Hridaya

A Tele-Medicine Initiative for Cardiovascular Disease through Convergence of Grid, Web 2.0 and SaaS

Karthik Sundararaman, Jinka Parthasarathi, Subrahmanya VRK Rao, GVN Appa Rao
Global Technology Office,
Cognizant Technology Solutions,
Chennai, India
Subrahmanyarao.vrk@cognizant.com

***Abstract* — Cardiovascular disease (CVD) is a major cause of death among humans. Rehabilitation after survival from a CVD is a long term process that includes frequent hospital visits, which could be avoided by the use of Hridaya on personal digital assistant (PDA) and mobile phones. These devices along with Hridaya could be used by the patients to report about their health to the physicians on a schedule basis who in turn can review their health conditions. List of clinical checkups would be similar in most cases of CVD and hence the objective of the study is to suggest Hridaya, a software as a service (SaaS) application, which would incorporate a decision support system along with some of these clinical routines.**

In addition, Hridaya is equipped with a knowledge base, which could be used by the patients to know more about CVD, an interface powered by technologies underlying Web 2.0 which has several advantages, computation grid which aids in improving throughput and availability of SaaS and reducing the complexity of infrastructure management for the vendor providing Hridaya.

Such a system can be used to prevent any adverse situations and can act as a medium of interaction between the physician and patients residing in a remote place.

***Keywords* —** cardiovascular disease, telemedicine, decision support system, questionnaire, Web 2.0, Grid, SaaS.

I. INTRODUCTION

Elderly people are vulnerable to CVD, which is one of the major causes of death among humans [1]. Recovery from a CVD is a very slow process that is usually marked by long term treatments. People with CVD have to travel to hospitals and clinics for rehabilitative purposes, owing to which they lose both time and money. Such people would prefer traveling only in case of emergencies and not for regular checkups, which would consists of a subjective analysis of the symptoms, heart beat check, checking of vital signs like Blood Pressure (BP), pulse and a Electrocardiogram (ECG) test. Owing to advances in technology, essential medical devices like ECG, X-Ray machines have become portable, which has reduced travel for people who live in remote places. Data recorded from these portable instruments can be sent over the internet to the concerned physicians who on accessing these medical records can provide their feedback on the condition of the patient [2-3].

Recent advances in convergence of information, communication and computing technologies has made telemedicine a very potent technology. Mobile phones and PDA are now being used in healthcare applications like accessing electronic medical record, drug reference information, prescription refill, sending an Electrocardiogram (ECG) or some of the vital signs like BP, pulse rate, body temperature etc to the physician in case of regular checkups [4]. Use of these devices in telemedicine application can be made more powerful by linking or embedding them to a clinical decision support system. These support systems accurately identify certain conditions and assist the physicians during decision making [5]. Hence in the absence of physicians they could serve as a virtual physician in case of diagnosis of certain clinical events, which could be very useful in analyzing huge amount of clinical data pertaining to patients. Such systems could be further used by National Health Centers to help in diagnosis of people who live in remote places.

A. SaaS

SaaS is software that is owned, delivered and managed remotely by one or more providers. The provider delivers an application based on a single set of common code and data definitions, which are consumed in a one-to-many model by all contracted customers, at any time, on a pay-for-use basis, or as a subscription based on usage metrics [10].

Features of SaaS include:

a). Web browser helps in working with the software and the data.
b). Software and hardware are not owned by user organization and the fee is paid for the number of licenses of the software that a user possesses. This license fee includes for both software as well as hardware.
c). Software sits at the vendor facility or at a secure data center.

PERVASIVEHEALTH 2008, 30 Jan - 1 Feb. Tampere, Finland

DOI 10.4108/ICST.PERVASIVEHEALTH2008.2756

d). Data and software security issues are taken care by the vendor.
e). Vendor is responsible for hosting service fee for upgrades.

Hridaya System includes a SaaS based Algorithm was used to detect an abnormal ECG, a self evaluation questionnaire to access the condition of the patient, a provision to send the recorded ECG to the physician, and links to important websites which would enable the patient to know more about CVD with added value of Web 2.0 and grid computing. Such a system can be used by the patient to interact with the physician on a scheduled basis and can alert the physician to take necessary action in case of emergency. This system could also be used as a tool to gain knowledge of CVDs which would reduce risk of acquiring cardiovascular disease.

II. BUILDING BLOCKS OF HRIDAYA

a). An algorithm acting as a decision support system
b). Mashups / Web 2.0 Interfaces
c). A computational grid

III. DISCUSSION

Components of Hridaya system are briefly explained in the following sections.

A. SaaS Algorithm Behind Hridaya

Quantitative analysis of ECG can be used to provide additional and valuable insight into patient-specific physiological and pathological conditions [6]. Our algorithm would analyze the ECG of a subject and determine whether there is an abnormality and generate a report based on the findings. The report can then be sent to the physician, who can take necessary actions in case of an aberration. A pilot analysis was performed on ECG of 30 patients who suffered from a well known CVD, MI (myocardial infarction) and 30 normal subjects respectively, which were extracted from the PTB diagnostic ECG database [7]. Basic steps involved in detecting the abnormal ECG are shown in the Fig. 1. Validation of the algorithm was performed by testing it with 20 ECG of MI and normal subjects extracted from the same database.

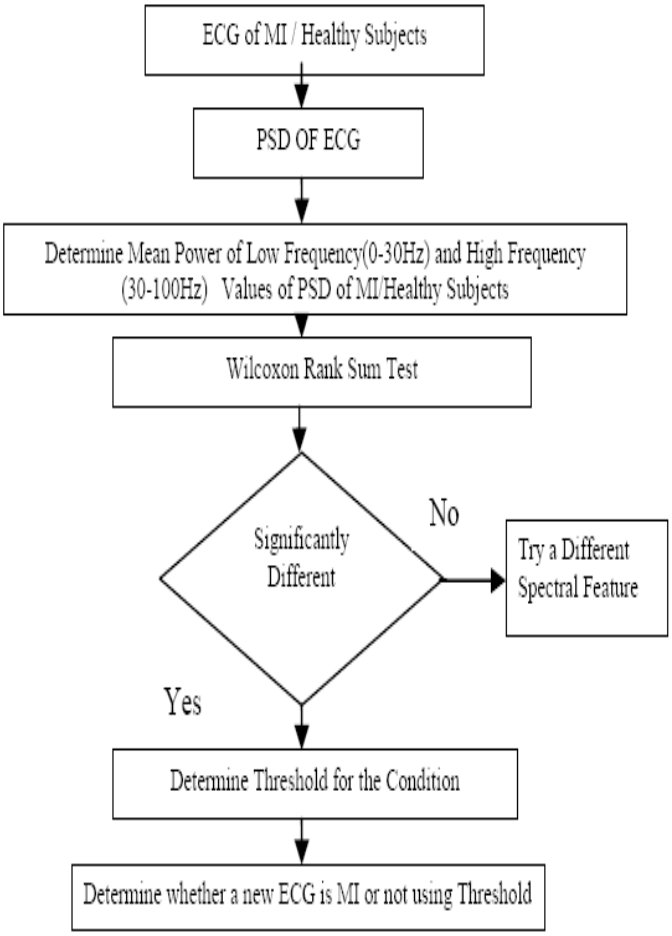

Fig. 1. Steps involved in detecting whether an ECG is indicator of MI or healthy condition.

PSD computed from a channel of ECG obtained from the MI and normal subject is shown in Fig. 2.

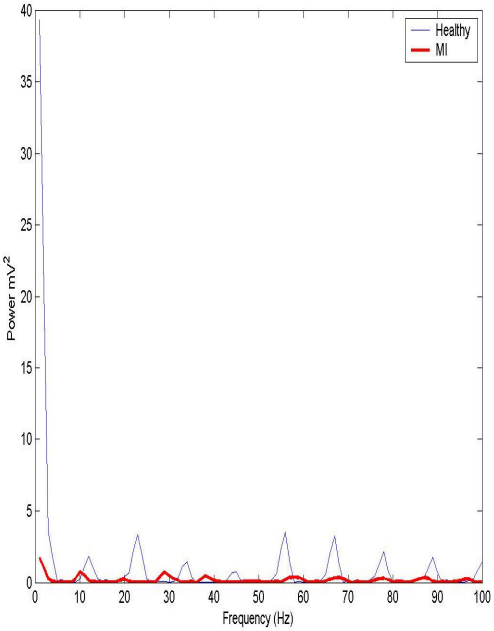

Fig. 2. PSD of a single channel of ECG obtained from a MI patient and a healthy subject.

Mean power extracted from low (0-30Hz) and high frequency (30-100Hz) components of MI was significantly different from normal condition. Thresholds for the normal and MI conditions were calculated, which were then used to determine whether the test inputs indicate MI or normal condition. It was observed that 95% of both MI and normal condition were detected correctly.

CVD is a family of disorders that include MI, coronary heart disease, arrhythmias, atrial fibrillation, heart valve disease, congenital heart disease, pericarditis etc. ECG is a preliminary test used for diagnosis of a CVD, which can some times be normal even if the patient has a cardiovascular problem [8]. In such cases, response of the patient to the subjective analysis performed by the physician has a bearing on the future course of treatment. Physicians usually decide to go for a more sophisticated diagnosis that would give an accurate insight of the underlying problem if the patient reports positive symptoms even though their ECG remains normal. This could be critical in case of patients' residing in a remote place, who send their ECG through a PDA or a mobile phone. Hence the Hridaya has a questionnaire, which would consist of a list of symptoms related to CVD. Response to this questionnaire along with ECG would be useful for the physician to decide on further course of treatment.

B. Web 2.0 and Hridaya

Web 2.0 is a set of economic, social, and technology trends that collectively form the basis for the next generation of the Internet—a more mature, distinctive medium characterized by user participation, openness, and network effects [11]. Technologies like Ajax, flash underlying Web 2.0 provide a means to have a user friendly interface along with a mechanism for effective participation from both ends in discussions, suggestions, clarifications etc that would resolve most of the issues in no time between physicians and patients. Also mash ups, an ingredient of Web 2.0 allows patients to understand the latest about their problem by having the information from various resources collected and shared online. It also helps in providing the patient with a search facility that helps in exploring about his condition online. Added to that, it could provide the information about the location and working schedules of preferred physicians by having maps online, which would make the travel flexible in case of an emergency.

Numerous APIs (application programming interface) are available [12] that could be used for specific applications like search, identifying a location through maps etc. In this study Google Ajax search API was used to develop user interfaces, which would allow the patient to easily search for information from various online resources as shown in Fig. 3. The search tool provided would provide health information from medical blogs, books, web, images and journals. Such a facility can help the patient to understand their present condition and also the remedy to overcome it which would enable them to lead a better quality of life. RSS reader was used to provide recent health news from various online sources such that people are aware of epidemic outbreaks, recent developments in field of medicine etc.

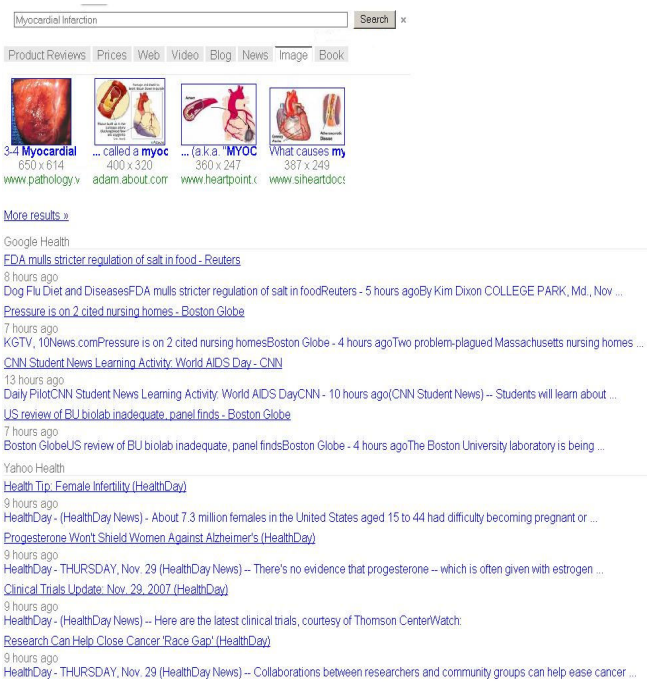

Fig. 3. A sample search along with health news

C. Computational Grid and Hridaya

A grid can be defined as: "A large-scale geographically distributed hardware and software infrastructure composed of heterogeneous networked resources owned and shared by multiple administrative organizations which are coordinated to provide transparent, dependable, pervasive and consistent computing support to a wide range of applications. These applications can perform distributed computing, high throughput computing, on-demand computing, data-intensive computing, collaborative computing or multimedia computing. [9]"

As the demand grows for Hridaya, the backend hardware infrastructure becomes complex and needs a better management of computing, communication and memory resources. Since Hridaya is an analytic application, it needs more and more computing power as the demand increases. So there exists a need for a shared infrastructure rather a centralized one. Here comes grid providing the required shared infrastructure reducing the risk of managing it. In addition grids help in improving the throughput with increase shared computing resources of Hridaya as more and more patients start using it. High Availability is one more advantage with grids. Since there is no limit for the number of independent resources in a grid, it has the capability to provide high availability to the patient at any instance.

IV. FUTURE SCOPE

Algorithm developed in this system has been tested on MI only. However MI is the most commonly occurring CVD and hence a larger database of the same would be used to validate the algorithm used in this study. In future the system will also be tested and validated using ECG corresponding to other disease groups which constitute CVD. Possibility of using emerging broadband technology like WiMax is also being explored for transferring the reports of Hridaya algorithm to the physicians.

V. CONCLUSION

Telemedicine can save life, time and money of people who are living in a remote location. PDA and mobile phone are being used to send some vital physiological parameters like BP and body temperature. Advancement in the convergence of information, computing and communication technologies has made it possible to understand, analyze, send the relevant data collected with increased service availability and increased speed of the entire process of immediate diagnosis of CVD patients. The system suggested has an algorithm that could be used to analyze ECG and detect abnormalities corresponding to CVD. The algorithm was tested on ECG corresponding to normal and MI and it was found to detect 95 % of the abnormalities corresponding to MI and normal cases. A questionnaire provided along with the system would subjectively evaluate the symptoms experienced by the patient and hence can be assist the physician to access the condition of the patient. Also the current paper suggested a way to prevent occurrence of CVD in some cases and help the patients to lead a better quality of life.

REFERENCES

[1] http://www.cdc.gov/nchs/fastats/lcod.htm

[2] Iwamoto J, Yonezawa Y, Maki H, Ogawa H, Ninomiya I, Sada K, Hamada S, Hahn AW, Caldwell WM, "A mobile phone-based ECG monitoring system", Biomedical Sciences Instrumentation, 2006,42: 217-222.

[3] Jim Grigsby, Jay H. Sanders, "Telemedicine: Where It Is and Where It's Going", Annals of internal medicine, 1998, 129 (2) : 123-127

[4] David W. Bates and Atul A. Gawande, "Improving Safety with Information Technology", New England Journal of Medicine, 2003, 348: 2526-2534

[5] Dereck L. Hunt; R. Brian Haynes; Steven E. Hanna; Kristina Smith, "Effects of Computer-Based Clinical Decision Support Systems on Physician Performance and Patient Outcomes: A Systematic Review", Journal of American Medical Association. 1998;280:1339-1346

[6] R. Silipo and C. Marchesi, "Artificial neural networks for automatic ECG analysis," IEEE Trans. Signal Processing, vol. 46, no. 5, pp. 1417--1425, 1998.

[7] Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng CK, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. *Circulation* 101(23):e215-e220 [Circulation Electronic Pages; http://circ.ahajournals.org/cgi/content/full/101/23/e215]; 2000 (June 13).

[8] http://www.netdoctor.co.uk/health_advice/examinations/ecg.htm

[9] O. Ardiaz, P. Artigas, L.Diaz de cerio, F. Freitay, A. Gallardo, R. Messenger, L.Navarro, D. Rojo, and K. Sanjeevan, UlabGrid, an infrastructure to develop distant laboratories for undergraduate students over a grid, Computer architecture department, Polytechnic university of catalonia, Spain.

[10] http://www.gartner.com

[11] O'Reilly Radar, Web 2.0 Principles and Best practices.

[12] http://code.google.com/apis/ajaxsearch/documentation/