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Research Article

Wireless Body Area Networks: Research Issues and Future Trends

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Abstract

The paper discusses the basic concept and issues of Wireless Body Area networks (WBANs), and its applications in various domains. The basic architectural requirements of WBANs, the current scenario, energy consumption issues, authentication, reliability, integrity, data security, compatibility, traffic load, periodic scheduling, switching, real time working etc are discussed in length. The need of algorithmic research has also been highlighted. After these, the main application areas over which WBANs have been applied are discussed which further elaborates the implications of the technology. After all these deliberations we have focused on the research issues and future scope in the field. The paper is expected to be able to draw attention towards the vast scope of research in this domain.

Keywords: Wireless body area networks, periodic scheduling, WBAN protocols

1. Introduction

With the upsurge in Internet of Things (IoT) applications, sensors and in particular, personalized sensors have also seen a boom in their applicability. Since sensors basically collect data, a whole lot of work expands as soon as some data is collected. The data collected needs to be converted to database, knowledge and subsequently information. The more the availability and use of personal sensor devices, the more is this data monitoring and data networking. A Body Area network (BAN) is basically this networking topology of several sensors which form a hub for data exchange. Generally, this hub is mobile and responsible for coordination of all these sensors, through a wireless medium and also then sends the collected data or information to a server. The complete data transfer has to be according to different IEEE standards of wireless communication (WiFi, Zigbee, Bluetooth, etc.). In case of medical applications, the sensors are special purpose and may be located outside as well as inside of human body. We observe a set of sensor nodes [6-10], a coordination node (Central Control Unit, CCU), a wireless communication protocol and an end node at the output device, which may be a storage or display system.

2. Basic Issues related to Wireless Body Area Networks (WBANs)

Some of the basic research issues related to WBANs are discussed below:

1. Energy Consumption:

The devices are battery-operated most of the times, since the devices are mobile. Therefore, in addition to good data collection, energy saving is another important principle to be taken care of while developing BAN

protocols/ topologies. Sleep-wakeup scheduling is one such common method of energy saving used in sensors. While this technique works fairly good for traditional sensors networking, the strategy becomes somewhat inefficient dynamic systems like BANs. Also, since the networking is wireless mostly, the quality of wireless network is another constraint to BAN. This eventually results in wastage of energy, low bit-rate, longer channel time and thus higher consumption of energy. Various protocols have been proposed and also researched upon to overcome these shortcomings/ challenges, like CPMAC [1, 11-14]. A good channel increases the rate of successful transmission and higher bit-rate, we can say, almost instantaneous channeling, minimal usage of energy and also nil wastage. After this much is achieved, another requirement that pops up for researchers and industry is low system complexity and ultralow power consumption. Periodic monitored traffic scheduling, as discussed above, is used as Interbeacon Interval (IBI). The BANs based on this techniques have been termed SmartBANs [2, 15-18]. An average uplink delay is minimized by applying a time-optimized framework. Though Poisson traffic, ie based upon saturation/ non-saturation conditions/ assumptions, has also been studied extensively and analyzed using Markov Models. However, for healthcare applications, periodic monitoring is most commonly used. The medical WBANs may be duty-cycled also, the sensors wake-up after a certain amount of time. This discussion converges to a point that periodic scheduling, by one method or another, is an essential attribute of WBAN sensor devices.

2. Mutual Authentication:

Besides the above one aspect of challenges and solutions to the research problems related to WBANs, another important domain is the applications of new technologies. One technology is greatly affected by advances in another field. For example, the advancement in mobile phone technology has pressurized the medical e-health services for fast, cost-effective, secure and efficient adoption of mobile networking in e-health [3, 16-21]. BANs also had to face the same as soon as the technology came into existence. Each such practice of submerging one technology into another has potential risks of data/ information compatibility, data loss and leakage, security issues, and so on. Moreover, the nature of data of healthcare systems is all the more vulnerable to cyber threats. Such issues have given way to another domain of data encryption techniques of data transmission which ensures integrity and confidentiality as well as mutual authentication, like CLGSC algorithm. Hence, a circle of new research, applications, challenges and further research is what is observed in BANs like all other fields.

3. Data Security and Reliability:

It has been observed that the data loss due to malfunction in any sensor node is a severe issue in case of WBANs rather than conventional sensor networks. Keeping in view the seriousness of such incidence of node failure, especially if the data is related to healthcare (where any loss of parametric information may be fatal), WBANs work on a back-up mechanism and monitored evaluation of network performance for a given protocol, so that any failure may be seen at the nascent stage, before it may prove fatal. Such an algorithm may increase the reliability of a critical sensor node. Such a proposed algorithm [4, 22-26] AT-MAC has given good results for medical WBANs. The algorithm increases the probability of successful packet delivery, and hence increased reliability of the critical node of a sensor hub, also ensuring lesser delay in data transmission.to identify the critical node, each node is assigned a criticality index. Such algorithms aim at increasing reliability (decreasing the failure probability) even with highly complex and heavy sensor hub, since more number of nodes mean more chances of failure. The ultimate aim is that with increase in the number of sensor nodes, the reliability and working parameters should not be affected.

4. Discarding a packet due to busy channel (Traffic Load):

As the number of sensors and complexity increases, the chances of getting a channel busy are increased. Getting a channel busy results in discarding the packet of information. The source node then retries to transmit the packet, and the algorithm may have to allow more number of retries everytime an attempt fails. This increase the delay time or connection time, and eventually the processing time, as the packet is in a wait or retry mode till it finds an idle channel for transmission. Hence, optimization algorithms may be required to be applied for best results for a particular WBAN protocol.

5. Real-time working requirements:

WBANs sensors, in particular when used for monitoring of health of a patient using wearable sensors, should report real-time physiological data for accurate monitoring (for example, in Intensive Care Units) and diagnosis thereof. This monitoring is continuous and may extend upto long times to observe some vital functions. Since multiple sensors work at a time, the traffic load on the channel increases. C-MAC is such a protocol [5, 27-29] which enables a collision - free transmission over a channel and also switching quickly to an idle channel. This

also prevents the energy wastage over idle channels. In this respect, WBANs have proven to be better and more promising than the conventional medical sensor networks.

3. Applications

Some of the major areas where WBANs have been applied are discussed below:

1. Healthcare:

Since health monitoring is very much dependent on multiple wearable sensors, WBANs have been extensively applied and studied in health sector. Whereas the wearable monitoring devices are used outside the human body, the implantable ones are used inside, just beneath the superficial skin. In both the cases, the purpose is to monitor the body parameters like pulse rate, ECG, EEG, pO2, blood pressure, blood sugar, blood pH, urine pH, ketone bodies levels, respiration, temperature and many more closely and continuously. Besides, WBANs offer remote healthcare monitoring, assisted living, and telemedicine when integrated with other technologies like medical informatics, video conferencing, e-prescription, telesurgery, medical imaging technologies etc.

2. Sports:

WBANs offer as much applicability in sports as in medical sector, since the conditional requirements of sensing are more or less same in both, like monitoring of health parameters, mobility in devices, high number of simultaneous working sensors, precise, accurate, sensitive and real-time monitoring issues. In this case also, a delay or malfunction in sensing or delay in transmission may prove fatal to the sportsperson. All the physiological parameters as discussed in the previous section of health, are of significance in sports sector also.

3. Defence Services:

WBANs can be used to communicate the activities of soldiers in far field or a rough terrain. Different types of activities data may be transmitted and received by the other soldiers, like running, walking, digging, etc. Again, the data related to health parameters may be a signal to the fellow soldiers about injury, hydration level, location, etc. the different types of sensors may be physiological ones, or camera, GPS based, and thus WBANs may be a means of connectivity between a group of soldiers.

4. Entertainment:

Entertainment industry caters to the wholesome sensual requirements of human, which are related to almost all senses, be it audio, visual, tactile, or a combination of these. The high advancements in the industry and usage of almost all the latest wireless technologies in the same exhibit a huge potential of WBANs in this application. In addition, the altered/ upgraded lifestyle, eating habits also requires sensing and monitoring from time to time. Wearable sensing devices like pulse oximeters, blood pressure apparatus, thermal sensors, glucose monitors, IR sensors for blind, etc, are amongst the basic health amenities in homes like other traditional items.

4. Research Issues and Future Scope

Based upon the extensive survey of basics of WBANs, their implications, applications and the ongoing research in the field, it has been observed that there is a lot of potential of improvements and advancements in this domain. As has been discussed in earlier section, a lot of research prospects can be seen in the better battery operation, prevention of wastage of energy over idle channels or due to other reasons like delays, retries; lesser consumption of energy over transmission channel. The coordination node may be improved to allow more and more number of source sensor nodes without affecting the performance parameters of the BAN. The source nodes are an important center of attraction for researchers, as we wish to have less energy consuming, more accurate, more precise, less costly, light weight and reliable sensors at the source end. The end node sensor has a huge responsibility of mutual authentication of data and interoperability over various technologies. The end storage or display device has to be in perfect coherence with the end node, thus enabling great encryption and decryption. Different informatics and wireless communication techniques need to be upgraded for real-time transmission and lest delays along with least amount of data loss. The algorithms and protocols need to be more flexible as well as robust for complex and highly varying parametric applications. Besides, these operation al issues, lot of research is yet to be accomplished in all domains of sciences where WBANs have been applied already (as discussed in the application section) or yet to be applied like vehicular technology, aeronautics, automobile engineering, forensics, etc.

5. Conclusion and Discussion

Through the paper, we have tried to explore the field of Body Area Networks, its basics issues, applications and challenges. The aim of the study which was to take away the key points of required research in the field for betterment of mankind have been reached at. The work done in writing the paper has been fruitful and convincing to pursue research in this field as a lot of scope is seen for the same.

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