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A Traffic Aware Health Monitoring Application Embedded in Smart Ambulance (THESA)

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***Abstract*—** This paper discusses the use of pervasive computing in health monitoring using computer devices with enriched database distribution to virtually bring the experts to an emergency site. It examines the vision of new field pervasive healthcare and identifies new research thrusts: Convenient communication and access to PHR (Patient Health Record), Helping experts, patients and others to navigate and locate nearest health care, convenient traffic monitoring for health experts. Some of hypothetical pervasive computing scenarios are considered and uses them to find out key capabilities that are missing from today's systems. The paper ends with a discussion of the research necessary to develop these capabilities using embedded sensors.

***Keywords*—** smart ambulance, health, health care hospitals, doctors, mobile ambulance, patient monitoring, medical services,computerized monitoring, distributed database, pervasive computing.

I. INTRODUCTION

Pervasive computing moves beyond the sphere of personal computers where computing is made to appear everywhere and anywhere. It follows the advanced computing concept where everyday devices with embedded technology and connectivity as computing devices become progressively smaller and more powerful. Pervasive computing touches vast range of research topics such as distributed computing, mobile computing, location computing, mobile networking, sensor networks, and artificial intelligence. The main goal of researchers working in pervasive computing is to develop smart products using current network technologies where the connectivity of devices is unobtrusive and always available. The desire to improve patient care drives the design and implementation of new technologies in the hospital. Clinical work demands close coordination and collaboration amongst specialists distributed across both space and time. A time critical patient is one that has a life threatening problem involving either the airway, breathing, circulation or disability. Rapid identification of a problem is essential to guide extrication and evacuation planning. It is appropriate to wait for a controlled but slower extrication for a trapped but clinically stable patient. However, a patient with airway compromise or severe respiratory difficulties is likely to require an immediate, medical intervention. The proposed work aims to provide pre-hospital care to the time critical patients on route to hospital. The aim of pre-hospital care is to reduce the morbidity and mortality of those who are injured before they reach hospital. Our work attempts to provide consistent health services to the patient in a smart ambulance via constant on-line interaction with the doctor as well as hospital information system. It also takes into consideration traffic conditions on the road to avoid any further delays.

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II. RELATED WORKS

Several health care and traffic monitoring projects are in full swing in different universities and institutions, with the objective of providing more and more assistance to the critical patients.

The Stroke Angel case study, conducted at Bad Neustadt, Germany, covered the adoption of a mobile stroke diagnosis and data transmission device for emergency medical services (EMS). During the analysis period (November 2005 through May 2008), approximately 40 paramedics used five devices equipped with PDA-based software to examine patients' health status. The purpose of system is to shorten the time required for the entire process chain, from discovering and diagnosing the stroke victim to the patient's admission and treatment in a hospital. Typically, the main problem in stroke care is insufficient communication between EMS and hospitals. Critical time is lost when the patient isn't transported to the correct hospital. The receiving hospital should be chosen (where possible and reasonable) with regard to the patient's injury pattern. Thus, an unresponsive head-injured patient could be transferred directly to a centre with neurosurgical capability (which may require the bypassing of a nearer hospital) provided it has the resources for the management of the other injuries. So, the goal here was to meet the short time frame in which to treat stroke patients—the first three hours after a stroke are crucial for successful therapy and the patient's subsequent quality of life.

The ABC Framework is designed to be the computational infrastructure of the future hospital [3]. ABC is an acronym for Activity Based Computing, an architectural principle also referred to as Task-Based Computing in the Aura project at Carnegie Mellon University. In Activity Based Computing, the basic computational unit is no longer the file (e.g. a document) or

the application (e.g. MS Word) but the work activity of a user. The ABC Framework offers a unifying perspective on activity-based support for human-computer interaction. Users can simply carry with them around the hospital the various work activities that they are engaged in and seamlessly transfer these from one computer to another.

In Hi-Fi Traffic Clearance Technique for Life Saving Vehicles using Differential GPS System, an ambulance should switch on GPS, the GPS receiver connected with the onboard computer system transmits the diagnostic information via wireless transmitter, fleet management systems capable of capturing diagnostic information, estimates the location of life saving vehicle using wireless receiver [6]. There should be a WAN (Wide Area Network) between Fleet Management Systems and traffic management center to transfer the images of the lifesaving vehicles using mobile phones to provide medical information to hospital patients.

A recent exploration by Wilcox et al. [7] suggests that patient comfort and satisfaction during an Emergency Department (ED) visit might be greatly improved if, in addition to verbal communication, patients are kept informed of their health status in a real-time. A design for a "patient-friendly" hand held information display, including a real-time stream of simplified abstracted information is used for patients in the ED to provide them with a tremendous volume of information in a short time, much of it critical to medical decision-making and long term health management.

The project called the "Interactive Hospital" is concerned with the design and development of pervasive computing technology for hospitals [8]. More specifically, the aim was to build context-aware technologies that support distributed social awareness inside the hospital, communication and coordination before, during and after surgery.

Bio-sensor based mobile health monitoring system named as "Intelligent Mobile Health Monitoring System (IMHMS)" that uses the Wearable Wireless Body/Personal Area Network for collecting data from patients, mining the data, intelligently predicts patient's health status and provides feedback to patients through their mobile devices [5]. The patients will participate in the health care process by their mobile devices and thus can access their health information from anywhere any time. Moreover, so far there is no automated medical server used in any of the work related to mobile health care. To maintain the server, a large number of specialists are needed for continuous monitoring. The presence of a large number of specialists is not always possible. Moreover in the third world countries like ours specialist without proper knowledge may provide incorrect prescription. That motivates us to work for an intelligent medical server for mobile health care applications that will aid the specialists in the health care. As a large amount of medical data is handled by the server, the server will perform mine and analyze the data.

MobiHealth Project- MobiHealth project is going on to build a system for collecting vital body signals and manipulating those in distant health care institutes. The Terva [9] monitoring system has been introduced to collect data related to health condition like blood pressure, temperature, sleep conditions, weight etc.

III. OVERVIEW OF THE PROPOSED SCHEME

The proposed scheme has been named THESA (A Traffic Aware Health Monitoring Application Embedded in Smart Ambulance) as it is an application which allows consistent health monitoring of time critical patient on the way to hospital and facilitates continuous interactive text, audio and video sessions between ambulance attendant and hospital information control system, doctor and ambulance attendant, doctor and hospital information control system. Hospital information control system maintains the medical database of all the patients (currently being treated or previously treated) and provides all the doctors or concerned clinical with patient health record (PHR).

When a time critical patient is supposed to be taken to hospital in case of an emergency as a heart patient who gets a heart attack and must be treated within first 60 minutes from the time when heart attack is caused to increase the probability of survival by 60%, it becomes necessary to initiate pre-hospital treatment before reaching the hospital and the situation worsens further if the hospital is located at a considerable distance from the place where the patient resides. This application allows ambulance attendant to download patient's PHR from registered hospital's information system if the patient is already undergoing treatment in the same hospital and if it is a new case, all the details about the patient are gathered and sent to hospital information system through mobile from the ambulance so that the hospital may generate a report about this new time critical patient and the treatment may start in the ambulance only without any delay. The application consists of three main modules: Hospital information system, ambulance and doctor modules. The hospital Information system may be installed on the mobile as well as on any android based server situated in the hospital whereas ambulance module is installed on the mobile carried by ambulance incharge. The ambulance incharge must register himself first on the Thesa application using his mobile as ambulance in order to access its resources and services. In the same manner, the designated doctor for the patient must register himself as doctor on Thesa application in order to access patient's PHR provided by hospital information system and all the currently sent reports from ambulance about the time critical patient. All the three module hospital information control system, ambulance incharge and doctor may simultaneously interact with each other and receive and send the desired reports also without any delay. The doctor depending upon the patient's history and current health status may inform the hospital information system and ambulance bound incharge about the lifesaving threshold time limits within which the patient must reach the intensive care unit in the hospital. The Thesa application simultaneously works on traffic monitoring considering the traffic scenarios in metro cities. In case, the

ambulance gets stuck in the heavy traffic on the way to hospital, Thesa calculates the approximate time, the ambulance may take to reach the hospital, compares it with the lifesaving threshold time limits and triggers an alarm and displays a warning message on the ambulance bound incharge's mobile about the delay in reaching hospital. As soon as the warning message appears on the ambulance bound incharge's mobile screen, the ambulance incharge searches for a nearby already registered hospital so that patient may be taken there for emergency treatment as the ambulance cannot reach the destined hospital within threshold time limits. The Thesa application allows to register a number of hospitals so as the patient may be treated in any registered hospital without any delay in treatment, in case, an emergency occurs. In other words, the Thesa application provides a uniform platform for all the registered hospitals to treat all the time critical patients undergoing in any of the registered hospitals without causing any life threatening delay in the treatment and results in substantially reducing casualties caused due to delay in timely medical treatment of the time critical patients.

Figure 1 shows the THESA pre-hospital patient care scheme in which there are three modules. User has to enter in any one of the three given modules to which the particular user belongs. User then registers himself by filling in all the required details corresponding to the desired module they have opted for and finally, user will be transferred to the home page where he may get access to the respective selected option.

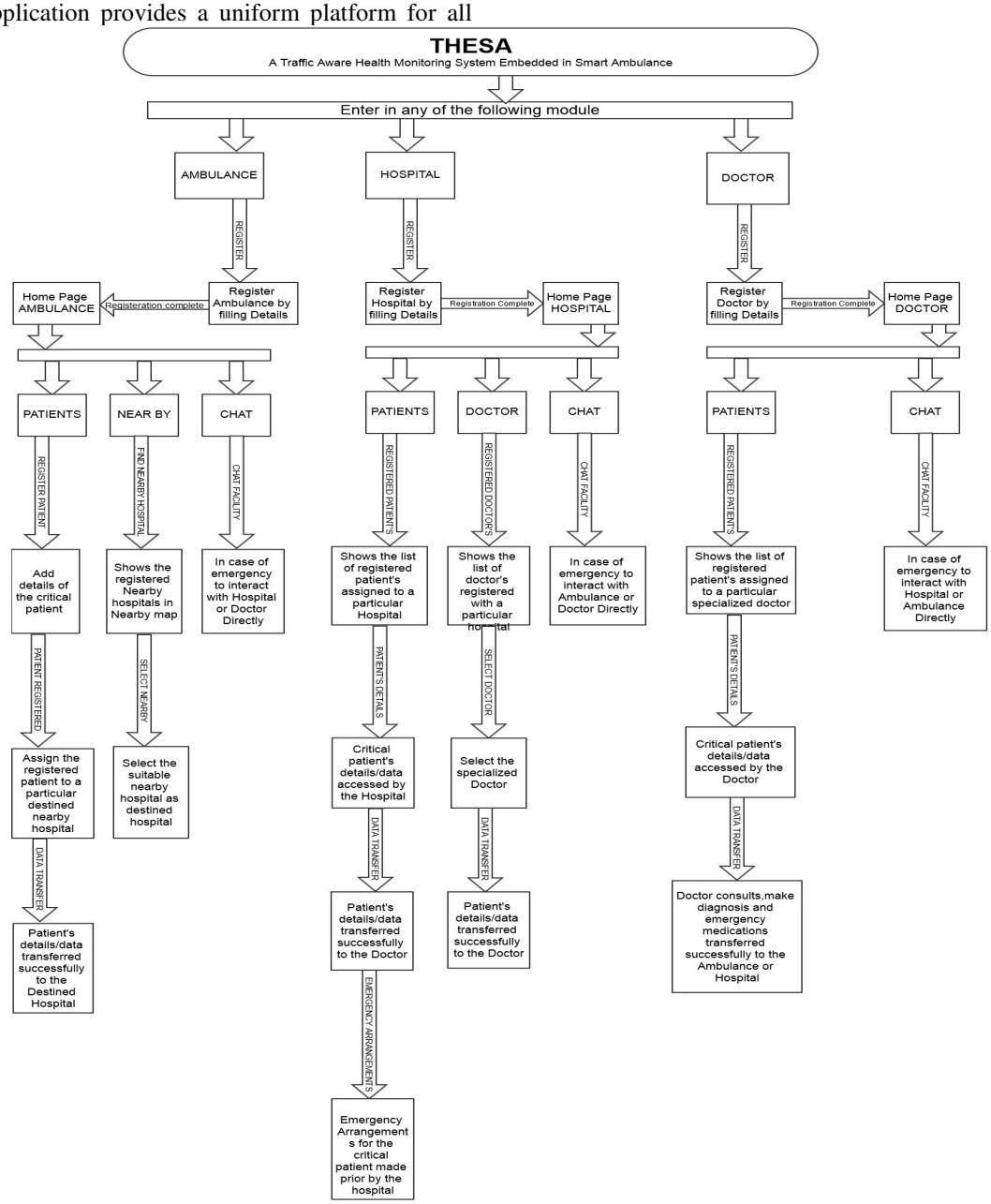

Figure 1: THESA Pre-Hospital Patient Care Scheme

IV. OBJECTIVES OF THESA

The scheme focuses on providing consistent round the clock health services to the time critical patients and attempts to achieve below mentioned objectives:

- It aims to provide people with a more natural way to interact with medical information and services.
- The personal healthcare information like referred doctors, disease or the ailment patient is suffering from, conditions, medications and clinical information is saved periodically.
- It helps in finding the nearest hospital, emergency room, urgent care and doctor.
- It facilitates in selecting Hospital Emergency Rooms and Urgent Care facilities using mobile phone application on the way to hospital.
- Appointment setting through mobile application for doctors and Emergency hotlines can be made.
- The system aims to provide the traffic monitoring if the ambulance gets stuck on the road in traffic jam carrying a critical patient so that information regarding the patient's health can be immediately forwarded to the destined hospital and the treating clinicians may further forward that information to some nearby registered hospital if immediate treatment is needed.
- Personal Health Record (PHR) may be viewed anytime, anywhere on mobile.

V. DESIGN & EVALUATION

Different modules developed in the Thesa application are depicted with the help of snapshots taken for each module.

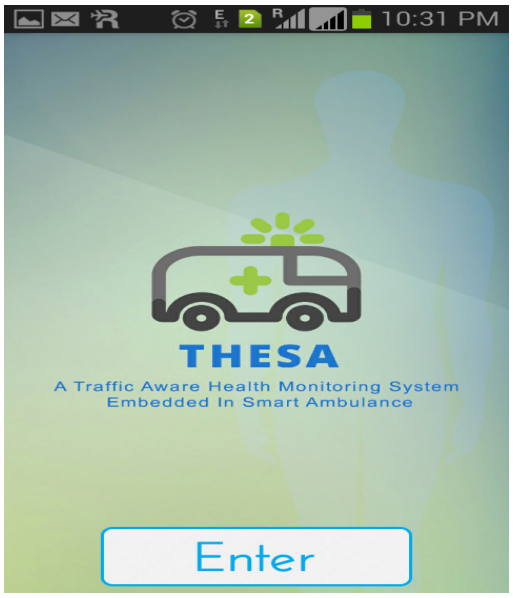

Figure 2: Welcome Screen

Figure 2 shows welcome screen of A Traffic Aware Health Monitoring System embedded in Smart Ambulance (THESA). A user enters into THESA application through this welcome screen by pressing enter button.

Figure 3: Home Screen

Figure 3 shows the Home screen of THESA application which allows the user to register himself/herself as a hospital, doctor or ambulance. Whatever the profile user chooses for, he/she will get registered with this application through this home screen.

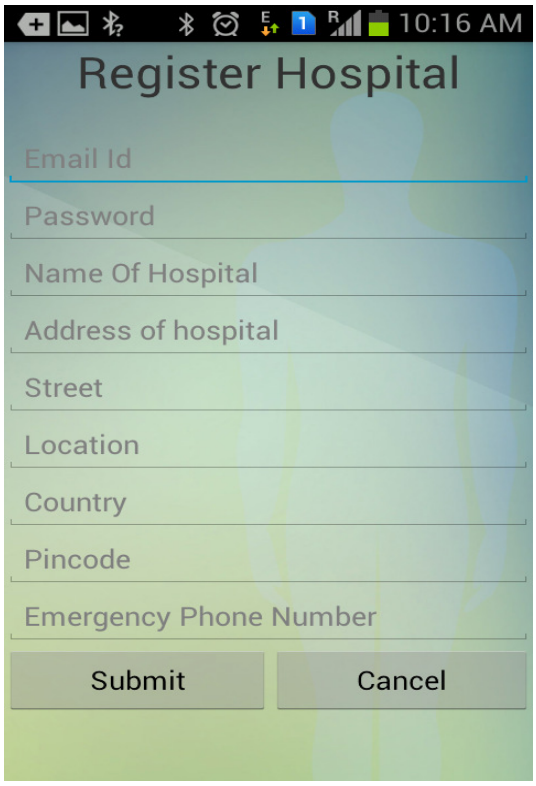

Figure 4: Registration Page for Hospital

The registration page for hospital is shown in figure 4. Hospital may register itself by filling in all the necessary details as depicted in the figure 4. Once the hospital gets registered, the application will automatically find and save the longitude and latitude values for that hospital in the application database so that the registered hospital gets added and shows up in the "nearby hospital list". Similarly, there will be a registration page for each other module also i.e. Doctor and Ambulance.

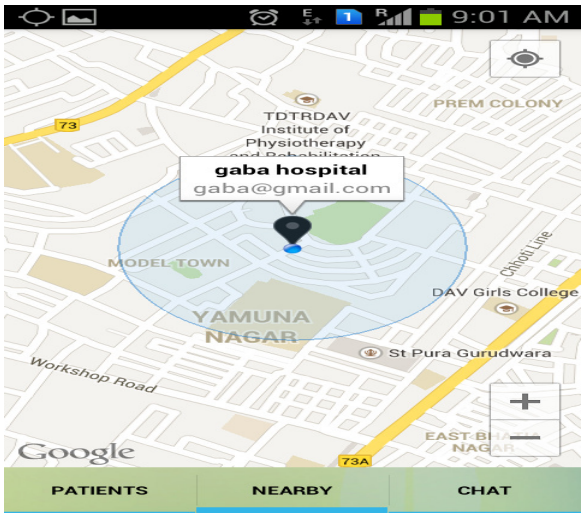

Figure 5: Nearby Hospital Page

A Nearby Hospital page is shown in figure 5. Nearby Hospital page shows the current location of ambulance, shares its current location information with the registered hospital and gives the details of all other registered nearby hospitals in the vicinity of moving ambulance in case of emergency or in case of traffic jam.

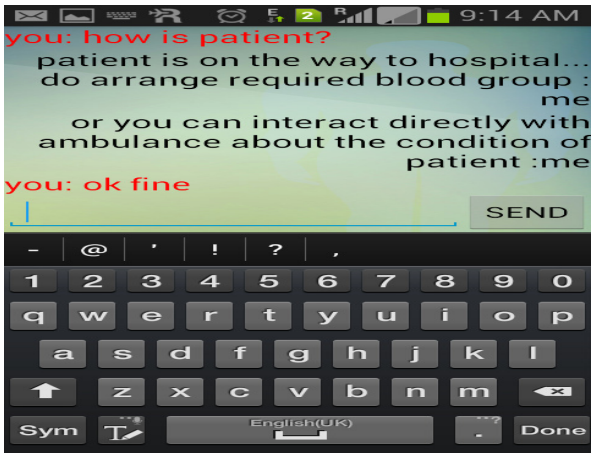

Figure 6: Interactive Chat Session between Hospital and Ambulance

Figure 6 depicts the interactive chat session between ambulance and registered hospital in case of an emergency.

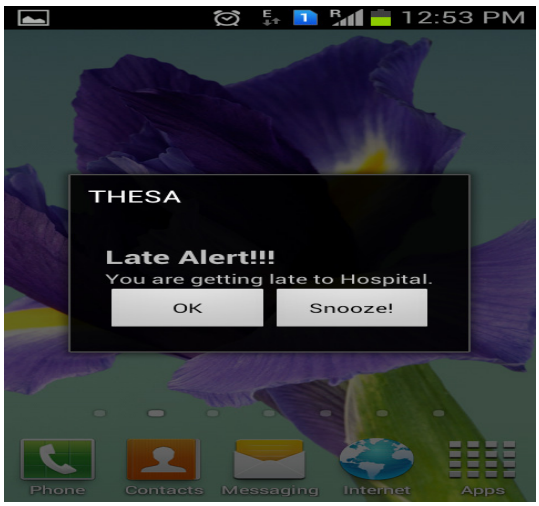

Figure 7: THESA Late Alert sent to Ambulance by Hospital

Figure 7 shows THESA Late Alert screen which triggers an alarm to inform the ambulance about delay in reaching hospital when the expected time to reach the destined hospital reaches above a preset threshold value. The delay may be caused due to heavy traffic jam or weather conditions such as storm, heavy rain, flood etc.

VI. CONCLUSION & FUTURE WORK

A Traffic Aware Health Monitoring Application Embedded in Smart Ambulance (THESA) is an application developed using Android & JSON Web Services. Of the trials (being conducted by almost 20 hospitals currently in different cities), all the facilities contained in this application have been running well. The advantage of this application is to provide services to facilitate the pre-hospital care to time-critical patient, processing of medical records by the actors that play a role in the processing of medical records such as ambulance, hospital and doctor. This application also provides a facility to the patient to access his medical records to enquire about his health condition. This application also includes interactive chat session facility to provide simultaneous interaction between all the actors (ambulance, hospital & doctor) which is necessary for constant monitoring of the health of the patient. This application is a prototype of the system that is a complete medical record and traffic monitoring system given to the actual hospital.

The application still lacks behind in meeting some advanced objectives that include

- Its integration with embedded smart systems which are preinstalled in the ambulance.
- Thousands of medical symptoms, diseases, conditions, procedures, medications and drugs will be preinstalled in ambulance to treat the patient in emergency with clear, concise and useful information.
- Besides finding the nearest hospital, emergency room for urgent care, an option to find the retail clinic,

pharmacy, physician, doctor, imaging center, mental health clinic also may become an integral part of it.

- If the ambulance gets stuck in traffic jam, Extended THESA can find out the length of traffic jam (in kilometers) with the help of embedded sensors.

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