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A Study on Requirements, Challenges and Applications of Wireless Body Area Network

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***Abstract* - Body Area Network (BAN) or Body Sensor Network (BSN) has became the most emerged research technology because of the recent advancement in wireless sensor networks. This has also provided many opportunities for researchers on wireless networks around the body. A BAN allows remote health monitoring of patients. The caregivers can monitor their patient's health status without disrupting their normal activities. This monitoring is possible by deploying of the low-power sensor nodes on human body as implanting or worn. This paper presents a description of BSNs, requirements, challenges and various applications associated with BAN. The most important requirement and challenges faced by BSN are Energy, quality of service and routing. These factors are analyzed in detail in this paper. An investigation of existing challenges and requirements with its solutions and technologies at physical, MAC, network, transport, and application layers also done in this paper. At the end, open research issues and challenges for each layer are discussed to be addressed in further research.**
***Keywords:* Body Area Network, Body Sensor Network, QoS, Zigbee, Routing, Helath monitoring**

I. INTRODUCTION

WSN is an advancement of Wireless technology. In healthcare, WSN is used. Only few sensors are used in wireless body area network, which are fixed in the body or placed on the body. etc. To measure vital signs like blood pressure, Glucose level, and pulse rate these small sensors are placed on patient's body. One side, Wireless body area network allow new applications and thus new plausible markets with respect to Wireless Sensor Networks (WSNs), on the other side, several issues caused to the WBAN, which call for new models and protocols.

Wireless sensor network helps to understand the human life in more significant conditions. Mobility, reliability is supported by WBAN. GSM or GPRS are used in healthcare services can be provide by body sensor network for managing medical data, audit medical data and transfer the information with physician by without any disturbance in patient's regular life. In the desired environment wireless sensor network can quite easy to deployed, and it collect the information, process it and sent it to the preferred location. By network it detects and transmits the data, which was developed using Wireless Sensor nodes. Energy utilization level is low in those nodes. Many advantages offers by WSN over conventional networking solutions, such as, scalability, lower costs, reliability, flexibility, ease of deployment and accuracy.

In BAN numerous applications are developed by WSN. On the body of the patient sensors are placed, by which parameters are to be taken examined for health care systems. In medical systems, WBAN gives various ways of evaluation. Different type of sensors are connected on the body or on the clothing or entrenched in the body. To compute the parameters from the patient's body these sensors are used. BAN is one of the interface of other wireless technologies like Wireless Sensor Networks, ZigBee, radio frequency identification (RFID) technology, Bluetooth, wireless personal area network (WPAN), video surveillance systems, cellular networks wireless local area networks (WLAN), and internet.

To reduce the form factor and widen the time between battery recharges is the common feedback from the user about those devices. BSN devices should eventually have very small volumes of 1 cm to 3cm or less than that. To these sizes the energy of the battery cannot be expanded. The necessity can be understood by WBAN group for a typical for use with devices inside and around close propinquity to the human body. To develop the standards for BAN, IEEE 802.15 established Task Group #6. The task of the BAN group has sketched a (private) normal that covers a large range of feasible devices. In this manner, the task group has given application and device developers the decision of how to balance data rate and power.

II. REQUIREMENTS

A difficult task is to improve the performance in the WBAN because the applications are imposed the broad range of the requirements. The OSI and model requirements are the two classifications of the Wireless Body Area Network requirements.

A.Requirements in BSNS

The most challenging requirements in WBAN are energy, routing and Qos. These can be described as follows.

Energy: In Wireless Sensor Network different types of wireless sensors are exists [14] such as chain based, cluster based and randomized approaches. It considers the energy saving schemes in a complete taxonomy [15]. For body sensor networks, energy conservation is very important, harvesting the renewal energy includes vibration, solar, and thermal energy [16]. Real time observation does not a necessity in Body Area Network, a low power standby mode set by a sensor nodes. If additional energy is needed, energy hunting is used. The vibrations and heat of body can offers extra energy [17].

QoS: Quality of Service is considered and interpreted in various methods. The definitions of Qos are interrelated to the applications. QoS can be distinguished by reliability, robustness; security, timeliness, and availability are depended by the applications. To evaluate the degree of supporting these services some of the Qos parameters are utilized, such as jitter, throughput, packet loss rate and delay [18, 19]. The different types of OSI Layers in Qos requirements are explain as follow.

B.Requirements in OSI Model

QoS , Energy, and routing are the most vital issues and requirements in Body Sensor Networks. Here are examined at different layers of OSI network model.

Physical layer

The two challenging task in the physical layer of BSNs is Qos and Energy, which are expressed at follows

IEEE 802.15.4: In Wireless Personal Area Networks (WPANs) a short-range (up to 100 m) communication system is a IEEE 802.15.4 wireless technology which is proposed to access the applications with calm throughput and latency requirements. low complexity, low power consumption, low cost, low bit rate transmissions are the key features of IEEE wireless technology, which can be supported by cheap either moving devices or stable devices. The implementation of Wireless Sensor Networks is the main goal in the application of wireless technology. The star, tree and mesh topologies are supported by the network topologies. The PHY and MAC layers are the two typical bottom layers of ISO/OSI stack of protocol. ZigBee protocols, which are indicated by the industrial consortia ZigBee Alliance, and 6Low PAN are some requirements of IEEE 802.15.6 are the two choices for upper layer definitions.

***Bit Rate and Quality of Service*:** The bit rate requirement differs on a most broad range, which depends on the transmission of data and its application. The analysis value may be taken less than 1 kbps (e.g., temperature monitoring) to 10 Mbps (e.g., video streaming). The intention bit rates of the probable applications is proposed. In military and medical applications, high level of QoS should be provided.

Zigbee: To develop the values (and products) for reliable, low-power wireless networking and cost effectiveness, the ZigBee Alliance is an connection of companies which works together. ZigBee technology will most likely be rooted in a broad range of products and applications across commercial, consumer, industrial and government markets in worldwide. The IEEE 802.15.4 standard built by the ZigBee [13]; which describes the low cost of physical and MAC layers.

***Routing*:**Routing in Body Sensor Networks can be classified in to five groups which are depicts as follows [21, 22].

Thermal Aware Routing

Nodes have specific weight in this routing. Some of the nodes have lower temperature and other nodes have higher temperature. Heating in nodes can be reduced by some of the algorithms which can be used [23]. A power absorbed per unit mass of the tissue is the Specific Absorption Rate (SAR).

DTN Routing

One of the mechanisms is Delay-Tolerant Networking (DTN), which is used in diverse networks without connecting continuously. Flooding strategy and forwarding strategy are the two categorization of DTN routing. More than one copies of a packet are transferred to other nodes in the flooding strategies. By using the information about the network topology, the packets send to next node is based in the forwarding strategy [24-26].

Cluster Based Routing

Routing is completed by node clustering methods by using this kind of algorithm. Each and every cluster has a head of cluster which collects data from the cluster and transfers them to the drop node. As a cluster head, the LEACH (Low Energy Adaptive Clustering Hierarchy) randomly picks the nodes. [27]. Energy can be measured for cluster head selections in other techniques [28].

Cross Layer Routing

To improve interaction between the protocols by inclusion some layers from the protocol stack is a way of this routing. Modular method is one of the methods in cross layering that has some benefits such as avoiding replication of functionality and sustaining heterogeneity [29, 30].

Qos-Aware Routing

The applications and their QoS requirements are related to the QOS-aware routing because, In BSNs non-real time and real time applications act as a big role. The policies of QoS-aware routing are very significant [28].

III. CHALLENGES ASSOCIATED WITH BAN

A still rising technology is BAN and there are a lot of challenges left to solve in BAN. To set aside moral issues like privacy, there is still abundance of technical problems that we must surmount before BAN will become a successful solution. For a lot of the essential wireless network protocols, the BAN draft submissions have defined solutions, but there is still lot of research that must be prepared to efficiently broadcast a signal in and around the human body.

A. Routing Challenges

In terms WBANs are related to MANETs, of the moving topology with cluster-based movement rather than node-based movement [31]. Though, WBANs have further strict energy restraints in conditions of broadcasts power which is compared to traditional sensor and Ad Hoc networks as replacements of nodes specifically for insert the nodes can be rather not at all comfortable and it might needs surgery in some situations. Consequently, it is critical for WBANs to have a longer period of network life span to stay away from steady recharging and substitution of nodes which was attached to a human. Moreover, the frequent topology changes and a moving higher speed are more in WBAN, at the same time as a WSN has fixed or low mobility states. Due to aforementioned problems and exact WBANs tasks, the routing protocols which are planned for WSNs and MANETs are not valid to WBANs.

1.Postural Body Movements

WBAN increases dynamism such as energy management, Node mobility, and environmental obstacles which includes numerous changes in topology and network mechanisms that amplifies the Quality of Service (QoS) complexity. Moreover, due to different body movements, the quality of the link between nodes in WBANs differs as operations of time [32]. Hence, to improve the various topology changes the planned routing algorithm should be adaptive. In this observation, due to detachment and frequent dividing relative to postural body movements, WBANs has to be in the category of Delay Tolerant Networks (DTN). Furthermore, someone segments and clothing consequence in signal blockage that step up the RF attenuation. More purposely, the WBAN's mobility pattern changes with the order of activities contained by tens of centimeters whereas the WSN's mobility's scale is in the sort of meters and tens of meters.

2.Temperature Rise and Interference

The nodes energy level requires to be considered in the proposed routing protocol in conditions of the existing energy and computing power. Also, in sequence to reduce interference and stay away from tissue heating, the nodes transmission power needs to be enormously low.

3.Local Energy Awareness

Communication data scatters the proposed routing protocol among nodes in the network to balance the usage of power and reduce the failure to battery providence of drainage.

4.Global Network Lifetime

The lifetime of network in WBANs is referred to as the time period from when the starting of the network to the time of the network which is significantly smashed, which guides to network dividing such that the target cannot be reached. The replacement of battery and charging is not possible in insert medical devices; the lifetime of the network is more important in WBANs which is evaluated to WPANs and WSNs [34].

5.Efficient Transmission Range

The low RF broadcast range in to frequent paneling lead by the WBAN and detachment amongst sensors in WBANs, which consequences in related demonstrates to DTNs [33]. In the cases where the range of broadcasts sensors are less than a value of threshold, there are lesser options for routing to neighboring sensors which leads to a larger number of broadcasts leading to overall temperature rise. Also, there are a smaller number of adjacent nodes, the lesser the prospect for packets to travel at the destination within a certain hop calculation. Therefore, the packets will take more distant to arrive at the target level which directs to an normal raise in on the whole temperature rise [35].

6.Limitation of Packet Hop Count

According to the IEEE 802.15.6, WBAN is a standard draft [36], interactions can be one-hop or two-hop is permitted in WBANs. At the same time as transmission of multi hop offers stronger links which moves to total increase in system reliability. Number of hops is larger and has more the energy utilization [37]. Though, the restraints of the hop of the packet count have not been measured in most WBAN routing protocols. Furthermore, WBAN has half-duplex devices which decrease the bandwidth as consecutive hops are initiated.

7.Heterogeneous Environment

The most particular applications of WBANs may needs collection of diverse data from various sensors with different rates of sampling. So, Quality of Service sustained in WBANs may be somewhat difficult.

8.Limitation of Resources

The capacity of Data, power and mechanisms lifetime of WBANs is firmly limited as they necessitate a few form of factor. Due to restrictions, In WBANs has accessible resources; so, the nodes in WBAN are connected to fail due to unavailable power of the battery, bandwidth and memory limitations, which are main intimidation to QoS. This part offers an outline of analysis being done in routing protocols for Wireless Body Area Networks, which only have been improved in little years ago, to aid about the whole knowledge of difficulties in routing in WBANs and probable solutions. In WBANs routing protocols can be divided into five groups depends on their network, location, structure, temperature, QoS metrics and layer.

B. Reproducibility Challenges

A general difficulty is a lack of access in the devices; access to medical devices is it may be non-existent or limited to older, Patients, relatives, or physicians receives the end of lifestyles. Halperin [41] et al in ICD analyzed, for example, Five years earlier a model can be introduced. The devices without access by itself, to examine probable attacks and defenses, researchers are essentially limited in their capacity; frequently the hardware of the device patterns is not in an open knowledge. From group the researchers give the result that have run to obtain and study specific IMDs are not likely to be authenticated by others, it happens as of be short of equipment. Although, to offers the access to remedial devices, some efforts have been taken [38]; by the security research community, from manufacturers to the straight access to devices emerged to be restricted at current.

The next problem in privacy experiments and computer security on medical devices is the exploits of a phantom food grade meat, or simulator of human tissue [41], [40], [39]. As Fu and Clark [42] examine, this way does not gives to reproducible research, perhaps due to the preface of unrestrained variables which can involve the tissue's impedance or signals propagation in the phantom. As a replacement for, researchers should use standardize solution of saline at 1.8 g/L at 21 _C [43] with electrodes are used to insert the suitable simulated physiological signals. The overall design is expressed in the ANSI/AAMI PC69:2007 standard [43]; this is the standard of accepted for medical devices which has a electromagnetic compatibility by researchers, regulators and device manufacturers.

C. Emerging Threats: Sensors, Remote Attacks and Privacy

The traditional postulation about IMDs and BANs is that several physiological signals stay within a patient's body, restraining the infiltration of data and the prospect for signal injection attacks. Both the security and privacy of patterns affected, when the postulation that certain physiological signals stay within the human body is incorrect, remote invaders are also a concern today, mainly with respect to perceiving physiological values assumed to be secret.

IV.APPLICATIONS

The range is too smaller in the BSN devices. It is less than 0.01m to 2.00 m. To take the advantage of numerous features of the human body this limited range is allowed by the developers. But, from a variety of sensors for longer time, Body Area Sensor Networks can constantly capture quantitative data. Tele health applications—medicine will enable the BASN by addressing issues such as the energy-fidelity tradeoff beyond the limits of hospitals and clinics1 because of their human-centricity, Moreover highly personalized and individual care will be possible. Furthermore, longitudinal assessment in delay-insensitive applications, Body Area Sensor Networks that can provide a real-time sensing, processing, and control will enhance and protect the body functions in human life. To improve deep brain stimulation, heart regulation, drug delivery, and prosthetic actuation, the researchers in BSN are already working. The existing work in Body Sensor networks fall detection shows how resolutions that enlarge to include more data from numerous sensors and from privileged layers in the system hierarchy (e.g., context) which offers the improved results. Amid the more possible applications that have been thought up for Body Area Networks are provide interactions in hospitals, communications on aero-plane, spaceships, and it may monitoring the patients at their home.

A.Medical Application

To expand the health care systems are enabling and more effective management and finding the illnesses and reaction to emergency rather than just wellness are expected by the use of Wireless Body Area Network [1, 2]. In some situations if abnormal conditions are noticed, data are collected by the sensors, which can be transfer to a gateway like as cell phone. The data can be deliver by the gateway through a mobile network or the Internet to a distant location like emergency center or to the pc of doctor's room based on which an act can be taken [3, 4]. The worldwide population over 65 will have twice in 2025 to 761 million from the 1990 population of 357 million are predicted by the demographers. This shows that medical aged care will become a major concern by 2050. Further one of the foremost causes of death is linked to cardiovascular disease, which is expected to be as much as 30 percent of deaths in worldwide [5,6]. So WBAN is more useful in future generation to prevent from dangerous diseases.

Wearable WBAN

Glucose diagnoses from the glucose module are received by the cellular phone, which may then be stored or transfer it data to a doctor for their study [13]. In WBANs, Wearable medical applications can be dividing into the following two subcategories:

1. Disability Assistance
2. Human Performance Management.

Some Features are mentioned below:

1. *Assessing Soldier Fatigue and Battle Readiness*

With the help of WBAN, Soldier's activity in battle field can be observed more strictly. policemen and fire-fighters can also use WBAN [8].

2. Aiding Professional and A mature Sport Training

In addition, the network allows the real time feedback offered to the user for the performance development and protect from injuries related to false training [9].

3. Sleep Staging

More people are troubled by sleeping disorder. The analysis shows an average of 27% people suffered from sleeping disorders in the world population. The cost of such disorders can be quite critical and it ahead to cardiovascular diseases, and drowsy driving. Delocalization of the intelligence and removal of all cables and instruments in their sensor nodes are capable by WBAN [8].

4. Asthma

Observing the allergic agents in the air and providing real time can be observed by Wireless Sensors and WBAN.

5. *Wearable Health Monitoring*

The combination of WBAN with sensors and other devices can offer real time health observing.

6. Sport and Entertainment

The blood pressure, blood oximetry, heartbeat, and posture are the real time important parameter can progress sport experiences and fitness. Furthermore, the motion capture along with post production techniques to realize highly realistic digital movies in which performer play the task of non-human subjects are the advantages in Film industry [10].

7. Military and Defense

Network-Enabled Capability is the name of the long term agenda which aimed to accomplish and improved military effect via the use of information systems [11]. Communication and Spatial localization techniques are the between different Wireless Body Area Networks (inter-WBAN communications) which act an vital role in this field, as well as protection in sequence to secure sensitive data from being trapped by the enemies [12].

V. MEDICAL DEVICE SECURITY AND PRIVACY TRENDS AND CONCLUSION

A class of wireless threats against a commercial ICD was introduced by Halperin et al. [45]; later then, attacks on the telemetry interface of IMDs have received a large amount of attention [46], [47], [48]. At the physical layer, ICD was targeted by Halperin et al.[45], and insulin pump system was targeted by Li et al. [46], using an off-the-shelf software defined radio (SDR) platform they develop passive and active attacks against their respective device.

Expectedly, to secure the wireless telemetry of IMDs and BANS many authentication techniques have been proposed, including the use of out-of-band authentication, external devices, biometrics, distance-bounding authentication and anomaly detection. Each of these areas is discover individually below.

A.Out-of-Band (OOB) Authentication

The Out-of-Bound techniques make use of auxiliary channels, such as audio, tactile and visual, that are outside the established data communication channel [61-64]. Authentication prevents the need for trusted third parties and key pre-distribution schemes by using auxiliary channels. A common notion in these patterns is that the chosen out-of-band channel is resistant to overhearing attacks.

B.External Wearable Devices

A unique methodology to securing IMD/BAN telemetry makes use of external devices worn by the patient. In this the external device mediates communication with the IMD is the basic idea, thus providing both privacy for transmitted data and security against unauthenticated communication. One concern with the use of such devices is their tolerability to the patient. An external device proposed by Denning et al. [62], named cloaker, those proxies authorized communication to the IMD. The IMD communicates openly, if the cloaker is absent (e.g., in case of a medical emergency, the cloaker fails open). By selectively jamming the cloaker, a malicious programmer can exploit this fail-open behavior or else to convincing the IMD of the absence in the cloaker, so to prevent such an attacker from sending the information with the IMD is the additional mitigation methods suggest by Denning *et al.*

C.Biometrics

Biometrics or physiological values (PV) used for popular techniques like key generation and key covenant in IMDs/BANs [49-59].Electrocardiograms (ECGs) are a common choice as a source of key material in these protocols, although other PVs such as blood glucose, blood pressure, temperature and heart rate have been proposed [56].

However, the security analyses of these protocols have been mostly unprepared in nature; in general more Wide-ranging valuations are required. For example, Rostami et al. [60] show simple, but damaging attacks against OPFKA and IMD Guard, which we discuss in Section V-A4.

D. Distance-Bounding Protocols

By scheduling the delay of sent and received transmissions a technique called distance bounding that creates physical distance between two entities. The various signals such as RF or ultrasonic sound (which is an acoustic signal above 20 kHz) can be computed by this distance bound technique. A distance bounding can used by a number of IMD/BAN access control and authentication protocols. Body-coupled communication (BCC) is also by Distance bounding. BCC uses the human body as a conduction medium; in order to communicate with the patient it requires physical proximity. However, the applicability of this protection to IMDs is debatable, in the occurrence of a medical emergency a patient may not be able to authenticate.

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