COHEZY – COLLABORATIVE HEALTH CARE SYSTEM MODEL

Olivera Kotevska
Faculty of Electrical Engineering and Information Technologies
Skopje, R.Macedonia

Elena Vlahu-Gjorgievska
Faculty of administration and management of information systems
Bitola, R.Macedonia

Vladimir Trajkovic
Faculty of Electrical Engineering and Information Technologies
Skopje, R.Macedonia

ABSTRACT

Wireless sensor networks (WSN) can be used to help and improve quality of living of medical patients especially in the post hospital care phase. In this paper is presented system which facilitates the remote monitoring of patients with WSN. This system provides caregivers with timely access to a patient's status, gives suggestions for preventive intervention instead of emergency care and hospital admissions. In addition, the system enables the patient to contact other people with similar condition and exchange their experience. In that way this system improve quality of care and life by offering freedom to enjoy life, with the confidence that a wearable monitoring device could immediately alert a family member and medical professional of any health changes or emergency needs.

Keywords: Mobile application, Personal health care system, Social network.

I. INTRODUCTION

Recent advances in wireless technology permit mobile and permanent monitoring of patients, even during their normal daily activities, and without compromising their quality of life.

A personal healthcare system consists of a group of sensors attached to clothes to a patient; in order to monitor signals to detect any life threatening abnormality.

Patient monitoring collects specific metrics from biomedical devices (diabetes, cardiovascular disease, chronic obstructive pulmonary disease, cancer) used by patients in their homes or other settings outside of a clinical facility.

Collect patient readings are represent in mobile phone and then transmit them to a remote server for storage and examinate by medical personnals, or transmit to social network. Once available on the server, the readings can be used in numerous ways by clinicians, by physicians, by policy makers or social networks. This capability of collecting data from different sources, social networks, other patients and clinics gives suggestions to patient using different level of validity.

Depending of type and state of patient health situation are used algorithms and consequently the healthcare network should adapt its performance requirements to the new situation. Higher monitoring activity and lower delay transmission of the signals might be required when the clinical situation of a patient changes. Healthcare networks should provide quality of service (QoS) facilities for emergency services, since these clearly demand for high reliability, guaranteed bandwidth, and short delays.

In this paper is proposed solution for a new dimension in the usage of wireless technologies in the healthcare. Its offered a system model that is easy to use. The most important benefits of proposed system model are: increased medical prevention, more immediate time response at emergency calls, 24 hour monitoring of the patients' condition, possibility for patient notification in different scenarios, transmitions of the collected bio signals automatically to medical personnel, increased flexibility in collecting medical data [6]. This system model creates the opportunity for increasing patient health care within their homes by 24 hour monitoring on the one hand, and increasing medical capacity of health care institutions on the other hand. This results in reducing the overall costs for patients and hospitals and improves the patient's quality of life [5]. It provides a better health care allowing suggestions and notifications based on knowledge from other patients, cases and experience.

The next chapter gives general model of system. Chapter 3 describes detail system design and implementation, while the last section concludes this paper.

II. GENERAL

Wireless sensors have more advantages; they are flexible and can be easily reconfigured. They can be used in places geographically far apart to monitor activities remotely. They also generally consume less power. Wireless sensing units integrate wireless communications and mobile computing to deliver a sensor platform which is inexpensive to install in numerous applications. Indeed, co locating computational power, Bluetooth or RF communication within sensor unit itself is a distinct feature of wireless sensing.

This system is deployed over three basic usage layers:

- The first layer is consisting of the bionetwork (implemented from various body sensors) and mobile application that collects users' bio data during various physical activities (e.g. walking, running, cycling).
- The second layer is presented by the social network implemented as web portal which enables different collaboration within the end user community.
- The third layer enables interoperability with the primary/secondary health care information systems

which can be implemented in the clinical centers, and different policy maker institutions.

The mobile technologies are used to support and enable collaboration. Collaboration between different layers of the Cohesy system is given on Figure 1. The installed mobile application, using various sensors (bionetwork), performs readings regarding users health during his physical activities (walking, running, cycling) and based on them, gives appropriate instructions, proposals and constraints of their execution, in order to improve his own health.

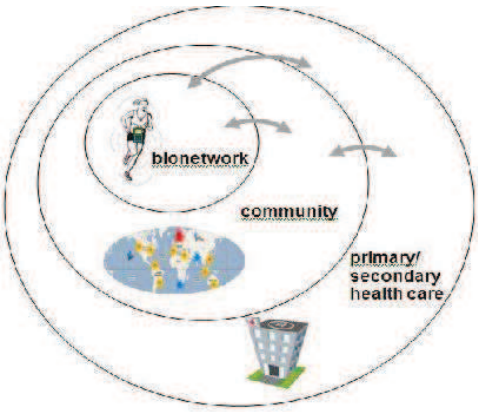

Figure 1:

The first layer is collecting data by sensors to mobile phone, and representing appropriate results to patients using mobile phone is useful and caring way. The tasks performed include measuring the relevant quantities, monitoring and collecting data, assessing and evaluating the information, formulating meaningful user displays, and performing decision making and notification functions. [1]

For representing collected data are used learn patterns of activities, and are applying these capabilities to health monitoring in the following ways:

- Represent notifications depending of received source that means level of validity;
- Use our data mining and prediction techniques to learn patterns in collected data;
- Identify trends that could indicate health concerns or a need for transition to assisted care;
- Detect anomalies in regular patterns that may require intervention;
- Provide reminder and automation assistance for inhabitants.
- Perform secure, context aware collection of inhabitant health and activity data;

By investigating these issues an intelligent system with learning algorithms is created that perform their individual tasks well, but also form a synergistic whole that is stronger than the parts.

The aim of this system is to offer different ways of interfaces in the system, like web services or API. In that way this system offers flexibility of integration to other systems. Medical sensor device vendors can add their devices to the system, and the system software can be augmented to integrate the devices. Application vendors can implement their applications so that they are independent of the device technologies.

III. System design

Presented platform contains core functions which will be needed by any solution that collects biomedical sensor data and stores the data on a remote server for long persistence and analysis. Here is presented initial version of the design and implementation.

The working of this basic model is as follows. Patient is wearing a smart clothes with embedded biosensors, they include data gathering module. The module (consisting of medical biosensors) will record the patient's data and forward it to the mobile device through a wireless protocol (depending of characteristics of used sensors). The mobile device will contain an application for local monitoring of patient's data that would display the current readings. It will have algorithms for calculating some parameters, (maybe local database) and possibility for third party services. The reading process is showed in flow chart in figure 2:

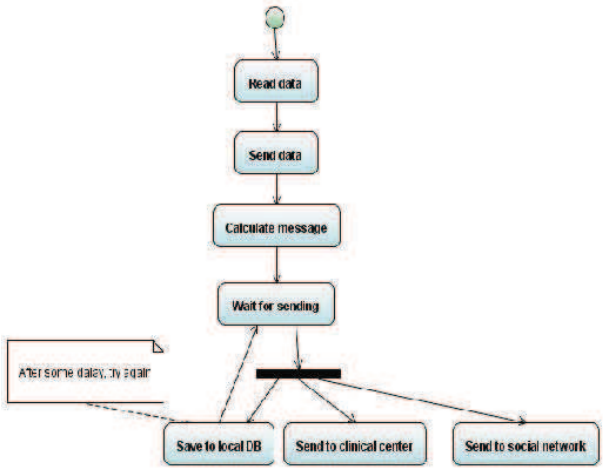

Figure 2:

Also, if some irregularity occurs while reading the data from bionetwork depending of their value (does archive critical limits), based on algorithms in mobile device, urgent messages will be send (mail, sms) to appropriate medical personal.

Along with the display of data, this application will also notify the user with the help of alarms in case any measurement goes out of its normal bounds. The application will also notify the user if some sensor is not responding for some time. For transfer to remote server, this application will

also provide some data compression techniques. This will help in reducing the payload of the information sent to the remote server.

This application will give opportunity to send data received from sensors to Social network (if previously have agreed with conditions, security and privacy statements of the social network), with possibility patient to choose which of them to send, but with no option to edit them and when to send. Also patient can receive data from this social network used by other patients, if he previously allowed that option. This data will help other patients with similar medical characteristics to follow conditions to other patient. Activities and care they have, recommendation that they offer for improving quality of life for all patient with similar medical characteristics.

Application to the mobile device also can connect to a remote server (clinical center) through TCP/IP, GPRS (whichever is available in the area or the least costly in case of multiple services availability) and transfer the data to it. The remote clinical center will receive the data, invoke process to perform analysis of data, and provide feedback to the patient mobile phone screen, notifying the decision given by the clinical center. Sequence diagram is presented in following figure 3:

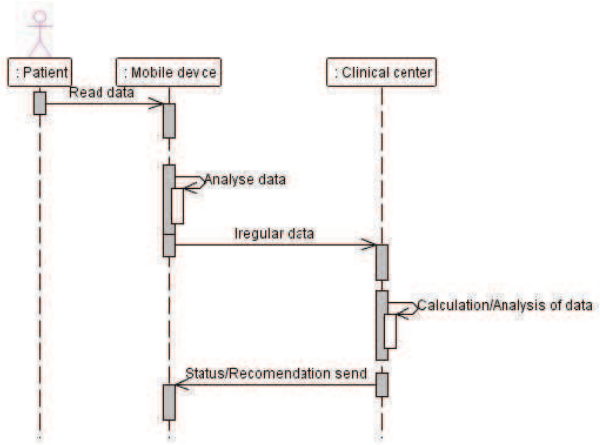

Figure 3:

There are also possibilities data cannot be send to Clinical center or other center. One scenario is:

- If TCP/IP or GPRS is not available in a region;
- Battery low;
- Not enough memory;
- Clinical center is not available;

Preventive solutions:

- Try again in some period of time;
- Try with other available (back up) center address;

Although it will be elaborated in more details later in the text, it should be noted that the special attention is given on security issues. They are not elaborated here in order not to increase complexity of the model.

The installed mobile application has access to the social network (web portal) where it can store users' data and read average data readings on bio and physical activities of all users. Social network allows direct communication between users (if approved by the user and stored in the user profile), sharing their results and exchange of their experience. This portal can provide interface and use data from a variety of medical databases and environmental databases (temperature, wind speed, humidity). In this way mobile application within the Cohesy system provides a tool for a complete personal healthcare. The social network has incorporated collaborative filtering that allows filtering large amounts of data on concrete condition.

This complex structure of data from a social network along with the data arriving from different clinical centers can be used by different medical databases for further analysis and research.

IV. SYSTEM IMPLEMENTATION

The system is divided of three modules, they are:

A. Sensor module

This module collect data from bio sensors (possible used smart clothes for implementing this system is a Visuresp™ tee-shirt (RBI, France) or Lifeshirt™ (Vivometrics, USA) [7]), they receive patient measurements. When the reading process is completed, data are sent to the sensor node. Limited processing is performed by the sensor node on the reading data before transmitting it through the network to the base station using wireless protocol.

This module sends notification alert if some sensor is not working.

B. Data collection module (validation module)

The mobile device sets up communication with the sensor module through a device driver. It transmits this data to the clinical main server and displays received feedback from the clinical server. Also transmits data to social network and receive feedback. The interaction need to be synchronous in real time.

A software abstraction layer will be provided to ease the process of development of local application as well as interaction with the main server at clinic through wide area wireless medium. The main server in the clinic provides the services of clinical decision support system and electronic clinic record system to the requests from the mobile device carried by the medical personnel. The database server will be

used to link the incoming data to the patient's record. The clinical decision support system will provide prevention to some automated analysis of data, based on data received from other sources (social network, medical database and other patients). The feedback is based on the clinical decision support systems analysis and decision made by medical personnel, it will be sent to the patient mobile device. There are three different types of feedback, depending of validity of information. The most relevant are information's received from clinical center (data from other patients), medical databases and biosensors. The second level of validity is data received from social networks and the third level is data from personal profiles. Depending of them patient receive recommendation, suggestion or notification.

The server will also serve requests for reports based on the patient's data and individual patient records requests from the concerned clients. The automated services provided by the server will reduce the workload of doctors and other hospital staff and increase their efficiency.

This module sends urgent messages to the medical personnel if some irregularity occurs.

C. Third-party module

This module gives possibility for using some features from healthcare institutions, policy makers or environmental database. It gives services (web services, API, db links) for using functionalities of data collection module. These services can be used as an example by medical personnel.

Following is an architecture overview of system:

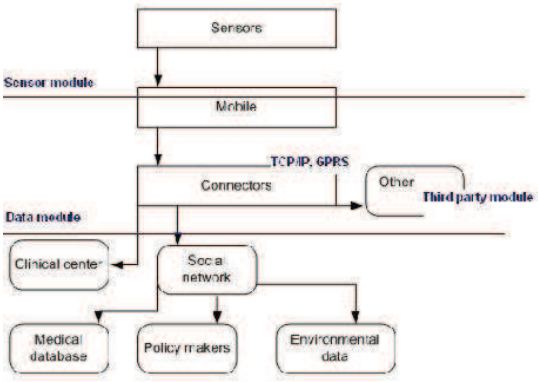

Figure 4:

This application will be based on the APIs for every type of sensor. Web services that will allow other service to use some functionality of system.

To implement this system, Android mobile application will be created and nosql database server, (CouchDB) will be used for storing data. Data format exchange between mobile device, clinical center, and social network will be in json or xml format.

Some of fields are mandatory while others may me optional.

Basic form of this file will be in this format:

```
{ healtcare:{
    general:{
            name:'name',
            therapy:'therapy'
            },
    data:{
            activity:"activity",
            sugarlevel:'3'
          }
    }
}
```

Or in XML format:

```
<healtcare>
   <general>
      <name>name</name>
      <therapy>therapy</therapy>
   </general>
   <data>
      <activity>activity</activity>
      <sugarlevel>3</sugarlevel>
   </data>
</healtcare>.
```

Data send to policy makers are filtered by using different confidential policies. And for that purpose file structure appropriate will be changed.

V. QUALITY AND SECURITY

This system should archive following qualities in the area of local data collection:

- Patient usability, the system should be easy for patients to use. It should require minimal training and minimal maintenance. It should minimize power consumption to avoid the inconvenience of recharging. It should be portable so that patients can take the system anywhere they go.
- Scalability, the system should scale to support large numbers of patients and their associated care providers. Successful remote monitoring system could face significant numbers of patients very quickly.
- Reliability, the system should collect and store patient data, even in the face of network failures. Patients may travel to places where network connectivity is poor. The system should cache data in these situations for later transmission to the system.

- Extensibility, the system should extend to a broad range of home monitoring devices by using a wide variety of data exchange protocols.
- Financial resources, the cost per patient required to deploy and maintain such a system should minimal.

These are security preventions, of patient and data:

- Local database (in mobile phone) stores data received by sensors, in case there is always back up of data (they will be saved only some period of time).
- When there are problems in sending data to clinical center, some of data is not going to be send, all transaction will be rolled back. In this way there will be always all sensors data and when service will be available data will be sending provide quality of service (QoS) facilities since these clearly demand for high reliability, guaranteed bandwidth and short delays.
- The communication with the remote server will be made secure by using state of the cryptographic techniques.
- Access to web services will be through secured protocols.
- Every user can choose what information can be private or public. User can choose his records to be public: (a) for medical purposes, (b) to all visitors of the Social network, (c) to users in his category, (d) to none. In order to have medical support the user has to agree to share personal information with clinical centers and medical databases, whose data are also protected. According to user agreement policy those data information would be exchanged through system.

The platform should give possibility for future upgrade, which means that biomedical device vendors and health care application vendors should be able to integrate their technology innovation in this platform.

VI. CONCLUSION

The system allows medical personnel to monitor a patient's health from a remote location without requiring the physician to be present to take the measurements. The system concept can be used for routing health information to a central location within the hospital premises as well as in applications that require monitoring from within a patient's.

The big advantage of this system compared with other is knowledge support capabilities. This system provides specialized problem solving expertise stored as facts, rules, procedures, similar structures of other patients. The generated information has different validity depending on the validity of the data that is used to generate information. The model accuracy increases as the number of users increase. It also gets more reliable with time and number of cases. The primary purpose of presented model is collecting different types of data and combining them into complex data structures based on collaboration. The system provides tool for personal health care by generating different recommendation, notification and suggestion to the users.

Data obtained from clinical centers and social networks, through the application (handled by the application) allows the user to adapt and align his physical activities while improving his health condition and overall way of rehabilitation, meaning to be fully able to take self care and professional concern about his health. This gives patients freedom to work, travel, and enjoy life, with the confidence that a wearable monitoring device could immediately alert a family member and medical professional of any health changes or emergency needs.

REFERENCES

[1] Subhas C. Mukhopadhyay, Anuroop Gaddam and Gourab S. Gupta, Wireless Sensors for Home Monitoring - A Review, Recent Patents on Electrical Engineering 2008, 1, 32-39.

[2] Oscar Gama, Paulo Carvalho, J. A. Afonso, P. M. Mendes, Quality of Service Support in Wireless Sensor (etworks for Emergency Healthcare Services, Engineering in Medicine and Biology Society, 2008. EMBS 2008. 30th Annual International Conference of the IEEE.

[3] Óscar Gama, P. M. Carvalho, Paulo Mendes. Self-Reconfigurable Biomedical Wireless Sensor Network. Proceeding SMC' 09 Proceedings of the 2009 IEEE international conference on Systems, Man and Cybernetics IEEE Press Piscataway, NJ, USA, 2009.

[4] William Walker, Todd Polk, Abhiman Hande, and Dinesh Bhatia. Remote Blood Pressure Monitoring Using a Wireless Sensor Network. Sensors 2006, 6, 1102-1117.

[5] Zimmerman, T., Chang, K. (2008). Simplifying home health monitoring by incorporating a cell phone in a weight scale In Proceedings of the 1st international conference on Pervasive Technologies Related to Assistive Environments, Athens, Greece. New York, USA: ACM.

[6] Komnakos, D., Vouyiokas, D., Maglogannis, I., Constantinou, P. (2008). Feasibility study of a joint e-health mobile high-speed and wireless sensor system. In Proceedings of the 1st international conference on Pervasive Technologies Related to Assistive Environments, Athens, Greece. New York, USA: ACM.

[7] Fabrice Axisa, Pierre Michael Schmitt, Claudine Gehin, Georges Delhomme, Eric McAdams, and André Dittmar. Flexible Technologies and Smart Clothing for Citizen Medicine, Home Healthcare, and Disease Prevention. IEEE Transactions on information technology in biomedicine, vol. 9, no. 3, September 2005.