

An Architecture for a Fully Automated Real-Time Web-Centric Expert System

P. M. Beulah Devamalar, V. Thulasi Bai, and Srivatsa S. K.

I. INTRODUCTION

Abstract—Diabetes is the single most important metabolic disease, which can affect nearly every organ system in the body. It has been projected that 300 million individuals would be afflicted with diabetes by the year 2025. In India, it is estimated that this deadly disease affects presently 19.4 million individuals. The figure is likely to go up to 57.2 million by the year 2025. However, access to medical care is sometimes very difficult for people living in rural and underserved areas. They have to trek long distances for a medical diagnosis. Even if medical facilities are available in urban areas, due to lack of time due to work schedule, time taken to go in for this comprehensive procedures of getting appointment and spending a whole day in the labs for screening are a woeful experience for many and in some cases, the elderly people may have no one to take them to the hospital for screening. We propose a medical network based on state-of-the-art medical kiosk that addresses the problems of providing preventive and diagnostic health care. The patients can directly enter and can be screened for diabetics with all the necessary tests that are fully automated. The web centric diabetic expert system runs on a Tele health server and is connected to the kiosk through the WWW. Based on the symptoms, tests taken and previous history of the patient, a prescription is generated by the expert system that is also sent to a hospital where the doctor is online. Any changes required can be made by the physician in the diagnosis and prescription generated by the expert system and sent to the patient at the kiosk end as a printout. This paper presents the architecture of a web-based telehealth system employing expert system rules to detect for a fully automatic diabetes screening system. Different kinds diabetes and focuses on the architecture of corresponding web applications. The types of diabetes that can be detected with this system are type1, type2 and gestational diabetes. The project was designed and programmed via the dot net framework. The expert rules were developed based on the symptoms of each type of diabetes. The expert system described in this paper is able to detect and give early diagnosis of three types of diabetes namely type 1,2, gestational diabetes for both adult and children.

Keywords—Diabetes, Web-centric, diabetic expert system, kiosk, tele health server, diagnostic health care.

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IN few years time, Internet and especially worldwide web developed quickly from a media of information sharing to a ubiquitous platform of several applications like online banking, e-governance, e-commerce, digital libraries etc [1]. Today, the developers of expert systems have a good chance to share their applications via the web also. The promotion of expert system includes a number of challenges that must be surmounted like: domain experts' identification and persuasion for collaboration, knowledge acquisition and knowledge representation, coding, validation, verification etc.

In addition to that if it is a web centric expert system the design, development and maintenance a complex web site, which embodies the expert system, should be looked into. Since there is a frantic rush to be on the web, the number of expert system is expected to grow, which is a reason for some of the current problems surrounding web based systems development. The ultimate aim of this paper is to clarify that web centric diabetic expert system can be developed by merging an expert system and a web application developing sub projects. The web application is referring to web centric diabetic expert system. This system consists of web centric expert system, data bases and a set of dynamic and static pages.

Diabetes is a damaging disease that makes a six times likelihood of getting cardiac failure and the risk of kidney failure. Diabetes not only impacts lifestyle, it can also cause serious health complications. It is a major risk factor for heart disease, stroke, kidney failure, adult blindness and amputations. If diabetes is managed effectively, these complications can be eliminated. Some of diabetes related complications are coronary artery disease, peripheral vascular disease, neuropathy, retinopathy, and nephropathy. People with diabetes are 25 times more likely to develop blindness, 17 times more likely to develop kidney disease, 30-40 times more likely to undergo amputation, 2-4 times more likely to develop myocardial infraction and twice likely to develop stroke than a non-diabetic. Thus a lifestyle modification inclusive of dietary modification, regular physical activity and weight reduction are necessary for prevention of diabetes.

The objective of this web based healthcare solution is to establish an intelligent health care kiosk, leveraging advanced computer technologies to enable delivery of health care services to the individual or a community level through the internet. The Tele health care diabetic diagnosis solution is an intelligent health care environment that aims to ensure lifelong coverage of patient specific health maintenance decision

support service using World Wide Web. The functionality of Tele health care diabetic solution involves (a) generation and delivery of diagnosis and treatment of diabetic and diabetic related diseases (b) remote diagnostic services through the kiosk. It is an amalgamation of diverse computer technologies such as artificial intelligence, Internet, multimedia, databases and medical informatics to implement a sophisticated tele healthcare delivery model.

II. OVERVIEW OF REAL-TIME WEB CENTRIC DIABETIC SYSTEM

A. Patient End

The patient end consists of a kiosk with two monitors supported by a single processor. One monitor is used for the patient interface and the other for testing. Two monitors are used to reduce the time taken for processing inside the kiosk. This kiosk end requires a technician to assist the patient in taking the tests.

B. Patient Kiosk End

A person with diabetic symptoms has to register himself with the telehealth server through means of Internet facility either at home or at the Kiosk end. Any registered user gets the privilege of accessing the Tele health care solution. Registered user has to enter his symptoms using a touch screen system user interface. Based on the symptoms given, the teleexpert system at the server end suggests suitable tests that have to be carried out by the patient through the Internet at the kiosk user interface. The patient has to move to the testing kiosk end, which is interfaced with all the needed diagnostic instruments. With the assistance of a technician, the user undergoes the prescribed tests. Data acquired during the tests process is automatically fed into the teleexpert system through the Internet for diagnosis.

C. Testing Kiosk End

The testing kiosk end is interfaced with all the needed diagnostic instruments. Assisted by a technician, the user undergoes the prescribed tests. Data acquired during the tests process is automatically fed into the teleexpert system through the Internet for diagnosis. The diagnosis report generated by the teleexpert system will be submitted to the doctor end of the chosen hospital for further review and confirmation. A confirmed diagnosis report along with the prescription will be submitted to the testing kiosk end for a print out.

D. Healthcare Institution End

The diagnosis report generated by the expert system will be submitted to the doctor end of the chosen hospital for further review and confirmation. Confirmed diagnosis report along with the prescription will be submitted to the patient end for print out. Under critical condition, the patient is suggested to come online with the doctor through videoconferencing facility or messaging for further medical assistance.

E. Tele Health Web Server End

All data generated during the process such as symptoms, test results, initial diagnosis made by the expert system, approved report from the doctor end are recorded into the tele health server database for future reference from any end. A registered user can use his patient ID along with the pin number for viewing his clinical history – episodic illness, medical check-up, medication suggested, tests undergone as web page sitting at home using Internet facility. All the information is given for display to the user as a static web page. The user can send queries through email to the specific doctor.

The teleexpert system would help doctors to make consistent diagnosis by integrating different experiences into the knowledge database. Besides diagnosis, other important outputs of the system could be the potential to evaluate the risk of diabetic occurrence, its progression and when and how should the patient be treated. Consultation typically takes no more than 15 minutes and the clinician will verify and modify the report generated by the expert system with the help of the patient answers, test results and past history and offer mental health advice.

III. ARCHITECTURE OF A FULLY AUTOMATED REAL-TIME TELE HEALTHCARE SOLUTION

Fig. 1 represents the system architecture of a fully automated real-time web centric expert system. This architecture includes a) hospital network, (b) telehealth kiosk (patient), (c) web server. Fig. 1 shows the system architecture of fully automated real-time web centric expert system.

A. Web-Centric Telehealth Server

This WCTS is a central learning diabetes expert system. It consists of a web application, an expert system, and data store. The expert system consists of inference engine and knowledge acquisition module, and an explanation sub system. The inference engine compares the patient information with the knowledge in the knowledge base, and derives whatever conclusions shall logically follow. The knowledge database is capable of holding large amounts of data and provides functionality for fast traversal of this data. It contains only data regarding the development of diabetes and does not hold any personal information about the patients involved.

An appropriate explanation subsystem and user interface is constructed, to help user query expert system and understand the result. The patients/registered users are not able to change any of their data. The only functionality that they have is to enter their symptoms into the system through touch screen or customized key board to obtain an updated diagnosis. Then that diagnosis will be sent back to this user. Fig. 2 shows the architecture of diabetic expert system.

The web application consists of (a) dot net framework with ASPX files, (b) dot net framework web services with ASMX files, (c) data access objects, (d) business objects, (e) style sheets, (f) html files. The data store consists of (a) diabetic

knowledge base, (b) patient database, (c) hospital database, (d) file data base.

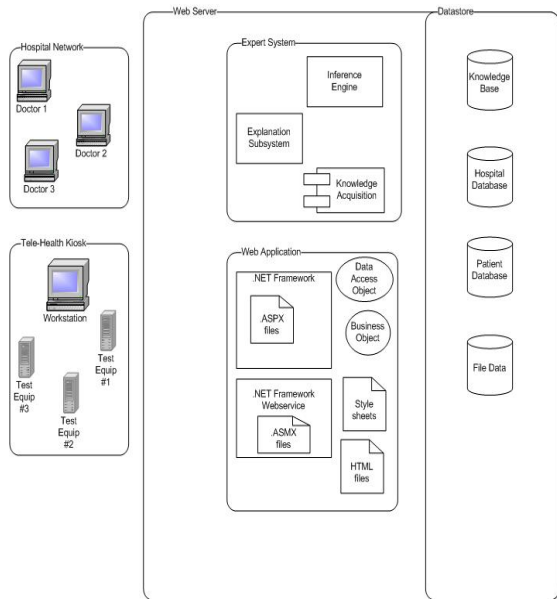


Fig. 1 System Architecture of a Fully Automated Real-Time web centric expert system

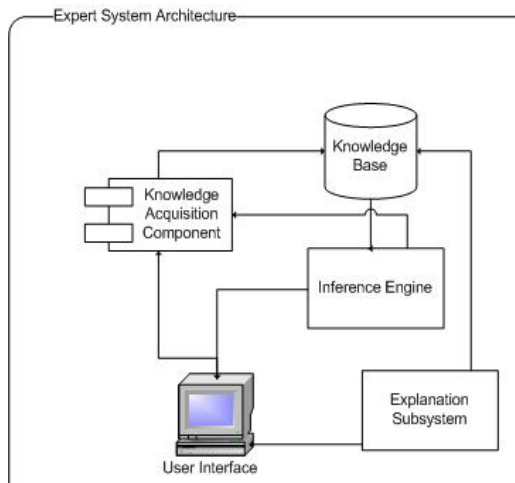


Fig. 2 Architecture of diabetic expert system

The patient database holds all existing patient data, permits changes to that data and allows for addition of new patients and patient data. Also, the registered user data is stored in this database so that these users also are able to obtain diabetic diagnosis from the system. Patient data is classified into two different types: 1. demographic, 2. Diabetic clinical data. Demographic data relates to information of the patient such as age, sex etc. Diabetic Clinical data is further distinguished in physical findings and laboratory results. Physical findings are those detected by a physical examination of the patient like weight, height, waist size, etc. laboratory results are those detected via laboratory tests, glucose test, HbA1c, GTT, etc. Fig. 3 shows the architecture of the web application.

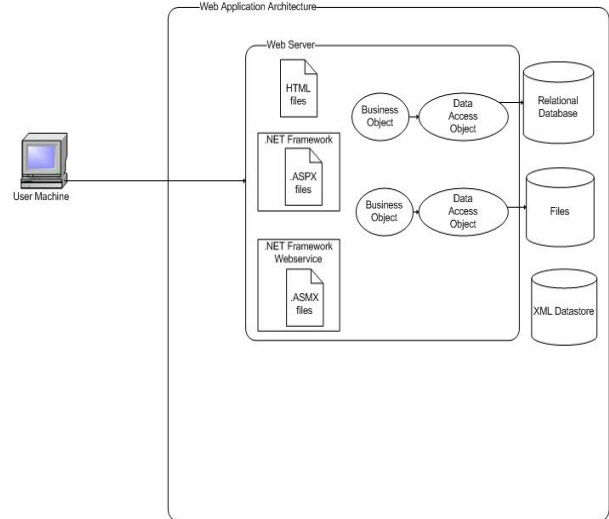


Fig. 3 Architecture of the web application

Diabetes diagnosis knowledge base deals with the way a diagnosis is performed. Diabetic knowledge is categorized into two types: (a) procedural diagnostic knowledge (b) heuristic diagnostic knowledge. The procedural diagnostic knowledge reflects the procedure of the diagnosis. An initial diagnosis or early diagnosis is made based on the demographic and clinical data of the patient. This is used to specify the test to be performed. The later diabetes diagnosis may or may not coincide with the initial. The heuristic diagnosis knowledge represents the experience accumulated through years and concerns the way an expert uses the patient data to make diagnoses. The hospital database consists of all on-line user operations, the case details, the medical information, health institution information.

B. Tele-Healthcare Institution End Client

The doctor’s Office is a typical Web-centric node. A typical on-line user has Internet browser. A doctor is able to perform all on-line user operations, but all data will be stored in the Tele health care institution data base and Tele health care patient database. The doctor is able to get the patient details on line such as his symptoms, test reports, diagnosis report with prescription generated by the expert system. If needed, he modifies the report generated by the expert system and submits the confirmed report to the Tele health server.

C. Tele-Healthcare Patient End Client

The Patient’s end system is also a typical Web-centric kiosk system. A typical on-line user has an Internet browser. The Patient is able to perform all on-line user operations, but all data will be stored in the telehealth care patient database. On-line patient is able to submit his symptoms and get the test reports, confirmed diagnosis report and prescription generated by the doctor at the institutional end as a print out.

IV. THE FUNCTIONALITY OF THE TELE-HEALTHCARE SOLUTION

The functionality of tele health care solution is to interact with the patient via the Internet through the user interface at

the patient kiosk. The teleexpert system will conduct a virtual consultation session with the user through the user interface to determine his/her current health profile. The virtual consultation session is a GUI based dialogue between the user and the tele expert System application during which the expert system forwards the number of questionnaire to the user either to collect information / verify available information and / or derived conclusions. The user is expected to provide valid responses to the questions presented by the expert system in a touch screen mode or through the customized keyboard.

Based on the user's responses, the next questionnaire is generated and passed back to the user. Each consultation session spans across multiple transactions between the user and the teleexpert system. The attractive feature of the tele expert system is that it dynamically generates the questions to be asked of the user based on the user's current health profile and his / her earlier submitted responses. During the consultation, patient is suggested to undergo a series of suitable tests. Patient has to move to the testing kiosk system, which is interfaced with all the needed diagnostic instruments. Assisted by a technician; user under goes the prescribed tests. Data acquired during the tests process is automatically fed into the teleexpert system for diagnosis.

The expert system makes a diagnosis by not just considering the current signs and symptoms of an individual but taking into account factors such as the individual medical history, present medications and treatment plans if any as recorded in the individual's telehealth patient database. The diagnosis report generated by the teleexpert system will be submitted to the doctor end of the chosen hospital for further review and confirmation.

The doctor interface helps the clinician to view his own patients who has requested for healthcare assistance. Doctor can view the patient history, test results and the diagnosis summary generated by the Expert system based on the symptoms and history of the patient and medication. The Doctor can review and confirm the diagnosis report and the same is forwarded to the patient end through the telehealth server. A copy of the summary is recorded in the Tele health patient database. A database (case database) is maintained to record the patient name, location of patient request, consulting doctor and the hospital and soon.

A confirmed diagnosis report along with the prescription will be submitted to the patient end for print out. Under critical conditions, the patient is suggested to come ONLINE with the doctor through videoconferencing or messaging facility for further medical assistance.

When any request is received from kiosk to the telehealth server, the server checks for validity of the user. If the patient is a registered user, the teleexpert system conducts a virtual consultation session based on previous history and is viewed as web page into the patient kiosk end. Load Balancing is the major feature that is looked after by the Tele health server. Server when receives multiple requests simultaneously, load balancing is done to get optimal resource utilization and decrease computing time. 2-mirrored HDD are used to attain

greater degree of fault tolerance, which allows the service to continue even in the face of server down time due to server failure or server maintenance.

Once the dialogue between the healthcare institution end and the patient kiosk end is complete, a copy of the generated report from the expert system and the finalized report from the doctor end is stored in the telehealth patient database. Fig. 2 shows the complete process flow involved in the entire system.

V. DISCUSSIONS

Many expert systems have been developed since the mid of 1960's and considerable experiences are available on their development. But which are not enough to develop a web based expert system. In that case it is necessary to have suitable engineering methods and processes in order to design and develop a web centric expert system that is something more than just a conventional expert system. Web based expert system development processes may require the use of several scientific principals like knowledge engineering, expert system programming, web designing and programming, data base design and management, network security etc. The architecture presented such principals, which applied WEDIACIN web centric expert system [12].

VI. CONCLUSION

This paper presents the architecture of fully automated real time web centric expert system. This architecture has been followed for WEBDIACIN development. As a case study, the architecture of WEBDIACIN, as well as its functionalities was presented. Real-Time web centric intelligent health care diagnosis system supplies (via usage of Web-centric technology) the ability to access our diabetic expert system from any part of the world. We have web based user interface to the diagnostic system that enables access from any part of the world. Tele healthcare solution aims to act as an "intelligent" proactive agent representing and guarding the person's long term health related interests and concerns, serve as an efficient healthcare information management infrastructure to collect, organize, and distribute relevant knowledge and service information to the individuals, provide remote, web based health care monitoring and diabetic diagnostic services, accessible from the home, or kiosk. The system includes integrated Web server, secured data storage and transfer, delivering of data. It can be adapted for any E-health System.

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