From H.I.T (Health Information Technology) to e-Healthcare; research and practice

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Over the last decade, communications and data processing have evolved beyond all predictions. Computing power has moved from the data-centre (mainframe) to the department (mini) and from the host to the desktop. In many applications, green-screens have given way to a bewildering choice of client-server GUI's and the same trend toward distributed computing has empowered users and changed business practices. Serial connections to hosts have given way to 1st generation networking protocols and early networking infrastructures that have in turn been eclipsed by TCP//IP, ATM and Gigabit technologies.

In the main however; healthcare has been slow to adopt these new technologies. With the mainstream arrival of the Internet and a number of its accompanying technologies; HealthCare IT is set to 'leapfrog' other industries and benefit from the 'network' phenomena. The face of medicine will change as clinical communication moves out of it's infancy to deliver distributed, multimedia enables medical records common, shared and distributed between Physicians, Laboratories, Imaging Centers, Pharmacies and Patients. In this endeavor, Telematics, EPR, Clinical Data Warehousing, Data Mining and sophisticated but standardized client applications will come together to drive a new paradigm.

Electronic information across clinical and organizational boundaries can now be accessed anywhere through Internet enabled devices, facilitating a broader continuity in healthcare, increased quality of care and ever decreasing cost. H.I.T professionals must now ask themselves not just how does the technology that they provide serve their organization; but how does it serve the patient and the healthcare profession.

1. History and Background

Over the last decade, both computing power and connectivity have progressed at a phenomenal rate. In the late 1970's the largest impediment to the creation of graphical user interfaces was the computer power required to drive them. More than one luminary of the near legendary Xerox-PARC complained that research into computer graphics was ill fated, believing that the cost of the computer power necessary even for an interactive teletype terminal was too much for a single user to bear[1]. At the beginning of the last decade, the only commercially available computer with a Graphical User Interface (GUI), the Apple LISA would cost some $10,000. The initial 'killer applications' for computing in healthcare focussed around patient accounting, gathering of statistical information and in some instances, room booking. These applications were developed around then mainframe-based architectures and accessed through green-screen terminals distributed at a small number of desks within the organisation. Networking for these machines was limited and often took the form of serial data lines radiating like spaghetti from the 'computer room', which was then a secure refrigerated room staffed by the pocket-protector wearing statisticians or mathematically minded finance types who were the first group of I.T. professionals. I.T in Healthcare has come a long way since then, or has it ?

Technology has advanced a great deal in, serial connections have made way for Ethernet or Token Ring, which have in tern in may places made way for Fast-Ethernet or FDDI and in some cases now even Gigabit technologies such as ATM and Gigabit Ethernet pervade. In short connectivity has arrived. The desktop 'Personal Computer' is now connected to local and often wide area networks. In many other industries these PC workstations are now running exclusively client server and local windows software delivering a rich user interface and empowering users to both access and utilise information at their disposal. A natural extension to the introduction of these new technologies is the user driven development of and utilisation of new information resources, through query tools, data mining, internet publishing and other new generation tools. Other industries from Banking to Manufacturing have harnessed the power of the PC to create a new breed of workers, the 'Knowledge Worker'. These 'Knowledge Workers' have benefited from client-server access to databases housed on departmental mini-computers providing unprecedented access to business information.

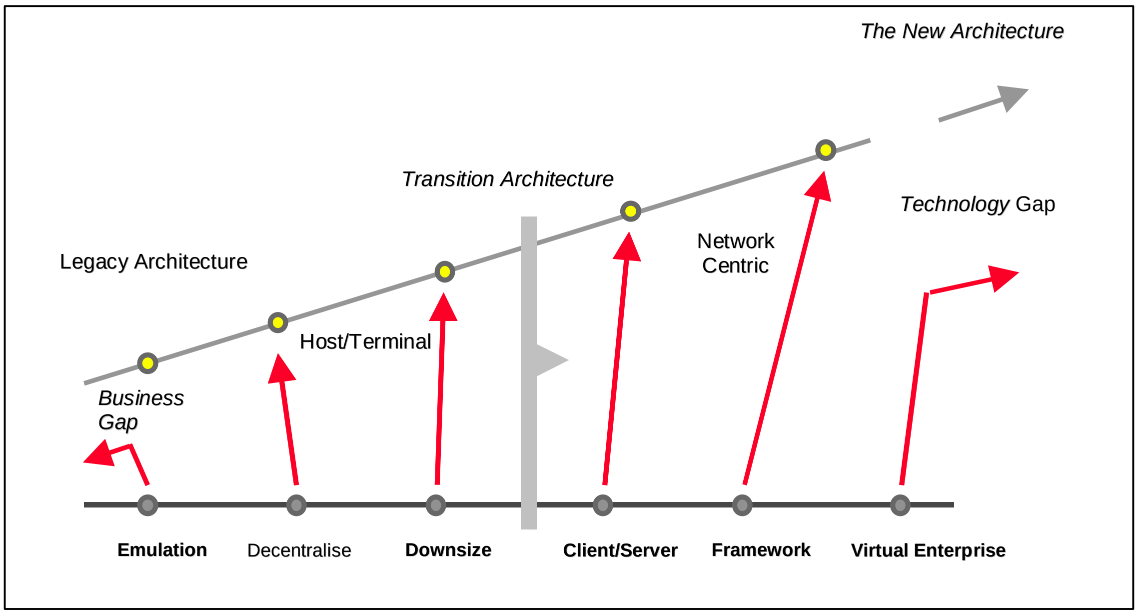

Figure 1 - The evolution of technology

The healthcare industry has been slow to or has failed to adapt to and adopt many of these new approaches and in many cases is still operating with limited electronic access to information, especially where that information is clinical. Many healthcare organisations remain firmly rooted in a 'VT100' culture, even where access is through a graphical workstation such as a PC it is delivered in a fixed text only interface. This is especially true with 'departmental' computer systems such as RIS (Radiology Information Systems) and LIS (Laboratory Information Systems), which with a few notable exceptions have only recently discovered the GUI. Even relative newcomers to the H.I.T space such as HIS (Health Information Systems or Hospital Information Systems) which promise to deliver more clinical information to the enterprise and indeed even offer clinical efficiency savings often attempt to garner the physicians attention through a basic textual interface.

Technology adoption or lifecycle[2] is often plotted as a 'bell-curve' showing 'Innovators' some two standard deviations from the normal. Examination of the evolutionary stages of technology and the level of adoption of each type of technology by industry would seem to suggest that different industries take a different attitude to new technology and risk and therefore allow us to derive a 'technology adoption cycle by industry' for new innovations in Information Technology.

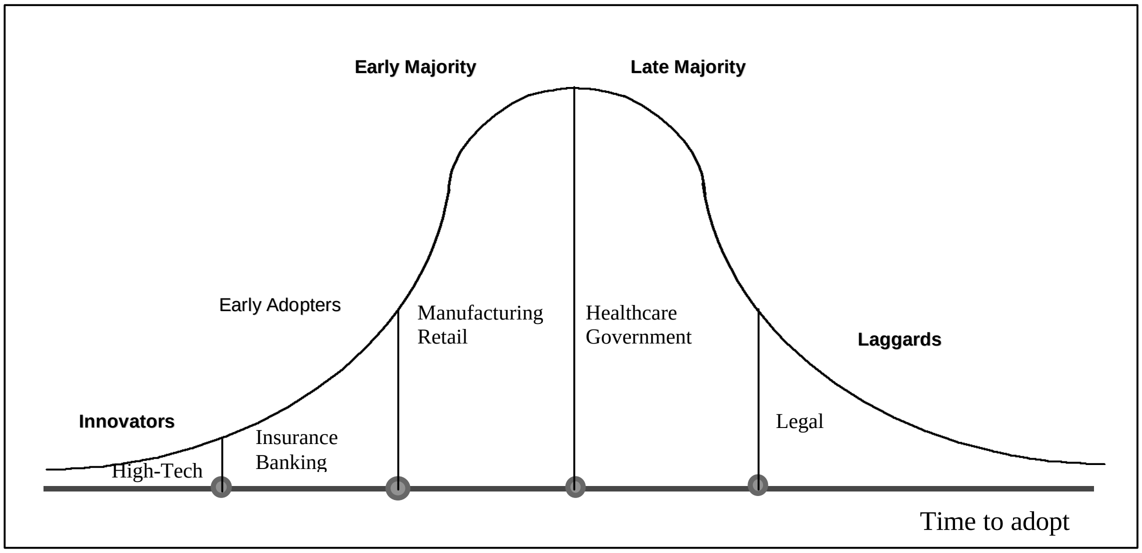

Figure 2 - The industry adoption lifecycle

While Insurance and Banking have been quick to adopt new technologies, especially information technologies, over the past decade; Healthcare has been relatively slow. With the mainstream arrival of the Internet and its accompanying technologies; I.T in healthcare, relatively unhindered by traditional PC based graphical clients, faces the unique opportunity to embrace Internet technologies to deliver true clinical information and patient records access throughout the healthcare enterprise. It may yet prove that relative under investment in recent years could still offer I.T an advantage in flexibility to 'leapfrog the future' in moving to n-tier Internet technologies, avoiding the client-server legacy.

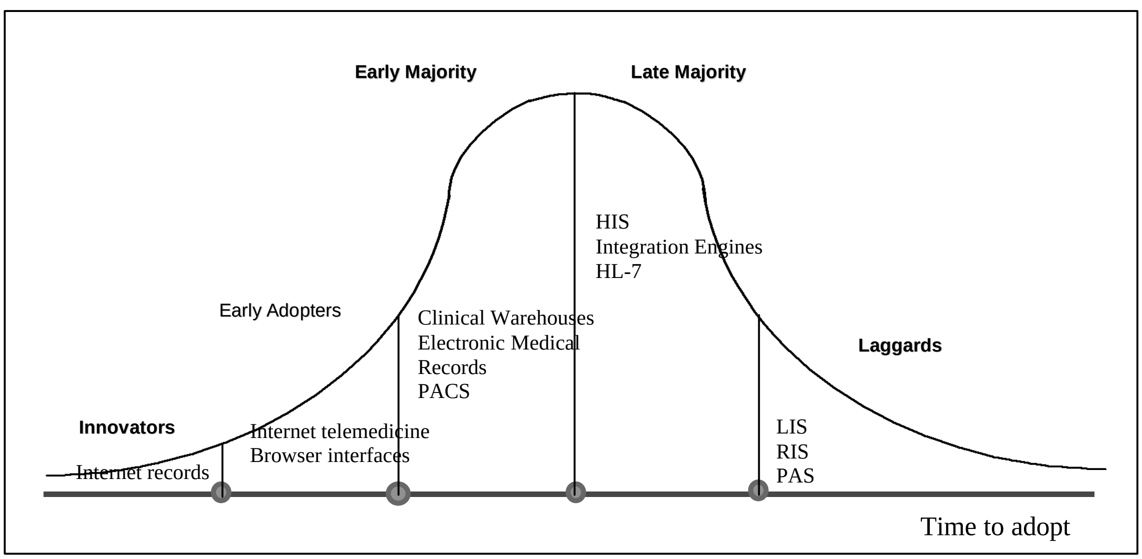

Figure 3 - Healthcare information technologies in the adoption lifecycle

2. Shaping forces and 'Tidal Waves'

2.1 Technology

The new trends towards Virtualisation that are currently being driven by the Internet will possibly surpass those previous most significant trends of the last 250 years: Industrialisation, Transportation, Communication and Computerisation. While each of these four trends have fundamentally changed the social, political and business landscapes they have been largely tangential to medicine and the delivery of healthcare. Historically, the practice and purpose of medicine has largely evolved around key scientific discoveries and national or regional political trends. The advent of the Internet and Virtualisation is set to radically re-engineer as a minimum both the delivery and expectations of the modern healthcare system.

Key to the creation of this new virtual environment has been the convergence of computing and communications technology around common standards and architectures, which coupled with the ubiquitous web-browser interface has driven straightforward access to digital information regardless of its location or any proprietary storage platform or database. Healthcare stands set to benefit from these technologies which can fundamentally change the way healthcare information is viewed and accessed.

The Internet imposes a further and perhaps greater pressure on healthcare professionals, which is education. It has set in motion a series of changes that will have a profound effect on the way healthcare is practised in the new millennium. Individual patients can now plug into an unbelievably rich and rewarding (if sometimes confusing and overwhelming) world of healthcare information. Healthcare enterprises can interact with their customers, the patients and referring physicians, in ways that have not previously been possible. While cyberspace is still fairly exotic and chaotic and will take some time before it becomes a familiar and trusted environment, it is already possible for patients to search online medical research databases and attempt to determine for themselves the best and most appropriate treatment for their condition. Physicians in the USA are increasingly encountering patients in their consulting rooms with reams of paper printed from the Internet. The healthcare profession will be driven to obtain better and continuing education utilising this same technology but will also be driven to still further specialisation and sub-specialist consultation. This clinical communication will continue the pressure on the healthcare I.T profession and suppliers to provide more and better telemedicine, tele-education and other clinical information sharing technologies.

Network centric Computing (NC) while historically a 'pipe-dream' of the anti-PC lobby has developed as a viable method to deliver and present healthcare applications both across an intranet and across the Internet. The 'NC' paradigm, while still existing in its pure form, as a lightweight as low maintenance non PC device receiving its software and data across the network and without local storage and software to maintain, is also being used by Microsoft and Intel in their NetPC model. The Internet coupled with NC type devices and network centric software is beginning to offer real, cost effective solutions for healthcare organisations. Work is underway in several European medical institutions and many in the United States to deliver a network centric solution to data access across their local intranet[3.] Variously, these solutions aim to deliver image data from the hospital's Picture Archiving and Communications System (PACS) and other departmental systems such as cardiology and ultrasound. This data is integrated with information from patient administration and with essential demographic information to deliver an integrated information system across the hospital's network. The more advanced systems provide this access through a browser interface and utilise Sun Microsystems JAVA to provide for platform independence. The increasing pressures in both cost and human resource availability in healthcare will undoubtedly drive further investigation of the benefits of these new low overhead desktop platforms.

The widespread availability of networks and networked computers has led to an increase in the use of object based programming techniques in the creation of software. This trend has been accelerated in recent years by the more widespread acceptance of JAVA, but is evidenced also in Microsoft's COM/D-COM/Active-X/Windows DNA software techniques and architectures. The acceptance, especially of CORBA and D-COM offers the possibility that software will evolve, over time, away from large, complex applications toward a plethora of interconnected and or inter-connectable software components. The first of these components that are arriving are specialised in providing interfaces to specific databases or systems, and in providing specific analysis or graphical functions to the healthcare application. If these software techniques evolve along with common standards for data representation, such as XML and HTML, and with industry specific data structures, such as HL-7, and DICOM, in healthcare it is likely that the industry landscape will change considerably. Component based software will place increased emphasis on the need to select a skilled and experienced integration partner for large scale projects and will likely place those integration partners as the prime customer for software component suppliers. Healthcare organisations will benefit from increased flexibility and more customisable solutions that will better enable their business process re-engineering.

2.2 Social, political and economic

The collapsing birth-rate throughout the developed world will fundamentally alter the demographics of the population being cared for by our healthcare systems. In Western Europe and Japan, the birth rate is already well below the rate required to reproduce the population. In some parts of Italy the 1999 birth rate is expected to be as low as 0.8; as opposed to the 2.1 children per couple average which is required to perpetuate the existing adult population[4]. Even in the United States, the birth rate has fallen below 2 and is falling steadily. More important than the general statistics are the age-distributions of the population. In 100 years time we can expect populations that are up to one-third over retirement age (60 years) and with a very small number of children. For the past 100 years the healthcare industry has developed based upon a growing population and until very recently upon a population whose majority is of working age. It is likely that the ageing demographic comprising on average better educated, better financially apportioned individuals will place new and increasingly complex demands on the healthcare system. Coupled with the technological advances, these are likely to be especially demanding patients both in terms of their approach to healthcare, which in many countries is now considered to be a 'right' and in their education and expectations of the healthcare system. In short, the population will steadily expect more, better, quicker.

Access to medical and other personal data has been a topic of increasing exposure in recent years throughout the developed world. In Europe recent legislation across the European Union as well as member countries such as the UK have imposed strict Data Protection requirements and legislation on all businesses including healthcare. In the United States of America, recent debate has centred around a 'Patient Bill of Rights' which is expected to give patients ultimate access to their own medical information. Increasingly patients are expecting and demanding access to their own medical records and histories, and in many cases being granted a legal right to such access. These developments raise new issues in electronic medical records but also begin to address the key question of "who owns my medical record?". As patients increasingly assert their right to both access their medical records and select alternate care providers, extraction and exchange of clinical information between different systems will increasingly become the issue of the day for healthcare I.T. managers and directors.

I.T. staffing is increasingly becoming an issue to achieving a successful healthcare I.T implementation. Recruiting to full time positions has become more difficult while simultaneously salaries and expectations in new-hires has increased. Especially in smaller in-house I.T organisations, long term career satisfaction is becoming increasingly unobtainable as the industry matures. Like any maturing industry, I.T has fragmented into several, specialised skills groups where once there was only one. The traditional programmers and analysts have been joined by ranks of specialist staff in networking, desktop, systems and database support. Each of these specialist tracks expecting some form of career advancement outside of the 'management track' that many of today's CIO's or I.T directors have followed. The increasing pace of change in the industry has also increased 'on the job absence' as more and more staff are requiring specialist off-site training for longer and longer periods of time in order to stay current in their field. These issues are and will continue to exert manpower and resourcing pressures in the healthcare environment. In addition to these pressures, recently the Year 2000 problem has impacted salaries and staffing availability world-wide, while further increasing demands for training and certification as I.T. professionals become increasingly aware of issues such as professional liability. These pressures and others will lead to increasing use of contract staff and pressures to outsource systems and support to specialised third parties who can provide the necessary incentives and career development while maintaining business continuity through economies of scale.

While staffing pressures may seem isolated to I.T, the healthcare profession in various parts of the world is undergoing change. In the USA, movements towards managed healthcare have created pressures for General Physicians to become salaried members of staff working in some cases directly for HMO's and in others as partners in consortia of other physicians acting for their corporate good. In both cases, they find themselves contracting their services with larger insurers or purchasers as opposed to their fee-for-service historical model. The same pressures have allowed many hospital physicians to group together and free themselves from the hospital and contract independently and directly with the payer as a separate physician group. In many cases, the healthcare organisation may increasingly play the larger role of hotel, talent scout and consortia management, bidding for and winning healthcare contracts with large payers in conjunction with the 'knowledge workers': the doctors, physiotherapists, radiographers, nurses and other specially trained staff. As these models develop it is fair to expect that certain individuals will contract with multiple institutions and as part of multiple consortia. These changes will further complicate the I.T infrastructure that must be developed in order to provide modern healthcare.

Staffing pressures, and costs, in some areas are being alleviated by increased globalisation of services. Hospitals in many parts of the English speaking world are now outsourcing some previously 'core' services to specialist providers in other countries. Transcription is one of the early services to undergo this shift. Several of the US hospitals using Indian or Middle-Eastern medical transcription services are seeing improved accuracy and improved turnaround, aided by the qualifications of the transcriptionists and by the time-zone differences between them and their contractors. As increasing volumes of the medical record become digital yet more of the daily workload of a hospital will be equally well executable regardless of the location of the individual performing the work. Academic medical centres world-wide experience difficulty in maintaining radiology staff interest in reporting routine chest examinations, the specialists instead preferring to work on complex more intellectually challenging work. Several UK radiologists have proposed 'centralised' reporting services for these more routine examinations enabled through tele-radiology and high performance networks, in the USA the transmission of radiographs from imaging centres to academic medical centres for reporting is not uncommon. The technology exists today for pressured hospitals to look outside their walls for additional resources, moving data and not patients to a remote site for diagnosis. WorldCare has been successfully providing for international second opinion diagnosis in complex clinical areas such as Oncology and Radiology through the electronic exchange of clinical data for over five years.

3. The evolution of Clinical Information Systems

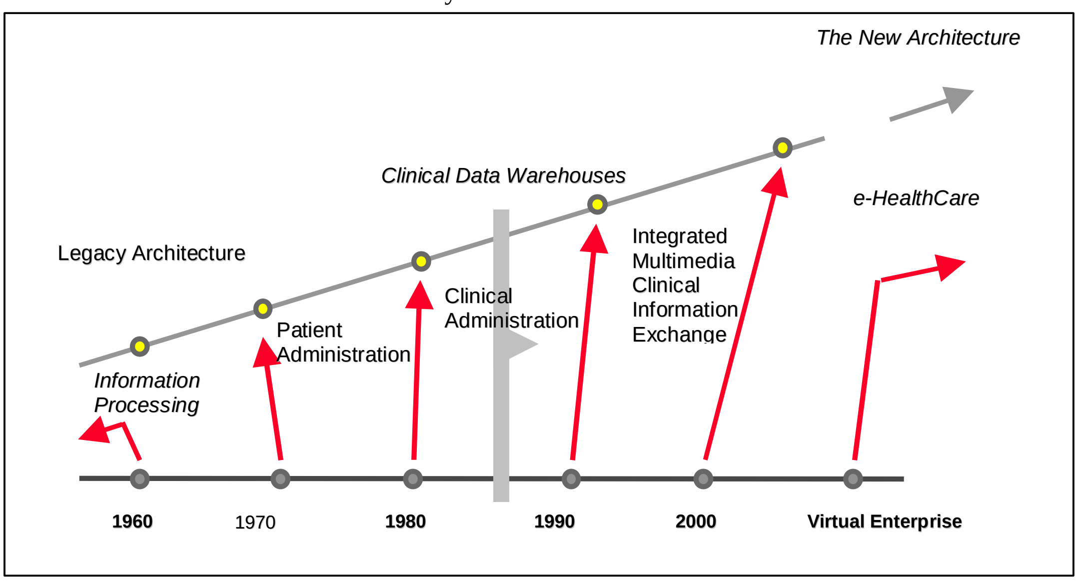

Figure 4 - Healthcare information systems in evolution

Traditional healthcare information technology has been built around the pillars of the departmental computer system. Healthcare I.T has typically been based around hospital information requirements and has typically been centred around the Patient Administration System (PAS). Over time hospitals have added (often incompatible) laboratory and radiology information systems to manage workload and in some cases clinical results within the laboratory and diagnostic imaging departments. Often finance systems have been computerised deploying standardised Enterprise Resource Planning (ERP) and statistics and reporting systems. This information engineering model produces isolated islands of information and has led many healthcare organisations to spend heavily in attempts to integrate basic demographics to eliminate re-keying of data and to provide order entry and results reporting systems. These systems have largely been developed and implemented at the level of the individual organisation providing limited if any telematic or inter-institutional communications capabilities.

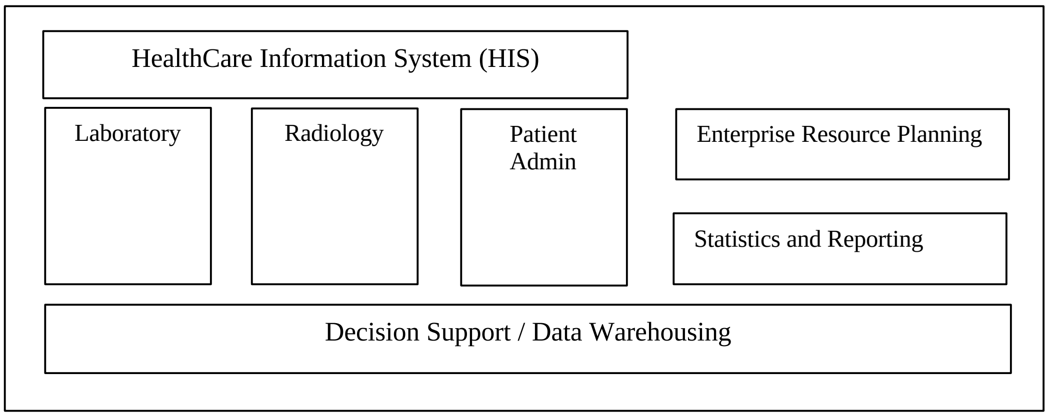

Figure 5 - Traditional healthcare I.T architecture

3.1 The traditional model transcended

The traditional I.T model for hospitals is slowly being replaced in leading healthcare organisations world-wide with a more integrated solutions oriented approach utilising integration engines and open-standards interfaces. Increasingly this next generation of healthcare information solutions include image information such as Radiographs, MRI scans, CT and Ultrasound images as well as nuclear medicine through Picture Archive and Communications Systems (PACS). These systems centre on one system, usually the HIS or PAS which maintains a master patient index but are typically 'episodic' in nature, managing data around the central element of the attendance or room booking.

The development of Open Standards has increased the level of integration possible, with HL-7 providing for straightforward exchange of demographics, clinical orders and results between proprietary systems. The DIgital COmmunications in Medicine (DICOM) standard in radiology is now being widely adopted and native DICOM PACS systems are now available from at least one vendor and under development by other specialist software vendors.

3.2 The patient as the 'core' object in healthcare architecture

During their treatment, Patients today see multiple healthcare professionals in a variety of healthcare locations often across multiple healthcare enterprises. Patient information is required in many places, often generating conflicting demand for today's paper and film based records. The flow of information can become a log-jam preventing or hampering timely and accurate diagnosis, impairing patient care and increasing stress and complexity in healthcare management - especially when you add factors such as second opinion referrals, evidence based medicine, managed care contracts, lab work and other tests to the process. By re-engineering both the information technology and the healthcare process to adopt a 'patient-centric' model it is possible to achieve great benefits in terms of workflow automation and therefore efficiency and effectiveness of care. The application of this new model requires pervasive access to the patient's clinical information at the point of care delivery and the sharing of clinical data across multiple healthcare enterprises.

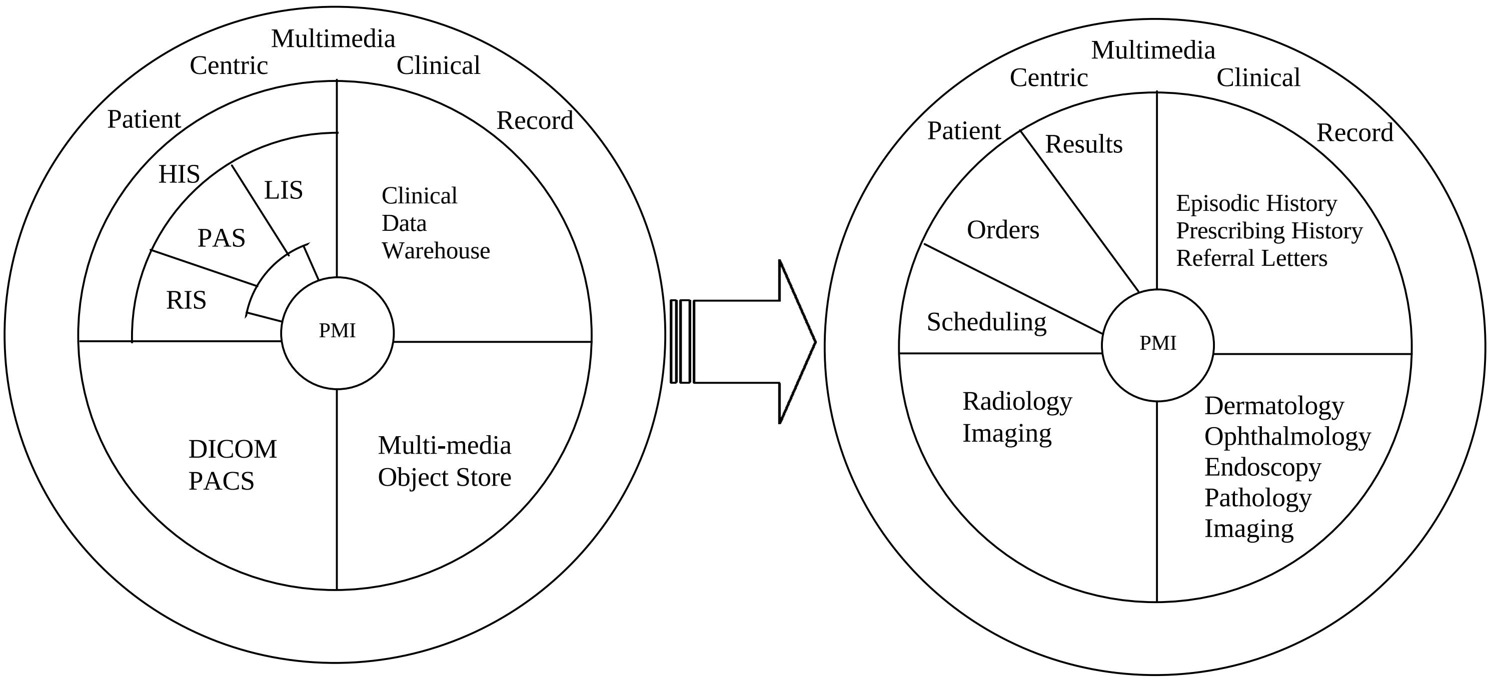

Figure 6 - Next generation healthcare; an architecture in transition

Through the use of a carefully structured, yet flexible data model and the application of a standardised network based user interface a multi-enterprise, shared, clinical record can be created which facilitates todays multi-disciplinary care profiles, while enabling tele-diagnosis, image and record sharing and ubiquitous access to the clinical record through a browser interface. The unique packaging of clinical data facilitates simple and straight-forward exchange of information between enterprises, allowing for simple inter-institution referall and for the multi-center patient management common in today's complex diseases.

3.3 True multimedia enabled records

In order to serve as a diagnostic system and therefore to enable telemedical consultations, a clinical information system must meet the key requirements of physicians for a truly multimedia medical record, the system must provide:

- Diagnostic quality medical images of suitable resolution, bit depth
- Suitable clinical image manipulation tools
- Access to clinical, diagnostic and imaging history for the patient
- The ability to accommodate a wide range of clinical specialities
- A long term record of consultations in order to build a longitudinal medical record
- Ubiquitous access from any suitable workstation within or without the organisation
- Integration with existing and future enterprise wide systems

While video conferencing has proven a useful tool in the introduction of remote consultation to the medical community, there is now considerable international agreement that it's utility is, in reality limited to certain specialities such as Psychiatry and Emergency medicine. In more general specialities such as Ophthalmology, Dermatology, Pathology and in complex multi-modality specialities such as Oncology and Neurology video-conferencing has been seen as an impediment to the acceptance of telemedical consultation, largely as a result of it's inherent shortcomings:

- Enforced ‘synchronicity’
- Limited image resolution and bit depth
- High cost / time overhead in transmitting detailed records or full history
- A lack of historical records and comparative data during follow up.
- Relatively high cost overhead in hardware per consulting physician
- Relatively complex scalability issues.
- Lack of integration with other hospital I.T
- Legal challenges around responsibility for diagnoses.

These and other limitations have recently led to a surge in the deployment of integrated store-and-forward type systems around the world. Increasingly the separation of telehealth systems from mainstream hospital I.T will recede resulting in all hospital ‘EMR’ systems including multi-media clinical imaging and integration communication and remote consultation facilities.

3.4 Production warehouses

Recent developments in database technologies facilitate the long term on-line storage and management of large amounts of patient clinical data in a production environment. For the first, time this offers the healthcare organisation an opportunity to maintain their complete clinical records in the digital domain for rapid access, clinical management, research or teaching. Recent prototypes developed by Data General Corporation and Microsoft, including their joint ‘TeraClin’[6] project have illustrated in excess of two terabytes of patient information under the management of a single enterprise class Windows NT server. Equipped with advanced query tools and technology this repository can provide not only production services but data warehousing, online analytical processing (OLAP) and aggregated research data for the healthcare enterprise. Image storage has developed as rapidly with MarkCare Medical Systems Inc., recently demonstrating a 9TB DICOM near-line PACS image store programmed with intelligent, integrated pre-fetching of required images against expected patient attendance or admittance.

3.5 Advanced compression

Advanced image compression techniques have been clinically tested and are now becoming commercially available for medical images. Wavelet compression technology pioneered by WorldCare Technologies, Inc. now offers compression of up to 30:1 for some radiological images[7]. This technology provides very significant reductions in cost for both image storage and for image communication across the wide area network or Internet necessary for the development successful telemedicine operations.

Effects of Compression on Image Transfer Time
e.g. 12 MB Chest X-Ray Film (including 10% protocol overhead)

Line Type	Line Speed (BPS)	1 Film Uncompressed	2 Films Uncompressed	1 Film with JPEG	1 Film with Wavelet	2 Films with JPEG	2 Films with Wavelet
ISDN BRI	56,000	31.429	62.857	12.572	1.048	25.144	2.096
ISDN PRI	128,000	13.750	27.500	5.5	0.458	11	0.916
T1	1,536,000	1.146	2.292	0.458	0.038	0.916	0.076
T3	44,000,000	0.040	0.080	0.016	0.001	0.032	0.002

Figure 7 - X-Ray film transmission time in minutes; uncompressed image vs 2.5:1 JPEG vs 30:1 Wavelet

Wavelet compression technology makes the volume transmission of even large radiological images possible over affordable ISDN or even POTS type telephone lines. The same technology can be utilised within an institutions own local area network (LAN) or intranet in order to forestall or obviate the need for expensive network infrastructure upgrades. Where infrastructure upgrades prove necessary, the use of application aware network management and switching protocols[8] will significantly improve performance. While historically many vendors’ Wavelet implementations have produced compression overheads of up to 90 seconds per image, modern processor design and new programmatic techniques have now bought this overhead down to an insignificant level (typically less than 3 seconds in WorldCare Technologies, Inc. applications using Intel Pentium II technology).

3.6 Adaptation for easy exchange of records

The addition of full record interchange facilities to the production warehouse with integrated imaging capabilities and compression provides for a fully telemedicine enabled clinical imaging and information management system within the enterprise. The utilisation of component technologies to facilitate the exchange of 'smart-objects' along with open-standards formatted data provides healthcare organisations with unique flexibility and adaptability to cope with evolving business issues. These developments, driven both from a telehealth and an enterprise system integration perspective will increasingly tear down organisational and territorial boundaries to facilitate electronic records exchange more freely and with less complexity than current paper records exchange.

3.7 Migration in ownership and management of clinical information.

As patient clinical records become increasingly mobile in the new healthcare environment there will be increasing political and social pressure to bring these records under the patients' own management. Patients will increasingly take more responsibility for the management of their own information and expect their healthcare provider to provide them with access to their own medical records in a format that allows them to maintain and manage it themselves.

Patients are increasingly expecting their healthcare provider to provide access to trusted medical information for their reference, this kind of information provision is already being undertaken by several hospitals in North America either independently or through outsourcing relationships with strong web-based players e.g. HealthGate[9].

These trends in external management and maintenance of clinical records and medical information will change the role of the healthcare provider to that of 'user' of the digital record. The pressures of maintaining external access to a much broader spectrum of systems and increasing difficulty in getting and keeping skilled I.T staff will force healthcare organisations to re-think their I.T. and I.S strategies. This shift will foster external businesses specialising in the outsourcing of electronic clinical record management both on behalf of the patients, HMO's and healthcare providers. Delivery of these new services is likely to take place across the Internet, utilising open systems protocols and object technologies and incorporating advanced encryption and authentication techniques.

As the provider increasingly becomes a user of the electronic record, rather than owner and operator; the baton of management will fall either to the healthcare payer / management organisation or to the patient themselves. Pressures to retain flexibility to choose healthcare plans and payment options will bias this trend towards patient owned and operated records, which in turn will further fuel the current trend towards healthcare information technology outsourcing. As it becomes increasingly common for entire health systems to outsource the management of key I.T systems and services, the internet will provide not only new methods for data delivery and access but new models for payments for services and financing of these outsourcing relationships.

3.8 Towards network based distributed records.

With a trend towards networked healthcare information well under way, many organisations and even countries are embarking on ambitious projects to re-engineer their entire healthcare systems. In the USA, Integrated Delivery Networks (IDN's) are bringing together primary, secondary and tertiary care providers, often with management organisations and utilising technology as the glue to develop a better integrated, lower cost knowledge based approach to care delivery. In Malaysia, the governments ambitious Multimedia Super Corridor[12] project has selected a wide range of flagship network based applications most prominent of which are healthcare applications in teleconsultation and delivering a lifetime health record. Both of these projects are intended to service each and every citizen and will bring together a wide range of clinical information into a distributed network providing access from each point of care delivery across the country.

As these network based projects develop it will become increasingly important that telehealth systems and healthcare information technology (H.I.T) in general migrate away from the 'push' based EDI interfacing models that have, up until now, been the normal and towards network centric distributed data objects. Once implemented, object based data architectures will facilitate entirely new opportunities to improve the process and quality of care delivery through point of care queries. These queries, potentially propagating throughout an entire region as 'agents' seeking relevant information[10] pertinent to the delivery of care for a specific individual regardless of its location on the network or the architecture of the underlying system in which it is stored.

4. Keys to success in e-Healthcare

Senior management must be change oriented and must recognise the strategic importance of e-Healthcare to the organisation's future. Early adopters of the technology will have visionary leaders who will champion new approaches and will drive the necessary business process change. Management will think strategically seeking opportunities for both partnership and identifying 'competitors'. The organisation will focus on utilising new technology and business processes to enable and empower healthcare professionals with knowledge and information essential to perform better and more effectively in patient care and management.

Organisations will examine and consider radical process reengineering, not just incrementally improving existing processes. Staff will examine workflow, information needs and care pathways to determine opportunities for integration of the organisations systems and processes.

The organisation's technology infrastructure must be aligned with it's current and twenty-first century business requirements. Technology must be appropriate to service the healthcare processes; reliable, resilient, and where necessary redundant so that it can be depended upon; it must be sufficiently scalable to deal with expected and projected growth for the short term. While business strategy should drive the technology infrastructure decisions, there must be strong communication from the I.T. organisation and from strategic technology partners so that it is also informed by technological possibilities[13].

Internal production systems must be fully integrated with the new generation of distributed network front-end and communications systems to ensure success.

Careful consideration must be made of the security implications of new networked solutions. Security will play an essential role not only in protecting information but also in building patient trust. Security measures must be designed into systems from the start rather than added later.

The role of the patient both as a user and as a potential stakeholder in each electronic healthcare record and transaction must be carefully assessed. Organisations must consider their roles as 'custodian' as both temporary and under continuous review. Leading organisations will understand the strategic need to begin to develop a strategy for patient involvement and access before patient empowerment forces an externally imposed solution upon them.

5. References

1 Hiltzic M A. (April 1999) *Dealers of Lightning : Xerox Parc and the Dawn of the Computer Age.:* Harperbusiness Publications

2 Moore G A, McKenna R. (August 1999) *Crossing the Chasm – Marketing and Selling High-Tech Products to Mainstream Customers* : Harperbusiness Publications.

3 Sun Microsystems. (1999) *Medical Center Gets Vital Information Where It's Needed Most :* http://www.sun.com/nc/customers/amc.html

4 Drucker P F (1999) *Management Challenges of the 21st Century* : Butterworth Heinemann

5 MarkCare Medical Systems, Inc. (1999*) Intrascan II Image Management System DICOM conformance statement* : http://www.markcare.com/markcare/confrmnc/ims_conf.pdf

6 Data General Corporation (1998) *TeraCLIN Project* : http://www.dg.com/teraclin/html/teraclin_project.html

7 Goldberg M A, Pivovarov M, Mayo-Smith W W et al. (1994) *Application of wavelet compression to digitized radiographs* :Amercan Journal of Radiology 1994; Volume 163:463-8

8 Gillett M A. (1997) Solving the Medical Bandwidth Problem : Mednet '97 proceedings – The World Congress on the Internet in Medicine, Brighton, UK. November 1997

9 HealthGate Corporation (1999) *Corporate Web Site* : http://www.healthgate.com

10 Gillett M A, Crisp J (1997) Technologies to address the needs of a distributed multimedia clinical teaching archive : proceedings - Medical Image Digitised Reference & Information Bank 'MIDRIB' Launch, Royal College of Surgeons, UK. February 1997

11 Stewart T R. (1998) *The E-Business Tidal Wave* : Deloitte Touche Tohmatsu

12 Malaysian Multimedia Development Corporation (MDC), (1998) : http://www.mdc.com.my/msc/flagship/tm.html

13 Meyer C, Davis S (March 1998) *Blur – The Speed of Change in the Connected Economy* : Perseus Press