AMADIA — ASTHMA MONITOR & ALLERGY DATA INFORMATION APPLIANCE

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Asthma is one of the major public problems in the world. This paper describes the design of an information appliance supporting asthma suffering patients. We considered specific characteristics of information appliances, such as a small form factor (*ie* easily carried in one's pocket), or simplicity of operation. The information appliance extensively uses data related to environment characteristics (such as weather or pollen counts) available on the Internet. We present our method for data gathering from the Internet, which allows a highly modular design. We use a relational database and the eXtensible Markup Language (XML) for asthma related data representation. A combination of the relational database and the XML provides the possibility for using data by other appliances, in particular for information interchange on the Internet. A prototype realization of the design — the system called AMADIA (Asthma Monitor & Allergy Data Information Appliance) is also reported.

K e y w o r d s: Asthma, allergy, peak flow, pollen and weather situation, information appliance, Internet, XML, WWW-parser method.

1 INTRODUCTION

Asthma is a serious health problem around the world. Over 150 million people in the world are diagnosed with asthma and the prevalence of asthma is rising [8]. Since asthma is a chronic disease, it usually requires continuous care. Patients should often take medications daily, continuously monitor the course of the disease and identify triggers that worsen their condition. However, asthma can be controlled by reducing a patient's exposure to the triggers. Consequently, much attention is devoted to increasing self-management of asthma. There exist several asthma related information sources accessible via the Internet that can help one to manage asthma [1, 2, 8]. The mentioned resources are primarily oriented to provide structured information related to the use of objective measurements of lung function and environmental characteristics so that one may monitor the course of the therapy. They are often represented by hypermedia [7].

Computer based information processing supporting self-management asthma may enhance the user's ability to make appropriate decisions according to self-management of asthma. An information appliance helps him/her enter, access, display, store and manipulate information important in the prevention or minimization of the symptoms of asthma. We proposed and developed a prototype of information appliance called AMADIA — Asthma Monitor & Data Information Appliance. Our aim is to have electronically available data that would enhance the quality of life for the asthma-suffering user.

The paper is organized as follows. In Section 2 we summarize the concepts of asthma related data collection and management. Section 3 presents the design of the AMADIA system. We concentrate on data representation and describe the proposed method for gathering data from the Internet. Next, in Section 4 we briefly describe realization of the prototype. We conclude the paper with our conclusions and give some proposals for the future work.

2 CONCEPTS OF COMPUTER SUPPORTED ASTHMA RELATED DATA COLLECTION AND MANAGEMENT

The AMADIA system is designed to fulfil three basic functions: collecting data about a user's health condition, collecting data about the environment and reviewing and managing the collected data.

2.1 Health Condition Data

The main task of AMADIA is to monitor a user's health condition. The user regularly enters the peak expiratory flow rate, heart rate, blood pressure and body temperature readings (obtained through simple home measurements) into the system. The recorded data, together with supplemental information about asthma triggers and symptoms, allow the patient and the patient's physician to make accurate treatment decisions.

The monitored data are manually entered into the information appliance because there is no standardized in-

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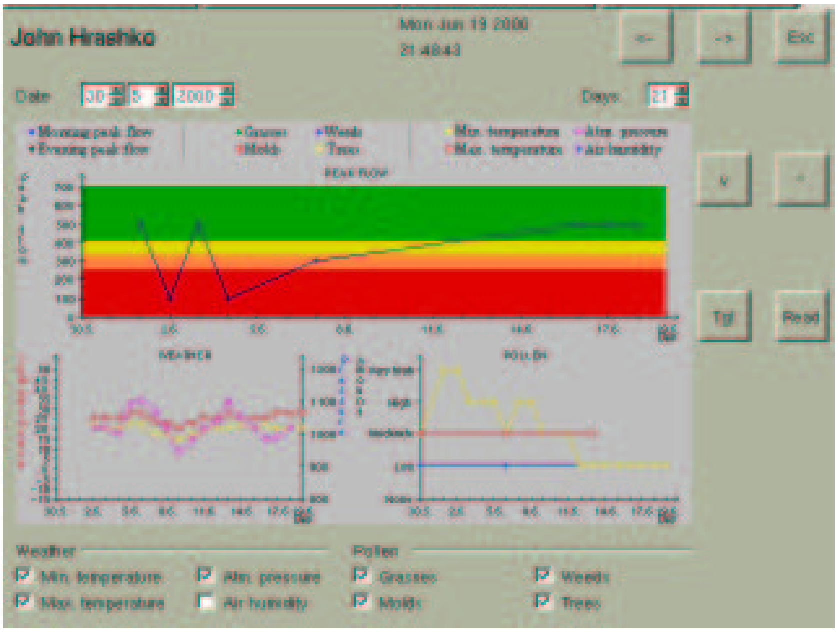

Fig. 1. Graphic presentation of collected data.

terface for acquiring such information directly from the measuring devices. Data entering is simplified by extending the user interface with a touch screen.

The design of the monitoring function is based on peak flow monitoring. The peak flow is measured by a peak flow meter — a small, portable, convenient and inexpensive device. Peak flow meters are widely used not only in hospitals but also at home to assess the severity of asthma and evaluate the response to therapy.

Peak flow monitoring gives early warnings about deterioration of the patient's asthma and could be used as a means to determine the effectiveness of prescribed asthma medications. AMADIA allows effective processing of data obtained from the peak flow meter and encourages regular measurement, which is important for self-management of asthma.

2.2 Environment Data

Since allergens and changes in either temperature or humidity are common triggers of asthma, the user is regularly informed about current pollen and weather conditions. The recorded environment data are obtained from the Internet. Data are always available to the user and can be used to identify triggers that cause his/her condition to worsen.

The source of pollen counts is the AAAAI (American Academy of Allergy, Asthma & Immunology) Web site [1]. Pollen counts are provided by the National Allergy Bureau for all regions of the United States. At the moment it is more complicated to obtain similar data for European cities because we have not found any satisfactory web page concerning actual information from European pollen stations.

Current weather is obtained from the Yahoo Weather web site (http://weather.yahoo.com/). We decided to use this web site because it provides weather forecasts for a large number of cities around the world, although parsing the data from these web pages is relatively difficult.

2.3 Reviewing Monitored Data

Recorded health condition data, along with pollen and weather data, can be displayed on a graph (see Fig. 1), hence transformed to valuable information for the user. Peak flow values are drawn into four zones that are calculated according to the user's personal best peak flow value. Default peak flow zones are defined in accordance with [6]:

- *green* zone (more than 80% of personal best) signals good control,
- *yellow* (high yellow) zone (65% - 80% of personal best) signals caution,
- *orange* (low yellow) zone (50% - 65% of personal best) signals warning and
- *red* zone (below 50% of personal best) signals a medical alert.

The AMADIA shows a warning if the peak flow values fall into the lower zone, so the user (according to his/her symptoms) can take a particular action from the action plan prepared by his/her physician.

2.4 Other Useful Features

History and current information about the user can help not only the user to self-manage asthma, but it can also help the physician to evaluate the course of the disease. The monitored data can be sent in regular intervals to the physician by e-mail. According to the received peak flow readings, the user's physician can effectively organize a user-specific asthma management plan, which is also a part of our system.

The AMADIA stores also practical information about the user's health care providers (like phone numbers, office hours and e-mail addresses). Information about physicians, health centers, pharmacies or emergency departments is maintained and updated directly from the Internet.

Asthma often occurs in families. The AMADIA is a multi-user system. It remembers basic personal information for each family member. In order to help the whole family, the system's interface should be easy-to-use. It should motivate all users to manage their asthma. That is why we considered different groups of users (*eg*, children and adults) and put special emphasis on the screen design, which is simple and intuitive. The system is provided with a simple touch screen, which allows people to use the information appliance effectively without becoming computer-literate.

3 GATHERING DATA FROM THE INTERNET

Every information appliance depends heavily on the entered, stored, accessed, and manipulated data. For this reason, we selected data-centered architecture [3], which allows the development of a highly modular software system.

Our system works with data from two basic sources:

1. health condition data entered by the user,
2. environment related data gathered automatically from the Internet.

The recorded data are represented by a passive repository using a relational database. Data from the repository are accessed by means of the Structured Query Language (SQL). The relational database is advantageous because of its flexibility, extensibility and portability. It is used for internal storing of collected and inferred data.

The database scheme of data from the first group is relatively stable. After series of interviews with physicians we identified the type of health condition data which should be recorded and monitored in order to improve self-management of asthma.

The structure of all data from the second group cannot be defined in advance. In order to use resources effectively, data already accessible on the Internet should be used. We use already available data accepting their structure (*eg*, current pollen and weather conditions) and designed an appropriate structure for not widely available data (*eg*, health care providers).

Problems arise because providers of these data modify their sites, or new sites with relevant data appear. Moreover such data are today mostly represented in HTML (Hypertext Markup Language), which only specifies how a document should be displayed. HTML does not describe the semantics of the presented information. Parsing data from such a format requires detailed knowledge of the document's structure, which has to remain unchanged. In HTML, there is no possibility to provide structured information in a standardized way. For these reasons HTML is not suitable for effective data exchange.

Recognizing the limitations of HTML for the representation and exchange of structured data, the World Wide Web Consortium (http://www.w3c.org/) developed XML (eXtensible Markup Language) together with a set of related standards. XML provides a platform for standard infrastructure in situations where text and other media are to be combined, exchanged and published [4]. XML is a metalanguage that allows the document structure to be described in terms of a hierarchy of named elements with additional properties expressed as attribute-value pairs.

XML offers great flexibility in data structuring. Undoubtedly, XML alone does not accomplish the job. We need powerful tools to manipulate data represented by XML. We proposed a WWW-parser method that uses a set of independent parser modules for differently structured web documents represented in both HTML and XML. Since XML is not yet widely used, our parsers also allow the specification of XML data into comments of an HTML document (this situation is going to be changed by designing XHTML [9]).

For example, the information about health care providers is represented in our own XML format because it is not widely available in a structured format and it is impossible for us to create a personalised parser for every physician's web page. To be supported by the AMADIA, a health care provider is asked to add a short HTML/XML section to his/her web page (see example in Fig. 2).

Weather and pollen data are obtained from the Internet every day even if there is no user currently logged in. WWW-parser method starts with reading a selected configuration file and executes the appropriate parsers to obtain data from all active information sources. The gathered data could then be used by all the AMADIA users, and saved into the relational database (see Fig. 3).

The configuration file is a text file that specifies which program (parser) should be used for parsing web pages containing particularly formatted data. An example of a configuration file is depicted in Fig. 4 (lines beginning with a # are comments).

The configuration file allows simple system reconfiguration for use with different or updated parsers if the structure of the used HTML pages radically changes (this could easily happen because pollen and weather information is not available in the XML format).

Using XML has several advantages:

- the content of the document is dynamic, depending on the actual gathered and monitored data sent to a physician,
- the content of the document is self-describing because of the text-based nature of XML documents,
- data transmission is highly error-free because of its non-binary character, and

```
<!-- <xml>
   <hc_provider id = "SWM-MN">
      <description> Steven W. Matthews, M.D.
                    - asthma specialist </description>
      <address> 510 10th Avenue South,
                Minneapolis, MN 55415 </address>
      <e_mail> swmatthews@toget.net </e_mail>
      <phone_number> (612) 278-9378 </phone_number>
      <office_hours day = "Mon"> 8:30am -- 5:00pm
      </office_hours>
      <office_hours day = "Sat"> on call </office_hours>
   </hc_provider>
</xml> -->
```

Fig. 2. Example of XML data stored inside HTML document.

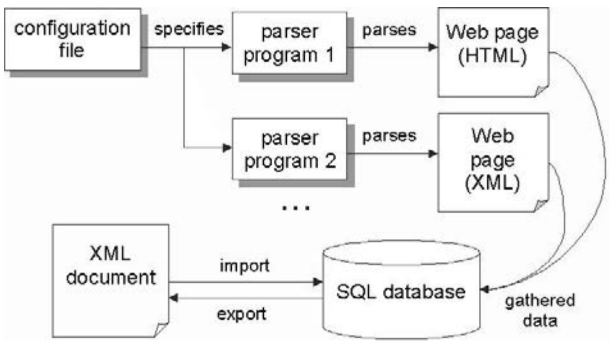

Fig. 3. WWW-parser method.

```
  # data_type: "Standard Pollen Situation"
  # data_formats: "Standard XML" / "NAB Pollen situation"
Pollen.XML = /usr/local/parse/pollenxml
Pollen.NAB = /usr/local/parse/pollennab

  # data_type: "Standard Weather Forecast"
  # data_formats: "Standard XML" / "Yahoo Weather Forecast"
Weather.XML = /usr/local/parse/weatherxml
Weather.Yahoo = /usr/local/parse/weatheryahoo

  # data_type: "Standard HC Provider Info"
  # data_formats: "Standard XML"
HCInfo.XML = /usr/local/parse/hcinfoxml
```

Fig. 4. Example of a configuration file.

- the transmitted data are "open" for a third party software processing.

The main disadvantage of such a data format is the length of the document and inefficient manipulation of the data. However, its combination with a relational database solves these problems.

4 REALIZATION OF THE AMADIA

The AMADIA was developed using the Computer Society International Design Competition (CSIDC2000) Project Kit [5]. It is implemented in OpenLinux operating system, KDevelop Integrated Development Environment both supplied in the CSIDC2000 Project Kit, and free PostgreSQL database system. For downloading all necessary information from the Internet we developed an independent program called `dwnldr`, which is launched daily by the Linux `cron` system daemon. Obtaining all current information from the Internet can also be done at every user login or on the user demand. The user may require download some types of information more often than other types. This is accomplished by reconfiguration the `+cron+daemon` so that it executes `+dwnldr+` with different configuration files at different times. One of the main goals of the AMADIA prototype was its user friendliness. We aimed to create a very intuitive and easy-to-use user interface. The AMADIA does not use any pull down menus or toolbars. Each function is represented by one screen. The user can access the screens through buttons on the main screen.

Another way to ease the user interface is to remove the keyboard and to use some sort of touch screen. To address this issue, we decided to build a prototype of simple touch screen. Our touch screen consists of eight infrared (IR) beams arranged around the LCD display in five rows and three columns. The software displays buttons on the display and the user has only to point his/her finger to activate them. After crossing an IR ray, the touch screen sends the identification number of the crossed ray to the host computer through the RS-232 port. If the user crosses two beams at the same time, the host computer will know that user's finger is at a certain position. Our screen can be arranged to provide fifteen buttons or ten buttons and one slider with five positions.

To keep a touch screen simple, our system currently uses only eight IR beams. However, the number of beams can be very easily increased. For example, adding 8 additional beams would require only one multiplexer, one demultiplexer, eight transistors, IR receivers and transmitters, larger connectors and some resistors. After this improvement, we would be able to determine the presence of user's finger at 64 locations if the beams are arranged in an 8x8 matrix. This number is sufficient for displaying a full alphanumeric keyboard.

5 CONCLUSIONS

In this paper we described the AMADIA system, which is an Information Appliance developed for people suffering from asthma. Our system can help to manage the user's asthma by both observing lung function measurements and information related to environment characteristics. With the AMADIA the user has all useful information related to his/her disease in one place.

The AMADIA is designed and realized using modern technology that helps to achieve easy maintenance and ability to extend the system. Several functions within the system are designed and implemented as independent utilities that can be added or extended.

There is a remarkable effort toward education of people how to effectively manage their asthma (*eg* [7, 10]). The AMADIA goes beyond many current approaches to help asthma-suffering people in actuall self-management.

There are two main lines of the future work: functional extensions and deeper elaboration of particular topics. The modular design and XML data representation in combination with the relational database allows experimenting with the developed software. The following extensions may be useful:

- a support for self-diagnosis (by the use of flow charts),
- more allergens gathered from the Internet,
- management of medications (related to peak flow monitoring).

There are many different functions that can support people suffering from asthma. However, the need for simplicity of the information appliance was foremost in order to maintain its usefulness. The solution lies in designing a universal information appliance with removable cards containing specific applications. Depending on the progress of technology, increasingly complex applications could be stored on one card. We also see a promising collaboration of different information appliances.

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