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A Personalised Healthcare Information Delivery System: Pushing Customised Healthcare Information Over the WWW

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Abstract. Easier and focused access to healthcare information can empower individuals to make 'informed' choices and judgements about personal health maintenance. To achieve 'optimum' patient empowerment, we need to re-evaluate and potentially re-design the processes of healthcare information delivery. Our suggestion is that healthcare information should be *personalised* according to each individual's healthcare needs and it should be pro-actively delivered, i.e. *pushed* towards the individual. We present an intelligent *Personalised Healthcare Information Delivery Systems* that aims to enhance patient empowerment by pro-actively pushing customised, based on one's Electronic Medical Record, health maintenance information via the WWW.

1. Introduction

Recent healthcare reforms, world-wide, aim to promote wellness maintenance programs—i.e. the adoption and adherence to healthier lifestyles—at the individual/community level [1, 2]. The underlying approach is to empower individuals to actively participate and even take charge of personal healthcare decision-making and management—*Patient (or Person) Empowerment* is the term used by the healthcare fraternity. Easier and focused access to healthcare information can empower individuals to make 'informed' choices and judgements about personal health maintenance [3].

The emergence of the Internet is making possible 'ubiquitous access' to volumes of healthcare information repositories (i.e. web-sites) [4, 5]. But, ironically the proliferation of Internet-based healthcare information brings about certain drawbacks: the individual needs to (a) meticulously sift through volumes of information; (b) make 'value' judgements about the validity and relevancy of the information; and (c) endeavour to find pertinent healthcare information—i.e. it's the individual prerogative to acquire healthcare information.

To achieve 'optimum' patient empowerment, therefore, we must re-evaluate and potentially re-design the processes of healthcare information delivery. It is our contention that despite the sophistication of delivery channels and medical content, the effect of the information will be diminished if the right information is not delivered at the right time. What we are arguing is that for optimum patient empowerment, healthcare information should have the following characteristics [1]:

- *Personalised Information*: Generic healthcare information should be 'dynamically' customised to specifically address the current health needs of individuals. In essence, personalised healthcare information should take into account the individual's (i) chronic (long term) and episodic (short term)healthcare needs, (ii) healthcare objectives, (iii) literacy level, (iv) social and community factors. In principle, personalisation of healthcare information predicates that no two individuals should ideally receive the same information, as in all likelihood they both may have different health profiles.

- *Just-in-time information:* Relevant and up-to-date information should be pro-actively delivered, at regular intervals, to the individual—i.e. instead of the individual 'pulling' the information, it should be periodically 'pushed' to the individual over the Internet.

In this paper we present an intelligent *Personalised Healthcare Information Delivery System (PHIDS)* that aims to elevate the health maintenance awareness amongst individuals by pro-actively delivering customised health maintenance information via the WWW. Functionally, PHIDS acts as an intelligent agent that (a) pro-actively monitors the health profile of an individual vis-à-vis his/her dynamic healthcare needs; (b) intelligently composes the 'best' personalised health maintenance information, specific to the individual's current health profile given in the EMR; and finally (c) autonomously 'pushes', over the WWW, personalised healthcare information to the individual. Henceforth, PHIDS enhances patient empowerment by offering both *personalised* and *just-in-time* health maintenance information.

2. A Functional Overview of PHIDS

To meet the aforementioned functional objectives, PHIDS is implemented as an Intelligent Info-Structure, involving a confluence of artificial intelligence, database and web technologies. Figure 1, shows the functional architecture of PHIDS. We briefly explain the workflow of PHIDS vis-à-vis the functionality and features of the individual modules:

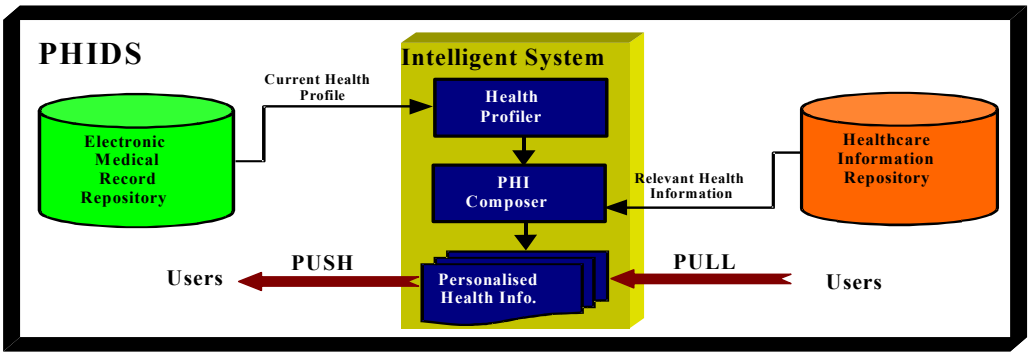

Figure 1: The functional architecture of PHIDS, illustrating the constituent modules and resources.

2.1. Electronic Medical Record Repository

The *Electronic Medical Record (EMR)* repository contains EMR for (Malaysian) individuals registered with PHIDS. The EMR adheres to ICD10 coding for recording patient information. Figure 2 shows some of the EMR contents. Currently, we are accessing EMRs from the on-campus medical centre over a LAN network.

2.2. Health Profiler

The *Health Profiler (HP)* determines the current health profile of an individual by examining his/her EMR. The HP, when invoked by PHIDS, proactively searches the EMR for (a) acute diseases with corresponding therapeutic regimes; and (b) episodic encounters with healthcare providers during a specified time frame (referred to as the *health status window*). The health profile intelligently generated comprises information about acute and recently encountered illnesses (symptoms and treatments), lifestyle changes (if any), therapeutic and rehabilitation programs and other relevant medical information. Features of the HP are: (1) It can conduct a WWW-based consultation session with the user to validate certain aspects of his/her compiled health profile. A built-in expert system intelligently asks

a series of relevant questions and subsequently infers the 'most representative' health profile of the user; (2) It compiles only the most current and imminent healthcare needs, if any, without conferring to 'old' (determined by the health status window), or previously addressed health needs. Currently, the health status window is set to 3 weeks by default, but can always be changed by the individual; and (3) It incorporates a medical thesaurus (UMLS meta-thesaurus) to translate the non-standard vocabulary found in the EMR to the standard vocabulary used to index the healthcare information within PHIDS.

2.3. Healthcare Information Repository

The *Healthcare Information Repository (HIR)* contains generic healthcare information (content) organised in a hierarchical (directory-based) structure, as shown in figure 3. Healthcare information is categorised into the following categories: Allergy, Diseases, Drugs, Lifestyle, Symptoms, Medical Dictionary, Medical Vocabulary and (PHIDS) Users. Each category, implemented as a directory, contains a number of individual, yet related, information items compiled as HTML files. For instance hypertension information is kept in the file medical/diseases/hypertension/hypertension.html. The features of HIR are (a) the hierarchical structure manifests a taxonomy of healthcare information ranging from generic to specialised; (b) new categories (or sub-categories) of information can be added by simply creating a directory at the right level; and (c) new healthcare information can be readily added by simply inserting a HTML file (in the correct format) in the relevant directory.

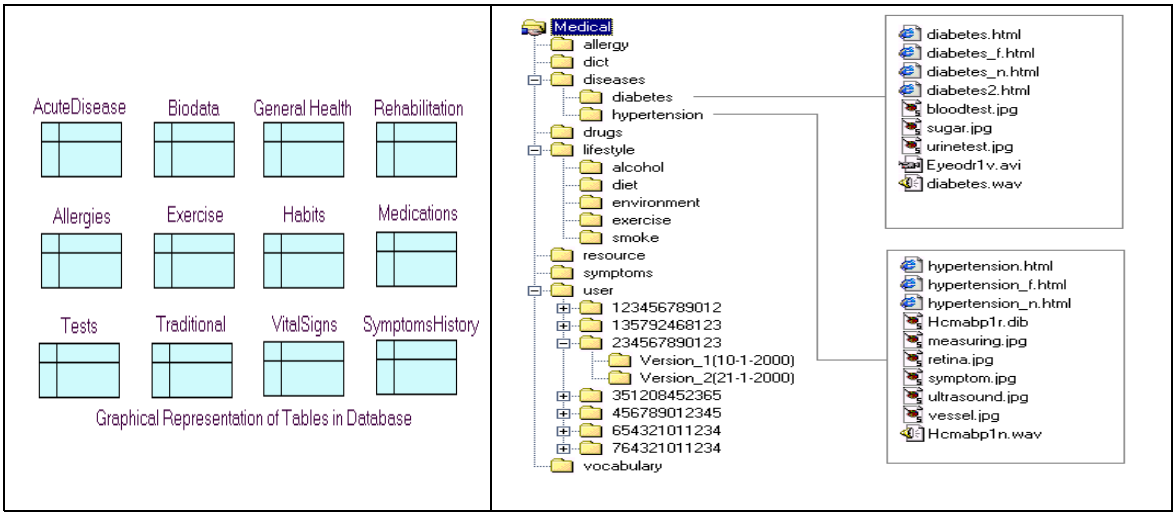

Figure 2: Some of the tables implemented within the EMR.

Figure 3: The taxonomic organisation of healthcare information as HTML files in HIR.

2.4. Personalised Health Information (PHI) Composer

The *PHI Composer*, dynamically composes PHI with respect to an individual's current health profile generated earlier. The PHI composer selects pertinent healthcare information (HTML files) from the HIR. Next, the multiple information items collected are systematically organised as a seamless dynamic HTML document to realise the *PHI File* (see figure 6) to be delivered to users. We have created a *PHI Content Template*—the layout of the dynamic HTML file—that determines the organisation of the different types of healthcare information at pre-specified positions within the document (see figures 4 and 5) [6]. An important feature of the PHI Composer is that it checks whether the information item selected had been previously delivered; if so, then depending upon the settings of the PHI Composer a decision is made whether to include it or not. Usually, we do not encourage the repetitive presentation of previously sent PHI, as it might diminish the

interest of the user. However, if the PHI Composer notices new or updated information within the HIR about some previously addressed, yet prevailing, illness then it includes the new/updated information in the PHI file.

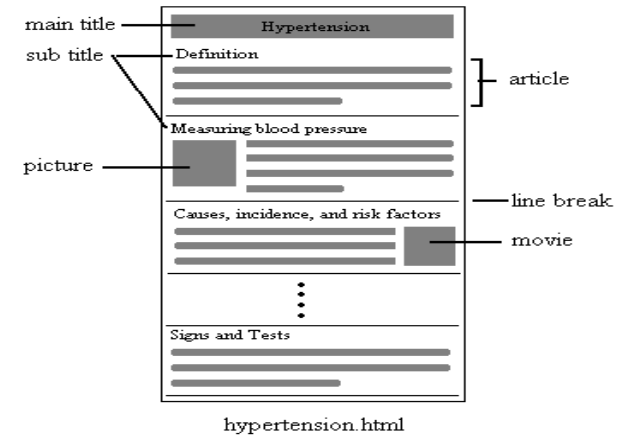

Figure 4: The PHI content template, illustrating the position of information items at designed locations

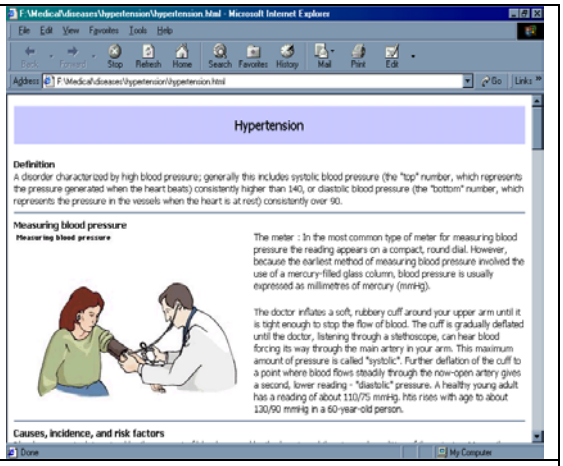

Figure 5: A dynamically composed PHI content (HTML format), based on the PHI (file) template.

2.5. PHI Delivery Modes

Delivery of PHI is made possible by two modes: (1) *Client-Motivated Mode* and (2) *System-Motivated Mode*. The functionality of each mode is as follows:

Client-Motivated Mode involves the typical *Pulling* of desired information from a web-site. The policy for determining the content of PHI is as follows: PHIDS intelligently examines the user's retrospective health profile from the current date to the last visit date to detect for any new chronic illness, lifestyle changes, rehabilitation plans, diet programs and so on during that period. Next, it invokes the Health Profiler's expert system to validate the 'autonomously' derived health profile of the user (as shown in figure 7), as it may be possible that certain past healthcare needs may not be relevant now. Finally, the most-appropriate PHI is composed and sent to the user's web browser.

System-Motivated Mode is the value-added and innovative delivery mode whereby up-to-date PHI is pro-actively and periodically *Pushed* to users, over the Internet to their email accounts—i.e. just-in-time PHI automatically delivered at the desktop. The feature of the *Push Technology* based delivery mode is that, for registered users, PHIDS takes charge of their dynamic health needs and pro-actively compiles and delivers the 'best' PHI at scheduled intervals, i.e. 2-3 week long *PHI Window*. In this way, individuals are continuously empowered with up-to-date PHI, without reaching out to various web-sites. Vis-à-vis the push delivery mode, PHIDS assumes the role of a *pro-active health guardian*.

3. PHIDS Implementation Details

PHIDS is implemented using the Prolog programming language, specifically Visual Prolog version 5. CGI scripts are used to process the HTML based input forms submitted by users and to deliver PHI over the WWW. Again, Visual Prolog is used to create the CGI script, whereby all the processing mechanisms are programmed and compiled as an executable CGI script. The healthcare information content is developed in both HTML and XML format. Microsoft Access 97 is used as a DBMS for the EMR repository. Finally, we use Windows NT server as the web server for the delivery of PHI.

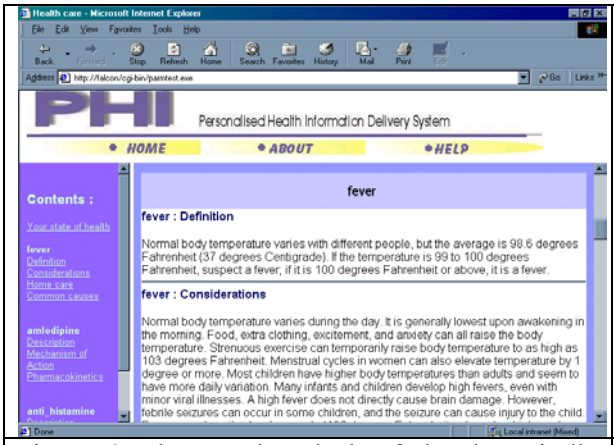

Figure 6: The actual outlook of the dynamically generated PHI File. The left side of the page contains the PHI Navigator—hyperlinks to various parts of the PHI content. The right side of the page contains the actual PHI content, as per the PHI content template.

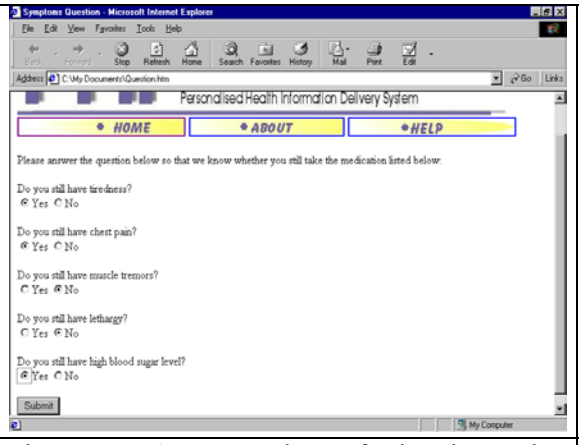

Figure 7: A screen-shot of the interactive consultation session conducted by the Health Profiler's expert system to validate the automatically generated health profile of the user.

4. Concluding Remarks—The State of Affairs

The Malaysian Tele-Medicine flagship initiative, under the auspices of the Multimedia Super Corridor project, aims to empower and encourage individuals to take charge of their (and their family) day-to-day health promotion and preservation needs [1, 7]. One (out of four) major project within the Malaysian Tele-Medicine portfolio is Mass Customised/Personalised Health Information and Education. This project is a functional prototype for the aforementioned Tele-Medicine project, though with limited community and content coverage. Nevertheless, the work reported here serves as a test-bed to evaluate the efficacy of PHI systems and content, together with system design and functionality considerations leading to long-term national roll-out of PHI services. On-going work focus on various issues, leading amongst them are (a) the use of *medical ontologies* in the classification and compilation of healthcare content; (b) security and confidentiality of the PHI delivered and during EMR access; (c) the incorporation of more intelligent technologies, in particular *constraint logic programming* to satisfy multiple medical constraints associated with an individuals health profile and *configuration technology* for compiling healthcare information from diverse sources. Currently, PHIDS is under trial, with consistent improvements to the health information content, involving around 200 registered members whose EMR's are locally available within our institution.

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