and cost of middleware required to enable interoperability of application across the enterprise,
- Increased patient centric care,
- Decreased errors in care,
- Optimally customizable use of information,
- As close to real time, plug-and-play interaction and communication among disparate applications and caregivers, payers and patients as possible,
- Time of system users freed from non value-adding work, and
- Better allocation of resources in just-in-time fashion.

Each BPF effort focuses on somewhat different realms within the healthcare industry and its work processes. The diagram below seeks to illustrate the realm of the various BPF efforts in healthcare.
The diagram shows:

- Workflow engineering applicable to all operations,
- HL7 addressing administrative communication across all realms,
- DICOM addressing image related communication among all realms,
- HIPAA addressing administrative communication among service providers and payers, as well as security and privacy for all patients,
- IHE addressing reusable processes to enable interoperability among applications,
- CCOW addressing context specific integration of information at the user’s desktop, and
- Web services addressing reusable processes across applications, without regard for the workings of the end applications, and without the need for traditional middleware.
5. An Illustration of the Convergence of Information Technologies in Healthcare

5.1 Background

To illustrate the application of the convergence of information technologies toward enabling a full measure of benefit to the institutional practice of medicine, the author will examine the installation of a Picture Archiving and Communications System (PACS) at the University of Rochester Medical Center in Rochester, New York. A PACS is a computer system intended to replace film, the analog technology used to visualize health care images for over one hundred years, with digital images viewed on computer monitors. Images and radiologists’ reports are archived and distributed digitally to authorized viewers over computer networks.

Prior to 2001, the University of Rochester Medical Center (URMC) experimented with PACS components using the native digital images generated by CT and MR scanners. This certainly places URMC among the early adopters of this technology. Prior to this experimentation, these modalities captured images digitally, displayed them on a scanner console monitor for acceptance and processing, stored the studies to optical disks for on-shelf storage, and then printed the images on film for diagnostic reading. Film was considered the permanent record of the images, with the optical disk serving as a backup copy of the raw data. This data could be processed further in various ways, at a later time, on specialized, proprietary workstations. Patient information, exam information and report information, for distribution, existed primarily on paper. There was also a radiology information system (RIS) in place however, that contained data about each patient and study. This was used to communicate primarily among radiologists, radiology technologists and radiology billers.
In 1998 a DICOM archive was purchased and the work was begun to integrate DICOM enabled modalities and the HL7-speaking RIS database into a true PACS. The first approach was intended to be a best-of-breed collection of interfaces, archive and viewing systems. After some experience with the difficulty of selecting and integrating each and every PACS component in-house however, the decision was made to purchase a PACS from a single vendor in late 2000. This author has served as the project manager/PACS Administrator at URMC since February 2001. The PACS team was comprised of staff knowledgeable in radiology operations, as well as staff from the Information Systems Division.

The URMC first generation of PACS required customized interfaces with all digital image capture devices, the RIS and an HL7/DICOM-specific interface engine known as a PACS Broker. The PACS also required a web-based image distribution system in order to communicate images and associated information to approximately 1900 referring physicians and other clinicians throughout the enterprise. During the years 2001 to 2003 this PACS was deployed for the main hospital, a satellite orthopedic ambulatory clinic and a freestanding, radiology imaging center. It took well over a year to deploy the system to encompass all imaging modalities and all image users throughout the enterprise.

There were a number of technological factors that had to converge in order for PACS to be able to serve all of the clinical needs within and between the health care organizations that comprise URMC. This illustration will describe the URMC PACS experience in the context of these IT factors. Indeed, the generation PACS that URMC bought and installed in 2001 was able to scale to the medical center’s needs only with
significant unanticipated expense for enhancements, unacceptably low reliability, unacceptable high maintenance needs and many unwieldy work-arounds. Today this PACS is still not ready to be integrated into a fully functional electronic medical record system. After fewer than three years, and an investment in the PACS of well over $5 million, in 2003 URMC began seriously shopping for a next generation PACS with IT functionality that was commercially unavailable when URMC made its first purchase. URMC anticipates installation of that next generation system in 2004 at a cost of many more millions of dollars.

To complete the first generation PACS picture at URMC it must be noted that there also existed several “mini-PACS” systems in imaging niches that were better served by specialty systems then by a general radiology PACS. Mini-PACS are comprised typically of their own archive and viewing applications with features specific to the image types that are being viewed. At URMC these include ultrasound, pediatric and adult echo-cardiology, mammography, obstetric ultrasound and nuclear medicine. A logical diagram of the entire system is depicted below.
5.2 Workflow

In large part, PACS deployment was made in a way that mimicked the film-based workflow. The digital technology mimicked the analog technology. This author thinks such an approach typical to new digital technologies. It is only after the new technology is in place for some time that the real breakthrough applications of the technology may take place.

At URMC, for the most part workflow analysis was not done prior to implementation. Instead there was a tendency to install the diagnostic workstations to enable digital reading while and continuing to print film until the digital workflow issues were identified, and addressed, and all users were comfortable that film could be
eliminated without negatively effecting patient care and productivity. The failure to analyze workflow, anticipate difficulties and address them prior to deployment resulted in increased and avoidable consternation among those being affected by the change as problems had to be fixed in the actual production setting.

The absence of having conducted a workflow analysis is exemplified by our experience in the Emergency Department (ED). This was the first department to receive a full PACS deployment capable of operating in a fully filmless state. The system was comprised of:

- A CT scanner,
- Two digital x-ray rooms,
- An archive comprised of
  - A digital tape jukebox and
  - A limited capacity, first-in-first-out (FIFO) RAID for faster access in front of the jukebox,
- A radiology reading suite with diagnostic workstations that were attached to a workgroup database server with a limited FIFO capacity, to which current studies were forwarded and prior studies of interest needed to be pre-routed or queried from the archive,
- A thick client, clinical viewing application for ED referring physicians that was fed by a workgroup server with a limited FIFO capacity, to which current studies and prior studies of interest needed to be pre-routed or queried from the archive,
- Clinical viewing, PC workstations throughout the ED, and
- The radiology information system. (RIS)

Although radiologists and radiology technologists were pleased with some of the advantages of the PACS, the ED physicians who were waiting for radiologists’ reports from a digital read were initially very dissatisfied because the PACS workflow differed from the film-based workflow in ways that disrupted their pattern of patient care. In the film-based system, a film was delivered to the ED with a radiologist’s report, on paper, attached to the film. In the digital system the image was immediately available to the ED, but there was no mechanism for notifying the ED physician of when the report was available in the system to view. Several workarounds were eventually developed after the system was in production. In the end, an unnecessarily prolonged period of chaos preceded an eventual successful deployment.

This experience can be contrasted with that of another, highly image-dependent department to which PACS was subsequently deployed. The Orthopedic Department PACS configuration was almost identical to the ED configuration but the workflows of the two departments were markedly dissimilar. The orthopedic ambulatory clinic was only months away from moving to a new building that had been designed specifically to increase orthopedist productivity in a film-based workflow when they learned rather suddenly that the film production equipment that they had expected to be present in the new building was to be replaced with the PACS. Their initial reaction was violent opposition. A survey of their colleagues at other institutions in early 2001 revealed that filmless operation within such a busy orthopedic clinic was almost unheard of in the world at that time. The Chair of Orthopedics viewed PACS as an experiment that had the potential to ruin their operation.
Prior to completing the orthopedic PACS design, URMC engaged a work process engineer to:

- Interview the orthopedists for user requirements,

  In this phase of work process analysis, those staff affected by the radiology process were interviewed. The questions and dialog that occurred were intended to achieve several ends:

  - Gain understanding sufficient to diagram the existing work process from its logical start to its logical end point. In this case that process moved from the ordering of a study, through initial and then follow up medical management decisions made by the orthopedist and communicated to the patient.

  - Gain understanding of what participants in the work process saw as strengths, weaknesses, absolutes, etc. in the current work process, and

  - Gain understanding of participants' expectations for the new system.

- Study the existing clinic's film-based work flow,

  In this phase, observation and measurement of a representative sampling of all critical path steps was completed. Selection of which steps to observe and measure flowed from the understanding gained from the interviews described above. In the case of the orthopedic clinic, the participants felt that they had sufficiently improved the processes that
occurred from the study request, to the production of film, and that the
digital system would leave some of these unaffected. The critical path that
would likely be affected by PACS was the process from completion of the
study exposure, to the delivery of the image first to the orthopod, and then
to the examination rooms where it would be shared with the patient. The
result of this phase of the workflow analysis was the performance metrics
of the existing workflow that the participants believed necessary to
maintain or improve upon.

- Study a pilot of the digital workflow in the existing clinic,

In this phase a representative pilot of the PACS technologies was designed, run,
observed and measured. This test system could then be modified until participants
reached consensus that critical performance metrics identified in the previous
phase had been met or exceeded by the pilot system.

- Document that the new orthopedic clinic PACS design, based upon the workflow
observations and testing, would match or exceed the film-based workflow
performance in all required parameters in the production setting.

The piloted process was implemented in actual production, performance measured
and consensus reached that the process was acceptable. Ideally this phase should
be conducted with a means of backing out the new system while modifications are
made if initial performance is unacceptable.
The result of this workflow analysis was a system that delighted the orthopedists and increased their productivity and effectiveness. In fact, that system has scaled nicely over time as the clinic’s volume has increased by 100% since the system was installed.

Other analyses, typically less formal than the orthopedic effort, were conducted for the PACS configuration that served other hospital departments such as other specialty clinics, the operating rooms, and the distribution system that eventually was installed to bring images to the all physicians throughout the enterprise who refer to radiology. Some of what is learned from earlier efforts does generalize well to all departments, although there can be significant differences among departments that may not be immediately evident. Some departments, such as the ED are quite unique in their workflow requirements. The URMC experience was that the success of the PACS deployment was, in each case, in part proportional to the quality of the prior workflow analysis that was done. This experience resonates with the results of a Veteran’s Administration hospital study that concludes that workflow redesign is the key to full efficiency when implementing a PACS. (Siegel & Reiner, 2003)

5.3 Network

When the PACS deployment occurred, URMC resisted a vendor recommendation to create a separate PACS network that was routed to and from the enterprise network. The IT division was rightly proud of their Fast Ethernet network with an ATM backbone and believed that low network saturation that they had measured should have allowed for the transmission of the many, very large, PACS files without contention. The PACS vendor relented and took the position that the system would work acceptably on the enterprise network. The network ultimately fell short of the task. The transmission of so
many large data sets caused bottlenecks and component time outs. There were also conflicts between the PACS transmissions and the main switches that controlled the enterprise network.

Network congestion was exacerbated by the fact that the design of the PACS required many re-sends of the same image file from a central, hierarchical database in order to ensure that every study had a likelihood to be found on the right database work group server, and thus at the work station where it was desired by a particular clinician. For each incoming new study transaction, URMC measured seven to ten outgoing study transactions. This system of routing of studies proved insufficient for the needs of the patients and physicians as the study volume grew. Eventually URMC did install a separate network connected to the enterprise network by a router that restricted traffic to PACS related data only. This PACS network did improve performance significantly.

In our analysis of the newest generation of PACS in the marketplace, the technologies that are providing better solutions to this problem include:

- Data streaming to minimize peak bandwidth utilization,
- Distributed, relational databases with global work lists and intelligent retrieval of images from where they can be accessed upon demand, most quickly, and with no need for pre-fetching of prior studies,
- Gbps network backbones, and perhaps even Gbps to the desktop as the on-the-fly processing and reading of larger, cross-sectional, 3D imaging deployment grows.
5.4 Database

Our experience with database design uncovered limitations as well. The database, controlling applications, and in/out handling applications used by our PACS archive were likely designed no later than the mid 1990s. (CA-Unicenter/OSM for Solaris) They proved insufficient for the full needs of our large and rapidly growing university medical center. The central archive database could not satisfy the high volume of in and out transactions directly and was incapable of being scaled to do so efficiently. The solution to avoid frequent archive crashes was to install a complete second archive and supporting infrastructure at an unanticipated list cost of well over $1 million dollars, only one year after deployment of the original, $5 million system.

In order to ensure that prior studies were available to clinicians when they needed them, a system of pre-fetching of studies from the archives to the various workgroup servers was required. The trigger for that posting of prior studies was the event of a study being scheduled in the RIS. Posting of prior studies is a complex endeavor. There were three basic scenarios:

- Scheduling of an examination sometimes occurs just before the study is performed. In this case an HL7 message is sent immediately to the archive by the RIS via the PACS Broker. The archive then endeavors to send the prior studies based upon code that describes the pre-fetching rules written by our staff. If the desired study was no longer on the front-end RAID, time needed to load the tape that contained the study and read the study from the tape added wait time for the user. Often there would be a queue of posting and query requests, and a queue for
jukebox tape drives to slow the process as well. Busy drives and tapes often failed.

- Other times, the study would be scheduled far into the future. In those cases the central archive database would hold the posting request until 72 hours prior to the exam before sending the prior studies to a queue according to the set of complex rules that determined which prior studies would likely be of interest.

- Another common situation was when prior studies were required for a patient follow-up appointment but no new study-scheduling event occurred to trigger the pre-fetch of studies. In this case, manual queries of the archive needed to be performed in real-time by the physician. Waiting an uncertain amount of time for the study to arrive at the work group server proved an unacceptable use of a physician’s time. In the case of the busy orthopedic clinic, the solution was a huge, manual, batch query for the prior studies of up to 700 patients per day, performed before the day that they were scheduled for follow-up appointments. This was an investment of more than four hours of staff time every day. In other cases lists of patient appointments would be sent to radiology staff prior to clinic appointments and the prior studies for these patients would be manually transferred to the appropriate work group servers.

Because of the unreliability of the archive in the face of such a large number of in and out transactions, the system often failed and queues grew while software processes and sometimes hardware needed to be restarted or repaired.

Of course this complex system to move studies when and to where they should be found was difficult to maintain and was error prone. The code that eventually
accumulated to represent the rules that needed to be run to determine what studies should be routed where and when totaled over 30 pages.

Even the smaller workgroup database applications had unacceptable inherent limitations. They were designed as first-in-first-out caches of RAID, each attached to their own servers, and each supporting a limited number of workstations. Their capacity was also limited by the database design itself. One application for example, had a limit of 19,000 studies in its cache even if there were available storage space to contain more. As the operation grew, these caches became too small. Required studies were available to the servers for too short a time to meet the clinical needs of the patients. The only solution was to add additional workgroups, each of which would contain a different subset of studies. The ability to predict where and when studies could be found became even more complex. Manual queries of the central archive occurred constantly and were too slow for clinical needs.

In our analysis of the newest generation of PACS in the marketplace, the technologies that are providing solutions to this problem include:

- More sophisticated, more powerful, less limited, relational databases,

- Distributed databases that will retrieve data from whatever locations they reside,

- Load balancing among servers to manage large volumes of in and out transactions. This also allows all transactions to be directly managed by the central archive thus eliminating the needs for workgroup server caches and posting of prior studies. The central database can present a global work list so that users can see all studies for every patient and retrieve only those that are required for their clinical purpose from wherever those studies are stored.
5.5 Integration of Applications

In institutional healthcare there is an integration problem caused by the fact that healthcare suffers from the lack of a universal identifier for patients across a system in which patients are very often served by a diverse, loosely affiliated network of providers. The identifier used within provider organizations is known as the medical record number (MRN). This facility specific, facility unique MRN is typically assigned to a patient upon their first registration into that provider’s health information system (HIS). That MRN is guaranteed to be unique only within the system that assigns it. Baring errors and complications, that patient will have that same MRN for every encounter with that provider thereafter. Other clinical information stored in other providers’ repositories, whether in digital or analog form, is filed under different identifiers and so not easily accessible across systems. Different institutions can inadvertently be using the same number for different patients that get care at each facility if there is overlap in their numbering systems. Other identifying information such as name, date of birth and address are unreliable for differentiation of patients because they are not unique. This problem exists even within single provider organizations as economic pressures have driven the consolidation of healthcare providers over the past twenty years into integrated health systems. As hospitals, clinics, labs and other provider organizations have become affiliated, each bringing their own MRN systems, investment in a single MRN registration system, or Master Patient Index (MPI) application was not always judged as feasible for reasons of initial expense, and because such a move might require a re-registration of multiple application databases to reconcile prior records’ MRNs with those of the new system.
For these reasons an MPI, has not been deployed between URMC’s two hospitals. As a result, URMC has been unable to include its second hospital in its PACS because the PACS can only store studies under a single patient identifier. If URMC allowed the second hospital to store studies in the PACS, medical errors of commission and omission could occur for from two causes:

- Two different patients, one at each facility, could be assigned the same MRN because the numbering systems overlap, and
- The same patient could have studies in the PACS filed under different MRNs.

An enterprise-wide MPI application is an expensive acquisition and a non-trivial installation. In the latest generation PACS in the marketplace, a PACS-specific, MPI-like solution is emerging. The systems can differ in functionality and sophistication, but they operate in the same basic manner. When a study is received it is compared against all other studies in the database, looking for an exact match of some number of common fields such as MRN, name, date of birth, gender, address, etc. The MPI-like process is programmed to identify likely matches based upon its internal matching algorithms and provider configurable rules. If a threshold match occurs, such as exact first name, last name and date of birth, but the MRN is different, the application might be configured to link these studies together for all time. In the future, if a user searches for that patient’s records under either of the facilities’ MRN, the PACS will display a list of all of the studies stored with both MRNs. Or, if the match is less certain, or the provider requires a more certain match, the MPI-like application may display the study in an exceptions list where it can be reviewed by provider staff, a decision made as to whether or not the
patients are indeed the same person, and the records joined or otherwise modified. This process is known as reconciliation.

At URMC, the Health Information System (HIS) is the master database for patient demographic information. Patient demographics and other information are shared among the HIS and departmental applications using an interface engine within which customized interfaces must be developed.

In the case of radiology, the PACS created another layer of complexity. Most departmental information systems communicate in HL7 or some other format that needs to be translated to various "flavors" of HL7 by the enterprise interface engine for communication among programs with a need to keep synchronized with patient information. PACS, and the image capture devices however, operate on the DICOM standard. The RIS database is what drives radiology operations. The PACS database is largely restricted to the storage, retrieval and display of images and the related information contained in their DICOM files. This situation requires another middleware device known as a PACS Broker.

In the URMC installation the PACS Broker maintains its own patient database and performs the following functions:

- Translation of RIS HL7 messages to DICOM and vice versa,
- Communication to the image capture devices (the DICOM Modality Work List function or MWL) and to the PACS of what studies have been scheduled in the RIS, with all patient and study demographics, and
- Storage of reports from the RIS that can be displayed with the study on the PACS view stations when the image is displayed.
In order for radiology staff to complete all of their work, they are required to view and interact with both the RIS and the PACS on different workstations, as the systems perform disparate and necessary functions. There is no CCOW-like context integration of applications at the desktop. Communication between the PACS and RIS are essentially one-way, from the RIS to the PACS. Changes to studies must be made on the RIS and then flow from RIS to the PACS. If studies that appear to be of different patients, but then discovered to be the same patient are to be joined, they must be joined separately in the RIS and PACS.

Diagram note: ORM and ADT are HL7 message types. See section 4.2.3
Improvements in database design and in the DICOM standard are changing this arrangement. URMC’s search for a new PACS has revealed that PACS vendors are incorporating the DICOM translation and the MWL functions within the PACS itself. They are also storing reports and other text based information within their database. They are also sending value adding HL7 messages regarding the stages of the study progress to the RIS. Communication between PACS and RIS is now increasingly two-way.

With the most competent PACS and the most competent RIS, the question now arises, which database should drive PACS and department workflow. The ultimate solution now emerging in the marketplace is a single database for both applications. For a healthcare provider with a large historical RIS database however, changing the RIS when one selects a new PACS is a complex and major IT project. Given improved RIS and PACS ability to communicate, the interface of a fully competent RIS as the driver of the PACS database may be a preferable option for many institutions.

5.6 Storage

One aspect of storage is capacity. Radiology studies in New York must be retained for at least seven years. In the case of pediatric studies, they must be retained until the age of majority. URMC is producing about 13 TB of uncompressed data per year for PACS, approaching 400,000 studies, and growing at a rate of close to 10% annually. Studies are compressed at a lossless 2:1 ratio for storage. There have been some studies that have indicated that much greater, lossy compression can produce studies that are able to be read with comparable clinical accuracy, but there is not a medical/legal consensus that greater compression ratios are acceptable.
Until recently the cost of spinning disk storage for long term archiving of all medical images was prohibitive for providers. The solution was to design a two-tiered archive. At URMC, and prevalent throughout the industry, tier one was a FIFO, spinning disk array to allow for quick in and out transactions. Studies were moved to a large tape jukebox overnight when contention for the database processors, the tape drives and the network was lightest, or during the day as system capacity allowed. This hierarchical model has several disadvantages:

- Tape is slow for study retrieval. At URMC, physicians have expressed a frequent desire for studies up to two years old. Older studies are requested much less frequently. Studies have shown that about 80% of relevant priors occur within the last six months of patient history. (Radiology Informatics) After 6 months, the demand for older studies drops off dramatically. (Prior)

- Tape is unreliable. Tape jukeboxes of the vintage owned by URMC were digital linear tape (DLT). URMC has found these tapes and the jukebox drives to be insufficiently reliable for frequent recording and playback. URMC has had poor experience with newer, faster AIT tape drives as well.

- Different levels of storage require a hierarchical storage management system that keeps track of where all studies reside. This process itself on our system was an unreliable, single point of system failure.

Today the marketplace is moving to all spinning disk PACS solutions as the price gap between disk and tape is rapidly closing.

Inexpensive spinning disk and increasing intelligent and powerful storage systems are not only increasing the effectiveness of PACS storage, but are also bringing PACS
closer to an affordable continuation-of-business, disaster recovery model. For patient care and financial reasons, the prospect of an institution’s imaging capability becoming unavailable because of a disaster that destroys the archiving and processing equipment is unacceptable. As storage costs grow smaller, and sophisticated and powerful computing systems become less expensive, the creation of mirrored, spinning disk archives, with acceptable in and out capability and containing at least two years’ FIFO storage, if not a store of all images, becomes more affordable.

Globally, facilities are amassing archives of digital images that law, regulation and good clinical practice demand be kept for many years. As technology advances however, the need to move to new hardware and software will be faced by all. This has spawned a new industry of solutions for migrating DICOM data from one system to another. As observed earlier, DICOM is a de facto standard that allows for variability in application among vendors. In the case of URMC, the estimate of the migration cost of the archived data from tape to our next PACS archive is more than $385,000. This does not include the cost of the new media on which to store these studies in the new archive. The alternative to migration is to maintain this data on hardware and software that is growing obsolete and will likely stop being supported by vendors before all of the data can be legally discarded. In the case of URMC, this solution would add $220,000 in annual maintenance and support costs for our old archive that must be expended for as long as they are retained. This author suspects that the market may drive the industry to further standardization of PACS storage as a result of providers looking for a solution to this potentially recurring PACS cost, but we have not yet seen this development in the marketplace.
5.7 Workstations

For more than 100 years physicians have viewed radiographic images on film by holding them against a light source. The options for doing this were few. The main technological advance over a fixed, brightly lit box of translucent panels was the alternator, a large, mechanical console that moves translucent panels in front of the light source so that physicians can move, at the touch of a button, large numbers of films that had been hung by assistants. In this way physician productivity was increased. Physicians could sit or stand before alternators or single light boxes, since the angle of view from the eye to the film was a relatively negligible factor. Ergonomics was not a common concern for most of those years.

With PACS, alternators gradually disappeared, replaced with computer monitors and we found that ergonomics was indeed a concern. We encountered complaints of fatigue and some radiologists developed repetitive motion injuries. The need to sit in a fixed position while reading studies was exacerbated by LCD monitors upon which image quality quickly degrades with increased angle of vision. Solutions to date are primarily the same low-tech ergonomic interventions familiar to every work place where long hours at a computer are required. These include wrist supports for mouse or track ball use, adjustable seating, rest periods, simple exercises, etc. Even with such measures in place, users may be ignorant of the measures that they can take to minimize risk of injury, or non-compliant. This author suggests that training and visual cues in the reading environment could be of significant value.
5.8 Enterprise-wide distribution

As many institutions do, URMC began PACS deployment first within radiology and then to fixed locations that were large imaging dependent departments like the ED and orthopedics. What PACS is really about, however, is distribution of images and image related information to all of the users in the enterprise in order to enable them to serve their patients. This includes delivering these images and related information to them wherever they are, twenty-four hours-a-day, seven days a week.

To accomplish this in an affordable manner URMC acquired a web-based, thin client clinical viewer. The viewer needed to be available on some critical mass of the thousands of PCs that were available throughout the enterprise. Even though URMC endeavors to upgrade 25% of their PC stock annually there are always a number of machines that are somewhat dated. The client specifications of the viewer that we chose were:

- A personal computer (or Mac G4 running Virtual PC)
- Windows ’98 2nd edition, NT or 2000
- Microsoft Internet Explorer version 5.5 or version 6.0
- A graphic card resolution minimum of 24 bits.
- Minimum computer specifications of:
  - Pentium 700 MHz processor
  - 128 MB RAM
  - Mouse
Recommended computer specifications of:

- 256 MB RAM
- Wheeled mouse
- 17" monitor or larger

Providing access on such a relatively ubiquitous and affordable platform was critical to the success of PACS at URMC. Indeed rapid web-based distribution proved to be the killer application for PACS. Physicians have embraced the service because it improves the quality of their care delivery and the quality of their working lives.

Operation on such a modest hardware platform would require an effective data streaming protocol. We chose a vendor that was first to market with a remarkably fast and facile, proprietary streaming protocol. There was no DICOM standard for such a protocol at that time. DICOM has since adopted JPEG 2000 into their standard.

For Internet access we required a system that would work at acceptable speeds across a broadband service. Cable modem and digital subscriber service were both readily available in the Rochester area.

5.9 Security

We also required a robust and secure means of providing access over the Internet. The development of capable Virtual Private Network (VPN) systems that provided secure user authorization and data encryption were essential to this task.

Windows Secure socket layer (SSL) encryption is another option for the encryption of data to be transmitted over the Internet. Our vendor did not support SSL however because the actual image, containing overlays of patient health information
(PHI), could not pass through the SSL process when being transmitted by the vendor’s system.

5.10 HIPAA and Security

HIPAA, as well as good practice standards, also requires that workstations displaying PHI be secure from unauthorized access. Two approaches to providing this security are:

- Access controls such as passwords and biometric measures (before-the-breach actions), and
- Audits of who is accessing what information, (after-the-breach actions)

For busy physicians access controls presented difficulties. In the ED, physicians are charged to act rapidly to increase the chances of saving lives. For them, logging in and out of an application using a sufficiently secure, individually unique password of perhaps a minimum of six characters, containing a combination of letters and numbers, was unacceptable. In the Orthopedic clinic the issue is not life and death but physician productivity as physicians move from their own workstations to patient exam rooms in an effort to provide quality care while seeing as many patients in a period of time as possible. Biometric login measures may be the solution, but URMC judges the technology as relatively too new, expensive, and unproven on the scale of a university medical center to deploy widely at this time. Login tokens, such as smart cards and card readers are another option. Proximity tokens using Blue tooth or other wireless protocol are a third.
Audit capabilities can act as a complement to less stringent access barriers. To make after-the-breach auditing effective as a deterrent to misconduct, however, there needs to be a means of producing useful information, in a timely manner, out of a very high volume of viewing transactions that are logged by the system. Our current PACS offers insufficient auditable logs to make even after-the-breach efforts feasible.

5.11 IHE

IHE had not been adopted by vendors on any practical scale when URMC purchased their first PACS. All interfaces between among components had to be individually tested and validated by all vendors involved and there was a cost attached to each validation. This process was often long, laborious and expensive. As URMC shops for our next PACS, all of the eight PACS vendors that we have solicited have professed support of IHE, but their proposal materials do not yet describe enough adopted and implement IHE integration profiles to significantly affect our cost of integration.

To illustrate, the cost of integrating our RIS to the next PACS that URMC selects has been quoted at $415,000, plus a monthly support fee paid to the RIS vendor of over $4,000 per month for support of the interfaces.

5.12 CCOW - integration at the desktop

In the first generation URMC PACS there was no application integration on the diagnostic desktop. The diagnostic workstation was a single use, FDA approved device. The vendor was not willing to go through complex customized programming with multiple vendor applications and then obtain FDA approval to provide desktop integration.
For URMC's next generation PACS, the dollar amount stated in the section above for the RIS/PACS interface includes context specific integration at the desktop, but it appears to be a vendor specific, customized approach. There is little mention of the CCOW standard in the integration materials that the vendors have provided. Nor was CCOW mentioned in any meaningful way in any of the eight proposals that we solicited from leading PACS vendors.

5.13 High availability

High availability was a prohibitively expensive option when URMC purchased its first PACS. This time around, all of the eight vendors are offering fail-over and some are offering load balancing on the central servers for their systems. Only one of the eight, however, is using content switches for load balancing in their proposed configuration.
6. Summary

Before summarizing the lessons learned from the review of the literature, and from URMC’s experience regarding the future benefits of the application of IT to the delivery of healthcare, we should be certain that we have a grasp of economic realities. Institutional healthcare operates in an economic environment of small margins and limited capital budgets. The healthcare enterprise needs to consider where it wants to strategically place itself along the curve of advancing technology. This author would hazard the opinion that most providers, given the financial position of the industry, would not realize any added financial benefit from being early adopters of technology. Having very limited capital dollars, providers would be prudent to try to stay:

- on the crest of the curve, or

- slightly behind the curve if more risk averse and believers that it is better to be the tortoise than the hare, or

- Slightly ahead of the curve if they believe that they possess sufficient technical expertise and resources to risk any disadvantage that might accompany that position.

The following statement applies powerfully to healthcare.

“The essence of smart deployment is knowing where and when to invest. Which technology expenditures will yield a sustainable, differentiable advantage? Will the bleeding edge of technology bolster a company’s bid to be a leader, or should executives wait until the risks and costs fall? These perennially difficult questions—which hinge on a complex array of industry-specific factors—become even thornier when earnings pressures are high.” (source unknown)
It is this author’s opinion that the quote above explains part of the reason why broad attainment of the EMR has not yet occurred. Healthcare Chief Information Officers and Chief Executive Officers should be continuously trying to apply capital and operations IT dollars where sustainable advantage can be obtained and/or where some reasonable return on investment can be calculated. If these factors were obtainable in the marketplace at a reasonable cost, perhaps even the limited capital dollars available to healthcare would have sought them out before now and the EMR would have become reality.

6.1 What barriers remain for healthcare IT

The author’s conclusion is that the pre-requisite technologies have not yet fully converged and that this is the cause of the failure of the ubiquitous EMR to materialize. Once the requisite technologies exist in enough supply to become generally affordable to the industry, sufficient market forces should exist, even with government’s large involvement in healthcare economics, to ensure that they will be deployed.

The table below is meant to illustrate that in 2001, when the IOM first called for the common use of the EMR, there were a number of technologies that were insufficiently evolved, still too rare and so too expensive for healthcare, or as yet not truly present in the commercial marketplace at all. The author would identify these technologies as:

- Relational databases and database management systems of sufficient capability and robustness to quickly and reliably supply multi-media data to the very high number of transactions characteristic to healthcare,
• Storage systems capable of rapidly managing multimedia files, and also as affordable as digital tape, and yet as fast, robust and reliable as RAID spinning disk,

• A critical mass in hospitals of Fast Ethernet (100 Mbps) networks to the desktop with better-than-Fast-Ethernet backbones,

• Sufficiently fast and capable, thin client, web-based image distribution applications, and

• Sufficient development and adoption of business process fusion standards and an installed critical mass of standards compliant software and hardware in the marketplace.

Of these factors, the author would argue that the last bullet represents the technologies that are furthest from fully developed today, in 2004, and that they must be sufficiently deployed before the ubiquitous EMR becomes a reality. Given what we have learned from this analysis this author thinks it likely that, contingent upon economic conditions, the industry will likely see significant progress toward the EMR in production, by the IOM’s newest target date of 2013.
<table>
<thead>
<tr>
<th>Year</th>
<th>Pertinent Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>HL7 Working Group Founded</td>
</tr>
<tr>
<td>1989</td>
<td>PACS pilots running on network backbones at 40 Mbps. Teleradiology practice to remote sites at 1.5 Mbps.</td>
</tr>
<tr>
<td>1990</td>
<td>First 486 chip PCs shipped</td>
</tr>
<tr>
<td>1990</td>
<td>“All confirm what would be expected from common sense: The complexity of modern medicine exceeds the inherent limitations of the human mind.”</td>
</tr>
<tr>
<td>1991</td>
<td><strong>Institute of Medicine calls for a fully functional electronic medical record as standard technology by 2001</strong></td>
</tr>
<tr>
<td>1991</td>
<td>DICOM 3.0 released</td>
</tr>
<tr>
<td>1991</td>
<td>Fast Ethernet standard released (100 Mbps)</td>
</tr>
<tr>
<td>1991</td>
<td>HIPAA passed</td>
</tr>
<tr>
<td>1991</td>
<td>Gbps Ethernet standard released</td>
</tr>
<tr>
<td>1991</td>
<td>Pentium III shipped</td>
</tr>
<tr>
<td>1991</td>
<td>Institute of Medicine estimated that 98,000 patients die each year through preventable medical errors.</td>
</tr>
<tr>
<td>2000</td>
<td>Object oriented relational databases reach the broad IT market</td>
</tr>
<tr>
<td>2001</td>
<td>URMC begins PACS deployment</td>
</tr>
<tr>
<td>2001</td>
<td>Pentium IV shipped at 2 GHz</td>
</tr>
<tr>
<td>2001</td>
<td><strong>The Institute of Medicine called for electronic medical record fails to materialize</strong></td>
</tr>
<tr>
<td>2002</td>
<td>CCOW v.1.5 released</td>
</tr>
<tr>
<td>2003</td>
<td>Only 7 to 10% of U.S. hospitals have made serious progress toward an electronic medical record. Only 1 to 2% have a true computer physician order entry system, which is the touchstone of an EMR.</td>
</tr>
<tr>
<td>2003</td>
<td>The New England Journal of Medicine states that only about half of adults receive the care recommended by physicians.</td>
</tr>
<tr>
<td>2003</td>
<td>IBM releases the first color, LCD, 20”, diagnostic quality grayscale monitor at $8,000 while 3-mega-pixel grayscale, LCD monitors are at $14,000.</td>
</tr>
<tr>
<td>2003</td>
<td><strong>The Institute of Medicine defines the functions of an electronic medical record and again calls for the EMR to be standard technology within 10 years.</strong></td>
</tr>
<tr>
<td>2004</td>
<td>Ernst &amp; Young states that healthcare’s access to capital is severely limited.</td>
</tr>
<tr>
<td>2004</td>
<td>Fast spinning disc, RAID storage continues closing the cost gap with slower tape solutions</td>
</tr>
<tr>
<td>2004</td>
<td>PACS vendors recommending diagnostic workstations at 3 GB RAM with 1 Gbps Ethernet to the desktop</td>
</tr>
<tr>
<td>2004</td>
<td>URMC solicited PACS proposals that contained limited references to deployment of IHE and CCOW functionality</td>
</tr>
<tr>
<td>2013</td>
<td><strong>Institute of Medicine target date for the EMR to be standard technology</strong></td>
</tr>
</tbody>
</table>
6.2 Lessons learned

To further illustrate the lessons learned by this review of technological factors and the URMC PACS experience, following is a discussion of factors that this author considers most important to the search for next generation healthcare information systems that will converge to become the electronic medical record that the industry envisions.

6.2.1 Workflow

Healthcare IT design and implementation planning should be accompanied by consideration of its interaction with workflow, particularly in the most information dependant departments and settings. Indeed, URMC is planning inclusion of a budget for formal workflow analysis over a multi-year period to work to obtain the maximum increase in efficiency from the opportunity that a new PACS will offer.

6.2.2 Network

Particularly because of the demands of moving digital image files, the EMR must be accompanied by very capable healthcare network infrastructures. The next PACS procurement at URMC will be preceded by a re-analysis of the network in relation to the design and capabilities of that PACS. The network required for optimal PACS performance will be specified and installed at the start of the project. Network redundancy will also be considered in the design as to its effect on maintaining very high reliability of all critical information systems.
This network design will include consideration of the additional demands to be placed on the system by increasingly larger datasets resulting from 16-slice and larger CT studies that will require the ability to perform “on-the-fly”, 3D processing at most diagnostic workstations. In order to perform such processing, the user must have the entire data set present on the workstation vs. working with portions of the data set while streaming technologies deliver the rest in the background. This will likely require eventual Gbps Ethernet to the diagnostic desktop and perhaps 10Gbps backbone bandwidth to enable maximum radiologist productivity. This change in imaging may raise the bar significantly for portable and wireless workstations.

6.2.3 Database

The next URMC PACS database should be capable of both centralized and distributed storage locations, while presenting a global work list to users that includes all studies stored. The database management application and associated hardware must be capable of handling the anticipated volumes of transactions over a multi-year period of operation.

Pre-fetching of prior images to workgroup servers will be unnecessary as all workstations will pull images from the archive database manager, All studies will be essentially on-line, all of the time. The qualifier “essentially” may still apply because most PACS solutions that URMC has examined still contain hierarchical levels of faster disk storage for the most recent studies and slower disk for the “deeper” archive. In fact, this means that some pre-fetching is still occurring as users pull from the faster “front-end” disk while the database management system is moving studies from the deeper, slower archive to the front-end.
The author thinks it unlikely in the foreseeable future that the EMR application will pull all data from a central, integrated database of patient health information. Instead it will be designed to retrieve data from many disparate databases and display them using various applications, "seamlessly" integrated at the desktop from the users' perspectives.

6.2.4 Storage

The next URMC PACS will be capable of storing all DICOM images. Separate storage for niche mini-PACS such as echo-cardiology and nuclear medicine will likely be retired as they run out of space in their own archives. Eventually the central PACS archive will become the repository for all "ologies" including those that use visible light.

The archive will also employ all spinning disk technology. Tape will be relegated at most, to the off-site, disaster recovery medium. Some vendors offer off-site spinning disk backup for disaster recovery in central "storage farms".

Over time, patient health information will increasingly be contained on centrally managed, storage-area-network-like systems rather than in totally disparate stores.

6.2.5 High availability

The next URMC PACS will perform at a minimum of .1% (44 minutes) unscheduled downtime per month (99.9% reliability). Downtime will be carefully defined in the vendor contract, as will the causes and amounts of scheduled downtime that will be tolerated. Vendor penalties will pertain for downtime in excess of contractual amounts.

The likely primary means of achieving this reliability will be fail over of both essential hardware and software processes. A redundant archive will exist at a remote site from the primary archive to offer continuation-of-business capability in the case of
damage to the site of the primary archive. A test system will be also be included in the PACS configuration so that upgrades and changes can be tested prior to moving into production.

As a means of maintaining operations in remote sites in case of a network or core database manager application failure, some combination of remotely located database and image caches and redundant network connections will be employed. The final design and balance among these continuation-of-business measures will be determined primarily by cost and feasibility within the URMC environment.

6.2.6 Workstations

Although this author has had a bias for web-based, thin-client applications and consumer-grade PC hardware in order to simplify deployment of work stations and reduce cost, the increasing 3D requirements for diagnostic reading is trending toward more powerful PCs. With the exception of a single vendor out of the eight included in the URMC request for proposals, all required a minimum of 2 GB of RAM for optimal performance. Dual processor machines are recommended by several of the vendors. This change in imaging may raise the bar significantly for portable and wireless workstations.

For the application that will distribute images throughout the enterprise however, the next URMC PACS web-based application will run acceptably on a 700 MHz PC with 256 MB of RAM, even over a broadband Internet connection.

As the hardware of the new workstations are specified, the Department of Radiology will be asked to decide upon ergonomic considerations in light of a continuing problem with repetitive motion injuries among radiologists and residents. These include
monitor type, mouse type, worktables and chairs, lighting, location, etc. It will be this author’s recommendation that a consultant be selected to assist with this facet of design.

6.2.7 Integration of Applications

The next URMC PACS will be “brokerless” in that the HL7/DICOM interface engine will be a process inherent in the PACS software. The PACS will also either be comprised of an integrated PACS/RIS from a single vendor, or it will be a PACS that is driven by the RIS database through CCOW or CCOW-like, desktop integration. Vendors are using documents known as Functional and Technical integration documents (FID and TID) to describe in detail the integration efforts among applications. Attached is a sample template FID document for integration of PACS, RIS and voice recognition reporting applications. (Appendix 2) The reader will see that there are no references to CCOW in this template. This is why this author refers to the desktop integration that URMC will be expecting as CCOW or CCOW-like.

The vendor(s) of the URMC PACS/RIS integrated unit will provide compliance with all DICOM functions and will be committed to delivering compliance with all of the IHE integration profiles with all capable image capture devices. They will also collaborate on a means of successfully addressing the issue of archiving studies from two hospitals with different MRN numbering systems.

A voice recognition, reporting application will also be integrated at the desktop in a CCOW or CCOW-like manner.

The PACS will interface with the clinical information system (CIS), likely through an application programmer interface. CIS is URMC’s embryonic electronic medical record. In this way, physicians will be able to launch the web-based viewer
through a CCOW or CCOW-like, context specific integration from the CIS where they typically view other results such as lab reports.

Integration of applications raises the issue of the possibility of obtaining most or all of an institution’s key applications from a single source. URMC’s RIS vendor also offers a PACS product. They are one of the few, if not the only PACS vendor who offers a single database for both PACS and RIS. Their RIS product is a market leader and is rather uniquely capable of PACS integration. This vendor is also the provider of the ambulatory services information system at URMC. At the same time this vendor is in consideration for the planned replacement of URMC’s HIS. There is potential then, for a single vendor to provide the HIS, RIS, PACS and ambulatory information systems. To make the proposal even more attractive, the company’s road map for the HIS and ambulatory systems is to eventually drive these from a single database as well. It would be a rather short step to considering this vendor for the clinical information system, or EMR application. This single source opportunity is a very attractive proposition on its face. One can imagine the simplification of interfacing that this might provide, even without the use of business process fusion standards. The potential downside of such an approach is the huge reliance that an organization would then have on a single vendor and the potentially huge switching cost that might be incurred if the institution ever wanted to move away from this vendor. To the extent that this single source approach allowed the vendor to use proprietary approaches vs. standards-based approaches, the switching costs could be multiplied.
6.2.8 Security

Patient information systems must have audit capabilities sufficient to provide a prudent level of protection against inappropriate viewing. The university medical center is engaged in the education of many interns and residents every year who require access to clinical information. There is also a large and varied full-time and part-time faculty of specialists and community practitioners that need access as well. Placing before-the-breech security measures in place, such as strict limitations to view patient information only if one’s name appears in the information system as a physician-of-record, risks posing too great an interference with the productivity and the teaching mission of the institution. Instead this author envisions the need for effective enforcement based upon a regimen of auditing who accesses what patient records. One approach being considered in RIS/PACS is a message that presents itself to any user who is not listed as a physician-of-record. The message notifies the user that they are requesting access to a patient for whom the information system is unaware that they are a physician-of-record, and that this fact is being recorded and this record will be audited. This would be most effective if such access could then be captured in a separate log and audited regularly. Indeed, failure to maintain a representative sampling audit of such access could render the warning ineffective.

In terms of physical access to workstations and applications, URMC is planning to continue a traditional user name and password challenge. As HIPAA privacy and security regulations continue to be developed, it remains to be seen if biometric or token devices such as smart cards or proximity devices will gain acceptance.
References

About HL7, Health Level Seven, http://www.hl7.org


Advantages of the IBM T221 flat panel color monitor for medical imaging, IBM, May 2003


Baldwin, Fred D., CPRs In The Winner’s Circle, Healthcare Informatics, pages 33-36, May 2003

Bell, Lawrence National Health Insurance Would Save Overhead Costs, Democrat and Chronicle, Rochester, New York, September 9, 2003


Butler, Janet Storage Gets Strategic, Software Magazine, June 2000


Chow, C. Edward, Godavari, Ganesh Kumar and Xie, Jianhua, Content Switch Rules and Their Conflict Detection, 2002, Department of CS, University of Colorado at Colorado Springs


Erikson, Bradley J., *Irreversible Compression of Medical Images*, Society for Computer Applications in Radiology, November 2000

**Evolution of Gigabit Technology: From the Backbone to the Desktop**, Intel, 2001


Freudenheim, Milt, *Many Hospitals Resist Computerized Patient Care*, New York Times, Tuesday, April 6, 2004

Gainer, Randy and Coplan, Scott, *Liability of Hospitals and Their Officials When Technology Projects Fail*, Davis Wright Tremain LLP, November 2003


Gardner, Stuart C. and Hughes, Kris K., *FDA ruling opens door to new PACS storage options*, AuntMinnie.com, July 4, 2003


Hagland, Mark, *Reduced Errors Ahead*, Healthcare Informatics, August 2003


Healthcare’s Top Business Issues and Responses for 2004, Cap, Ernst & Young


H17 Desktop Reference Guide, Neotool


IHE Radiology Integration Profiles: The Key to Integrated Systems, IHE Working Group, 2003-2004


Integrating the Healthcare Enterprise IHE Technical Framework Volume I, Integration profiles, Revision 5.5-for Trial Implementation, April 7, 2003


Key Capabilities of an Electronic Health Record System, Committee on Data Standards for Patient Safety, Board of Health Care Services, Institute of Medicine of the National Academies, The National Academies Press, 2003


Koller, John S. and Smith, Edward M., Seamless Information Exchange: Integrating the RIS-Modality-PACS, KAI Consulting


McGee, Marianne Kolbasuk, As Databases Grow, Storage Size Matters, Information Week, March 25, 2004


Network Load Balancing, Windows 2000 Hosting Deployment

Peterson, Jessica, *Healthcare Information Technology Spending is Growing Rapidly*, Sheldon I. Dorenfest Ltd., 2003


Reed, Gary, *Data Migration Challenges PACS Vendors and Users*, Diagnostic Imaging, May 2003:57-61


Siegel, Elliot and Reiner, Bruce, Huge Sets of Slices Will Transform Interpretations, Diagnostic Imaging, May 2003:39-94


Sun, Preparing the Enterprise for Web Services, March 30, 2003


The DICOM Standard, http://www.psychology.nottingham.ac.uk/staff/crl/dicom.html


Windows 2000 Clustering Technologies: Cluster Service Architecture, Microsoft Corporation White Paper
Appendix

1. The Open System Interconnect model (OSI)

Just as we have discussed integration of applications within the healthcare enterprise, at a more basic level, the advent of computer networking presented the problem of integration among machines and applications across any and all networks. The OSI model was a critical development that categorized computer and computer network functions into seven layers. Each layer performs certain specified functions. The critical functionality of the model lies in the fact that the functions of each layer are performed independently, and without regard for the other layers or the applications being used. In this way a change can be made in the functions and in the protocols operating within a single layer, without requiring changes in all other factors that comprise the system within which we are communicating. Computers use protocols to communicate. These protocols are sets of rules, sometimes quite complex, that govern how messages are constructed and handled. Categorizing these protocols and their functions into layers make systems easier to design and maintain.

The typical OSI model is shown below. Computer messages must pass down through each level, from the Application layer, layer 7 to the Physical layer, layer 1, before a message from a computer can reach the network physical medium. In a similar way, messages received at the network physical medium must go up through these same layers, from layer 1 to layer 7, before being delivered to the computer user. (http://www.nd.edu/~lemmon/courses/UNIX/16/node1.html)

<table>
<thead>
<tr>
<th>Network Services</th>
<th>Higher Level Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical layer</td>
<td>Application layer</td>
</tr>
<tr>
<td>Data link layer</td>
<td>Presentation layer</td>
</tr>
<tr>
<td>Network layer</td>
<td>Session layer</td>
</tr>
<tr>
<td>Data link layer</td>
<td>Transport layer</td>
</tr>
<tr>
<td>Physical layer</td>
<td>End User A</td>
</tr>
<tr>
<td>Physical layer</td>
<td>End User B</td>
</tr>
<tr>
<td>Physical layer</td>
<td>End User A</td>
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<tr>
<td>Data link layer</td>
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<td>Transport layer</td>
</tr>
<tr>
<td>Physical layer</td>
<td>End User B</td>
</tr>
</tbody>
</table>

These layers can be divided into two groups; protocols providing network services and higher level protocols. The network protocols are associated with transmitting data over different sorts of networks (ethernet, ATN, etc.). The higher-level protocols provide for services that ensure that messages are transmitted error-free and in the proper format for the receiver computer. The bottom three layers (physical, data link, and network) provide the network services. The top four levels (transport, session,
presentation, and application) form the user services which are generally resident on the host computer.

Although the names of the layers do represent the kind of functions contained within each, study beyond the scope of this paper is required to fully understand the distinctions among layer functions. A basic description of the functions at each level is as follows: (http://www.webopedia.com/quick_ref/OSI_Layers.asp)

**Application layer 7**
- This layer supports application and end-user processes.
- Communication partners are identified.
- Quality of service is identified.
- User authentication and privacy are considered, and
- Any constraints on data syntax are identified.
- Everything at this layer is application-specific.

**Presentation layer 6**
- This layer provides independence from differences in data representation by translating from application to network format, and vice versa.
- The presentation layer works to transform data into the form that the application layer can accept and vice versa.
- This layer formats and encrypts data to be sent across a network, providing freedom from compatibility problems.

**Session layer 5**
- This layer establishes, manages and terminates connections between applications.
- The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications at each end.
- It deals with session and connection coordination.

**Transport layer 4**
- This layer provides transparent transfer of data between end systems, or hosts.
- It is responsible for end-to-end error recovery and flow control.
- It ensures complete data transfer.

**Network layer 3**
- This layer provides switching and routing technologies.
- It creates logical paths for transmitting data from node to node.
- It handles addressing, internetworking, error handling, congestion control and packet sequencing.

**Data link layer 2**
At this layer, data packets are encoded and decoded into bits.

- It furnishes transmission protocol knowledge and management
- It handles errors in the physical layer, flow control and frame synchronization.
- It controls how a computer on the network gains access to the data and permission to transmit it.

**Physical layer 1**

- This layer conveys the bit stream, the electrical impulse, and light or radio signal through the network medium in electrical and mechanical terms.
- It provides the hardware means of sending and receiving data on a carrier.
- It includes defining cables, connectors, cards and other physical aspects.
2. Functional Integration Document Example

Introduction/Base Requirements

The purpose of this document is to provide a solid understanding of the functional interoperability between the FIRST PARTY VENDOR RIS products and Third Party Vendor PACS products. Special considerations to the user's workflow at each component of the system as well as application look and feel have been carefully considered.

The document describes two (2) models. The first, the Radiologist uses the First Party Vendor Application running on the Third Party Vendor Diagnostic Workstation. The second, the Referring provider and/or Clinician uses the FIRST PARTY VENDOR Referring Provider Work list to view reports and may invoke the Third Party Vendor and/or the Third Party Vendor Clinical Workstation application.

In this document, all connectivity is assumed between Third Party Vendor PACS Products running on an NT-Based Operating System integrated to First Party Vendor Application V.X using Internet Explorer 5.0 or above. The basic requirements for interoperability are that the products provide an integrated diagnostic workstation desktop that can be used by the radiologist to manage the imaging and non-imaging aspects of their daily work. The Referring Provider and Clinician viewing applications maintain the demand for the same basic requirements. As such, FIRST PARTY VENDOR and Third Party Vendor shall provide common secure login and logout functionality for the applications described within this document as well as synchronized "context" or "shared focus" between imaging and non-imaging applications.

Matrixed Documents

- Third Party Vendor - FIRST PARTY VENDOR Functional Integration Documents (Third Party Vendor - IFID) – The Third Party Vendor- IFID (this document) provides full functional and workflow requirements between FIRST PARTY VENDOR and Third Party Vendor. Emphasis on look and feel provides clear application behavior and interaction. Each company shall be subject to working within the boundaries described in the Third Party Vendor IFID. However, Third Party Vendor shall have the opportunity to integrate with FIRST PARTY VENDOR uniquely based on collaboration and agreement, which must be documented by the Third Party Vendor IFID. Furthermore, both Third Party Vendor and FIRST PARTY VENDOR shall mutually construct and agree upon the Technical Integration by co-authoring the Third Party Vendor FIRST PARTY VENDOR Technical Integration Document (Third Party Vendor - ITID).
- Third Party Vendor - FIRST PARTY VENDOR Technical Integration Documents (Third Party Vendor - ITID) – The Third Party Vendor ITID shall provide all technical integration specifications and detail by which engineers may both develop and then later support the integrated product offering described in the corresponding Third Party Vendor FIRST PARTY VENDOR Functional Integration Document (Third Party Vendor IFID). The Third Party Vendor - ITID shall be both versioned, and held by each party i.e. FIRST PARTY VENDOR and Third Party Vendor.

Matrixed Document Control:

Functional Specification:
Third Party Vendor - IFID
Third Party Vendor - FIRST PARTY VENDOR Functional

Technical Specification:
Third Party Vendor - ITID
Third Party Vendor - FIRST PARTY VENDOR Technical

“Report Creation System”
Functional & Technical Specification:

"Report Creation System"-IFTID
Report Creation System FIRST PARTY VENDOR Functional &

Note: The Third Party Vendor - IFID shall reference multiple “Report Creation System”-IFIDs.

Product Nomenclature

Third Party Vendor Product Nomenclature

Note: Third Party Vendor must provide specifics on Product Nomenclature
Third Party Vendor– Diagnostic Reading Workstation
Third Party Vendor– Archive
Third Party Vendor– Web Server/Viewer

FIRST PARTY VENDOR Product Nomenclature

FIRST PARTY VENDOR Modality Worklist (“Technologists Worklist”)

- Provides a display of a customizable worklist of exams to be performed. This worklist may be displayed on any computer that can support a browser, including the modality console.
- From the worklist, the user may access all RIS functionality.
  * Change exam codes
  * View Protocol for the exam
• Arrive exam
• Begin exam
• Complete exam with all pertinent end exam data
• Depart exam
• Resolve Exceptions (Broken Studies)

FIRST PARTY VENDOR Interpretation Worklist
➤ Provides an integrated Customizable worklist is available from any computer on the network, including the diagnostic workstation.
  • Enterprise view for patient exams, digital and analog, to be interpreted by the Radiologist.
  • Enterprise patient exam history from the RIS
  • Worklist may be created by any combination of organ system, modality type and sub-specialty
  • Worklist may be created for a specific date or date range
  • Worklist may be created for a single organization or multiple organizations
  • Worklist may be sorted by several criteria including exam code, exam date and time, patient name, and requesting provider
  • Related priors may be displayed automatically or chosen for display from a drop down list.

FIRST PARTY VENDOR Protocol Worklist
➤ Provides worklist for adding protocols to scheduled exams.
➤ Gives the radiologist an Enterprise view of the patient, including all results no matter under which MRN the exam took place, or whether they are film based.
  • Change exam codes
  • Access to exam history and all prior reports
  • Order new exams
  • Schedule new exams

Referring Physician Worklist
➤ Customizable worklist is available from any computer on the network.
  ➤ Provides access to diagnostic reports and images (requires Third Party Image Viewer) from anywhere (given proper security).
  ➤ Additional First Party Vendor Application functions are available from within the Referring Physician Worklist.
  • Access to exam history and all prior reports
  • Order new exams
  • Schedule new exams
  • Print diagnostic reports

Signature Queue
➤ Provides access to the Physician list of preliminary status exams requiring signature and finalization.
  • Send reports to colleagues for review
  • View reports to review
Hold reports in signature queue
• Edit reports
• Apply standard reports

Clinical Exam Note
➢ Provides multiple levels of RIS information within a single dynamic window.
• Access to the current exam history in detail
• Access to the list of system calculated related prior reports at a quick glance.
• Access to all the patients RIS information, all prior reports, scheduled exams, and a view of all exams regardless of their current status.
• Provides access to “other clinical information” i.e. Labs, Pathology, Allergies, Problem lists and any other information based on integration at each site.

Order Request Screen-Available upon request.
➢ Provides the ability to order additional studies right from the integrated diagnostic workstation desktop.

High Level Functional and Technical Interactions

RIS-PACS Integration Workflow

Direct Bi-directional RIS – PACS Integration
Step 1. FIRST PARTY VENDOR shall provide required patient and exam information to Third Party Vendor PACS.
Step 2. FIRST PARTY VENDOR shall provide DICOM Worklist to compliant acquisition devices
Step 3. Newly acquired images are transmitted to Third Party Vendor PACS
Step 4. Upon reception of new images, Third Party Vendor PACS transmits availability notification to RIS containing required patient, exam and image information.
Step 5. FIRST PARTY VENDOR performs validation comparing RIS and Image data, provides PASS/FAIL and or correction to PACS.

NOTE: Refer to the Third Party Vendor-ITID for additional technical specificity and requirements.

Pre-Fetching Integration Workflow

Direct Bi-directional RIS – PACS Integration
Step 1 New exam(s) are scheduled in the FIRST PARTY VENDOR RIS
Step 2 Third Party Vendor PACS performs pre-fetch comparison with its internally calculated list and adds RIS provided studies if not already identified. PACS moves studies from long-term archive to on line.
Step 3 Third Party Vendor PACS provides notification to FIRST PARTY VENDOR RIS indicating that images are available. Third Party Vendor has images available locally “all the time”.

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Step 4  Upon reception of new images, Third Party Vendor PACS transmits availability notification to RIS containing required patient, exam and image information.

Step 5  FIRST PARTY VENDOR performs validation comparing RIS and Image data, provides PASS/FAIL and or correction to PACS.

**NOTE:** Third Party Vendor Archive shall provide update information to FIRST PARTY VENDOR RIS whenever a study is archived to the long-term storage.

**NOTE:** Refer to the Third Party Vendor-ITID for additional technical specificity and requirements.

**NOTE:** Archive Reconciliation may be required to support access to historical image information.

(See Third Party Vendor - ITID for more details.)

**Functional Requirements**

**RIS/Archive Integration**

First Party Vendor Application shall forward the following patient information to Third Party Vendor Archive upon performing a First Party Vendor Application Patient Registration, Edit, or Merge.

- Organization and ID
- Name
- Birth Date
- Sex
- Maiden Name
- Size and Weight (future release)

First Party Vendor Application shall forward the following exam information to Third Party Vendor Archive upon performing a First Party Vendor Application Exam Schedule, Edit or Status Change.

- Accession Number
- Study UID
- Signs and Symptoms
- Study Status
- Requesting Physician
- Exam Description
- Exam code and description
- Physician Reading Study (last signer)
- Scheduled date and time

**Desktop Integration**

Two desktop integration models are possible:

- RIS Driven Desktop – The user begins by logging into the FIRST PARTY VENDOR application. The Worklists are created by RIS. The user selects studies from the worklist. A Third Party Vendor viewer automatically displays the page.
The Third Party Vendor workstation can be configured with images “locally” or “on-demand.” Both configurations shall be integrated with First Party Vendor Application.

(ADD VENDOR SCREEN SHOT)

- PACS Driven Desktop – The user logs into the Third Party Vendor Diagnostic Workstation application. The Worklist is created on the PACS Workstation and order information is created from the RIS. The user shall mainly view the selected studies or exams. After the selected exam(s) is viewed, the user may launch the built-in report dictation system to generate reports. The reports are dictated via the Third Party Vendor PACS Workstation. After the report is dictated, the report text shall be transferred to FIRST PARTY VENDOR. Meanwhile, during the study reading process, the user may access the FIRST PARTY VENDOR application to review the current report and status and prior study related reports.

- Limitation – Only one of above integration model can be used per user/workstation based on preference.

**Desktop Configuration**

Two desktop configurations are possible for the Third Party Vendor Clinical and Diagnostic Reading Workstation. Both configurations support one Server (box) with one or more Diagnostic Monitors; however an enhanced configuration supports an additional SVGA monitor.

- The Diagnostic monitors shall be used for displaying images.
- The SVGA monitor shall be used for First Party Vendor Application and the Dictation System.

The user can configure the placement of First Party Vendor Application modules on the monitor, and the application shall store the screen placement for future reference.

**1.6.1.1 Standard configuration showing First Party Vendor Application Interpretation Worklist and Third Party Vendor Diagnostic Review Station** (ADD VENDOR SPECIFIC SCREEN SHOT) sharing a single Diagnostic Monitor.

**1.6.1.2 Enhanced configuration showing First Party Vendor Application Interpretation Worklist and Third Party Vendor Diagnostic Review Station** (ADD VENDOR SPECIFIC SCREEN SHOT) running on separate monitors.

The configuration shall provide the ability to turn “off” or “on” access to First Party Vendor Application modules, and the automatic display of Clinical Exam Notes and Dictation.

**Automatic Display of Clinical Exam Notes**

When an image is displayed, FIRST PARTY VENDOR shall provide the ability to automatically display Clinical Exam Notes for RIS information, exam history, and a list of all prior and related exams.
Automatic Launching of Dictation

When an image is displayed, FIRST PARTY VENDOR shall provide the ability to automatically launch the Dictation System.

RIS Driven Desktop

Workflow Scenarios at the Diagnostic Workstation

Login

Users may begin using the First Party Vendor Application. Successful login into First Party Vendor Application shall provide auto-login and authentication for the Third Party Vendor Diagnostic Workstation application. The login shall bring up related desktop preference settings.

Hold

The user in Third Party Vendor Diagnostic Workstation shall be able to hold (pause) the current study and switch to another study to view.

Resume

The user in Third Party Vendor Diagnostic Workstation shall be able to return to the same point of the previously held study to continue diagnostic activities.

Display

Initiate Display

The user shall have the ability to select and display a single exam, or a list of exams from the FIRST PARTY VENDOR Interpretation Worklist. The exams may be on the same patient or multiple patients.

“Double clicking” the check box next to the exam, shall immediately display the image in the Third Party Vendor Clinical/Diagnostic Reading Workstation.

“Single clicking” the check box for one or more exams, and clicking the “Display” command button, shall display a list of exams in the Third Party Vendor Clinical/Diagnostic Reading Workstation.

Third Party Vendor shall display exam selections in the order selected from the Interpretation worklist for multiple exams for the same patient.

If the images are not available for immediate viewing (i.e. Long Term Storage), First Party Vendor Application shall send a message to move the images from Long Term Storage to the Archive. To improve performance, First Party Vendor Application will check for image availability, and perform any required moves after selecting the exams, but prior to requesting multiple the studies be displayed.

The integration shall support any combination of the following four scenarios:

Displaying exams for multiple patients

The FIRST PARTY VENDOR user may select multiple patients to view. In the case of selecting multiple patients, only the first patient shall be loaded and displayed on Third Party Vendor Diagnostic Workstation. By clicking a button labeled “Next Patient” within
Third Party Vendor Diagnostic Workstation, the workstation shall signal FIRST PARTY VENDOR to automatically feed the next patient to the Third Party Vendor Diagnostic Workstation (Add Vendor Screen Shot below).

**Displaying multiple exams for a single patient**
For a single patient, the FIRST PARTY VENDOR user may select multiple exams to view. In the case of selecting multiple exams for the same patient, only the first exam will be loaded and displayed on Third Party Vendor Diagnostic Workstation. By clicking a button labeled “Next Patient” within Third Party Vendor Diagnostic Workstation, the workstation will signal FIRST PARTY VENDOR to automatically feed the next exam to Third Party Vendor Diagnostic Workstation.

(ADD VENDOR SCREEN SHOT)

1.1.1.1.1.1.1 **Displaying multiple exams for multiple patients**
For multiple patients, the FIRST PARTY VENDOR user may select multiple exams to view. In the case of selecting multiple exams for multiple patients, only the first exam will be loaded and displayed on Third Party Vendor Diagnostic Workstation. By clicking a button labeled “Next Patient” within Third Party Vendor Diagnostic Workstation, the workstation will signal FIRST PARTY VENDOR to automatically feed the next exam to Third Party Vendor Diagnostic Workstation.

1.1.1.1.1.2 **Viewing the CEN**
Users shall be able to click the Clinical Exam Notes button to view clinical information for studies displayed on the diagnostic workstation. Users may also view prior exam information by branching through the “related exams” or “all exams” at the bottom of the CEN.

1.6.2.1.4.1.1 If exams are linked, then the following screen shall display allowing the user to display the appropriate clinical exam notes.

1.1.1.1.1.1.3 **Displaying related priors**
For a single patient, the FIRST PARTY VENDOR user may select multiple related priors to view. In the case of selecting related priors for the same patient, all exams will be loaded and displayed on Third Party Vendor Diagnostic Workstation (ADD Vendor Screen Shot).

**Return to FIRST PARTY VENDOR Interpretation Worklist**
The Third Party Vendor Diagnostic Workstation user may return to the FIRST PARTY VENDOR Interpretation Worklist by selecting a button labeled “Interpretation Worklist” located within the UI of the Third Party Vendor Diagnostic Workstation.
Next Patient

By clicking a button labeled “Next Patient” within Third Party Vendor Diagnostic Workstation, the workstation will signal FIRST PARTY VENDOR to automatically feed the next patient or exam to Third Party Vendor Diagnostic Workstation.

Selecting “Next Patient” shall automatically close any open First Party Vendor Application windows, such as the Clinical Exam Note for that exam.

When dictating a report with TalkStation, the configuration shall provide the ability to automatically launch the Next Patient upon completing dictation. For example, upon saving the dictated report, TalkStation will signal Third Party Vendor to display the next patient and relaunch TalkStation for the next exam. If multiple exams are displayed, TalkStation is launched for the first and most recent exam.

Hold Viewing Session

FIRST PARTY VENDOR user may wish to hold the current viewing session and go back to FIRST PARTY VENDOR application. By clicking “Hold Session” button within Third Party Vendor Diagnostic Workstation, the First Party Vendor Application Interpretation Worklist is displayed. Once exam(s) have been selected, the user may select the “display” button thus initiating a new instance of the Third Party Vendor Clinical/Diagnostic Review Station to view the selected exams. For example, a clinician wishes to review a study with the radiologist, who is currently dictating on a different study. The radiologist may click “Hold” for the study he/she is dictating upon, discuss the patient with the clinician, and then return to finish dictating on the original study.

Launch FIRST PARTY VENDOR RIS for Prior Reports

User views the RIS prior reports and current exam information via the FIRST PARTY VENDOR Clinical Exam Note / Report. The Third Party Vendor Diagnostic Workstation user may launch the FIRST PARTY VENDOR clinical exam note to view current patient and exam information as well as gaining access to prior related and all other prior RIS reports and exam information. A button labeled “Report” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide this access to the FIRST PARTY VENDOR Clinical Exam Note.

Review Preliminary Exam Status and Sign off Reports

The Third Party Vendor Diagnostic Workstation user shall have the ability to launch the radiologist’s list of exams in preliminary status to be reviewed and signed off in the RIS.

Launch Report Signature

A button labeled “Signature” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide this access to the
Radiologists Report Signature Queue within FIRST PARTY VENDOR.

**Review Reports**
The Radiologist may perform the following report actions:
- View the list of Preliminary Status reports.
- Send reports for Review
- Edit reports via simple text editor.
- Select reports to sign and finalize

(ADD VENDOR SCREEN SHOT)

**Order a study by Third Party Vendor Diagnostic Workstation**
The Third Party Vendor Diagnostic Workstation user may wish to order a study. This is accomplished by launching the componentized FIRST PARTY VENDOR Order Request screen.

**Launch an “Order Request”**
- A button labeled “Order Request” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide the ability to order additional studies.

(ADD VENDOR SCREEN SHOT)

**Third Party Vendor Diagnostic Workstation launches the FIRST PARTY VENDOR Protocol Worklist**
The user shall have the ability to launch a Worklist of exams requiring protocol within the RIS. This application can be launched with the context of a single study or directly to the main Protocol Worklist.

**Launch a “First Party Vendor Application Protocol Worklist”**
A button labeled “Protocol Worklist” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide this access.

(ADD VENDOR SCREEN SHOT)

**Dictate Report**
Third Party Vendor Diagnostic Workstation user dictates report. The Third Party Vendor Diagnostic Workstation user shall have the ability to initiate FIRST PARTY VENDOR to appropriately invoke the report creation system via the Third Party Vendor Diagnostic Workstation UI.

1.6.2.1.9.1 If users have Linked studies in Modality Worklist (IE: Chest, Abdomen, Pelvis so that any accession number that is selected from the linked exams shall display all linked images), only the primary exam can display Clinical Exam Notes and provide Dictation Services without the following additional selection screen.

1.6.2.1.9.2 If exams are linked, then the following screen shall display allowing the user to display the appropriate exam.

1.6.2.1.9.3 The user shall also have the option to associate any Completed exams.
Launch Report Creation System

Click "Dictate" -

A button labeled "Dictate" located within the UI of the Third Party Vendor Diagnostic Workstation shall provide this access.

5.2.2.1.9.2.1 Users may choose to dictate using Voice Recognition.

5.2.2.1.9.2.1.1 Users may choose to save (P) or sign (F) the report in the dictation system.

5.2.2.1.9.2.2 Users may sign saved (P) reports in either the dictation system or in First Party Vendor Application.

5.2.2.1.9.2.3 If users sign the saved report (P) in First Party Vendor Application, Then the final report repository shall be First Party Vendor Application. The update will not be provided to the voice recognition system.

5.2.2.1.9.2.2 Users may choose to dictate using the dictation system and save for transcription.

5.2.2.1.9.2.2.1 Transcription shall access the voice recognition transcription queue and shall listen to the wav file.

5.2.2.1.9.2.2.1.1 Transcription shall type the report into First Party Vendor Application.

5.2.2.1.9.2.2.1.2 The radiologist may sign the report in either the Dictation system or First Party Vendor Application.

(ADD VENDOR SCREEN SHOT)

Invoke FIRST PARTY VENDOR Reporting Activities

Upon selection of the "Dictate" button, the Third Party Vendor Diagnostic Workstation shall invoke the FIRST PARTY VENDOR reporting activities functionality.

- FIRST PARTY VENDOR shall accept the dictate call from the Third Party Vendor Diagnostic Workstation.
If only a single exam for the current patient is awaiting dictation, FIRST PARTY VENDOR will invoke the report creation system passing necessary patient and exam information.

If more than a single exam for the current patient is awaiting dictation, FIRST PARTY VENDOR shall present the Third Party Vendor Diagnostic Workstation user with a window displaying the list of exams, which may be candidates for association.

The Third Party Vendor Diagnostic Workstation user may select additional exams for association or dictate the report for the single exam.

Report Creation System Integration

High-Level Report Creation System Interaction
Third Party Vendor User Launches Talk Technology Workstation
- The Third Party Vendor Diagnostic Workstation User shall have the ability to select “dictate” while viewing images in Third Party Vendor Diagnostic Workstation. Selection of “dictate” shall initiate the Talk Technologies application to enable report generation.
- SEE Talk Technology –FIRST PARTY VENDOR Functional and Technical Specifications document (Talk Technologies-IFTID) for more information.
- A “Dictate” button shall be available in Third Party Vendor Diagnostic Workstation. When user clicks “Dictate” button, Third Party Vendor Diagnostic Workstation shall send a signal to FIRST PARTY VENDOR application. After the signal is acknowledged by FIRST PARTY VENDOR application, FIRST PARTY VENDOR application shall invoke pre-configured dictation function, which is transparent to Diagnostic Workstation application.

Login

First Party Vendor Application login shall log the user into Talk Station, and log the following message.

Manual Launch of TalkStation – Voice Recognition
Selecting “Dictation” from Third Party Vendor, will automatically launch dictation for the appropriate exam.

(ADD VENDOR SCREEN SHOT)
Choosing save report will update the exam status to Preliminary and close Talk.
Choosing sign report will update the exam status to Final and close Talk.

(ADD VENDOR SCREEN SHOT)

**Manual Launch of TalkStation – Digital Dictation**

Selecting “Dictation” from THIRD PARTY VENDOR, will automatically launch dictation for the appropriate exam. Choosing save report will update the exam status to Dictated and close Talk.

**Automatic Launch of TalkStation**

*The server shall have the ability to automatically launch TalkStation.*

*Under this scenario, discarding, signing, or saving the report shall automatically launch the next image in the worklist with TalkStation.*

*Note: Simply discarding, signing, or saving the report will automatically perform the action of clicking the “Next Patient” button and “dictation” button without actually clicking buttons.*

**Third Party Vendor User Launches PowerScribe**

- The Third Party Vendor Diagnostic Workstation User shall have the ability to select “dictate” while viewing images in Third Party Vendor Diagnostic Workstation. Selection of “dictate” will initiate the PowerScribe application to enable report generation.
- **SEE PowerScribe –FIRST PARTY VENDOR Functional and Technical Specifications document (PowerScribe-IFTID) for more information.**
- A “Dictate” button shall be available in Third Party Vendor Diagnostic Workstation. When user clicks “Dictate” button, Third Party Vendor Diagnostic Workstation will send a signal to FIRST PARTY VENDOR application. After the signal is acknowledged by FIRST PARTY VENDOR application, FIRST PARTY VENDOR application shall invoke pre-configured dictation function, which is transparent to Diagnostic Workstation application.

**Third Party Vendor User Launches Dictaphone**

- The Third Party Vendor Diagnostic Workstation shall have the ability to select “dictate” while viewing images in Third Party Vendor Diagnostic Workstation. Selection of “dictate” shall initiate the Dictaphone application to enable report generation.
- **SEE Dictaphone –FIRST PARTY VENDOR Functional and Technical Specifications document (Dictaphone-IFTID) for more information.**
- A “Dictate” button is currently available in Third Party Vendor Diagnostic Workstation. When user clicks “Dictate” button, Third Party Vendor Diagnostic Workstation will send a signal to the FIRST PARTY VENDOR application. After the signal is acknowledged by the FIRST PARTY VENDOR application, the FIRST PARTY VENDOR application shall invoke pre-configured
dictation function, which is transparent to Diagnostic Workstation application.

**Third Party Vendor User Launches Linear System**
- The Third Party Vendor Diagnostic Workstation shall have the ability to select “dictate” while viewing images in Third Party Vendor Diagnostic Workstation. Selection of “dictate” shall initiate the Linear application to enable report generation.
- **SEE Linear–FIRST PARTY VENDOR Functional and Technical Specifications document (Linear-IFTID) for more information.**
- A “Dictate” button shall be available in Third Party Vendor Diagnostic Workstation. When user clicks “Dictate” button, Third Party Vendor Diagnostic Workstation will send a signal to FIRST PARTY VENDOR application. After the signal is acknowledged by FIRST PARTY VENDOR application, FIRST PARTY VENDOR application shall invoke pre-configured dictation function, which is transparent to Diagnostic Workstation application.

PACS Driven Desktop

**Workflow Scenarios at the Diagnostic Workstation**

**Login**
*Users may begin using the Third Party Vendor Diagnostic Workstation application. Successful login into Third Party Vendor application shall provide auto-login and authentication for the First Party Vendor Application.*

**Display**

**Select exam(s)**
The user shall have the ability to select an exam or a list of exams from the study list of Third Party Vendor Diagnostic Workstation to view. The relevant prior exams are listed. Each exam shall indicate whether it is on-line (RAID) or in the long-term storage. Both on-line and long-term stored exams can be selected.

*(ADD VENDOR SCREEN SHOT)*

**Initiate Image Display**
The user may double click the selected exam(s) thus initiating the Third Party Vendor Diagnostic Workstation.

**View Images**
Once exam(s) has been selected, the Third Party Vendor Diagnostic Workstation loads the images of the selected exams for the first patient on the study list.

*(ADD VENDOR SCREEN SHOT)*
**Next Patient**

The user may select multiple patients to view. In the case of selecting multiple patients, only the first patient will be loaded and displayed on Third Party Vendor Diagnostic Workstation. By clicking a button labeled “Next Patient” within Third Party Vendor Diagnostic Workstation, the workstation will automatically load the next patient to view.

**Launch FIRST PARTY VENDOR RIS for Prior Reports**

Third Party Vendor Diagnostic Workstation user views the RIS prior reports and current exam information via the FIRST PARTY VENDOR Clinical Exam Note / Report. The Third Party Vendor Diagnostic Workstation user may launch the FIRST PARTY VENDOR clinical exam note to view current Patient and exam information as well as gaining access to prior related and all other prior RIS reports and exam information. A button labeled “Report” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide this access to the FIRST PARTY VENDOR Clinical Exam Note.

**Third Party Vendor Diagnostic Workstation displays the FIRST PARTY VENDOR RIS interface**

The Third Party Vendor Diagnostic Workstation shall have the ability to access the RIS interface via a single click from the diagnostic workstation application. If the access is the first time, FIRST PARTY VENDOR RIS home page will be brought up. Subsequent selections bring up the FIRST PARTY VENDOR RIS interface to where it was used. FIRST PARTY VENDOR may need to disable the “Display” button in the Worklist. FIRST PARTY VENDOR may also need to leave the interface at “Non-full size” window so the users can click the background Third Party Vendor application to switch back easily.

**Launch a “FIRST PARTY VENDOR RIS Interface”**

A button labeled “FIRST PARTY VENDOR RIS Interface” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide access to the main menu.

**Dictate Report**

Third Party Vendor Diagnostic Workstation user dictates a report by using the built-in report creation system. The Third Party Vendor Diagnostic Workstation user shall have the ability to invoke the report creation system via the Third Party Vendor Diagnostic Workstation UI.

**Launch Report Creation System**

**Access “Dictate”**

A menu option, labeled “Dictate” located within the UI of the Third Party Vendor Diagnostic Workstation shall provide access.

**Invoke Report Dictation**
Upon selection of the “Dictate” button, the Third Party Vendor Diagnostic Workstation shall invoke its report dictation functionality. When the user finishes report dictation, a dialog window will be displayed with the transcribed text generated using a speech converter. The user may edit the text and then sign the report. As soon as the report is signed, it will be transferred to FIRST PARTY VENDOR.

**Transfer Dictated Report(s) to FIRST PARTY VENDOR RIS**

After the report dictation is completed, the Third Party Vendor Diagnostic Workstation shall notify the FIRST PARTY VENDOR application the readiness of reports. Then, the dictated report(s) shall be transferred to FIRST PARTY VENDOR application to store.

**Special Case Management (Exception Handling/Broken Study Management)**

**RIS Exam Information Validation**

*RIS Validation is provided between FIRST PARTY VENDOR and Third Party Vendor by new study acquisition notification i.e. Image Availability Notification (See also the Third Party Vendor -ITID)*

**Third Party Vendor PACS Exam Information Update**

Exception (Broken Study) is resolved within FIRST PARTY VENDOR, Third Party Vendor PACS shall accept the update and make the necessary changes within the PACS realm to ensure that image and patient/exam information is synchronized. (See the *IHE Framework for more information.*) (See also the Third Party Vendor -ITID)

**Third Party Vendor PACS Exam Information Update Exception Handling / Broken Study Management – “Trauma Case”**

**Step 1**  Newly acquired images are transmitted to Third Party Vendor PACS

**Step 2**  Upon receipt of new images, Third Party Vendor PACS transmits availability notification to RIS containing required patient, exam and image information.

**Step 3**  *FIRST PARTY VENDOR performs validation comparing RIS and Image data, provides PASS/FAIL.*

**Step 4**  Study information, which fails the RIS validation, is presented to the Technologist directly at the acquisition device (and RIS System Admin) in the form of an exception. The Tech may perform the required RIS functions to correct the exception.
Step 5  Updated and corrected study information is the transmitted to the Third Party Vendor PACS. PACS accepts updates and performs necessary reconciliation and corrections.

The user shall have the ability to view images for Exceptions (Broken Studies). Selecting the command button next to the Exception in the FIRST PARTY VENDOR Interpretation Worklist shall launch the image in a separate instance of the Third Party Vendor Review Station.

NOTE: Refer to the Third Party Vendor -ITID for additional technical specificity and requirements.

Non-Diagnostic Image Viewer Integration

Web Viewer Integration

Login

The Web Viewer shall provide a secure user id and password. The integration shall support one common user, or a unique user id and password for each First Party Vendor Application user.

Referring Provider

The Referring Provider shall initially log on to the FIRST PARTY VENDOR Referring Provider Worklist application to view his/her list of Patients’ exam results. The user’s security information shall be encrypted and passed to the application thus auto-logging the user in.

Report

The Physician may select specific reports to review.

Select Exams

Exams, which have images available for view, shall present with a check box. Upon selection on a particular exam, or exams, the “viewer” button shall become enabled.

View Exams

Selection of the “viewer” button shall launch the image viewer displaying the first selected exam.

- If multiple exams are selected, the image viewer shall provide navigation to all selected exams.
- The user may launch the FIRST PARTY VENDOR clinical exam note to view current patient and exam information as well as gaining access to prior related and all other prior RIS reports and exam information.
- Closing the image viewer shall return the user to the FIRST PARTY VENDOR Referring Provider Worklist.

(ADD VENDOR SCREEN SHOT)

Close

Upon exiting the FIRST PARTY VENDOR Referring Provider Worklist, both systems are terminated and closed simultaneously.
First Party Vendor Application Results Module

The user shall have the ability to select an exam from the First Party Vendor Application Results module, and view the image on the Web Viewer.

Digital Image Management

The user shall have the ability to select a Study UID from the First Party Vendor Application Digital Image Management module, and view the image on the Web Viewer.

Exception Worklist

The user shall have the ability to select a Study UID from the First Party Vendor Application Exception Worklist, and view the image on the Web Viewer.

Results Reporting

The user shall have the ability to create or edit a report on an exam from the First Party Vendor Application Results Reporting module, and view the image on the Web Viewer.

Future Requirements

*FIRST PARTY VENDOR Referring Provider Worklist User Display Key Images on*

Clinician Viewer Integration

Note: This part shall be functionally same as Section 5.1 except “Dictate” Functionality.