A WWW Based Tele-Healthcare Information and Diagnostic Environment

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ABSTRACT

The Malaysian Multimedia Super Corridor (MSC) project promotes Telemedicine as a flagship application. The primary objective of MSC-based telemedicine—more appropriately Tele-Healthcare—is to establish a healthcare system leveraging advanced information and multimedia technologies so as to deliver hitherto unattainable services at the individual level. With similar vision, though limited in scope, we present a Tele-healthcare infostructure (TIDE) which provides a testbed to explicate the efficacy of innovative IT technologies in defining an Internet based healthcare delivery system. TIDE—Tele-Healthcare Information and Diagnostic Environment—manifests an 'intelligent' information theoretic Tele-healthcare environment featuring knowledge-based medical reasoning techniques applied to two AI-based healthcare systems: (1) AIMS (Automated Health Monitoring System) for wellness maintenance and (2) IDEAS (Intelligent Diagnostic & Advisory Services) for illness management. In technical terms, TIDE’s implementation demonstrates a confluence of diverse information technologies—artificial intelligence, medical informatics, multimedia, Internet and databases.

KEYWORDS: Telemedicine, Health monitoring, Infostructure, Intelligent diagnostic aid, Consumer Health Informatics

1.0. INTRODUCTION

The Malaysian Multimedia Super Corridor (MSC) initiative promises a large-scale infrastructure—with high-speed Wide Area Network (WAN) connectivity—that will support several cutting-edge application-layer “flagship” projects. Initially, these projects will explore conceptual and implementation models as regards to 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 [1], (5) Research and Development (R&D) Clusters, (6) World-wide Manufacturing Webs and (7) Borderless Marketing.

Our interest pertains to the MSC’s Telemedicine pilot project [2]; heralding a broad definition and an all-encompassing scope beyond the traditional point-to-point data exchange model useful primarily to healthcare professionals. The MSC telemedicine initiative, on the contrary, is meant to articulate a user-centred and wellness-focused system that will inform and empower individuals with regards to consistently maintaining the highest state of health throughout a lifetime [3]. Hence, the label “Tele-Healthcare”—cognate with the modern healthcare concept of Consumer Health Informatics [4]—is perhaps a more appropriate description of the MSC telemedicine project.

The primary objective of MSC-based telemedicine is to establish a healthcare system leveraging advanced information and multimedia technologies so as to deliver hitherto unattainable services at the individual, family and community-level [5] [6]. The basic healthcare principle here is to empower people to play a more greater role in their own healthcare and to be active participants in decisions affecting their health. Instead of illness management the emphasis here is on taking measures to prevent illness and disease, by adjusting lifestyles or taking safety precautions, thereby rendering a positive impact on the health care delivery system and consequently enabling people to lead healthier lives—primarily the tenets of Consumer Health Informatics. For maximum utility, such services will be made available over the Internet, accessible from the home, or at least from within the user’s immediate community; a feature made practical by the MSC’s high-bandwidth multimedia environment.

Emerging healthcare concepts and services are reflective of innovative IT trends—Innovations such as computer-based patient records, hospital information systems, computer-based decision support tools, image processing, data compression, community health information networks, telemedicine and new ways of distributing health information to consumers are beginning to affect the cost, quality and expanded access to healthcare information and services. Innovation and sophistication in healthcare delivery practices is much due to the powerful functionalities offered by a variety of
available IT technologies—mostly applied in tandem with each other—such as network communications, artificial intelligence, medical informatics, multimedia, relational databases, distributed processing architectures, optical disk storage and others [7].

This paper discusses the efficacy of innovative IT technologies in defining an Internet based healthcare delivery system. We present an on-going in-house Tele-Healthcare project, TIDE—Tele-Healthcare Information and Diagnostic Environment. TIDE manifests an ‘intelligent’ information theoretic Tele-healthcare environment with the objective of empowering individuals with relevant, customised and personalised health information so that a continuum of healthcare is ensured throughout the life-time of the individual. Technical realisation of TIDE involves a confluence of information technologies—artificial intelligence, medical informatics, multimedia, Internet and database technologies. The use of artificial intelligence would encapsulate areas such as expert systems and case based reasoning. Internet technology allows for these medical services to be universally accessible via the World Wide Web (WWW). Database technology is used to manage the centralised Electronic Medical Records (EMR) and multimedia is used for information explication and dissemination. TIDE’s unique confluence of technologies gives rise to an efficacious info-structure that is in line with a new era of healthcare delivery systems.

2.0. TOWARDS A TELE-HEALTHCARE INFO-STRUCTURE

TIDE is a manifestation of the emerging trends in modern healthcare practices—namely Consumer Health Informatics—that advocate services being more person-centred as opposed to doctor-centred together with an emphasis on wellness maintenance as opposed to illness management. In essence, TIDE is reminiscent with the objectives of the MSC based Lifetime Health Plan (LHP) pilot project. The intended functionality of TIDE is based on the following three philosophical postulates:

1. Prevention is better than cure – This is to promote the use of healthcare services in order to maintain a healthy community as opposed to the development of advanced methods to treat illnesses.
2. Health monitoring and care from womb to tomb – This is to provide health monitoring for the entire community across space and time.
3. Maximum medical coverage; minimum doctor exigency – This is to provide maximum health coverage with minimum presence of health professionals through the use of ‘intelligent’ diagnostic systems.

To address the above objectives, within TIDE we have implemented two AI-based consultation applications: (1) AiMS (Automated Health Monitoring System) and (2) IDEAS (Intelligent Diagnostic & Treatment System). Both systems are intended to address the healthcare needs of individuals, over the Internet, on a personalised day-to-day basis from the confines of their home/workplace. We understand that during an individual’s lifetime he/she is more likely to remain in the wellness cycle but periodically one is expected to fall into the illness cycle. The objective of AiMS is wellness maintenance, i.e. to ensure individuals remain healthy for prolonged periods of time—AiMS provides personalised healthcare services, i.e. simplified Personalised Lifetime Health Plans (PLHP), to assist individuals to manage and interpret their healthcare needs. The focus of IDEAS is illness management—to provide timely medical advice whenever an individual falls in the illness cycle. IDEAS is adept to provide primary healthcare for non-critical illnesses: it would make a diagnosis, prescribe a treatment plan and direct the patient to the nearest pharmacy. In principle, then, AiMS addresses the earlier mentioned philosophical postulates 1 and 2, whilst IDEAS tackles postulate 3.

The basic idea of the PLHP is to integrate various health plans such as immunisation plans, rehabilitation plans, fitness plans, diet plans, etc. into a single personalised longitudinal health plan that would chart and monitor a person’s state of wellness and illness in relation to his/her earlier or known medical records, i.e. Electronic Medical Record (EMR). Ideally, each individual will be assigned a single PLHP; generated at birth the PLHP will maintain currency by being periodically updated according to the individual’s state of health throughout his/her lifetime. Currently, the medical and health-related knowledge incorporated in a PLHP is pertinent towards Malaysian lifestyles.

Functionally, TIDE is responsible for the maintenance and delivery of each individual’s PLHP, comprising both a wellness and illness plans (see Figure 1). The wellness plan includes personalised versions of healthcare plans as well as information and education plans to keep a person healthy. The illness part, on the other hand, contains rehabilitation and treatment plans for episodic illnesses. When an individual is in the wellness state, his/her health would be regularly monitored by AiMS to ensure the individual remains in the best of health. The moment the individual falls ill, control of the PLHP will be passed over to IDEAS which will perform a diagnosis based on the signs and symptoms submitted by the individual and then subsequently generate a treatment plan. Hence, both AiMS and IDEAS operate in tandem, alternating healthcare duties depending on the health status of the individual. The EMR repository on the left of the diagram provides past medical profiles of an individual that are essential for all services performed by TIDE.

The TIDE info-structure (see Figure 2) is an exhibition of synergy between diverse IT technologies, namely Artificial Intelligence, Internet and Databases [8]. Both AiMS and IDEAS are sophisticated AI-based consultation systems [9] that employs logic programming techniques for the elicitation of the knowledge base and for the
implementation of a hybrid (backward and forward chaining) inference strategy. TIDE’s interaction with users entail a Web-based ‘virtual consultation session’ in which users interact via web forms. Each consultation session may involve the submission of numerous web forms to the TIDE applications, retrieval/storage of person-specific data from the EMR repository, manipulation—by AiMS or IDEAS—of information provided by users and that derived from the database to determine the next action in the consultation session, i.e. the generation of the next ‘dynamic’ web page.

Since TIDE is still in the prototype stage, we are able to deal with only few selected medical conditions:
- AiMS: depression, hypertension, diabetes and cardiovascular related diseases.
- IDEAS: cough, cold, sore throat, diarrhoea, abdominal pain, chest pain, dizziness and earache.

3.0. AUTOMATED HEALTH MONITORING SERVICES (AiMS)

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. It is believed that constant health monitoring provides for improved healthcare for various illnesses such as hypertension, diabetics, cardiac problems and so on. What will be most attractive for monitoring such illnesses is the facility to do so from the confines of the home/office, without regular visits to the hospital/community health centre. An IT system is therefore deemed to be quite useful for geriatric care for illnesses for which home-based treatment and monitoring is possible and is beneficial over institutionalisation.

AiMS is a personalised health monitoring system that helps to keep track, manage, interpret an individual’s health history and offer health maintenance advice. Each session with AiMS entails several important functions: (a) it collects an individual’s current health data—a dynamic and pro-active web-based questionnaire is generated to acquire specialised information; (b) it interprets the acquired information and explains to the individual medically relevant facts; (c) it monitors the individual’s health status based on his/her personalised health plans and it subsequently renders medically-relevant advice to maintain a healthy lifestyle; (d) it provides reminders for scheduled therapy and appointments and can electronically schedule medical appointments; (e) it also alerts healthcare agencies whenever an emergency situation is detected. In order to meet the above functionalities, AiMS comprises 3 main components:

**Personalised Life Plan Monitoring**

From a health maintenance perspective, health monitoring involves a daily check of the PLHP—looking out for any health-related abnormalities and inconsistencies with current health status—to ensure that the PLHP is observed and is maintaining the health of the individual, to motivate and entice the individual in case the PLHP is not observed, to inform healthcare professionals with the current status of the individual, to provide health guides and tips to ensure that the individual maintains a healthy lifestyle.

AiMS incorporates a suite of health monitoring routines that will systematically determine the individual’s current health status. At the initiation of a consultation session, AiMS will extract the PLHP of the individual together with the medical history from the centralised...
EMR database. Based on this information, AiMS will then proceed to ‘intelligently’ ask pertinent questions to determine the user’s current health profile (as shown in Figure 3). Intelligence derives from the fact that the questions posted to the user are dynamically generated (on the fly) after analysing the answers furnished to previous questions. Typical responses of AiMS are shown in Figure 4 and are:

- An advice in the form of a list of do and don’t activities.
- An advice to monitor certain health indicators such as cholesterol and glucose levels and perhaps suggest procedures to monitor these indicators.
- Suggestions on how to amicably follow the PLHP.
- An advice for a detailed medical examination as AiMS isn’t too satisfied with the individual’s current health status.
- An advice for a particular immunisation programme.
- An advice to immediately seek medical treatment as AiMS senses that the user may be seriously ill.
- An alert to the relevant healthcare practitioner.

Electronically produced suggestions of AiMS are shown in Figure 4 and are:

- An advice in the form of a list of do and don’t activities.
- An advice to monitor certain health indicators such as cholesterol and glucose levels and perhaps suggest procedures to monitor these indicators.
- Suggestions on how to amicably follow the PLHP.
- An advice for a detailed medical examination as AiMS isn’t too satisfied with the individual’s current health status.
- An advice for a particular immunisation programme.
- An advice to immediately seek medical treatment as AiMS senses that the user may be seriously ill.
- An alert to the relevant healthcare practitioner.

Presently, AiMS is not connected to any hospital/community healthcare centre (although it has the functionality to inform remote healthcare practitioners). However, soon we intend to connect AiMS to a few nearby hospitals/community healthcare centres. With such connectivity, individuals will also be able to exploit the in-built scheduling tools to electronically schedule medical appointments and procedures with the online hospitals. Furthermore, we will implement a centralised appointment and schedules database that will store records of schedule related information of all online hospitals.

Electronic Health Surveys

AiMS provides the facility to perform ‘electronic’ health surveys of the ‘cyber’ community to gauge their general health status. Such an exercise has twofold objectives: (1) The information collected from the surveys is vital for informed ‘decision making’ by healthcare authorities, i.e. public health authorities and medical research teams can detect and delineate epidemics, outbreak of diseases, contamination and current lifestyle trends of the community and consequently plan for counter measures; (2) To an individual, the electronic health survey serves as a benchmark against which he/she can evaluate his/her own health. It is psychological fact that if one is informed that he/she is more unfit than 90% of the community then he/she will be more alarmed and he/she will thus probably be motivated to take preventive measures a bit more seriously.

AiMS conducts electronic surveys on various issues, ranging from determining fitness levels to stress levels to health knowledge. Health surveys comprise generic health concepts, that is concepts that are not specific to any age, disease, or treatment group to ensure that the surveys are both well-understood and representative of the community at large.

The cross-section of the community to be chosen for a survey is randomly determined (though some basic selection criteria is observed). AiMS would request the selected public to answer the questions, collect their responses electronically (Figure 5) and finally compile the findings of the survey. This involves the use of some
statistical techniques together with the manipulation of information through the use of an AI based program. The findings of this health surveys are visually represented by using graphs, data sheets (tables) and health reports (Figure 6). Such visual representation would be made available to the general public through the AiMS web-site, whereas the individuals taking part in the survey are sent their individual benchmarking results.

4.3. ‘Personalised’ Health Tips and Facts (PHTF)

AiMS incorporates a module that provides web-based general health tips (specifically tailored to Malaysian culture), customised according to an individual’s health requirements. PHTF builds on an individual’s PLHP to provide a variety of services, including: an immunisation planner—an intelligent program that keeps track of personal (and family) immunisation and rehabilitation programmes (shown in Figure 7); a dietary guide to calculate the daily/weekly calorie intake and consequently propose dietary plans (shown in Figure 8); an exercise/fitness monitor that charts exercise plans, ranging from rudimentary to strenuous exercises, again based on the individual’s health needs; a stress level indicator that can identify the stress level of each individual based on his/her lifestyle, etc.

In summary, this component is anticipated to play an important role in assisting individuals to plan and schedule their individual healthcare programs, thus making them more responsible for their health.

4.0. INTELLIGENT DIAGNOSTIC AND TREATMENT ADVISORY SERVICES (IDEAS)

TIDE offers a continuum of healthcare—to cater for illness management TIDE incorporates an AI-based medical diagnostic and treatment system: IDEAS (Illness Diagnostic and Advisory System). IDEAS encapsulates medical practice rules and treatment protocols practised by doctors (Malaysian doctors in particular), thereby providing the community quality ‘virtual’ medical consultation for non-critical illnesses over the WWW.

There is a growing trend (especially in urban populations) to self-prescribe over-the-counter medication for minor ailments for instance cough, cold, sore throat, fever, etc. For such non-critical illnesses, it is often deemed inconvenient and time-consuming by individuals to visit a doctor for which treatment can be self-diagnosed (by interacting with a medical expert system) and for
which a prescribed treatment could be obtained over-the-counter. IDEAS aims to provide medically-informed support towards self-diagnosis: with a WWW interface, individuals can (a) readily consult IDEAS by submitting their symptoms; and (b) obtain a medically-validated diagnosis and prescription. For medical completeness and accuracy, IDEAS makes a diagnosis by not just considering the current signs and symptoms encountered by the patient, rather it also takes into account factors such as the individual’s medical history, present medications and treatment plans if any and also the effects of certain drug combinations, together with an extensive database of approved pharmaceuticals within Malaysia.

Functionally, IDEAS will conduct a web-based ‘virtual consultation session’ comprising dynamically generated questionnaires for the collection of relevant patient’s health information (see Figure 9). Next, based on the collected information and the patient’s health record (i.e. centralised EMR), IDEAS would come up with a diagnosis and treatment plan (see Figure 10). In another role, IDEAS serves as a patient data collection and entry (to the centralised EMR) system: IDEAS records clinical observations in a structured data entry language, thereby not only ensuring data integrity but also facilitates integration with other information processing and decision support systems.

It may be noted that the inherent expert system within IDEAS is not only responsible for the final diagnosis and treatment plan, but it is also involved in the ‘intelligent’ generation of subsequent questionnaires (i.e. web-pages) that may contain only the next pertinent questions to be asked at that stage of the consultation. The questions generated aim to satisfy the multiple active hypothesis.

In a Tele-healthcare environment where emphasis is on quality and immediate primary healthcare with minimum involvement of doctors, IDEAS is intended to be the community’s initial point of contact when in need of illness-related health-care services. In this role, IDEAS will serve as a patient screening agent—screening patients in need of just primary healthcare as opposed to patients in need of tertiary health-care. Furthermore, by way of providing home-based diagnostic services to the public in need of just primary healthcare for non-critical situations, IDEAS purges them from the illness cycle without any delay and without taxing valuable healthcare resources.

5.0. ELECTRONIC MEDICAL RECORDS

Central to all TIDE activities is an individual’s medical profile—both past medical history and prospective future healthcare plans—which is documented as the Electronic Medical Record (EMR). The universality of services proposed by TIDE is a consequence of the Internet infrastructure and a centralised EMR repository. The benefits of a centralised EMR database are as follows:

1. With the emergence of IT-based healthcare systems at various levels—say hospitals, GP clinics and community health centres—we are talking about the possibility of the generation of multiple records for the same individual. Duplication of data is an undesirable fact and it leads to serious data integrity problems. Hence, a centralised EMR database can ensure no duplication of patient records and in turn better data integrity.

2. A centralised EMR database allows an individual’s patient record to be referred by various healthcare agencies. This is highly desirable when an individual
moves from one place to another or when he/she changes doctors or hospitals. Ideally, an individual’s medical record should be available nationally so that he/she can enjoy nation-wide healthcare services.

3. A centralised EMR repository provides a continuous health profile of an individual regardless of the fact that he/she has been serviced by different entities of the healthcare enterprise. For lifetime health monitoring, such a continuous health profile is essential to be readily available (most preferably to all entities of the healthcare enterprise: consultants, GPS, paramedics and so on).

4. Medical history data is quite invaluable and should not be restricted for just meeting the healthcare needs of individuals. Rather, the data should be used for decision-making, planning—data mining the medical data is a typical application—and to support other IT healthcare systems. With a centralised EMR database it is possible to extend the efficacy of the collected medical data to other services and systems.

To address the above demands we have implemented a prototype centralised EMR repository to store records for a number of individuals. Ideally, a medical record should be created at the birth of a child. However, at present in TIDE, a new EMR is generated whenever an individual makes its first interaction with TIDE. The EMR repository practices a set of confidentiality and security protocols.

The development of a standard EMR suitable for the Malaysian medical environment is currently a major area of research as there is no standard EMR currently in existence locally. The Malaysian EMR will have to reflect the local medical environment, supporting all forms of health care provided by the various levels of health care providers ranging from specialist, general practitioners, health support personnel such as physiotherapists, dieticians and even practitioners of traditional medicine.

<table>
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<th>Table Name</th>
<th>Some Relevant Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information</td>
<td>Personal Info. Name, Address, Gender, DOB, Race, Religion, Tel. No., Married, IC No.</td>
</tr>
<tr>
<td></td>
<td>Occupation Detail Employer, Address, Designation, Date Started, Date Ended, Nature Of Job.</td>
</tr>
<tr>
<td></td>
<td>Insurance Info. Insurance Policy, Company, Policy No., Group No., Effective Date, Termination Date, Special Conditions</td>
</tr>
<tr>
<td></td>
<td>Emergency Contact Next-Of-Kin, Phone No., Address, Relationship, GP Details</td>
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<tr>
<td></td>
<td>Healthcare Providers GP Name, Contact Address, Phone No.</td>
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<tr>
<td></td>
<td>General Health Blood Type, Bp, Height, Weight, Special Conditions</td>
</tr>
<tr>
<td>Medical History</td>
<td>Medications Drug, Dose, Date Prescribed, For How Long, Why Prescribed</td>
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<tr>
<td></td>
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<td>Family History Mother’s Record (Link), Father’s Record Link</td>
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<tr>
<td></td>
<td>Surgery History Surgery Name, Surgeon, Date Operated, Outcome, Hospitalisation (Link), Anaesthesia, Referral Provider</td>
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<tr>
<td></td>
<td>Residence History Hospital Name, How Long, When, For What, Outcome, Comments</td>
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<tr>
<td></td>
<td>HDT Disease History Disease, Relationship with Sufferer</td>
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<tr>
<td></td>
<td>Immunisations Vaccine, Date Taken, Where</td>
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<tr>
<td></td>
<td>Exercises Activity, Duration, Frequency, Date Started, Date End.</td>
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<td></td>
<td>Allergies Allergy Type, Allergy Agent, Medications</td>
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<td></td>
<td>Vital Sign History BP, Temp, Heart Rate, Blood Sugar, Measurement Dates, Measured By</td>
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<td></td>
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<td></td>
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<td></td>
<td>Habits Smoking, Diet, Social Life, Sleeping</td>
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</tbody>
</table>

Figure 11: EMR data model

We have proposed a data model for a Malaysian oriented EMR (a fragment is shown in Figure 11), which derives from the combination and enhancement of several existing global EMR models. Our EMR data model is quite flexible and can include additional tables for specific illnesses such as cardiovascular, renal, cancer and other diseases. The architecture of the centralised EMR database is modelled along the lines of a ‘data warehouse’ model to facilitate future data mining activities.

6.0. TIDE IMPLEMENTATION DETAILS

TIDE manifests an info-structure that provides a seamless synthesis of AI-based medical decision-making systems (expert systems embedded within AlIMS and IDEAS), databases storing the EMRs and web protocols. The TIDE info-structure is being developed along the lines of an ‘open architecture’ which not only supports a
synthesis of diverse technologies but also allows expansion of the info-structure by providing means to integrate it with software agents used by other healthcare resources/systems.

At the heart of AiMS and IDEAS are two expert systems, encapsulating medical knowledge and techniques to reason with the medical knowledge [15]. Both employ an inference strategy that is a hybrid of forward and backward chaining. Expert medical knowledge, in particular the Malaysian medical practice procedures, are represented using typical \textit{if \ldots then \ldots else} statements. Each rule is represented as the predicate—\textit{rule/6}—which has the following form:

\begin{verbatim}
    rule(Rule No, Disease Type, Premise-List, Conclusion-List, Conclusion Level, Confidence Factor of Rule).
\end{verbatim}

Each rule has an associated confidence factor (CF) that is instrumental in the firing of the rule. For our purpose, we have two levels of confidence factors: every premise has an associated CF that is reflective of its significance within the rule, whilst the entire rule has another CF (used whenever the rule fires) known as the rule confidence factor (RCF). The CF scheme is implemented to introduce some flexibility within the rule structure and its firing, whereby a rule can fire even if some of its ‘more significant’ premises are satisfied, as opposed to the satisfaction of all premises within a rule. Both the expert systems are developed using the Prolog logic programming language, more specifically \textit{LPA Prolog 3.5}.

AiMS and IDEAS support a web-based GUIs that is both adaptive and conversational. The applications reside on a server and can be accessed by remote clients over the WWW. User’s interaction with the TIDE applications is via a dynamically generated HTML user interface. This strategy is a step forward from the traditionally ‘static’ web user-interfaces in which a set of pre-determined, yet at times irrelevant, questions are presented to the user. For our purpose, where personalised health monitoring is desired, we need to ask questions that are pertinent to the answers earlier submitted by the user (during the same consultation session) and are also relevant to his/her health profile. Hence, the web-page is dynamically generated and passed back and forth to realise the many interactions during a consultation session. This approach is highly appropriate as in the context of personalised healthcare services, the health needs and conditions of individuals may vary, hence it is unrealistic to pre-determine a standard set of questions for all users. AiMS and IDEAS are designed to generate dynamic questions by way of intelligently searching the knowledge base for relevant questions. The questions selected are then mapped onto HTML pages and posted to the client. Subsequent questions will be generated based on answers furnished by the client to previous questions.

Interactions between the client (the users) and TIDE applications are accomplished using \textit{ProWeb}—a Prolog-Web interface toolkit supplied by LPA. The use of ProWeb allows clients to effectively ‘talk’ with indigenous expert systems residing on the server. The web-based user-interface is developed using HTML and Java Script and the graphical charts are derived from Java applets—Java takes the values from ProWeb interfaced applications to generate the graphical charts on the fly.

TIDE applications need to frequently access the centralised EMR repository. Interactions with a DBMS is achieved by using the ProData toolkit—a LPA product that allows a tight coupling between LPA Prolog and all ODBC supportive DBMS—which enables the EMR database tables to be accessed from Prolog as though they existed within Prolog’s environment as facts. This facilitates the use of Prolog rules over the contents of the database, with no need to download any part of the database, as all database accesses are done ‘on the fly’. The added availability of ODBC within the TIDE environment is also quite beneficial as it renders TIDE to be able to work with a variety of databases, if need be.

Finally, we will like to point out that TIDE is one of the few successful Prolog based AI applications that extend their functionality over the WWW.

\section*{7.0. CONCLUDING REMARKS}

The Malaysian Tele-healthcare vision specifies the development of innovative systems, services, infrastructures, skills and shared values. For maximum effectiveness, it is argued that Tele-healthcare should feature individuals who are well informed on healthcare issues and able to select healthy lifestyles and health management options thereby resulting in sustained wellness. Tele-healthcare services need to be provided at home or close to the home and that they should be seamless in implementation, and continuous in presence and tailored to the individual’s and community’s requirements.

From our end, the realisation of TIDE has identified opportunities to improve healthcare delivery through increased use of information technology as per the Malaysian Tele-healthcare vision. Both AiMS and IDEAS serve as personal health maintenance systems that will help track, manage, and interpret an individual’s health history, and in return offer advice to individuals and patient-health-updates to healthcare providers. Each interaction with TIDE is an active process, with an intelligence bias, that performs several important functions: it collects patient data; it checks, interprets, and explains to the subject medically-relevant facts and plans; it adapts its advice based on the subject’s prior experiences and stated preferences; it performs “sanity checks” on both medical efficacy and cost-effectiveness of diagnostic conclusions and therapeutic plans; it monitors wellness progress and it helps educate, encourage, and inform the individuals [10].
Finally, the TIDE info-structure is a showcase application demonstrating the efficacy of AI concepts and functionality on the WWW. The realisation of the TIDE info-structure again demonstrates how divergent technologies, i.e. database, Internet and medical informatics can be synthesised with AI to yield practical applications. The TIDE project is still in progress and more sophisticated and extended services are expected to evolve.

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REFERENCES