Continuous Health-monitoring for early Detection of Patient by Web Telemedicine System

Hafez Fouad , hafez@eri.sci.eg

Microelectronics Dept., Electronics research Institute, Cairo, Egypt

ABSTRACT___Continuous Monitoring of vital signs of a patient by Wireless Sensor network (WSN) can help in diagnosis and can monitor patient's history in routine life activities to provide accurate diagnosis. Doctors can check the complete details of patients from remote location and can recommend a suitable medication. The main purpose of this technology is to reduce the load at hospitals and provide efficient healthcare facility remotely. To monitor the patients in their natural environments is not practical when devices or sensors are connected through a wire that is why we use Wireless body area network (WBAN) to carrying out daily activities through unobtrusive and contented way. In these networks various sensors are attached on clothing or on the body or even implanted under the skin. The wireless nature of the network and the wide variety of sensors offer numerous new, practical and innovative applications to improve health care and the Quality of Life. Using a WBAN, the patient experiences a greater physical mobility and is no longer compelled to stay in the hospital. This technology can provide very cheaper, easier and quick respondent history of patient. This paper discusses the architecture of (WBAN), and its position between different technologies. The paper also introduces the web portal telemedicine solution, and the implementation of telemedicine monitoring system using Wireless Body Area Networks.

KEYWORDS___Health Monitoring system, Telemedicine, Wireless Body Area Networks (WBAN), Body sensor network (BSN).

1. INTRODUCTION

The aging population in many developed countries and the rising costs of health care have triggered the introduction of novel technology-driven enhancements to current health care practices. Recent advances in electronics have enabled the development of small and intelligent bio-medical sensors which can be worn on or implanted in the human body. These sensors need to send their data to an external medical server where it can be analyzed and stored. Using a wired connection for this purpose turns out to be too cumbersome and involves a high cost for deployment and maintenance.

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Hafez Fouad Author is with the Electronics Research institute since 1994, (corresponding author phone: 202-333-10503; fax: 202-333-69738; e-mail: hafez@eri.sci.eg).

However, the use of a wireless interface enables an easier application and is more cost efficient [1]. The patient experiences a greater physical mobility and is no longer compelled to stay in a hospital. This process can be considered as the next step in enhancing the personal health care and in coping with the costs of the health care system. Where eHealth is defined as the health care practice supported by electronic processes and communication, the health care is now going a step further by becoming mobile. This is referred to as mHealth [2]. In order to fully exploit the benefits of wireless technologies in telemedicine and mHealth, a new type of wireless network emerges: a wireless on-body network or a Wireless Body Area Network (WBAN). This term was first coined by Van Damet al. in 2001 [3] and received the interest of several researchers [4-8].

Wireless Body Area Networks (WBAN) has emerged as a key technology to provide real-time health monitoring of a patient and diagnose many life threatening diseases. WBAN is a communication network composed of wireless sensor devices operates in close vicinity to, on, or inside a human body to acquire critical data for remote monitoring by health care providers. IEEE 802 has established a Task Group called IEEE 802.15.6 for the standardization of WBAN. The purpose of the group is to establish a communication standard optimized for low-power in-body/ on-body nodes to serve a variety of medical and non-medical applications.

2. SYSTEM ANALYSIS AND DESIGN

2.1. Wireless Sensor Networks

Body area network (BAN), is also called Body sensor networks (BSN) and wireless body area network (WBAN). it is being very popular in society because patient's data monitoring is a leading issue for health & disease management, when patient enters the hospital, doctors & paramedical staff question him about symptoms and try to find the actual symptoms through different tests and prolonged stay at hospital, now the patient is equipped with different sensors, all these are connected by wires, it

is very uncomfortable situation. The core concept behind Wireless body area networks is to remove all wires connecting sensors on the patient and developing wireless network between sensors. All these devices are connected without cables and without reducing patient comfort. Moreover, patient could be monitored remotely. Doctors are mostly interested in diagnostic of cardiogram, blood pressure, oxygen saturation, sugar level and cancer, which can be measured using a number of sensors nodes attached to the patient [1,7]. The goal of e-health approach is to empower the citizen to fight against diseases and reduce the logistic constraints for patients and doctors. This technology has potential to revolutionize the health care diligence by providing real time patient monitoring capabilities to the health care professionals, Implanted wireless body area networks (IWBN) have emerged as an important and growing area of research [4-8].

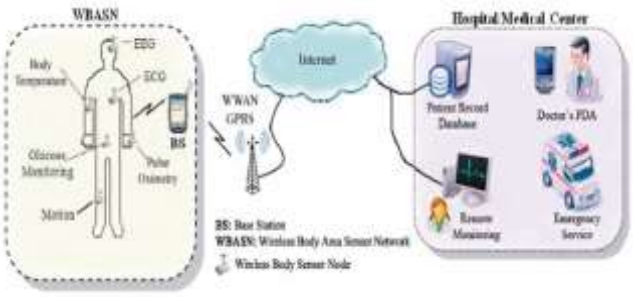

Figure.1 WBASN as an example of WSN [10].

2.2. Architecture of Wireless Body Area Network

A Wireless Body Area Network consists of small, intelligent devices attached on or implanted in the body which are capable of establishing a wireless communication link. These devices provide continuous health monitoring and real-time feedback to the user or medical personnel. Furthermore, the measurements can be recorded over a longer period of time, improving the quality of the measured data [12].

In order to realize communication between these devices, techniques from Wireless Sensor Networks (WSNs) and ad hoc networks could be used. However, because of the typical properties of a WBAN, current protocols designed for these networks are not always well suited to support a WBAN. The following table illustrates the differences between a Wireless Sensor Network and a Wireless Body Area Network:

Challenges	Wireless Sensor Network	Wireless Body Area Network
Scale	Monitored environment (meters / kilometers)	Human body (centimeters / meters)
Node Number	Many redundant nodes for wide area coverage	Fewer, limited in space
Result accuracy	Through node redundancy	Through node accuracy and robustness
Node Tasks	Node performs a dedicated task	Node performs multiple tasks
Node Size	Small is preferred, but not important	Small is essential
Network Topology	Very likely to be fixed or static	More variable due to body movement
Data Rates	Most often homogeneous	Most often heterogeneous
Node Replacement	Performed easily, nodes even disposable	Replacement of implanted nodes difficult
Node Lifetime	Several years / months	Several years / months, smaller battery capacity
Power Supply	Accessible and likely to be replaced more easily and frequently	Inaccessible and difficult to replaced in an implantable setting
Power Demand	Likely to be large, energy supply easier	Likely to be lower, energy supply more difficult
Energy Scavenging Source	Most likely solar and wind power	Most likely motion (vibration) and thermal (body heat)
Biocompatibility	Not a consideration in most applications	A must for implants and some external sensors
Security Level	Lower	Higher, to protect patient information
Impact of Data Loss	Likely to be compensated by redundant nodes	More significant, may require additional measures to ensure QoS and real-time data delivery.
Wireless Technology	Bluetooth, ZigBee, GPRS, WLAN, . . .	Low power technology required

Table.1 Schematic overview of differences between Wireless Sensor Networks and WBANs

2.3. Wireless Body Area Network Devices

Generally speaking, two types of devices can be distinguished: sensors and actuators. The sensors are used to measure certain parameters of the human body, either externally or internally. Examples include measuring the heartbeat, body temperature or recording a prolonged electrocardiogram (ECG). The actuators (or actors) on the other hand take some specific actions according to the data they receive from the sensors or through interaction with the user. E.g., an actuator equipped with a built-in reservoir and pump administers the correct dose of insulin to give to diabetics based on the glucose level measurements. Interaction with the user or other persons is usually handled by a personal device, e.g. a PDA or a smart phone which acts as a sink for data of the wireless devices.

There are three kinds of devices used in wireless body area network which are described as following:

(Wireless) Sensor node: A device that responds to and gathers data on physical stimuli, processes the data if necessary and reports this information wirelessly. It consists of several components: sensor hardware, a power unit, a processor, memory and a transmitter or transceiver [13].

(Wireless) Actuator node: A device that acts according to data received from the sensors or through interaction with the user. The components of an actuator are similar to the sensor's: actuator hardware (e.g. hardware for medicine administration, including a reservoir to hold the medicine), a power unit, a processor, memory and a receiver or transceiver.

(Wireless) Personal Device (PD): A device that gathers all the information acquired by the sensors and actuators

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and informs the user (i.e. the patient, a nurse, a GP etc.) via an external gateway, an actuator or a display/LEDS on the device. The components are a power unit, a (large) processor, memory and a transceiver. This device is also called a Body Control Unit (BCU) [14], body gateway or a sink. In some implementations, a Personal Digital Assistant (PDA) or smart phone is used. ,it is provide suitable graphic or audio interface to client and transfer health related data to medical server through internet, wimax, volte or mobile telephone networks.

Many different types of sensors and actuators are used in a WBAN. The main use of all these devices is to be found in the area of health applications. In the following, the term nodes refer to both the sensor as actuator nodes. The number of nodes in a WBAN is limited by nature of the network. It is expected that the number of nodes will be in the range of 20-50 [15, 16].

The data rates for the different applications are given in Table (2) and are calculated by means of the sampling rate, the range and the desired accuracy of the measurements [17,18].

Application	Data Rate	Bandwidth	Accuracy
ECG (12 leads)	288 kbps	100-1000 Hz	12 bits
ECG (6 leads)	71 kbps	100-500 Hz	12 bits
EMG	320 kbps	0-10,000 Hz	16 bits
EEG (12 leads)	43.2 kbps	0-150 Hz	12 bits
Blood saturation	16 bps	0-1 Hz	8 bits
Glucose monitoring	1600 bps	0-50 Hz	16 bits
Temperature	120 bps	0-1 Hz	8 bits
Motion sensor	35 kbps	0-500 Hz	12 bits
Cochlear implant	100 kbps	–	–
Artificial retina	50-700 kbps	–	–
Audio	1 Mbps	–	–
Voice	50-100 kbps	–	–

Table.2 Examples of medical WBAN applications [15-18, 21]

An example of a medical WBAN used for patient monitoring is shown in Figure (2). Several sensors are placed in clothes, directly on the body or under the skin of a person and measure the temperature, blood pressure, heart rate, ECG, EEG, respiration rate, SpO2-levels etc. Next to sensing devices, the patient has actuators which act as drug delivery systems. The medicine can be delivered on predetermined moments, triggered by an external source (i.e. a doctor who analyzes the data) or immediately when a sensor notices a problem.

One example is the monitoring of the glucose level in the blood of diabetics. If the sensor monitors a sudden drop of glucose, a signal can be sent to the actuator in order to start the injection of insulin. Consequently, the patient will experience fewer nuisances from his disease. Another example of an actuator is a spinal cord stimulator implanted in the body for long-term pain relief [19].

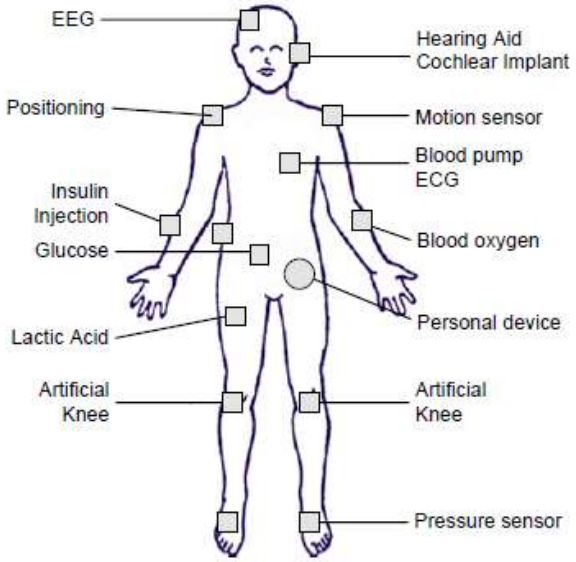

Figure.2 Example of patient monitoring in a Wireless Body Area Network [15]

A WBAN can also be used to offer assistance to the disabled. For example, a paraplegic can be equipped with sensors determining the position of the legs or with sensors attached to the nerves [20]. In addition, actuators positioned on the legs can stimulate the muscles. Interaction between the data from the sensors and the actuators makes it possible to restore the ability to move. Another example is aid for the visually impaired.

An artificial retina, consisting of a matrix of micro sensors, can be implanted into the eye beneath the surface of the retina. The artificial retina translates the electrical impulses into neurological signals. The input can be obtained locally from light sensitive sensors or by an external camera mounted on a pair of glasses [21].

2.4. Positioning WBANs between technologies

In order to have clear understanding, we propose the following definitions: intra-body communication and extra-body communication. An example is shown on Figure (3).

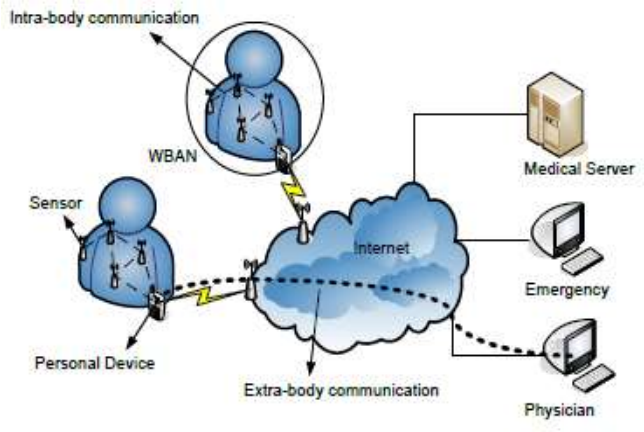

Figure.3 Example of intra-body and extra-body communication in a WBAN.

The former controls the information handling on the body between the sensors or actuators and the personal device [23-26], the latter ensures communication between the personal device and an external network [27] , [28-30]. Doing so, the medical data from the patient at home can be consulted by a physician or stored in a medical database. This segmentation is similar to the one defined in [30] where a multi-tiered telemedicine system is presented. Tier 1 encompasses the intra-body communication, tier 2 the extra-body communication between the personal device and the Internet and tier 3 represents the extra-body communication from the Internet to the medical server. The combination of intra-body and extra-body communication can be seen as an enabler for ubiquitous health care service provisioning. An example can be found in [31] where Utility Grid Computing is combined with a WBAN. Doing so, the data extracted from the WBAN is sent to the grid that provides access to appropriate computational services with high bandwidth and to a large collection of distributed time-varying resources.

To date, development has been mainly focused on building the system architecture and service platform for extra-body communication. Much of these implementations focus on the repackaging of traditional sensors (e.g. ECG, heart rate) with existing wireless devices. They consider a very limited WBAN consisting of only a few sensors that are directly and wirelessly connected to a personal device. Further they use transceivers with a large form factor and large antennas that are not adapted for use on a body.

In Figure (4), a WBAN is compared with other types of wireless networks, such as Wireless Personal (WPAN), Wireless Local (WLAN), Wireless Metropolitan (WMAN) and Wide Area Networks (WAN) [42]. A WBAN is operated close to the human body and its communication range will be restricted to a few meters, with typical values around 1-2 meters. While a WBAN is devoted to interconnection of one person's wearable devices, a WPAN is a network in the environment around the person. The communication range can reach up to 10 meters for high data rate applications and up to several dozens of meters for low data rate applications.

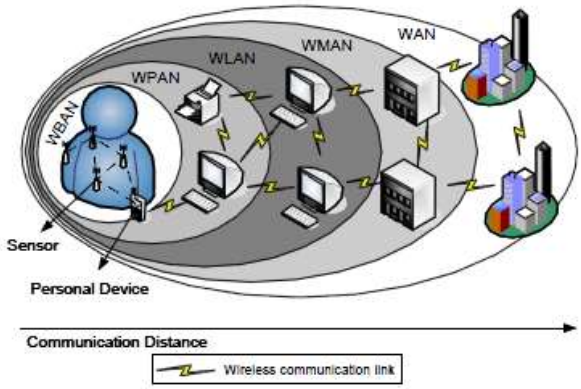

Figure.4 Positioning of a Wireless Body Area Network in the realm of wireless networks.

2.5. Web Portal Telemedicine System

Telemedicine enables the remote delivery of patient care using integrated health information systems and telecommunication technologies and allows scientists, physicians and other medical professionals around the world to serve more patients. The healthcare servers keep electronic medical records of registered users and provide different services to patients, medical consultants and informal caregivers. The patient's consultant can access the data from office via internet and examine the patient's history, current symptoms and patient's response to a give treatment. Once WBAN network is configured, the healthcare server manages the network, taking care of channel sharing, time synchronization, data retrieval and processing [22].

For patients to use these services he must register on our healthcare server; Ain Medical portal (www.ainmedical.com), and insert his/her medical history (all personal information, radiograph and tests). The system Requirements is the registration of a new user as Patient which allows him to become a member of the AinMedical's portal with Pre-condition having a valid email address to complete registration. AinMedical portal sends message to the patient to activate his/her account. A Message is also sent to AinMedical's Administrator (new Patient has been registered), AinMedical presents welcome

page for New Patient and provide link to login his account. As indicated in figure (5).

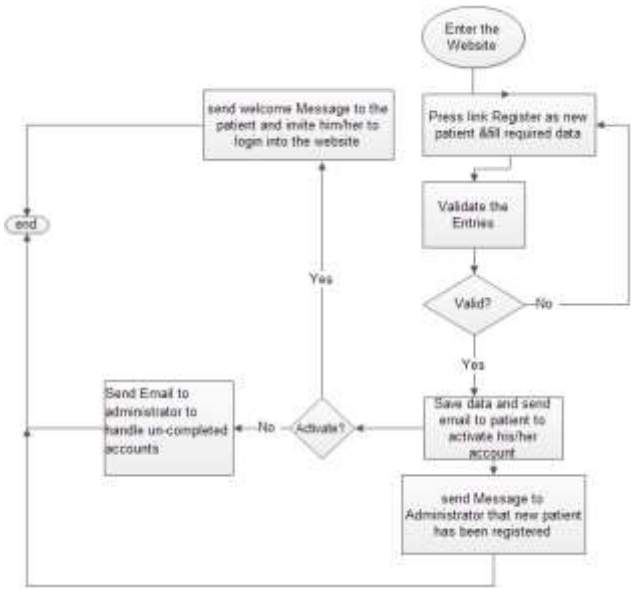

Figure.5 Patient Registration

Portal's patient needs to add his basic information. The patient enter to Telemedicine link, then user press " Add/View medical history", and select the needed link to review/add data for (basic information, diseases, symptoms ,pharmaceuticals, surgeries, sensitivities, radiograph, tests).

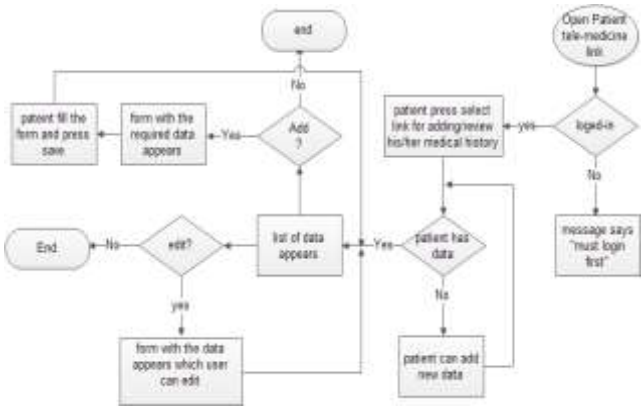

Figure.6 Patient add basic information & medical history

If Portal's patient needs to use telemedicine services and make booking, this requires the patient to review doctor list or search doctors. The patient press "book now" which beside the doctor he needs, fills the form of booking and selects the time and press send. The request will be sent and the payment taken from patient credit.

If Portal's patient needs to review his booking list. the patient enter to Telemedicine link, then user press "booking data" link & review his booking list. If the conversation with doctor done, patient can review the prescription and required radiograph & tests.

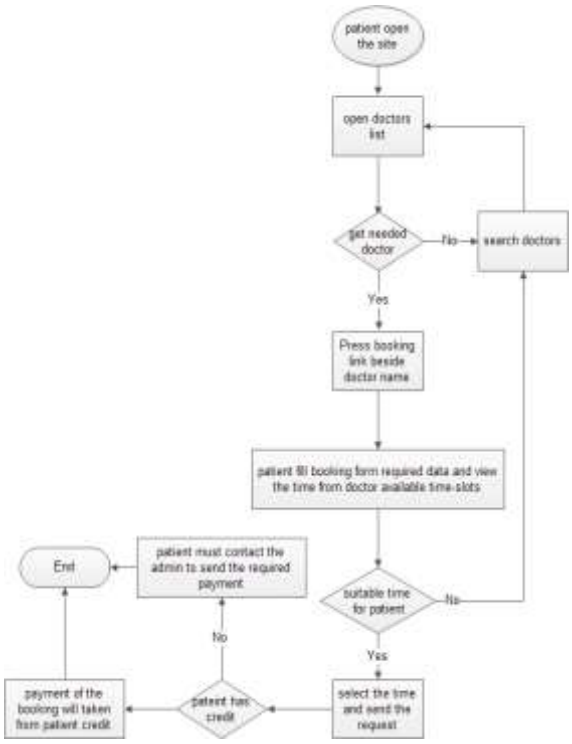

Figure.7 Patient reviews his booking list

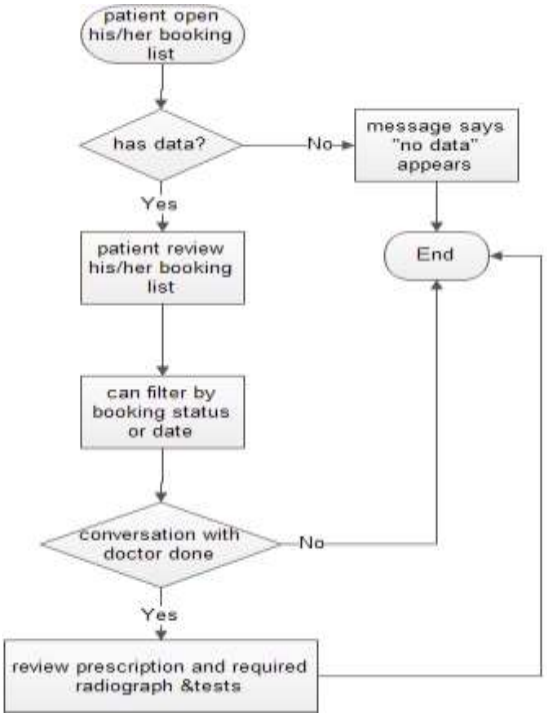

Figure.8 Patient makes booking

The patient can reserve an appointment with any doctor regardless his position through Ain Medical portal and a sample of the video conference between the doctor and patient in figure (9). The patient will use wireless sensor devices to acquire different data (to take prearrangement measures to control the following diseases: Blood pressure, Heart Attack, Diabetes, Glucose Level & many others) for remote monitoring by the doctor such that he could diagnose diseases.

Figure.9 Video conference between the doctor and patient through Ain Medical Portal

The complete telemedicine system process with its steps appears in Figure (10).

Figure.10 Telemedicine system process between the doctor and patient through Ain Medical Portal

Figure (11) shows an example of Ain Medical Web Telemedicine monitoring system. There are 2 graphics on each side. The first graphic shows real-time values of the received data from the selected sensor as a function of time. Maximum and minimum values are shown as dashed lines in same graphic. The second graphic, which is located under the first, displays average values belonging to the selected sensor as a bar graph according to the input value and unit (daily, weekly, monthly). For example, the second graphic on the right side in shows the average value of the sensed body temperature as a function of the last 5 weeks. This feature provides doctors with useful information about patients.

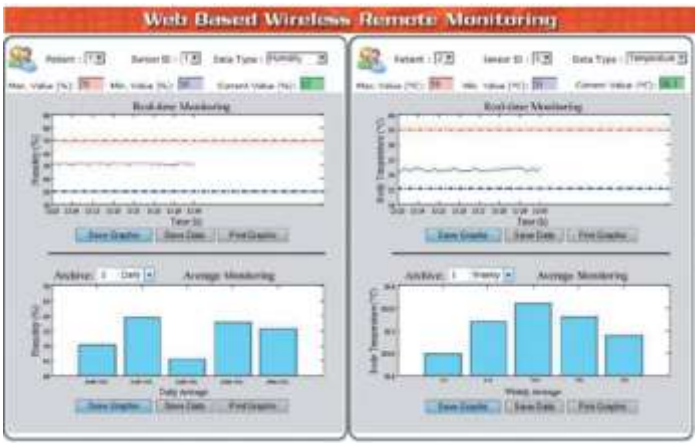

Figure.11 Web-based Telemedicine monitoring system

There is an additional important feature, such as the ability to save graphics and sensed data, and then print them. These properties make it possible to report on patient health information. Thus, medical professionals can detect vital sign variations with long-term health monitoring.

2.6. Telemedicine Hardware requirements

As discussed before, the patient can reserve an appointment with any doctor through Ain Medical portal and make the video conference with the doctor. The patient will use wireless sensor devices to acquire different data for remote monitoring by the doctor such that he could diagnose diseases as shown in Figure (8). The following points determine the needs in a Telemedicine Setup:

- High quality video which leads to a great patient experience.
- Doctor not restricted to a room, can be located anywhere with his laptop and internet.
- Integrated with patient hardware such as digital stethoscope, BP, ECG etc -much more than just a video conferencing experience.
- Integrated with a teleradiology platform enabling Xrays/CT's etc of patient to be transmitted to the treating doctor.
- Works on Low bandwidth (512 kbps), ideal for rural area.

There are two types of hardware devices required of BAN.

- Wearable devices are used on the body surface of human.
- Medical Implanted devices are inserted inside human body.

In wireless body area network, wearable systems for incessant health monitoring are a key technology in helping the transition to more pre-emptive and affordable healthcare. They allow monitoring the diagnostic status of patient and providing feedback to maintain an optimal health status and provide her /his better healthcare.

WBAN traffic is divided in three categories

- **Normal traffic** is the data traffic which we use to monitor the normal condition of patient without any criticality and on demand events.
- **On demand traffic** is initiated by the doctor or consultant to acquire certain information for diagnostic purpose.
- **Emergency traffic** is initiated by nodes when they exceed a predefined threshold and should be accommodate immediately. Such type of traffic is totally unpredictable.

This technology includes unobtrusive & routine health monitoring of patient, and treatment of many other diseases. All data collected through body network coordinator.

3. CONCLUSION

The patient can reserve an appointment with any doctor through Ain Medical portal and make the video conference with him. The patient will use wireless sensor devices to acquire different data for remote monitoring by the doctor such that he could diagnose diseases. Wireless body area network is integrated into telemedical system that promises inexpensive, unobtrusive and ambulatory monitoring during the routine activities. It has the potential to provide a better and less expensive alternative for rehabilitation healthcare and may provide benefit to patients, physicians, and society through continuous monitoring.

A WBAN is expected to be a very useful technology with potential to offer a wide range of benefits to patients, medical personnel and society through continuous monitoring and early detection of possible problems.

4. FUTURE WORK

To make this technology ubiquitous and affordable, a number of challenging issues should be resolved, such as system design, configuration and customization, seamless integration, standardization, further utilization of common off-the-shelf components, security and privacy, and social issues.

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Hafez Fouad, Author, he received his BSc. degree in Electronics and communications engineering in 1993, EGYPT and received his M.Sc. and Ph.D. degrees from Ain Shams University in 2001 and 2008. His Ph.D. is dedicated to Performance Optimization of CMOS RF Power Amplifiers for Mobile Communication systems. The M.Sc. is dedicated to Design and Optimization of Silicon RF Front-ends For Mobile Communication Systems. He is a researcher at the Electronics Research Institute (ERI), Ministry of Scientific Research since 1994, Cairo, Egypt. His current research interests are Telemedicine Systems, wireless sensors network, Bioelectronics, Bioinformatics and their applications.