.In B. Cesnik, A. McCray & J. Scherrer (Eds), MedInfo'98 (9th World Congress on Medical Informatics, August 18-22, Seoul) IOS Press, Amsterdam.

Telemedicine and Medical Informatics in the Multimedia Super Corridor: The Malaysian Vision

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Abstract

The practice of medicine, with its wide range of environmental conditions and complex dependencies, has long been used as a testbed for various advanced technologies. Telemedicine as conceptualised within the Multimedia Super Corridor (MSC) context is seen as the application of several relatively mature technologies—artificial intelligence (AI), multimedia communication and information systems (IS) amongst others. We will discuss in general terms the Malaysian vision on the comprehensive MSC telemedicine solution, its functionality and associated operational conditions. In particular, this paper focuses on the conceptualisation of one key telemedicine component i.e. the Lifetime Health Plan (LHP) system, which is eventually intended to be a distributed multi-module application for the periodic monitoring and generation of health-care advisories for upwards of 20 million Malaysians.

Keywords:

Multimedia Super Corridor; Lifetime Health Planner; TeleHealth, Telemedicine, Medical Informatics

Introduction

The Multimedia Super Corridor (MSC) [1] is a large-scale infrastructure and services project initiated by the Malaysian government. Its geographical location will be in a rectangular area bracketed by the Kuala Lumpur City Centre (KLCC) to the north and the new Kuala Lumpur International Airport (KLIA) to the south, with high-speed Wide Area Network (WAN) connectivity. The MSC will also feature advance logistical facilities and physical infrastructure including a pair of "intelligent garden" cities—i.e. Putrajaya and Cyberjaya, respectively the future administrative and commercial hubs of the nation.

MSC's growth in the initial stages will be focused along the lines of several ambitious application-layer "flagship" projects [1] earmarked for rapid development and eventual nation-wide deployment. These projects will explore conceptual and implementation models as regards the application of Information Technology (IT) on a societal basis, spearheading the post-industrial transformation of Malaysia and serving as a global testbed for innovative solutions. The areas targeted for intensive development are (1) Electronic Government, (2) Multi-purpose Card, (3) Smart Schools, (4) Telemedicine, (5) Research and Development (R&D) Clusters, (6) World-wide Manufacturing Webs and (7) Borderless Marketing.

Telemedicine within the MSC

Health maintenance and illness prevention, needless to say, play a crucial role not only to an individual's quality of life but also to societal well-being. The primary objective of MSC-based telemedicine project is to establish a healthcare system leveraging advanced information and multimedia technologies so as to deliver hitherto unattainable healthcare services at the individual, family and community-level. For maximum utility, such services must be accessible from the home, or at least from within the individual's immediate community; a feature made practical by the MSC's high-bandwidth multimedia environment. In addition, the unavoidably complex system—in recognition of the realities inherent in contemporary healthcare—must be perceived to be as seamless as possible, while being custom-tailored to the needs of all parties involved i.e. the individual, community, healthcare professionals and associated service providers (eg. insurance firms) amongst others.

The most innovative feature of MSC telemedicine is its broad definition and all-encompassing scope beyond the traditional point-to-point data exchange model useful primarily to healthcare professionals in well-equipped urban hospitals and laboratories. The MSC telemedicine initiative is meant to articulate a person-centred and wellness-focused system able to inform and empower individuals with regards to consistently maintaining the highest state of health throughout a lifetime. Hence, the label "TeleHealth" is perhaps a more appropriate description of MSC telemedicine initiative as pointed out by no less than the Health Minister. The above-mentioned characteristics are very much in line with the national healthcare vision statement [1], i.e.:-

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"Malaysia is to be a nation of healthy individuals, families and communities; through a health system that is equitable, affordable, efficient, technologically appropriate, environmentally adaptable and consumer friendly; with the emphasis on quality, innovation, health promotion and respect for individual and community participation towards an enhanced quality of life"

The MSC telemedicine model was designed to encompass four key pilot projects i.e. (1) *Customised/Personalised Health Information and Education,* (2) *Continuing Medical Education (CME),* (3) *Teleconsultation* and (4) *Lifetime Health Plan (LHP).* The first two are essentially informational and educational services respectively targeted at the general public [2] and the healthcare community [3], with major advancements anticipated in terms of services/information delivery system technology. Teleconsultation [4] covers multimedia connectivity between healthcare service providers with the objective of enhancing and extending basic work processes. The remainder of this paper specifically concentrates on fleshing out the LHP component of MSC-telemedicine project. Figure 1 [5], illustrates the entire scope, together with functional interactions between the four pilot projects, of the MSC telemedicine project.

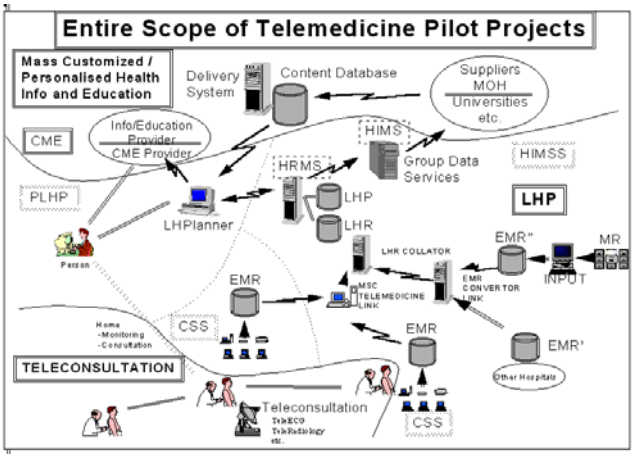

Figure 1 - Scope of MSC Telemedicine (taken from CRFP: Lifetime Health Plan, pg. 35)

The top of Figure 1 shows the Mass Customised/ Personalised Information and Education (Info/Edu) and Continuing Medical Education (CME) projects. The bottom part of Figure 1 shows the Teleconsultation pilot project. The middle part of Figure 1 gives an alternative but equivalent view of the LHP project, showing the LHP project interfacing with the Info/Edu and Teleconsultation projects.

Conceptual Model of LHP Systems

The LHP is probably the most unique and yet complex of all the telemedicine pilot projects. Key features in any successful LHP system will be a person-centred implementation and also a lifelong continuity between episodic contacts with healthcare service providers (throughout the nation). This very much depends on the existence and controlled availability of Electronic Medical Records (EMR) compiled over an individual's life-span. A systematic, consistent and temporally relevant summary of an individual's EMRs will manifest as the Lifetime Health Record (LHR)—which can then be used to formulate prospective Personalised Lifetime Health Plans (PLHP) that caters for wellness preservation together with illness treatment for each individual.

The need for transformation of patient data into an electronic format, i.e. EMR is driven by the necessity of obtaining an individual's medical history during initial contact with a medical professional. This process often consumes a substantial portion of the practitioner's time, especially during episodic encounters with patients possessing a potentially complex case history. New information must also be recorded and integrated in a organised manner before an appropriate diagnosis can be attained and treatment administered. Ensuring the availability, accuracy and completeness of medical records will therefore be of great value to medical professionals. Data comprehensiveness should progress not merely chronologically within a single healthcare facility, but should also extend across different institutions. Such a seamless temporal record of an individual's health will enable individualised pro-active medical planning, thereby resulting in continuous and consistent *"womb-to-tomb"* healthcare system that is independent of geographical location, specific healthcare providers and other environmental conditions. All of these elements are central to the design of the PLHP.

Accumulation of all health data (EMR, LHR & PLHP) on a nation-wide scale will be a major endeavour, but will also encourage development in innovative applications to "mine" the raw health data. Knowledge extracted from health data repositories will not only benefit practitioners and healthcare providers, but ultimately will have a significant impact on satisfying the healthcare needs of individual users and society as a whole.

In summary, LHP will provide the healthcare infrastructure with which to deliver PLHPs directly to individuals or alternatively via primary healthcare providers or general physicians. A large-scale implementation of the LHP project will necessitate the design and implementation of IT-based mechanisms for the nation-wide acquisition and storage of the pertinent biomedical records. The LHP project can therefore be envisaged as a suite of integrated applications systems divided into three basic components on the basis of their intended functionality [5]:
(1) The *Clinical Support Systems (CSS)* being used in a "front-line" capacity, comprising the following sub-systems: Hospital Information System (HIS), Clinical Information System (CIS), Laboratory Information System (LIS), Radiology Information System (RIS), Picture Archiving & Communication System (PACS), Pharmacy

Information System (PhIS), Critical Care System (CSS), Decision Support System (DSS)
(2) The *Healthcare Information Management and Support Services (HIMSS)* for the integrated large-scale data repository management; will include Lifetime Health Records (LHR) Repository, Lifetime Health Plans (LHP) Repository, Health Records Management System (HRMS), Healthcare Information Management System (HIMS). A suite of *Group Data Services* will yield 'inherent' knowledge from the data repositories.
(3) The *PLHP system* for the generation and delivery of lifelong healthcare plans, customised to each individual's specific health needs, both in wellness and illness.

Used in an integrated manner, these WAN-interconnected applications will allow for the collection and generation of the data necessary for PLHP formulation; and in addition provide data and services intended to enhance national healthcare policy-making and to support medical research. Figure 2 [5] gives an overview of the LHP project.

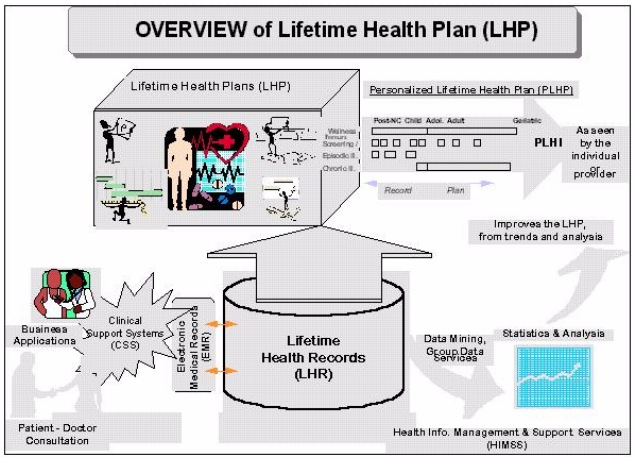

Figure 2 - LHP Overview (taken from CRFP: Lifetime Health Plan, pg. 17)

The net effect of the LHP and its constituent components (PLHP, HIMSS and CSS) is intended to enhance overall healthcare quality and also the individual productivity of practitioners and institutions. Over the long-term, the proactive and preventive nature of LHP utilisation—in which wellness preservation is accorded equal importance to illness treatment—is also expected to control and perhaps even reduce expenses associated with healthcare and support services. The following sections will discuss the functionality and workflow of the LHP components.

Clinical Support Systems (CSS)

The major objective of the CSS is to improve the workflow of healthcare practitioners, both clinically and administratively. In essence, CSS applications will provide support for clinical and administrative services at healthcare facilities—including consultation services, investigative requests (pathological and imaging), results retrieval, diagnosis, treatment, drugs prescriptions, etc—while concurrently creating the EMRs, which contribute towards the continuous updating of the LHR repository. All CSS functions will contribute directly towards "on-the-ground" support of medical practitioners; thereby allowing more accurate and informed diagnosis, more effective treatment and enhanced level of healthcare.

Delivery of such services assumes transparent cross-institutional access of past medical records (i.e. EMR and PLHP)—documenting treatments, drug prescriptions and earlier health plans. CSS will also provide decision support in terms of diagnosis and treatment; particularly for pharmaceutical dispensation and clinical test administration. In addition, scheduling, monitoring and consolidation of all relevant patient data will also be handled by CSS, so as to present the clinician with a comprehensive and logically-ordered outlook. To achieve this objective, it will be important for CSS to synergise with the Teleconsultation applications that will generate a variety of health related data.

CSS applications will be sited at major regional medical centres, but made accessible—via WAN connection—from primary service dispensation clinics. Hence, primary healthcare clinics will benefit from CSS services, while simultaneously generating the required EMRs that will in turn contribute towards the LHRs and hence PLHPs.

Healthcare Information Management and Support Services (HIMSS)

HIMSS is a set of applications geared towards maintaining repositories for LHRs and LHPs. The former are basically a systematic aggregation of various episodic EMRs—both illness and wellness related—pertaining to an individual, collated from various health institutions across the nation and hence constituting a comprehensive womb-to-tomb medical history. LHPs on the other hand are summarised and personalised health-plans for individuals, which integrate all episodic and situational sub-plans i.e. immunisation and rehabilitation programs. HIMSS will be concerned with LHP storage and retrieval. Personalisation of LHPs will be undertaken by the PLHP component of the LHP project to be discussed later. HIMSS will be located in a central IT centre, but will be linked and constantly accessed by various CSS sites in order to ensure LHR-to-EMR consistency. The HIMSS workflow [5] can be categorised into four major activities:-

LHR Collection

LHR can be envisaged as a virtual entity realised via the establishment of relational links between the central LHR repository and the remote EMR storage sites across the nation. LHR collection will then constitute EMR collation and their systematic summarisation to form a longitudinal health record of significant health information.

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PLHP Formulation
PLHPs are formulated based on comprehensive, life-long, information in the LHRs, which will be discussed later in a later section. It is important to note that the HIMSS will have to initiate this process by sending the LHR to the PLHP component for the initial formulation of the PLHP, and its subsequent updates whenever necessary.

LHR/LHP Management
HIMSS will be responsible for the data integrity of both LHRs and PLHPs. This is an important activity as the two repositories are central to the LHP project, therefore proper and efficient database management is imperative.

Group Data Services
The effective delivery of healthcare services hinges on the ability to deliver proactive value-added services to different client segments on a timely basis. While the other projects such as Info/Edu and Teleconsultation services address the healthcare needs of certain individuals, the impact is constrained by the healthcare industry's difficulty in identifying and delivering the appropriate services to suitable clients. Irrespective of the access enablers, distribution channels and technology employed; these services need to be packaged according to usage patterns, demographics and behavioural psychographics. HIMSS will facilitate such studies as a suite of services known as the *Group Data Services*, provided by a component known as the Health Information Management System (HIMS).

HIMS will exploit the data within the EMR, LHR and PLHP repositories to evaluate the effectiveness of healthcare programs and products. This will enable the focussed delivery of medical services so as to be more proactive and effective *vis-à-vis* the end-users. Examples of such services include:- (1) data mining for forecasting and resource optimisation, (2) statistical and trend analysis, (3) market research, (4) publication of regulatory documents, (5) reports to R&D institutions (i.e. drug effectiveness studies), (6) financial data analysis, (7) analysis for community action planning, (8) analysis for policy formulation, (9) analysis for epidemiological and large-scale health surveillance, and (10) quality assurance and service evaluation.

Group Data Services will enable regulatory organisations to obtain strategic information so as to better control and guide healthcare activities. It is anticipated that healthcare planners and administrators—i.e. the Ministry of Health (MOH), pharmaceutical companies, community health organisations, private service providers and R&D organisations—will benefit from such information services. Specific services made possible include:- (1) epidemic control, (2) pre-emptive alerts (for potential outbreaks of diseases), (3) drug monitoring and control, and (4) real-time market analysis of products and services.

Personalised Lifetime Health Plan System

The third component of the LHP project is the PLHP system, which can also be considered to be its ultimate objective. The major role of the PLHP component will be to generate individual PLHPs tailored to specific wellness and illness requirements of individuals. Ideally, no two people would have the same health plan as indeed different individuals have dissimilar health needs. Once generated, the PLHPs will be stored in the LHP repository, and are intended to be frequently referenced by their 'owners' for the self-maintenance of health. Also, healthcare providers may refer to an individual's PLHP to ensure a continuum of care to the individual.

An individual will typically encounter many situational healthcare plans in his lifetime, these include immunisations, various disease prevention plans, treatment and rehabilitation programmes and geriatric care packages. The PLHP will integrate all existing medical records generated through encounters with the healthcare system (the past), with all recommended plans assigned by various healthcare providers (the future). This "intelligent" amalgamation of LHRs and LHPs is intended to be easily understood by individuals, thereby placing them in a much better position to make well-informed health-related choices. The PLHP system will also chart and monitor an individual's state of wellness and illness in relation to known medical and family records, even community and racial profiles.

The value-added component of the PLHP system will be extrapolated information and advice automatically formulated from the current data. In addition, the PLHP is intended to dynamically adjust itself with respect to changes in an individual's state of health, i.e. during temporary disablement or occurrence of a chronic illness.

PLHPs may be generated on demand by individuals or via medical service providers. They may then be used as a basis to provide continuous and consistent healthcare. It is anticipated that extensive PLHP functionality will be provided by the following modules:-

Generic Planner
At present, there exist situational health plans—such as immunisation, cervical screening, breast examination, ante and post-natal—that are delivered to the public through various means. This module will integrate existing health plans together with pertinent HIMSS information to formulate value-added integrated generic plans.

Personalised Planner
This module will tailor the relevant generic plans to the specific needs of an individual based on LHR information. This will yield a PLHP comprising both wellness and illness plans. The wellness plans are intended to educate individuals so that they understand the exact state of health, and are subsequently able to take preventive measures for health improvement. On the other hand, the

illness plans will enable individuals—or their families—to manage their weakened conditions so as to ensure a speedy recovery. This will also cover the required post-illness actions i.e. consultation appointments, rehabilitation programs (exercises, diet, drug use and interactions, complications and so on), personalised illness information and context-sensitive education material.

Triggering and Monitoring Module

With a Pro-active mode of operation, the PLHP system will incorporate various triggering mechanisms—the so-called Triggering and Monitoring module--which will prompt and even induce individuals to refer to their PLHPs. A few services envisaged within the scope of this module are:-

Reminder Service: Within the context of wellness, this service will distribute reminders for immunisations, recommended medical screening, etc. During episodes of illness, reminders will be for follow-up visits, medical check-ups, specific screenings, etc.

Information Routing to Providers: This will be useful in scenarios requiring home-care monitoring, continuing treatment procedures, etc. The Information Router module will facilitate the efficient delivery of critical information to relevant healthcare providers.

Donor-Recipient Matching: There are numerous obstacles in the present healthcare system for donor location with respect to rare blood types and organ transplants. This module will provide a call-up facility to alert prospective donors and co-ordinating agencies.

Alerting of Selected Groups: This is to deliver important announcements in response to potential epidemics, health-alert warnings or forecasted diseases outbreaks in localised areas. The announcement may be "narrow-casted" i.e. disseminated to individuals with specific PLHP profiles, thereby enabling them to act accordingly.

Figure 3 [5] gives an overall view of the entire LHP project, showing the functionality of the various modules.

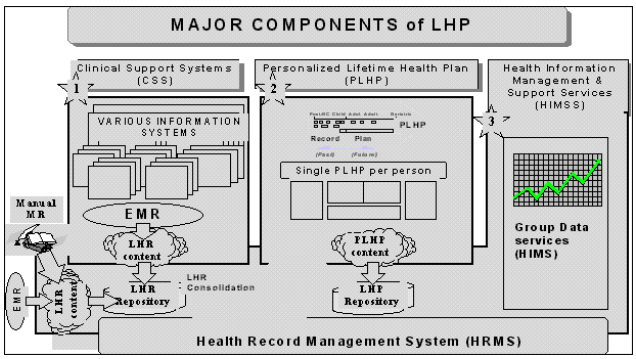

Figure 3 - Integrated view of LHP (taken from CRFP: Lifetime Health Plan, pg. 21)

Concluding Remarks

Malaysia has proposed an enterprising and challenging 'TeleHealth' vision for national healthcare. The vision is in line with international trends in healthcare and advances in IT technology, more so the systematic amalgamation of an innovative healthcare philosophy with leading edge Information Technology support have realised an all-encompassing healthcare model for Malaysia. The infrastructual support offered by MSC allows the telemedicine project not only to reach out to a wider segment of the nation but it also seeds indigenous IT research and development endeavours by way of providing a testbed for the exploitation of leading IT technology in a variety of areas, including healthcare.

The LHP pilot project promotes a paradigm shift towards a 'person-centred system of healthcare'. Cutting-edge IT technology will be the catalyst for shifting the responsibility of health management from the healthcare provider to 'informed' individuals. This transformation will demand substantial changes on all levels and for all participants in the healthcare system. For maximum effectiveness. the 'TeleHealth' vision will feature informed, health conscious and empowered individuals able to select optimum lifestyle and health management options resulting in sustained wellness. These services will pro-actively reach out to individuals, most likely at their homes or work places. They will be seamless in implementation, and continuous in presence, and tailored to the individual's and community's requirements.

The four telemedicine pilot projects represent a starting point for the 'TeleHealth' vision. They will act as the catalyst and provide the framework for the future healthcare system. As of Feb. 1998 implementation will commence, with the completion being targeted for 2003.

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