

# A Survey: Wireless Body Area Network for Health Monitoring

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## Abstract

With an increasingly mobile society and the worldwide deployment of mobile and wireless networks, the wireless infrastructure can support many current and emerging health care applications. Citizens, being patients or non-patients, will not only be able to get medical advice from a distance but will also be able to send from any location full detailed and accurate vital signal measurements, as if they had been taken in medical centers. Towards this direction, the proposed system is highly customizable vital signal monitoring system based on Wireless Body Area Networks (WBAN). The proposed system allows the incorporation of diverse medical sensors via wireless connections and the live transmission of the measured vital signals over public wireless networks to healthcare providers. This paper discusses different scenarios where this wearable health monitoring system can be used and different types of sensors are used to measure the different parameters such as temperatures, glucose, heart beats, ECG, EEG, etc. Finally, through a case study, we demonstrate how the diabetic patient takes the advantage of this system.

**Keywords:** WBAN (Wireless Body Area Network; Sensor; Wireless network; medical server; PDA (personal digital access).

## 1. Introduction

Body area network (BAN), wireless body area network (WBAN) or body sensor network (BSN) is terms used to describe the application of wearable computing devices.

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This will enable wireless communication between several miniaturized body sensor units (BSU) and a single body central unit (BCU) worn at the body. The development of WBAN technology started around 1995 by considering wireless personal area network (WPAN) technologies for communications on, near and around the human body. Later around 2001, this application of WPAN has been named as body area network (BAN) to represent the communications on, in and near the body only. A WBAN [4] system can use WPAN wireless technologies as gateways to reach longer ranges.

The rapid growth in physiological sensors, low power integrated circuits and wireless communication has enabled a new generation of wireless sensor network. These wireless sensor networks are used to monitor traffic, crops, infrastructure and health. The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records via internet. A number of intelligent physiological sensors [2] can be integrated into a wearable wireless body area network, which can be used for computer assisted rehabilitation or early detection of medical conditions. This area relies on the feasibility of implanting very small bio-sensors inside the human body that are comfortable and that don't impair normal activities. The implanted sensors in the human body will collect various physiological changes in order to monitor the patient's health status in spite of their location. The information will be transmitted wirelessly to an external processing unit.

### ***1.1 Applications***

Initial applications of BANs are expected to appear primarily in the healthcare domain, especially for continuous monitoring [8] and logging vital parameters of patients suffering from chronic diseases such as diabetes, asthma and heart attacks.

- A WBAN network in place on a patient can alert the hospital, even before they have a heart attack, through measuring changes in their vital signs.
- A WBAN network on a diabetic patient could auto inject insulin through a pump, as soon as their insulin level declines.

Other applications of this technology include sports, military, or security. Extending the technology to new areas could also assist communication by seamless exchanges of information between individuals, or between individual and machines.

### ***1.2 Components***

A typical BAN or BSN requires vital sign monitoring sensors, motion detectors (through accelerometer) to help identify the location of the monitored individual and some form of communication, to transmit vital sign and motion readings to medical practitioners or care givers. A typical body area network kit will consist of sensors, a Processor, a transceiver and a battery. Physiological sensors, such as ECG and SpO<sub>2</sub> sensors, have been developed. Other sensors such as a blood pressure sensor, EEG sensor and a PDA for BSN interface are development.

## **2. WBAN technologies**

WBAN may involve different technologies at different levels; a comprehensive study of the main proposed technologies for WBAN [7,5] is as follows :

### **2.1 Bluetooth**

It is designed as a short range wireless communication standard, intended to maintain high levels of security. In this technology, each device can simultaneously communicate with up to seven other devices within a single piconet, an ad hoc network including one device acting as a master and up to seven others as slaves for the lifetime of the piconet. The main attractive characteristic of Bluetooth is to allow a wide range of Bluetooth enabled devices to connect and communicate with each other, almost everywhere in the world. Another key feature is the ability of devices to communicate without need of line-of-sight positioning of connected devices. Thus, it is widely used for connecting a variety of personally carried devices to support data and voice applications. Bluetooth devices operate in the 2.4 GHz ISM band (Industrial, Scientific and Medical band), utilizing frequency hopping among 79 1 MHz channels at a nominal rate of 1600 hops/sec to reduce interference. Bluetooth gives coverage from 1 to 100m with maximum data rate of 3 Mbps.

### **2.2 Bluetooth Low Energy**

A derived option of the Bluetooth standard is the Bluetooth Low Energy (BLE) [5], which was introduced as a more suitable choice for WBAN applications where less power consumption is possible using low duty cycle operation. Bluetooth LE was designed to wirelessly connect small devices to mobile terminals. Those devices are often too tiny to bear the power consumption as well as cost associated with a standard Bluetooth radio, but are ideal choices for the health-monitoring applications. Bluetooth Low Energy technology is expected to provide a data rate of up to 1 Mbps. Using fewer channels for pairing devices, synchronization can be done in a few milliseconds compared to Bluetooth seconds. This benefits latency-critical BAN applications, like alarm generation and emergency response, and enhances power saving. Its nominal data rate, low latency and low energy consumption make BLE suitable for communication between the wearable sensor nodes and the access point (AP). Moreover, adaptive frequency hop spread spectrum allows BLE to co-exist with Wi-Fi. BLE is most convenient for short-term high data rate applications in which two peer to peer devices are connected in an ad hoc configuration, such as between two personal servers of two WBANs or between a WBAN and a personal computer.

### **2.3 Zigbee and 802.15.4**

ZigBee is one of the wireless network technologies which is widely used from the low power environment. ZigBee is targeted at radio-frequency applications that require a low data rate, long battery life and secure networking, thanks to its 128-bit security support to perform authentication and guarantee integrity and privacy of messages. Through the sleep mode, ZigBee enabled devices are capable of being operational for several years before their batteries need to be replaced. ZigBee technology is separated into two parts. First, ZigBee alliance designates the application layers, defining the network, security and application software layers. Second, IEEE

802.15.4 standard defines the physical and medium access control layers, where access to wireless channel is through employing unslotted/slotted CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) mechanism for channel access and handling guaranteed time slot (GTS) allocation and management. ZigBee-based wireless devices operate in 868 MHz, 915 MHz, and 2.4 GHz frequency bands. Thus, one significant disadvantage of Zigbee for WBAN applications is due to interference with wireless local area network (WLAN) transmission, especially in 2.4 GHz where numerous wireless systems operate. Another disadvantage of Zigbee is related to its low data rate (250 Kbps), which makes it inappropriate for large-scale and real time WBAN applications. In fact, due to the low data rate, it is difficult to implement in hospitals or clinics (multiple patients); But, it is ideal for personal use (single patient).

#### **2.4 IEEE 802.11**

IEEE 802.11 is a set of standards for wireless local area network (WLAN). Based on the IEEE 802.11 standards, Wi-Fi allows users to surf the Internet at broadband speeds when connected to an access point (AP) or in ad hoc mode. It is ideally suited for large data transfers by providing high-speed wireless connectivity and allowing videoconferencing, voice calls and video streaming. An important advantage is that all smartphones, tablets and laptops have Wi-Fi enabled however; high energy consumption is an important drawback.

#### **2.5 IEEE 802.15.6**

IEEE 802.15.6 is the first WBAN standard that serves various medical and non-medical applications and supports communications inside and around the human body. IEEE 802.15.6 standard [10] uses different frequency bands for data transmission including: The Narrowband (NB) which includes the 400, 800, 900 MHz and the 2.3 and 2.4 GHz bands; the Ultra Wideband (UWB) [4], which uses the 3.1-10.5 GHz; and the Human Body Communication (HBC) [1] which uses the frequencies within the range of 1050MHz. This standard is a step forward in wearable wireless sensor networks as it is designed specifically for use with a wide range of data rates, less energy consumption, low range, ample number of nodes (256) per body area network and different node priorities according to the application requirements. The channel access is handled using CSMA/CA [2] or slotted Aloha access procedure. It provides flexibility in security features, since it defines three security schemes. IEEE 802.15.6 standard can reach data rates up to 10 Mbps while being extremely low power. In addition, it can consider some movements of body (i.e. straight walking from one point to another), which is not suitable for emerging WBAN applications requiring scenarios such as sitting, laying, standing up, jogging, swimming and running. This standard can satisfy most of the WBAN applications throughput requirements by maximum achieving 680 Kbps. But, it is not able to meet the constraints of the emerging applications which require high quality audio or video transmissions.

#### **2.6 Other radio technologies**

In addition to most common technologies used in WBAN application development, other radio technologies can be efficient. The Ultra Wideband (UWB) technology is used for short-range communication systems and provides a high bandwidth. Because of localization of users is particularly important for indoor localization in

assisted living facilities and in hospitals, UWB provides the only reliable method of localization. However, due to its complexity, it is unsuitable for wearable applications. ANT protocol<sup>10</sup> is another emerging standard for wellness and health monitoring applications. ANT is a low speed and low power protocol being supported by several sensor manufacturers. The Zarlink technology<sup>16,12</sup> is ultra-low power, which makes it suitable for medical implant applications requiring low frequency and low data rates. Rubee active wireless protocol<sup>12</sup> uses Long Wave magnetic signals to send and receive short (128 byte) data packets in a local network. Rubee does not require line of sight communication for its operation. Additionally, Rubee has the advantages of efficient transmission distance, high security level, ultra-low power consumption, stable operation providence and long battery lifetime, which make convenient for many WBANs applications such as patient monitoring and mobile healthcare.

### 3. Challenges

Problems [12] with the use of this technology could include:

- *Interoperability:* WBAN systems would have to ensure seamless data transfer across standards such as Bluetooth, ZigBee etc. to promote information exchange, plug and play device interaction. Further, the systems would have to be scalable, ensure efficient migration across networks and offer uninterrupted connectivity.
- *System devices:* The sensors used in WBAN would have to be low on complexity, small in form factor, light in weight, power efficient, easy to use and reconfigurable. Further, the storage devices need to facilitate remote storage and viewing of patient data as well as access to external processing and analysis tools via the Internet.
- *Sensor validation:* Pervasive sensing devices are subject to inherent communication and hardware constraints including unreliable wired / wireless network links, interference and limited power reserves. This may result in erroneous datasets being transmitted back to the end user. It is of the utmost importance especially within a healthcare domain that all sensor readings are validated. This helps to reduce false alarm generation and to identify possible weaknesses within the hardware and software design.
- *Data consistency:* Data residing on multiple mobile devices and wireless patient notes need to be collected and analyzed in a seamless fashion. Within body area networks, vital patient datasets may be fragmented over several nodes and across several networked PCs or Laptops. If a medical practitioner's mobile device does not contain all known information, then the quality of patient care may degrade.
- *Interference:* The wireless link used for body sensors should reduce the interference and increase the coexistence of sensor node devices with other network devices available in the environment. This is especially important for large scale implementation of WBAN systems. Besides hardware-centric challenges, the following human-centric challenges should be addressed for practical BAN development. These include
  - *Cost:* Today's consumers expect low cost health monitoring solutions which provide high functionality. WBAN implementations will need to be cost optimized to be appealing alternatives to health-conscious

consumers.

- *Constant Monitoring:* Users may require different levels of monitoring, for example those at risk of cardiac ischemia may want their WBANs to function constantly, while others at risk of falls may only need WBANs to monitor them while they are walking or moving. The level of monitoring influences the amount of energy required and the life cycle of the BAN before the energy source is depleted.
- *Constrained Deployment:* The WBAN needs to be wearable, lightweight and non-intrusive. It should not alter or encumber the user's daily activities. The technology should ultimately be transparent to the user i.e., it should perform its monitoring tasks without the user realizing it.
- *Consistent Performance:* The performance of the WBAN should be consistent. Sensor measurements should be accurate and calibrated even when the WBAN is switched off and switched on again. The wireless links should be robust and work under various user environments
- *System and device-level security:* Considerable effort would be required to make BAN transmission secure and accurate. It would have to be made sure that the patient secure data is only derived from each patient's dedicated BAN system and is not mixed up with other patient's data. Further, the data generated from WBAN should have secure and limited access.

#### **4 . WBAN Application Scenarios**

Following are the scenarios [11] where WBAN can be used for wireless health monitoring.

##### *1. Telemonitoring of patients with cardiac arrhythmia*

Cardiac arrhythmia is very common and in many cases, is related to coronary heart disease [5]. Around one million patients suffer from coronary heart disease. In patients suffering from arrhythmia, ECG measurements have to be taken regularly to monitor the efficacy of drug therapy. To save time and reduce costs, the patient can transmit ECG and blood pressure via GPRS from home or elsewhere to the health call centre, where the vital signs are monitored by a cardiologist. The intention is that irregular patterns will be detected quickly and appropriate intervention can be initiated. This scenario will evaluate how the patients and the cardiologist can gain time and reduce the related costs.

##### *2. Integrated homecare for women with high-risk pregnancies*

Women with high-risk pregnancies are often admitted to the hospital for longer periods of time because of possible pregnancy-related complications. Admission is necessary for the intensive monitoring of the patient and the unborn child. Homecare with continuous monitoring is desirable and can postpone hospitalization and reduce costs, as well as offering more security for the mother and unborn child. In this scenario, patients are monitored from home using the BAN and the (maternal and foetal) bio signals are transmitted to the hospital. An additional objective of the scenario is to evaluate if such a solution postpones hospitalization and reduces costs. The scenario will use both GPRS and UMTS networks.

##### *3. Tele trauma team*

The trauma patient BAN will measure vital signs which will be transmitted from the scene to the members of the trauma team located at the hospital. The paramedics wear trauma team BANs which incorporate an audio system and a wireless communication link to the hospital. The purpose of this scenario is to evaluate whether use of mobile communications can improve quality of care and decrease lag-time between the accident and the intervention. When using telemetry technology, time can be saved and thus treatment and chances for patient recovery improved. Parameters to be measured are breathing frequency, oxygen saturation, pulse rate, blood pressure, pupil size and reactions and amount of fluids infused. The scenario will use both GPRS and UMTS networks.

#### *4. Support of home-based healthcare services*

This scenario involves use of GPRS for supporting remote assistance and home-based care for elderly and chronically ill patients suffering from co-morbidities. The wireless health monitoring nurse-BAN will be used to perform patient measurements during nurse home visits and the wireless health monitoring patient-BAN will be used for continuous monitoring during patient rehabilitation at home, or even outdoors. It is very important to facilitate patients' access to healthcare professionals without saturating the available resources, and this is one of main expected outcomes of the wireless health remote monitoring approach. Parameters to be measured are oxygen saturation, ECG, spirometry, temperature, glucose and blood pressure.

#### *5. Outdoor patient rehabilitation*

The patients involved in this scenario are chronic respiratory patients who are expected to benefit from rehabilitation programs to improve their functional status. The study aims to check the feasibility of remotely supervised outdoor training programs based on control of walking speed enabled by use of the wireless health monitoring BAN. The physiotherapist will receive online information on the patient's exercise performance and will provide feedback and advice. It is expected that by enabling patients to perform physical training in their own local settings, the benefits, in terms of cost and social acceptance, can be significant. Parameters to be measured are pulse oximetry, ECG and mobility with audio communication between patient and remote supervising physiotherapist.

#### *6. Lighthouse alarm and locator scenario*

The target group involved in the scenario is patients at the Lighthouse care resource centre and also clients living at home, but with the common characteristic that all have an alarm system located in their room at the Lighthouse Centre or in their home. The current system does not allow the patient any freedom related to mobility and forces the patient to be trapped at home or in their room at the Centre. By replacing the fixed alarm system with the wireless health monitoring BAN system, the patient can move freely anywhere. In addition, positioning and vital signs are monitored and video communication is planned with UMTS. The effectiveness of the new GPRS/UMTS-based alarm and locating device will be tested according to several determining factors: safety, convenience, empowerment of user, mobility of user and improvement in efficiency of care given.

#### *7. Physical activity and impediments to activity for women with RA*

This scenario will subject women with Rheumatoid Arthritis. The use of the BAN together with the mobile communications will enable collection of a completely new kind of research data which will enhance the understanding of the difficulties and limitations which these patients face. The objective is to offer solutions that will make their lives easier. By this collection of data, the scarce knowledge about what factors impede normal life will be supplemented and quality of life of RA patients may thereby be improved. By use of wireless health monitoring BANs, the activity of the patients will be continually monitored. Parameters measured include heart rate, activity level, and walking distance and stride length.

#### *8. Monitoring of vital parameters in patients with respiratory insufficiency*

The group of patients involved in this scenario suffers from respiratory insufficiency due to chronic pulmonary diseases. These people need to be under constant medical supervision in case they suffer an aggravation of their condition. Besides needing regular check-ups, they are also dependent on oxygen therapy at home, which means oxygen delivery and close supervision. The use of the wireless health monitoring BANs is designed to enable the early detection of this group of diseases but also to support homecare for diagnosed patients by detecting situations where the patient requires intervention. The expected benefits are a reduction of the number of check-ups and hospitalizations needed, thus saving both time and money. Parameters measured are pulse rate, oxygen saturation and signals from a motion sensor (accelerometer).

#### *9. Home care and remote consultation for recently released patients in a rural area*

Home care services and the possibility of monitoring health conditions at a distance are changing the way of providing care to patient. If suitable, home-based services are provided and patients do not need to be in hospital, for example they are recovering from an intervention. By investing in home care, hospitals have been able to significantly reduce Pressure on beds and on staff time dedicated to the kind of patients named above. This scenario tests transmission of clinical patient data by means of portable GPRS/UMTS equipment to a physician or a registered district nurse (RDN) from patients living in a rural, low population density area. The expected benefit is that this solution will reduce the number of cases where the patient is supposed to visit a hospital for consultation unnecessarily.

#### *10. Ambient Assisted Living*

The aging population, [5] the increasing cost of formal health care and the importance that the individuals place on living independently, all motivate the development of innovative-assisted living technologies for safe and independent aging. Applications in this field improve quality of life to maintain a more independent lifestyle using home automation. In fact, assisted living facilities have emerged as an alternative housing facility for people with disabilities and elderly who are not considered independent but do not need around-the-clock medical care, as in nursing or retirement homes. An ambient sensor network can sense and control the parameters of the living environment and then delivers the body data to a central station, thanks to a continuous cognitive and physical monitoring. The health condition of these people can be estimated from their heart beat rate, blood pressure and accelerometer data. The system may be connected to a health care center for



observation and emergency assistance, in case of strong changes in the observed parameters or deviations from the normal range.

Measurements and monitoring of body functions, parameters and characteristics are crucial for human health. Methods based on optoelectronics, micro and nano sensors and telemedicine are being developed and refined. Data collected from the body can be used to prevent injuries or to help the patient to obtain his/her medication on time and at the correct dose (e.g with special drug release devices)

Wearable health monitoring systems integrated into a telemedicine system are novel information technology that will be able to support early detection of abnormal conditions and prevention of its serious consequences. Many patients can benefit from continuous ambulatory monitoring as a part of a diagnostic procedure, optimal maintenance of a chronic condition or during supervised recovery from an acute event or surgical procedure.

Wearable Health Monitoring Systems (WHMS) are devices that the patient or consumer wears to monitor a specific trait of their body, such as blood pressure or heart rate. These devices provide a more accurate report of the patient health rather than just screenshot traditional measurements provide. This allows the patient to be more accurately treated for the condition they have. WHMS can also help in prevention of disease as trends are immediately noticed as a starting point is established.

*Important limitations for wider acceptance of the existing systems for continuous monitoring are:*

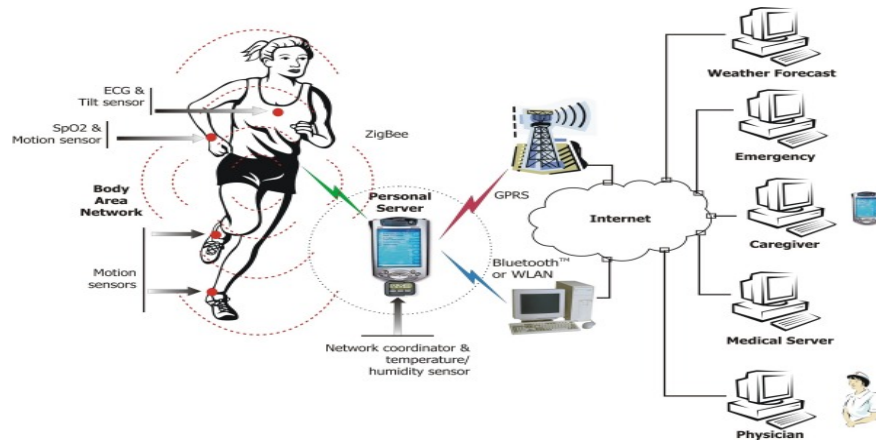
- Unwieldy wires between sensors and a processing unit
- Lack of system integration of individual sensors
- Interference on a wireless communication channel shared by multiple devices
- Non-existent support for massive data collection and knowledge discovery.

Traditionally, personal medical monitoring systems, such as Holter monitors, have been used only to collect data for off-line processing. Systems with multiple sensors for physical rehabilitation feature unwieldy wires between electrodes and the monitoring system. These wires may limit the patient's activity and level of comfort and thus negatively influence the measured results. A wearable health-monitoring device using a Personal Area Network (PAN) or Body Area Network (BAN) can be integrated into a user's clothing. Recent technology advances in wireless networking, micro-fabrication, and integration of physical sensors, embedded microcontrollers and radio interfaces on a single chip, promise a new generation of wireless sensors suitable for many applications, such as stroke rehabilitation, physical rehabilitation after hip or knee surgeries, myocardial infarction rehabilitation, and traumatic brain injury rehabilitation. Increased system processing power allows sophisticated real-time data processing on sensors, which reduces wireless channel utilization and power consumption. We propose a wireless BAN composed of off-the-shelf sensor platforms with application-specific signal conditioning modules.

## **5. System Architecture**

A general multi-tier system architecture [3] is shown in Figure 1; the lowest level encompasses a set of

intelligent physiological sensors; the second level is the personal server (Internet enabled PDA, cell-phone, or home computer); and the third level encompasses a network of remote health care servers and related services (Caregiver, Physician, Clinic, Emergency, Weather). Each level represents a complex subsystem with a local hierarchy employed to ensure efficiency, portability, security, and reduced cost. The personal server, running on a PDA or a 3G cell phone, provides the human-computer interface and communicates with the remote server(s).



**Figure1:** Wireless Body Area Network of Intelligent Sensors for Health Monitoring

### 5.1 Biometric Sensor

Biometric sensor combines the physical traits of human body with digital technology to give birth to biometric security. These semiconductor devices are provided with template database and algorithms to match live biometric samples with those stored in the database. Various fields around us have been touched by the usefulness of these devices and more application areas are being discovered. Tagged as state-of-the-art biometric devices, you can depend upon them for high recognition accuracy.

#### Features of Biometric Sensor

- i. Distinct algorithms are installed in a biometric sensor to ensure precise user authentication as the output.
- ii. Analog to digital converters are main features of these devices, which convert biometric analog data to digital codes.
- iii. The physical traits, like fingerprints, face metrics, vein structures in hands and others are used by these devices to prepare templates.
- iv. Fast identification and verification are included in the list of features offered by these biometric security devices.
- v. These devices are available in three different categories, including semiconductor sensors, optical sensors and ultrasound sensors

In this section, we demonstrate the use of sensors for continuous monitoring of glucose in WBAN through a

case study.

### 5.2 Scenario

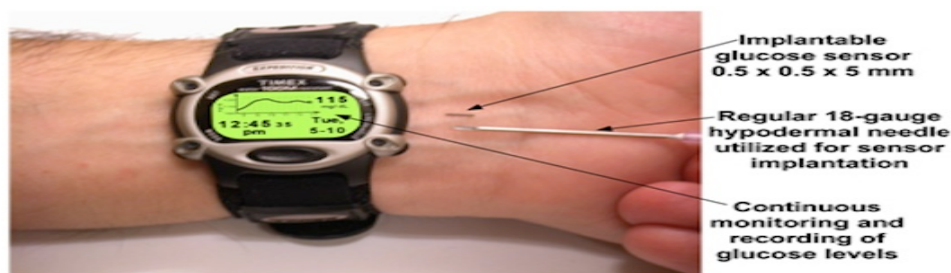
Serena is an elderly woman with type 2 diabetes. She uses a blood glucose sensor that monitors her blood sugar level continuously and sends it to the hospital server for monitoring purpose. During her last visit, the physician prescribed the Metformin and Glimpiride, and also advised her to go on diet. The physician wants to ensure that Serena stays on her diet until her next regular monthly appointment. Meanwhile, the physician is interested in how well the prescribed medication work during this period. However, if Alisha’s blood sugar level stays high, even for a week, she will need to visit sooner than her scheduled appointment. As well she is at the risk of hypoglycemia (i.e. low blood sugar level) that could result in losing consciousness. Consequently, the physician wants to make sure that she receives emergency medical services promptly in the case of extreme hypoglycemia. Finally, in case of an emergency, the physician should get the information through wearable Body Access Network which mainly includes the sensors for continuously glucose monitoring.

The above considerations suggest that there is a need for a glucose sensing device that can function as a hypoglycemia alarm. To be effective for hypoglycemia detection, this sensing system should operate continuously and not rely on the initiative of the user for sample collection. A continuous glucose sensor would also be of great value in the management of hyperglycemia and, in conjunction with a controllable insulin delivery system, may lead to much closer blood glucose control. It is desirable to exploit the continuous glucose sensor.

**Table 1:** Blood sugar levels for human being.

	Normal	Diabetes
Fasting blood sugar	80-99 mg/dl	126 mg/dl and above
Random blood sugar	80-139 mg/dl	200 mg/dl and above
2 hours glucose tolerance test	80-139 mg/dl	200 mg/dl and above

### 5.2 Enzyme electrode sensors based on hydrogen peroxide detection



**Figure 2:** Proposed prototype sensor for blood sugar monitoring.

One type of glucose sensor is an acute subcutaneous implantable sensor based on the enzyme electrode principle and detection of hydrogen peroxide. This system consists of a small, needle-like sensor to be placed under the skin by the patient himself on a 3–7 day basis, and of an electronic control unit (ECU) for processing the sensor output. This sensor has been fabricated at the size of an insulin injection needle, is flexible, and can be implanted through a 21-gauge needle in the subcutaneous tissue. The team [6] has developed a wearable, battery-driven ECU, which controls the sensor potential, stores and processes the current. An in vivo calibration procedure is made possible by entering the device the values of two different blood glucose concentrations and the corresponding currents, during a temporary connection of the ECU to a portable personal computer. Signal processing is performed by sophisticated algorithms based on mathematical morphology techniques. Data have been generated by implanting sensors in the subcutaneous tissue of rats, dogs, and human volunteers.

### **5.3 Measurement of glucose**

A two-point in vivo calibration procedure has been developed for transforming the sensor output into an estimation of glucose concentration. By this method, the blood glucose level is changed by administering glucose (or during a meal) and two blood glucose levels are measured. By comparing them with corresponding values of the current, it is possible by linear extrapolation to determine an in vivo sensitivity,  $S$ , and an extrapolated background current,  $I_0$ , that would be observed in vivo in the absence of glucose, and then to apply these parameters to the current  $I$ , to get an estimation of the subcutaneous glucose concentration as  $G = (I - I_0)/S$ . This procedure has been validated with a glucose sensor implanted in the subcutaneous tissue of rats, dogs, and human volunteers. Software is developed for sensor calibration based on recognizing a sensor output plateau, which triggers a request for blood glucose determination. The ECU is now able to compare its estimation of glucose concentration to a hypoglycemic threshold, which can be set by the user, and to trigger an alarm.

Issues related with this sensor

- Longevity of the sensor;
- Need for re-calibration;
- The relationship between blood and subcutaneous glucose concentration, especially during or after hypoglycemia, and during exercise.

In this scenario, the enzyme electrode sensor based on hydrogen peroxide detection can be made a component of Wearable BAN in the form of wearable device which will continuously measure the blood sugar level of the patient/user. Then these signals are transmitted to the Medical server through a PDA using wireless network such as ZigBee, 2.5/3G. In hospital, the patient's database is present which is set with certain value and if it goes above or below the threshold value, few immediate responses will be sent back to the patient's /user for necessary preventive action.

## **6. Conclusion**

The starting point was a vision of ubiquitous mobile health services based on Body Area Networks (BAN).

During this we were trying to designed and prototyped a health BAN and a BAN service platform and developed services for the different patient's groups according to the requirement specified by the clinical partners. Ten different scenarios have been discussed, as per the scenario we have to evaluate the data such as which types of sensors are required, how they will be cost effective. The main element of this evaluation will be an analysis of the suitability of 2.5/3G public wireless infrastructure for the support of remote healthcare monitoring.

In this several issues need to be resolved by both networks operators and hardware manufacturer for a better support to mobile health services. Ambulatory monitoring is more successful for some bio signals than others, for example some measurements are severely disrupted by movement artefacts, some monitoring equipment is still too cumbersome for ambulatory use, because of the nature of equipment or because of power requirement, while even with 2.5 and 3G we will still suffer from limited bandwidth for applications that serve many simultaneous users. Other challenges related to security, integrity and privacy of data during transmission to both local transmissions e.g. intra BAN and long range extra BAN communications. Powering always on devices and continuous transmission will continue to raise technical challenges. Business models for healthcare and accounting and billing models for network services need to evolve if technical innovative are to be exploited fully. Standardization at all levels is essentials for open solutions to prevail.

At the same time specialization, customization and personalization are widely considered to be success criteria for innovative services. So work can be carried out with any of the ten scenarios with proper evaluation of data, resources availability, with high level of security and accuracy by developing a suitable model for it and employing highly accurate and proper sensors so that the data of illness will be transferred to the clinical centers for proper corrective measures.

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