IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 12 (December. 2018), ||V (III) || PP 72-80

A Survey of Study on WBAN Architecture for Biomedical and Scientific Applications

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ABSTRACT: Recent technologies and developments on Wireless Body Area Networks (WBANs) emphasize remote control health monitoring and continuous, real-time individual care. WBAN is usually a challenging style concern. Since such systems contain small sensors positioned on the body, they impose source and computational limitations, therefore making the usage of advanced encryption algorithms infeasible. This hassles the algorithms with a robust important generation administration scheme, which are reasonably resource ideal. The main reason for the WBAN is definitely to create it easy for individuals who need long term monitoring to become fully cellular. The WBAN can be worn by an individual and basically includes a couple of lightweight products that monitor and wirelessly transmit particular bio signals (essential indicators) to a Backend Program at a Health care middle. A monitoring health care specialist retrieves the individual data over a trusted wired connection. This paper discusses many uses of the WBANs technology, the most apparent software of a WBAN has been in the medical sector. However, additionally, there are even more recreational uses to WBANs which are pointed out right here. This paper discusses the technologies about WBANs and also different applications for WBAN and provides the study of the condition of artwork in Cellular Body Area Systems is directed to provide a much better understanding of the existing research problems in this emerging field.

Keywords: Healthcare, Healthcare applications, Implant communication, Low power MAC, Personal area networks, Physiological signal device, Sensor networks, WBAN applications.

Date of Submission: 13-12-2018 Date of acceptance: 28-12-2018

I. BACKGROUND

System designers and application developers have developed a new type of network architecture generally known as Body Sensor Networks (BSNs) or Wireless Body Area Networks (WBANs). There has been cumulative interest from researchers, have made viable by unique advances on trivial, small-size, ultra-low-power, and intellectual monitoring wearable sensors [1]. In body sensor networks, sensors continuously observe human's physiological activities and actions, such as health status and motion pattern.

Modern health care related technologies and many other field key technologies rely on it as WBANs have many applications. One of them is medical monitoring which have the specific hardware and network requirements to insure their functions and to solve encountered problems. Sensor, battery, and processor have built up WBAN. The security of WBAN is also another very critical issue. Although many protocols and algorithms have been proposed for traditional Wireless Sensor Networks (WSNs) [2], they are not well suited to the unique features and application requirements of WBANs.

WBANs is a technology used for communicating in, on and around the human body .Body sensor networks designate the networks and applications poised and supported by sensors which are safe and convenient that are able to communicate over the wireless environment. It. A precarious survey of current wireless bodyarea network is given here [1–4] by highlighting the technological aspects of biomedical and scientific applications.

II. BODY AREA NETWORK

A wireless body area network comprises of a group of trivial sensor nodes that are placed around the body. The nodes can mutually communicate with the central node which consecutively connects to the internet. The sensors can be attached directly to the skin and also can be placed as a part of special clothing. Each and every node has a small power source otherwise takes power from the body. The nodes can transmit the data from the sensors to a particular application or person.

WBAN can be used not only on remote patients but also enables to make patients wireless within the hospital, especially, in intensive care units and operating theatres. Not only this would enhance patient comfort but also it would make the work of doctors and nurses a lot more efficient and easy. On accident site communication is performed via WBAN, wherein a paramedic strap on the WBAN sensors start providing vital information to the hospital directly, to increase efficiency, reduced reaction time, and saving of crucial life.

Body Sensor Networks uses low power radio frequencies and so to facilitate the Body Area Network I accordance to supply the patients' data in real time. In case of any problems with their current pacemaker if the patient encounters it then it is quite possible that they will have to endure more surgery simply to alter the settings on the pacemaker. The frequency range is between 402 and 405 MHz for Body Area Networks, known as Medical Implantable Communication Service (MICS) band, and is specifically for entrenched devices in order to communicate with the other peripheral devices so that it reaches the doctor in real-time. Hence the added assistance of the 'Healthy Aims' project is the fact that the patient will only ever need to have surgery performed once and this is only to have the device fitted.

The doctors not only monitor patients' general health but also have the ability to change the settings for specific implanted devices so that they perform much better, consequently taming the patients' health. The patients necessitating the pacemakers have to sustain the pain and stress of surgery in order to have their pacemaker device fitted. The pacemakers are arranged as a part of a Body Area Network wirelessly in order to send the patients' health status to a near-by RF transceiver. The very first implantable pacemaker invented was produced in the 1960's and has progressed enormously. From this RF transceiver the data is transmitted to a doctor. The fact that the patient's health status is regularly being forwarded to the doctor means that their health record is always up-to-date and the information is reconciled and updated.

As Body Sensor Networks deals with linking the body to the wireless devices and it has applications in numerous areas such as sports, entertainment, and defense forces. In this attempt, a few research groups throughout the world have initiated channel modeling [3].To build any wireless device, the first vital step is to study the transmission channel and model it precisely.

They have performed measurement campaigns and path loss studies for wireless nodes on the body [4–10]. Some have also considered implanted devices, an area of WBAN called Intra-body Communication [11]. Due to the short-range low data-rate communication in WBAN scenarios, measurement groups have considered UWB as the appropriate air-interface.

Although there are quite a few measurement campaigns, each model developed by them is only a path loss model and does not provide any detail description of the propagation channel.

Even though, a while ago the human body was under focus for the measurement of electromagnetic absorption studies, such as specific absorption rate and dosimeter [12–15]. It is important to study the propagation mechanism of wireless radio waves on and inside the body in order to cultivate a general and accurate wireless body area network channel model .These kind of study will reveal the core transmission characteristics. This will assist in the development of enriched Wireless BAN transceivers, which are apt to the body environment. The human body is a very complex environment and has not been studied unambiguously for wireless communication.

For a WBAN channel model, it is required to determine the electromagnetic field at each point on inside the body for a given position of the transmitter on inside the body. This is a huge problem numerically, which requires enormous amounts of computational power. Therefore, it is desirable to derive an analytical expression which performs this objective. Analytically resolving this problem means solving the Maxwell's equations for each point of the body. In effect this determines which propagation mechanism is taking place, i.e. diffraction, reflection, transmission, surface waves [16]. An elegant manner of doing this task is using the dyadic Green's function. Dyadic Green's functions have been used in Electromagnetic (EM) theory and have solutions for canonical problems, such as cylinders, multilayered cylinders and spheres [17–19]. Wireless Body Area Net-works (WBANs) are composed of wireless nodes, ranging from hand-held devices such as mobile-phones, over smart objects in the environment to miniaturized sensor nodes interacted into garments. These devices provide a heterogeneous collection with varying capabilities in terms of sensors, actuators, processing power, memory, and available energy. The number and type of devices forming a WBANs change over time, as a result of the interaction with other WBANs, e.g. people exchanging objects, or between the WBANs and the environment, e.g. clothes or objects taken from chairs. Wireless Body Area Networks are formed dynamically because the connectivity between nodes depends on their position and their position variation over the time. A sensor node is composed by a transmitter, a receiver, and it offers services of routing between nodes without direct vision, as well as records data from other sensors

III. WBAN BASICS AND APPLICABILITY TO HEALTHCARE

In this section, we review works related to the basic empowering technologies of WBAN and their applicability to healthcare systems.

There are numerous survey papers on WBANs and its technologies. In [39] the authors give a comprehensive survey on WBANs, technologies used, issues and research challenges.[04] discusses about the enabling technologies of WBANs and more about the issues related to healthcare applications. Similar works of survey on WBANs include [05], [07] and [38]

In [16], the authors introduce a multi-tier telemedicine system and define how they augmented our prototype WBAN operation for computer-assisted physical reintegration applications and ambulatory monitoring. The system makes real-time analysis of sensors' data, offers guidance and feedback to the user, and can create cautions based on the user's state, level of activity, and environmental conditions. In addition, all recorded information can be transmitted to medical servers via the Internet and seamlessly incorporated into the user's electronic medical record and research databases.

In [37], the authors examine ZigBee's capability to meet WBSN requirements, with higher communication efficiency and lower power consumption than a Bluetooth serial port profile (SPP) based solution. As a case study an accelerometer-based fall detection algorithm was applied, able to identify eight different fall topologies by means of a single sensor worn on the subjects' waist. This system has a low computational complexity and can be processed on an embedded platform. In this case study it was established that, in a typical operating point, the lifetime in the ZigBee-optimized case is 40% longer than in the non-optimized version of the protocol, and 88% longer than the Bluetooth version.

In [41] the authors present an overview of body area networks, and a discussion of BAN communications types and their related issues. A detailed investigation of sensor devices, physical layer, data link layer, and radio technology aspects of BAN research has been provided. They also present taxonomy of BAN projects that have been introduced/proposed to date. Finally, some of the design challenges and open issues that still need to be addressed to make BANs truly ubiquitous for a wide range of applications have been highlighted.

Wearable monitoring systems can offer constant physiological data, as well as enhanced information about the general health of individuals. Hence, such vital-sign monitoring systems will decrease health-care charges by disease prevention and improve the quality of life with disease management. In [60], recent growth in non-invasive monitoring technologies for chronic disease management is revised. In specific, devices and techniques for monitoring blood pressure, blood glucose levels, cardiac activity and respiratory activity are deliberated. Current sensors technology for vital-sign monitoring is promising to modify the traditional chronic monitoring routine. However, designing non-invasive body-worn sensors is very challenging, often requiring an extensive understanding of the nature of the disease and its effect on physiological constraints. Even though there are sensors available off-the-shelf for cardiac and blood-pressure monitoring, there is still a necessity for enhancement to attain continuous and truly non-invasive monitoring of these constraints.

[03] Presents an energy-efficient MAC protocol for communication within the Wireless Body Area Network. The protocol takes benefit of the static nature of the Body Area Network to implement a TDMA strategy with very little communication overhead, long sleep times for the sensor transceivers and robustness to communicate faults. The protocol is applied on the Analog Devices ADF.7020 RF transceivers.

[25] Defines the concept of sensor networks which has been made feasible by the conjunction of micro electro-mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the prospective sensor networks applications are discovered, and a review of aspects manipulating the design of sensor networks is provided.

[12] Present a multi-hopping network for a Mobility management in WBAN system that can be used in medical environments for isolated monitoring of physiological constraints. The system is different than the existing implemented ones in that consider monitoring of physiological signals from several patients to signify a real implementation in hospital environments has been measured. The proposed system offers mobility to patients and flexibility to Doctor & medical staff to attain patient's physiological data on constant basis via Internet or Mobile. The collected data is transmitted to isolated stations with a multi-hopping technique using the medical gateway. The gateway nodes unite the sensor nodes to the local area network and the internet.

In [23] the authors describe an experimental system that combines a wireless body area network (WBAN) with satellite communication links to enable remote medical treatment and healthcare services. One main advantage of WBAN is that it enables automatic bio signal collection in real time which is essential in medical treatment and healthcare vigilance. The WBAN is implemented using ultra-wideband technology. Multi-hop mechanism is adopted to guarantee reliable connection. In case of less of medical resources such as in emergency, in rural or isolated areas, the system can send the corresponding bio signal to a remote hospital in real time to help patient management by introducing satellite communication links.

In [03] a Medium Access Control Protocol (MAC) for a Wireless Body Area Network (WBAN) has been offered. Designing of MAC for WBAN has key challenges like power competence and flexibility in duty cycle on energy constraint sensor node. To solve it Time Division Multiple Access (TDMA) and Multi beam Anterma method have been exploited simultaneously. Together it provides Spatial Division Multiple Access (SDMA), which has clear benefit over FDMA, CSMA, TDMA etc. In this work Human body is divided in four sector keeping Body Area Network coordinator as its center. All the physiological sensors communicate in Omni directional mode with low power, while Body Area Network Coordinator transfers in directional mode.

In [06] a WBAN PHY simulator is applied static point that is identified PPDU structure and modulation method in WBAN TG6. In the WBAN PHY case, the modulations method is altered by frequency band and data rate. After implementation of simulator, WBAN for hardware implementation has been intended.

In [50] the authors motivation on the estimation of the impact of a collocated IEEE 802.llg the viability of WBAN systems in genuine medical environments has been estimated, considering their toughness to interference. WLAN interferer on the concert of IEEE 802.15.4/ZigBee transceivers, through a combination of physical (PHY) layer simulations and experimental interference tests in a hospital room.

In [35], an Urgency-based MAC (U-MAC) protocol, in which sensor nodes reporting urgent health information are given higher priority by cutting-off the number of packet retransmission of sensor nodes with non-urgent health information, is proposed. The main consideration of this work is providing Quality of Service (QoS) support in medical wireless sensor networks through differentiating nodal access to the medium. The proposed MAC protocol is mathematically analyzed considering a beacon-enabled star network configuration of the IEEE 802.15.4a standard at 2.4 GHz. The used wireless body area network (WBAN) consists of JV sensor nodes controlled by a single network coordinator.

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In [03] a MAC protocol for WBAN using wakeup radio mechanism has been proposed. A detailed analytical model for both energy consumption and delay has been presented. We have simulated the proposed MAC and compared the results. It is found that the proposed MAC has improved the performance in terms of energy consumption and delay. It is found that the proposed TDMA based MAC using wakeup radio can save a significant amount of energy while still having a low delay.

IV. WBAN SECURITY

[12] In this they explain about the general health care policy and isolate the security challenges and requirements. It is an extension of CICADA, which is a cross-layer protocol that handles both medium access and the routing of data in wireless body area networks. It also suggests and evaluates the CICADA-S protocol, a secure cross-layer protocol for WBANs. The CICADA-S protocol is the first cohesive solution that handles the threats that occur in this mobile medical monitoring scenario. It is shown that the assimilation of key management and securing the privacy preserving communication techniques within the CICADA-S protocol which has low influence on the power consumption and throughput.

[27] A novel lightweight protocol for data integrity in wireless sensor networks has been presented. This protocol is based on a leapfrog policy in which each cluster head authenticates its previous node has conserved the integrity of the packet using the secret key it shares with two hops up tree nodes. There is a negligible bandwidth overhead so that the protocol stances very low computational overhead, it needs to compute just a hash as compared to multiple complex operations required by any cryptographic implementation for verifying authenticity. The advantages of this protocol comprise that the protocol is simple, it needs only very fewer header bits, as low as three bits.

[58-59] highs the differences between WSN and WBAN and proposes an efficient key management scheme, which makes use of biometrics and is specifically designed for WBAN domain. It establishes that key management protocols for generic applications of WSN are overly complex for WBAN scenario and cannot exploit the application characteristics of WBAN. After that, it presents BARI+, which is a key management scheme designed specifically for WBAN applications. Also, it provides analysis of our scheme and its comparison with other schemes. Apart from attack prevention, it is also important to focus on attack detection in order to provide a complete security solution.

In [52-53], the authors first highlight major security requirements and Denial of Service (DoS) attacks in WBAN at Physical, Medium Access Control (MAC), Network, and Transport layers. They explain the IEEE 802.15.4 security framework and identify the security vulnerabilities and major attacks in the context of WBAN. Different types of attacks on the Contention Access Period (CAP) and Contention Free Period (CFP) parts of the super frame are analyzed and discussed. It is observed that a smart attacker can successfully corrupt an increasing number of GTS slots in the CFP period and can considerably affect the Quality of Service (QoS) in WBAN.

[48] Presents a security group for WBANs, comprised of lAMKeys, an autonomous and adaptive key management scheme for improving the security of WBANs, and KEMESIS, a key management scheme for security in inter-sensor communication. The innovation of these schemes lies in the use of a randomly generated key for encrypting each data frame that is generated autonomously at both the sender and the receiver, rejecting the need for any key exchange.

[55] Presents summary of WBAN infrastructure work in these areas currently underway in the Medical Component Design Laboratory at Kansas State University (KSU) and at the University of Alabama in Huntsville (UAH). WBAN efforts at UAH include the improvement of wearable activity and health monitors that integrate ZigBee-compliant wireless sensor platforms with hardware-level encryption and the TinyOS development environment. KSU efforts include the expansion of wearable health status monitoring systems that utilize ISO/IEEE 11073, Bluetooth, Health Level 7, and OpenEMed.

In [26] they amalgamate the Physiological values (PV's) based key management technique and pre-loading techniques by using electrocardiography (EKG/ECG) values of PVs and pre-loading based schemes to strengthen the security. The applied technique augments the security as well as reduces storage and power consumption.

In [42] a method that deeds the physiological signals (electrocardiogram (ECG)) to discourse security concerns in WBAN. It also aims to securely and anciently generating and distributing the session keys between the sensor nodes and the base station to secure end to end transmission. This approach accomplishes the generation and distribution of symmetric cryptographic keys to constituent sensors in a WBAN (using ECG signal) and protects the privacy. In this paper they have explained about a trust key management scheme for wireless body area network and the main aim attempts to solve the problem of security and privacy in WBANs. The main objective is to securely generate and distribute the session keys between the sensor nodes and the base station for a secure end to end transmission.

In [31] the authors discuss the security issues to WBANs and propose feasible hybrid security mechanisms to meet the security requirements of WBANs with strict resource constrains. They first introduce the recent advances of WBANs and analyze the main security risks to it, which makes it easy for WBANs to suffer from attacking than the other networks without resource constrains, and the security requirement of WBANs. Then they discuss the available cryptographic algorithms and propose a hybrid security structure for it. The proposed security mechanism provides a primitive to develop efficient and secure WBAN systems.

The scheme in [59] makes use of key refreshment schedule, which depict the turn of each node for key refreshment. The personal server (PS) issues new key refreshment schedule periodically. Each node refreshes the key in the slot allotted to it. This scheme uses three types of keys to manage a WBAN: communication key, administrative key and basic key. The authors present BARI, which is a key management scheme designed specifically for WBAN applications. BARI provides required level of security in WBAN while exploiting the application characteristics of WBAN, which other schemes are unable to do.

[43] Explains the packet scheduling schemes for real-time transmission in WBAN with proper security and privacy. Real-time and non-real-time traffic are classified to minimize the waiting time of the e-Health application's data traffic. The secure communication between medical sensors and PDA, as well as ensuring QoS for the real-time traffic has been investigated. The proposed secure communication scheme can minimize the key storage space and need less computation. An efficient secure data transmission scheme in wireless body area network is projected with data integrity. The scheme is user-centric and the secure key is shared among all sensors in a WBAN to minimize any additional memory and processing power requirements.. Patient privacy is ensured by using pseudo identity. A priority based traffic scheduling scheme for real-time application in WBAN is anticipated and analyzed.

V. WBAN RELIABILITY

[49] Proposed and executed an effective and consistent backup scheme for bridge monitoring systems. It is generally used a wireless sensor network (WSN) to collect the related environmental factors and to transmit the arithmetical data to the gateway through multiple-hopping relay. And then it further stores data in the back-end database for the professional monitoring staffs to examine and study. In addition, the future backup scheme can also improve the inconvenience to add or remove sensor nodes in an existing wired bridge monitoring network. The paper is mainly to apply the technology of WSN to bridge monitoring.

In [30] a video multicast protocol for multi-homed mobile terminals is projected as an alternate stream control transmission protocol (SCTP) for moderately reliable multicast services. It works with overlap peer-to-peer video multicast facility in the application layer. For a multi-homed mobile terminal, an error burst can arise when an assignment is in process in the main path switching procedure. The key issue concerned in this protocol is the capability to expect packet loss and to retransmit the lost packets as soon as a mobile terminal concludes its primary path switching procedure. This property controls the delay sensitivity of transmissions. Besides, it decreases the message overhead significantly and delivers an accessible communication mechanism for multicast applications.

In [64] a distributed Prediction based Secure and Reliable routing framework (PSR) for emerging Wireless Body Area Networks (WBANs) has been proposed. It can be integratedwith a specific routing protocol to improve the latter's reliability and prevent data injection attacks during data communication.

In [33] the concert of two very familiar routing paradigms, directed diffusion and Energy-Aware Routing are discovered, and a new routing algorithm, named SIR, which has the novelty of being based on the overview of neural networks in every sensor node has been projected. SIR is an innovative QoS-driven routing algorithm based on artificial intelligence. This routing protocol may be used over wireless sensor networks standard protocols, such as IEEE 802.15.4 and Bluetooth.

In [65], MBStar, a new real-time, high-frequency, rehabber, secure protocol for WBAN has been proposed. MBStar uses channel hopping and channel blacklist to decrease noise interference. Similarly it supports accredited transmission and retransmission to afford link reliability. MBStar employs both public/private key mechanisms for provisioning devices before join and uses AES (Advanced Encryption Standard) for encrypting health data after connection.

VI. CONCLUSION

From this paper we conclude that WBAN provide an excellent way for remote monitoring of patient data and are highly suitable for medical environments and e-healthcare. The technologies that enable these WBANs are state-of-the-art as these are applicable for WSNs in general. Security including privacy, reliability and energy efficiency are prime concerns especially for WBANs and these areas provide immense scope for research.

Many works concentrate on the security aspect of WBANs and many works have been done for improving reliability. But not much has been done to solve the problems of both security and reliability. In the proposals that do solve both the problems, energy efficiency has not been considered and their suitability for WBANs is questionable. Hence, in this paper we address all the above problems taking into consideration the context in which these systems would be deployed. Though medical context has been given importance, the system proposed in this paper would be applicable for any WBAN used for any purpose.

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Aishwariya.A. "A Survey of Study on WBAN Architecture for Biomedical and Scientific Applications." .IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 12, 2018, pp. 72-80.