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Wireless Body Area Network: Challenges, Applications and Security

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***Abstract*— Wireless Body Area Network (WBAN) is a replacement technology that can be used to incorporate these devices & thereby provide health monitoring applications in healthcare. Further development of wireless communications in recent years has led to the use of sensing element networks, which are low priced. These networks have a wide variety of applications. Various technical problems in these application areas are being resolved by researchers across the world. Apart from it, it addresses a wide variety of challenges in these technologies.**

***Keywords*— Wireless body area networks, Health care Applications, WSN, patient monitoring, sensor, MAC**

I. INTRODUCTION

Wireless body area network is a wireless networking technology based on Radio Frequency (RF) that connecting the number of small nodes with sensor or actuator capabilities. WBAN is defined as a sort of extremist short range wireless networking technology.Wireless Sensor Networks (WSNs) are used to screen certain parameters in numerous applications like environment checking, habitant observing, combat zone, farming field checking and shrewd homes. Energy consumption in WBAN very less in comparison to WSNs arrangement. In addition WBAN sensor devices are cheaper than WSNs.The remote sensors are scattered in detecting region to screen field. WBAN is new sub-field of WSN. A basic use of WBAN is well-being checking. Remote sensors are embedded in the body to screen signs like circulatory strain, body temperature, heart rate, glucose level and many more. With the assistance of WBAN, patients are observed at home for more period. Sensors perpetually sense information and forward to medicinal server. It is required to exploit minimum power for transmitting information from sensor hubs to sink. One of the important obstructions in WBAN is to energize the batteries. A productive directing convention is required to overcome this issue of energizing batteries. Innumerable vitality proficient directing conventions are proposed in WSN innovation. However, WSNs and WBANs have different designs, applications and work in various conditions. WSN steering conventions are hard to port to WBAN. Hence, energy effective directing convention for WBAN is required to screen patients for more period. We propose a high performance, dependable and stable directing convention for WBAN. Sensors for ECG and Glucose level are set proximate to the sink. Both these sensors have basic information of patient and required least constriction, high unwavering quality and long life therefore; these sensors dependably transmit their information specifically to sink. Different sensors take their guardian hub and transfer their information down via forwarder hub to sink. It spares hubs vitality and works with the system for longer time.

Body Area Networks (BANs) exhibit sundry application open doors in human accommodations, sports, and different territories where individual data is to be stored and given to another individual or a focal database.

Typical examples of potential uses include stroke recovery, physical rehabilitation following hip or knee surgeries, myocardial infarction rehabilitation, and rehabilitation of encephalon injury. The assessment of the efficacy of rehabilitation procedures has been circumscribed to the laboratory setting; relatively little is keened about rehabilitation in authentic-life situations. Miniature, wireless, wearable technology offers an enormous opportunity to tackle this issue.

II. REQUIREMENTS OF WBANS

Wireless medical sensors should satisfy the following main requirements such as wearability, reliability, security, and compatibility.

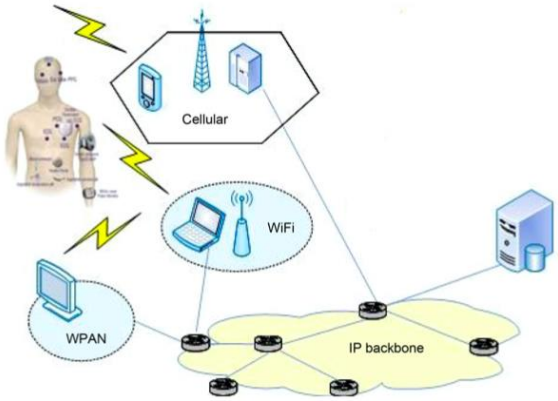

Fig. 1 A typical WBAN Communication

A. Wearibility

To achieve non-invasive and unobtrusive continuous monitoring. These sensors must be lightweight and small. Size and weight of sensors are chiefly decided by the battery size and weight. [1] But, a battery's capacity is directly proportional to its size.

B. Reliability

Reliable communication in WBANs is crucial for any WBAN application. So the designer should aim for a reliable communication technique that ensures uninterrupted communication and optimum output. A punctilious trade-off between communication and computation is very important for a reliable system design.

C. Security

Another consequential issue is the security of the network. All the wire- less medical sensors must meet the requirements of privacy and should ensure data integrity and authentication.

D. Compatibility

Wireless medical sensors should allow users to easily build a robust WBAN. Standards governing that interaction of wireless medical sensors will help vendor competition and eventually lead to more accessible systems [2].

III. ARCHITECTURE OF WBAN

Perpetual technological advances in integrated circuits, wireless communication, and sensors enable the development of miniature, non-invasive physiological sensors that communicate wirelessly with a personal server and then a remote emergency, weather forecast or medical database server through the Internet; using baseline, sensor (WBAN) and environmental information, algorithms may result in patient specific recommendations. The personal server provides the human-computer interface and connects the remote server(s), running on a PDA or 3G cell phone.

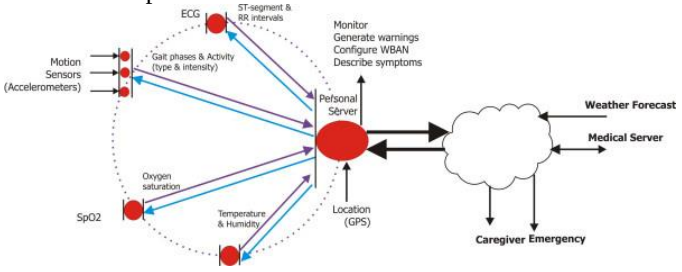

Fig. 2 Data flow in Integrated WBAN

Fig.2 shows a generalized overview of a multi-tier system architecture; 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. Each level represents a fairly intricate subsystem with a local hierarchy employed to ascertain efficiency, portability, security, and cost savings [3].

A. Sensor Level

Depending on the end-user application a WBAN can include a variety of physiological sensors. Multiple sensor information can be combined to generate new information, like total energy expenditure. An extensive set of physiological sensors may include the following:

- an ECG (electrocardiogram) sensor for monitoring heart activity
- an EMG (electromyography) sensor for monitoring muscle activity
- an EEG (electroencephalography) sensor for monitoring brain electrical activity
- a blood pressure sensor
- a breathing sensor for monitoring respiration
- movement sensors used to estimate user's activity
- a "smart sock" sensor or a sensor equipped shoe insole used to delineate phases of individual steps

These physiological sensors typically generate analog signals that are interfaced to standard wireless network plat- forms that provide computational, storage, and communication capabilities. Multiple physiological sensors can share a single wireless network node. In addition, physiological sensors can be interfaced with an intelligent sensor board that provides on-sensor processing capability and communicates with a standard wireless network platform through serial interfaces.

The wireless sensor nodes should satisfy the following requirements: minimal weight, miniature form-factor, low-power operation to permit prolonged continuous monitoring, seamless integration into a WBAN, standard-based interface protocols, and patient-specific calibration, tuning, and customization. These requirements represent a challenging task, but we believe a crucial one if we want to move beyond 'stovepipe' systems in healthcare where one vendor creates all components. Only hybrid systems implemented by combining off-the-shelf, commodity hardware and software components, manufactured by different vendors promise proliferation and dramatic cost reduction.

The wireless network nodes can be implemented as minute patches or incorporated into attire or shoes. The net- work nodes continuously collect and process raw information, store them locally, and send them to the personal server. Type and nature of a healthcare application will decide the frequency of germane events (sampling, processing, storing, and communicating). Ideally, sensors relay their status and events regularly, therefore significantly minimizing power consumption and elongating battery life. When local analysis of data is inconclusive or indicates an emergency situation, the upper level in the hierarchy can issue a request to transfer raw signals to the upper levels where advanced processing and storage is available.

B. Personal Server Level

The personal server performs the following tasks:

- Initialization, configuration, and synchronization of WBAN nodes.
- Control and monitor operation of WBAN nodes.
- Collection of sensor readings from physiological sensors.
- Processing and integration of data from various physiological sensors providing better insight into the user's state.
- Providing an audio and graphical user-interface that can be used to relay early warnings or guidance.
- Secure communication with remote healthcare provider servers in the upper level using Internet services.

The personal server can be implemented on an off-the- shelf Internet-enabled PDA (Personal Digital Assistant) or 3 G cell phone, or on a home personal computer. Multiple configurations are possible depending on the type of wire- less network employed. A network coordinator, attached to the personal server, can perform some of the pre-processing and synchronization tasks. Other communication scenarios are also possible. For example, the personal server running on a Bluetooth or WLAN enabled PDA can communicate with remote upper-level services through a home computer; the computer then serves as a gateway.

IV. APPLICATIONS OF WBANS

WBAN applications traverse a wide zone. A typical WBAN comprises three types of devices: sensors, actuators and personal digital assistant (PDA). WBANs provide an extremely reliable infrastructure for medical devices, particularly those ingrained inside the body. They consist of a variety of small sensors that may be fixed on the body as microchip, either beneath the skin or deeply.

A. Medical Applications

WBANs have an immense potential to alter the eventual fate of human services observing by diagnosing numerous life undermining sicknesses and giving ongoing patient checking [4]. By 2009, the medicinal services use in the United States was around 2.9 trillion and is assessed to achieve 4 trillion by 2015, very nearly 20% of the total national output. Likewise, one of the main sources of death is identified with cardiovascular malady, which is assessed to be as much as 30% of passing's overall [5,6].

In light of advances in innovation the organization and adjusting of human services administrations will be on a very basic level changed and modernized. The utilization of WBANs is required to expand human services frameworks to empower more successful administration and recognition of diseases, and response to emergency as opposed to simply wellbeing [6,7]. Utilizing WBANs as a part of medicinal applications takes into account persistent observing of one's physiological qualities, for example, pulse, heart beat and body temperature. In situations where irregular conditions are recognized, information being gathered by the sensors can be sent to a door, for example, a PDA. The portal then conveys its information by means of a cell system or the Internet to a remote area, for example, a crisis focus or a specialist's room taking into account which a move can be made [8,9]. Furthermore, WBANs will be a key arrangement in early conclusion, checking and treatment of patients with potentially pernicious ailments of several kinds, including diabetes, hypertension and cardiovascular cognate diseases.

WBANs provide interface for medical specialty, remote monitoring of human physiological knowledge. Patients will be treated remotely in near future. WBAN Provides healthcare application that offers immense contribution in improving patient's healthcare and diagnosing and monitoring.

Moreover, it provides medical rehabilitation and supervising of patients. Patients can now be examined at their homes while performing daily activities.

B. Lifestyle and Sports

In, Wireless BAN has its utility in golf as well, wherein it resolves the problem of proper direction of the golf club. In addition to this supplying period response as per the limb of participant in terms of hip movement is also resolved. Conserving energy &ability to perform at maximum altitude by the golf player corresponds to body sensory knowledge of player's movement. Not only does BAN provide better performance observation & nipper observation in sports but it also extends its area to new functions for wireless body area networks.

C. Military Applications

Accomplished experiments are using auditory sensing elements to detect and limit short signals from mortars, weapon systems have been successfully carried out by ARL, the Army Research laboratory which will have a powerful consequence on deadliness &survivability in battlefields [10]. Among the battlefield BAN's applicability is immense, which includes health monitoring, location based services& detection of hot temperature. BAN combined with military uniform forms a wearable network connecting devices like PDA's, cameras, life support sensors, health monitoring which then proceeds to transfer knowledge to & from the soldier's wearable laptop. Chemical recognition, prevention of victims from fire & observation of a soldier's state are some other functions provided by the networks.

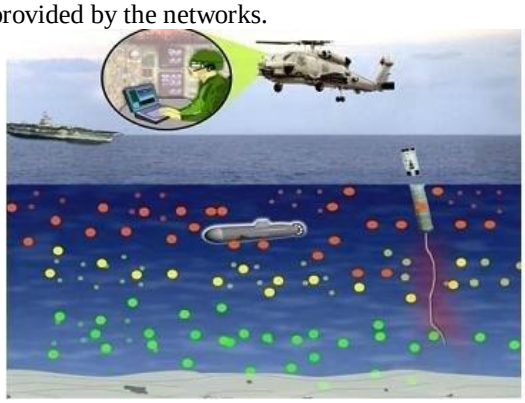

Fig. 3 WBAN in Military Applications

D. WBAN for Animals

Wireless BAN serves as an important tool for diagnosis of various infectious diseases in individuals & animals. This is quite important because both animals & humans share a symbiotic interdependent relationship.

E. Cable and Conductor Theft

Reports of cable glomming including both power cables and telecommunication lines have been reported. Variants of wires are being purloined due to incrementing price of metal.

F. Network and Communication

These technologies decrease the prices of different resources which accordingly facilitate integration with the internet.

V. CHALLENGES OF WBANS

Wireless BAN is an emerging technology with plenty of issues to be addressed. WBAN has to face a number of challenges like confidentiality which is the most important issue. Some important technical challenges are discussed below [11]:

A. Number of nodes

The number of nodes should neither be too many in number nor too less in number depending on the specific applicability.

B. Size of the node

This is an important challenge in WBANs.

C. Security of data

Various security provisions should be provided in WBANs to prevent the sensitive information.

D. Wireless tools

There is an increasing demand for supply of low power wireless tools in WBANs.

E. Compatibility

The various types of equipment's like sensors etc. used in WBANs should be compatible with each other, otherwise sensors supplied externally might increase cost.

VI. SECURITY OF WBANS

Wireless Body Area Networks (WBAN) are used to diagnose various diseases in patients. WBAN provides three levels of security i.e. level 1, level2 & level 3. Level 1 has no inbuilt mechanism for security. Level2 provides a mechanism for authentication only whereas level 3 provides a mechanism for encryption as well as authentication of data.

A. Data Confidentiality & Integrity

Data confidentiality in WBAN's is the most important issue that needs to be addressed. It avoids information leakage. Knowledge integrity is equally important. Import information of the patient could be lost & this could be detrimental from a privacy perspective.

B. Data Authentication

Authentication helps establish proof of identities. MAC (Message Authentication Code) computed using secret key can ensure data authentication.

C. Data Freshness and Secure Localization

Data needs to be refreshed. Old data is stale &useless. Data freshness has two type's i.e. strong freshness wherein data is sent quickly with less delay & weak freshness wherein only partial data is sent with some delay.

D. Availability and Secure Management

In healthcare, it is very important to respond to a patient quickly, supply him the medicines etc. Thus there should be systems that are available 24/7 for a fast response. If any node of the network is attacked, to ensure response to the patient; the compromised node should be changed to ensure secure management & high availability.

VII. CONCLUSIONS

The aim of paper is to study emerging technology called Wireless Body Area Networks (WBAN). The popularity of wearable devices is leading a revolution in traditional medical models. WBAN can not only free people from traditional hospitals and clinics but also reduce the burden of disease management for those with chronic diseases such as diabetes and hypertension especially. In addition to it, various applications, challenges and security issues are also discussed.

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