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# A mobile wireless body area network platform

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ABSTRACT

This paper aims to propose a system architecture for a mobile health-monitoring platform based on a wireless body area network (WBAN). We detail the WBAN features from either hardware and software point of view. The system architecture of this platform is three-tier system. Each tier is detailed. We have designed a flowchart of a use of the WBANs to illustrate the functioning of such platforms. We show the use of this platform in a wide area to detect and to track disease movement in the case of epidemic situation. Indeed, tracking epidemic disease is a very challenging issue. The success of such process could help medical administration to stop diseases quicker than usual. In this study, WBANs deployed over volunteers who agree to carry a light wireless sensor network. Sensors over the body will monitor some health parameters (temperature, pressure, etc) and will run some light classification algorithms to help disease diagnosis. Finally, the WBAN will send aggregated data about the disease to some base stations which collect the results. Our platform will run an on-line disease tracking program and to detect some information about how the disease is propagated.



## 1. Introduction

Over the last few years many academic and industrial development projects have been taking place to improve healthcare monitoring based on wireless sensor networks (WSN). Using WSN in healthcare might help to overcome the shortage of the medical staff in medical institutions around the world whereas the human population increasing continuously year by year. Moreover, the number of elderly over 65 years will be 761 million by 2025 [16]. Meaning that more obstacles will be added to be able to provide an efficient healthcare, but that might not easy without using new technologies such as WSN. The WBAN provides an excellent opportunity to enhance the quality of healthcare. They have allowed the application in this area increasingly moved toward. However, developing a WBAN platform is a very challenging issue. It needs more studies and researches to meet the needs of healthcare providers because of the quality standards requirements in the healthcare field.

Since the last decade, we observe the growth of wireless sensor networks (WSN) which allow a new way to perform unusual tasks. For example, a WSN may be deployed over a wild area to monitor some environmental changes. They can also be plugged on animals to study how they evolve in their natural habitat. Another well-studied field is patient monitoring. In such a context three main scenario are known. One consists in monitoring patient over an emergency site (in situ monitoring), another one deals with an in-hospital monitoring scenario, and a third one is dedicated to monitor patients at their home (in-home monitoring).

We investigate methods for disease monitoring and we work on a distributed approaches to track epidemic diseases over wireless sensor networks. In patient monitoring, the patient is commonly equipped with various physical sensors which allow to monitor several health parameters. Presently, most of the used equipments for medical care are based on private software environments. Contrary to these equipments, our platform can run specific algorithms which can fit to some adapted requirements. These requirements could be defined about the patient situation (older people, disabled people, etc.) or could be defined about diseases (new rules or methods to be applied in the diagnosis process for example).

In this paper, we propose a system architecture for a mobile health-monitoring platform based on a wireless body area network (WBAN). In our proposal of the mobile WBAN platform (TM-WBANP) we provide healthcare monitoring system that can detect some diseases indoor and outdoor, and we integrate a mobility management system (MMS) that will manage the different type of wireless connections. The MMS simply works as a router (connection manager) in TM-WBANP.

We focus on the use of such a platform to investigate people who may have a disease, who may propagate this disease (in the case

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of epidemic disease) and who move in an urban region. Then, we focus on plugging on some patients WBANs which exchange data when necessary and communicate with their neighbors in order to aggregate data extracted from people who are located in the same area.

We will present the state of the art of well known healthcare platforms in Section 2. In the third section, we will define the platform components. Section 4 is dedicated to the mobility model of the platform. In Section 5, we will give an example of using the WBAN platform. Finally, in Section 6, we will give a conclusion of the study and give some hints about future works.

## 2. Related works

The main purpose of healthcare platforms is to help patients in their current life. Indeed, the related-patient always needs to move from side to side and to practice his or her normal life without any barriers including sports and any other usual activity like shopping for instance. Such platforms integrate positioning system in order to get the exact position of the patient in emergency cases. We review in this section some well known studies on healthcare monitoring platforms.

Codeblue [13] is a complete infrastructure for in situ and in-hospital monitoring. It provides a publish/subscribe architecture which allows doctors or nurses to register to any particular event (new data from a given patient or an health parameter which has reached a given threshold) using a mobile wireless equipment. CodeBlue also provides a RF-based location tracking to locate patients in the hospital. In all these frameworks and algorithms, most of the computations are not done on local sites but the sensed data are sent to a base station where all data are analyzed.

AlarmNet (assisted-living and residential monitoring network) [10] is an architecture for medical sensor networks which allows to monitor patient at home. In AlarmNet, some alarms are raised in emergency situations (for example if the patient falls down). AlarmNet uses two main sensors' types (physiological and environmental) that can interact with the activity of daily living (ADL), this feature can be used as a health problem indicator program as well as power consumption controller by detecting the inactive status of patients. IBM PCC [20] provides a platform that is able to monitor patients with chronic diseases in their homes. So, the medical personal can monitor his/her patients remotely and continuously. The PCC also has the ability to monitor and control the daily medication dosage. Moreover, the PCC uses sensors that can be placed in the patent's slippers to monitor the changing of his/her walking gait. Some developers focused on using wearable or implantable and comfortable system that could enhance reliability and accuracy while gathering sensor's data, patients always need smooth healthcare in order to be able to treat them properly.

MEMESWEAR [21] and LOBIN [22] platforms are mainly similar, they have used smart-shirt equipped with sensors to monitor vitalsings, to detect patients position and to detect patients' fall as well.

Afterwards, many works focus on the detection of abnormal situations in a distributed manner [6–8,15]. Most of these works are not dedicated to medical monitoring but we notice that they can be applied in such a context.

In [6], the sensors which have detected an abnormal situation organize themselves dynamically, building a spanning tree over the existing network. This spanning tree allows the sensors to optimize the transmission of their measurements to the base station. In the specific medical field, complete architectures are generally studied. In [9] the authors propose algorithms to detect or prevent someone's long periods of inactivity at home.

MiTag [11] and Wiisard [12] focus on monitoring people over an emergency site. Here, one of the challenges is to treat a large number of casualties and to ensure that each patient can be efficiently monitored. Several mechanisms are deployed to ensure that the data sensed by a WBAN are effectively forwarded to the equipments of the medical staff (personal digital assistant or laptop computer), so that the patient can be treated. An interesting point is that a mote can reconfigure itself. An example is the modification of the data transmission rate according to some specific context. In-hospital monitoring generally provides a controlled environment with a fixed infrastructure. The goal is to monitor a patient anywhere during his hospital period. Refs. [17–19] provide continuous healthcare monitoring systems.

In [15], we have proposed an approach to detect anomalies in a distributed manner by using wireless sensor networks. We perform some distributed tasks on the sensors. We propose a distributed algorithm, which allows to raise alarms under some initial rules to alert efficiently medical staff in case of critical situations without needless warnings. Each mote monitors a parameter. When this parameter reaches an abnormal value, the mote communicates with other motes in order to check if it is a local anomaly or if the patient is in an abnormal situation. In such cases an alarm is raised. We implemented our algorithm over a network of micaZ sensors running under TinyOS.

## 3. System architecture

### 3.1. Wireless body area network

A medical protocol is usually described as follows: a disease is diagnosed if a set of symptoms is verified. These symptoms can be verified thanks to blood analysis results or by observing the patient behavior (vomiting or headache for example). In other cases, these symptoms rely on the fact that some health parameters (heart rate, electrocardiogram, temperature or blood sugar) have reached some abnormal values. Let us take the example of the gastroenteritis. A patient has the gastroenteritis if the following symptoms are verified: (a) diarrhea, (b) fever, (c) headaches, (d) vomiting, (e) loss of appetite, (f) abdominal cramps. In this case only one symptom (fever) can be sense by a transducer. We focus on such symptoms and intend to suggest some diseases. Even if the example we presented is quite simple our model is designed to handle more complex disease cases. The health parameters values are usually sensed by transducers which are embedded on the patient and which are linked to a specialized engine. First works that have been performed on the use of WSN in medical care, rely on such a centralized approach. A patient is equipped by a set of motes (a sensor linked to transducers) and each mote measures some health parameters. All sensed values are sent to a base station which performs all computations, analysis and detections. This centralized paradigm leads to some drawbacks. First, routing mechanisms have to be implemented in order to ensure that all the information sensed by the sensors is transmitted to the BS. Second, the BS failure implies that no detection is possible anymore. In a fine-grained multi-hop network, highly prone to congestion it remains difficult to ensure a real-time detection needed in an intensive care unit. In the context of in-hospital monitoring, we suppose that each wireless body area network transmits the data to a wired network responsible for forwarding it to the base station.

As shown in Fig. 1, the communication between all body sensors will run in order to collect the number of people having the disease and the number of people who could have the disease in the near future. The aim is that each body sensor network which diagnoses a disease or an "almost disease" will send the data to the neighborhood. Each body sensor network will aggregate its data with what