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Packet Size Optimization Techniques and Challenges for Wireless Body Area Networks

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Abstract

In WBANs, longer packets may encounter higher misfortune rates because of unforgiving channel conditions. Then again, shorter packets may experience the ill effects of more prominent overhead. Thus, the ideal packet size must be selected to different execution measurements of WBANs. According to the latest research, numerous methodologies have been suggested to decide ideal packet size in WBANs. Literature discussed in this paper primarily focuses on packet size optimization in a particular application or sending condition. This paper discusses the current trends and practices on packet size optimization for wireless body area networks to encourage the researchers for more investigation in that particular area. The objective of this paper is to give a superior comprehension of packet size streamlining methodologies and applications utilized in WBAN, it will likewise present some research issues that are still open for researchers and complications related to those issues.

Keywords: Energy proficiency; Network reliability; Cross-layer design; Packet size optimization; Wireless body area network

Abbreviations: WBANs: Wireless Body Area Networks; WUSNs: Wireless Underground Sensor Networks; TWSNs: Terrestrial WSNs; UWSNs: Underwater WSNs; BANs: Body Area Networks; QoS: Quality of Service; ARQ: Automatic Repeat Query; FEC: Forward Error Correction; BCH: Bose-Chaudhuri-Hocquenghem

Introduction

Wireless Body Area Networks (WBANs) are being used in numerous application extents, for example, armed forces, business, astronomical, graphic observation, horticulture, logistics and many more [1-3]. WBAN comprise of various sensors implanted on the body and sent to detect useful parameters in a field [4]. Those sensors are dependable from getting estimations on body on which they are implanted and passing on the information towards the sink hub that gathers, filters and aggregated data is sent to the central server for further processing on the data. As the nodes have restricted power supply, each part of WBAN ought to be composed with most extreme care to scatter the constrained vitality to augment the system lifespan [5,6]. Generally, wireless sensor networks have been classified in four wide classes as per the sending situations: Wireless Underground Sensor Networks (WUSNs), Terrestrial WSNs (TWSNs), Underwater WSNs (UWSNs), and Body Area Networks (BANs). Every one of the classifications has its unique and interesting attributes because of the kind of condition that is utilized for information transmission and has extra difficulties due to their questionable and variable divert qualities in various proliferation situations.

In the literature discussed in this paper, packet size optimization concentrates on a particular application area or surroundings in which it is deployed. The fundamental attributes of BANs are energy proficiency, Quality of Service (QoS) provisioning, flexibility and scalability [7]. These features are discussed in literature with several methodologies in their specific area of application. The vast majority of research is done to lessen power consumption and to alleviate the critical network conditions to encounter the prerequisites of BAN application areas that have specific nature of administration necessities, for example, throughput, vitality efficacy and delay. Prerequisites for BAN area in which they are deployed is not quite the same as each other, since a portion of the BAN applications require high vitality effectiveness, for example, military observation frameworks, while on the other hand application areas like health care and disaster management, require low inertness. In this way, packet size optimization methods need to fulfill the criteria of these BAN applications.

WBANs have significant difficulties in communication, information processing and administration. These difficulties are the tight asset limitations, flexible system design, powerfully evolving data transfer capacity, range, and computational power capabilities [8]. Power utilization is the most troublesome asset requirement to be fulfilled for BANs among the difficulties mentioned earlier. Subsequently, numerous energy-aware procedures are intended for giving force to preserve and manage the power on both link layer and network layer. Despite the fact that energy is devoured by means of the sensors while detecting, communication, and transmitting the information on the way to the sink, correspondence control utilization is the predominant

term in BANs [8]. Latest investigations in the area demonstrate that bundle of measures directly affects the execution of correspondence between sensor nodes. It is notable that due to severe network disorders longer packets observe higher data loss, whereas packets with shorter size basis greater data overhead.

To regulate the trade-off between network dependability and vitality proficiency, numerous methodologies are anticipated to decide the ideal packet measure in BANs. Figure 1 presents a run of the mill link-layer bundle arrange in sensor networks [9]. Packet format has three basic parts (i.e. trailer, header and payload). The header contains information related to current section number; adds number of fragments and source along with destination nodes. Trailer field includes parity bits to control the error. Payload incorporates data bits. Length of Header, Trailer, and Payload are represented as LH, LT, and LPL respectively (Figure 1).

Figure 1: Llink-layer packet arrangement in BANs.

Packet size can be improved agreeing to several networking criteria's [10-21]. Several measurements for example, output proficiency and the vitality effectiveness, are utilized for execution criteria for optimization of packet size. For example, energy productivity is utilized as an optimization metric [10] to decide the settled ideal packet length for expanding the energy proficiency. The fundamental target of the research is to give a superior comprehension of packet size optimization methodologies utilized in WBAN to present unaddressed issues and difficulties in this research area.

Literature Review

BANs are implanted inside the body of humans or located outside the body to collect useful parameters of the body. A large portion of the BAN uses are identified with medicinal services for nonstop observing of patients who have interminable maladies. There are likewise different applications where BANs are generally utilized, for example, crisis reaction, disaster management, and execution assessment of the athletes [10-13]. Besides, sensor nodes utilized in BANs have additionally unique operational attributes and network qualities for in and on body situations [14]. Human developments and dynamic proliferation conditions make acknowledgment of dependable and energy-efficient BANs a testing undertaking. Furthermore, the body shadowing, which happens when the flag way between the sensor nodes implanted and the transceiver is hindered, is likewise another testing issue for BANs correspondence [15]. Energy utilization is the most basic issue in BANs [16,17].

Optimal packet size for BANs is examined to increase the energy [18]. Distinctive error control mechanisms including Automatic Repeat Query (ARQ), Forward Error Correction (FEC) square codes, for example, Bose-Chaudhuri-Hocquenghem (BCH), RS, and FEC convolutional codes broke down. Hop-length expansion method with FEC square codes is connected. Major separations can be addressed by the FEC square codes with the hop-length expansion method, since the procedure broadens the broadcast extend for a similar communication power.

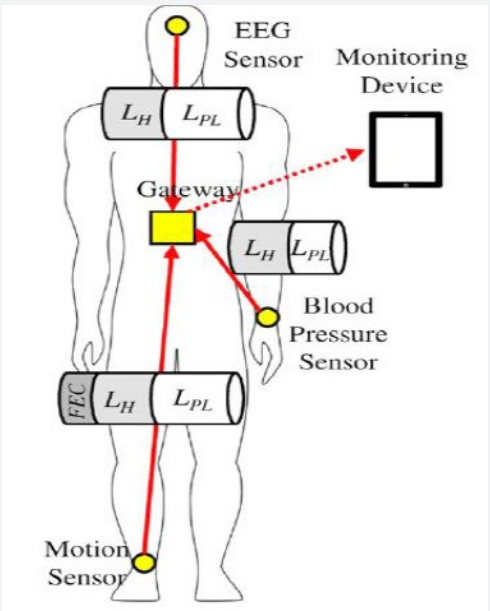

Figure 2: Packet size optimization for a typical BAN; EEG = electroencephalogram.

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Figure 2 shows the results, in which three nodes are deployed to screen electroencephalogram, movement, and circulation of blood in the body. The mounted nodes pass on the obtained information to focal passage node which is then checked by a portable observing gadget, (for example, an advanced cell). As the space between mobile node and central node is greater, so by utilizing a FEC component, lengthier distances can be come to with less mistakes; henceforth, longer packets are supported for such situation. Then again, sensor nodes don't utilize a FEC component; consequently, smaller packages are utilized.

Remote health care monitoring shows such kind of a research study. In this regard, the physical conditions of a man are examined with implanted and mounted nodes, after which the gathered parameters are transmitted through gateway via single-hop transmission. At that point, this information flows through a monitoring station by the access point. In this research, ideal packet size along with energy efficiency are planned with various plans for error controlling for in and on-body planted nodes.

Simulations are done by considering diverse situations for implanted and mounted propagating conditions. Statistical assessments are done to demonstrate energy effectiveness execution for the ARQ and FEC codes. Initially, effects of modulation schemes, for example, on-off keying (OOK) and BPSK on the BER for on and in-body systems are investigated due to the distance between the gateway and body surface get extended. Line-of-sight (LOS) and non-line-of-sight (NLOS) divert modeling techniques are utilized for reforms. Non-line-of-sight displays more way misfortune than LOS demonstrate, along these lines, bring down hop-length augmentations are supported by the NLOS models. It has been observed that BPSK has the ability to broaden the hop-length more as compare to OOK for a particular BER value and for all NLOS and LOS direct models in both implanted and mounted nodes. Moreover, packet size streamlining has the effects on the energy proficiency for to control error, for example, ARQ and convolutional code with Rc=1/2 are researched using various BER esteems i.e. 10 to 3 and 10 to 5.

The energy efficiency is supposed to be greater whereas decay dejects with the growth of packet payload for both implanted and mounted systems. This is obvious that on-body sensing systems are influenced with variety of fading. Subsequently, ideal packet payload lengths are gotten for both systems (in and on-body) as per the distinctive BER standards. Outcomes demonstrated that packet size is smaller for mounted sensing systems than the implanted sensing systems in view fading impacts. Moreover, it is additionally demonstrated, the ARQ conspire gives more vitality proficiency as soon as payload length increases than the convolutional code with Rc=1/2 for both systems (in and on-body). Furthermore, energy proficiency becomes down as soon as the payload length increase with FEC square codes, for both implanted and mounted systems. It has been learnt from this research that FEC square codes offer more energy efficacy as compare to other error control plans. In the event where the payload of length k square code builds, the ideal packet size and energy efficiency increases equally.

Medium access control (MAC) outlines are advanced to build the vitality proficiency in IEEE 802.15.6 ultra-wideband (UWB) BANs. For accomplishing the objective, the likelihood of packets recognition and effective gathering of the packets are reckoned in two QoS manners: the default approach and high QoS approach, of UWB. The default approach uses BCH (63, 51) code for FEC and on-off motioning for wide-ranging WBAN applications.

While, the other high QoS approach is utilized for greater needs and health related facilities and exploits type II hybrid ARQ with differential signaling. In the current research, the energy production is displayed by consolidating vitality utilization expenses of uplink and downlink channels and gathering and communicating energies. The anticipated framework demonstrates, IEEE 802.15.6 UWB physical layer Protocol Data Unit (PPDU) is utilized. Physical layer convention information unit comprises of 3 sections, i.e., physical layer benefit information component, a physical layer header (PHR) and a synchronization header (SHR). Packet identification and synchronization information is given by SHR. Details are done keeping in view end goal to discover the likelihood of fruitful packet recognition (PSHR), the likelihood of effective gathering of PHR (PPHR), and the likelihood of achievement of transferring of packets (PPPDU).

Hypothetical outcomes remain contrasted and the reproduced effects for default approach and high QoS approach as per SNR increments. Accordingly, it has been discovered, that the base SNR esteems must be in range of 15.5 to 9.8 dB to make 99% of packets progress likelihood (PPPDU) for vitality identification by using the default approach and for autocorrelation with high QoS approach, separately. Besides, vitality productivity is estimated for different frame lengths and bit error probabilities Packet measure advancement for a regular BANs [19-21] 7.3×10^{-2}, 1.2×10^{-2}, 8.8×10^{-3}, 5.2×10^{-3}, and 3.4×10^{-3} as the frame size get increased. Outcomes demonstrated that ideal package size estimate increments as soon as bit error probability reduces. For example, the ideal package measure is about 300 octets when the bit error probability is 5.2×10^{-3} for default approach and becomes the 76 octets as the bit error is 1.2×10^{-2}. At long last, ideal frame size to boost vitality effectiveness in IEEE 802.15.6 UWB BASNs is additionally found by a shut shape articulation for the default approach.

An adaptable non-layered and solicitation-oriented role-based engineering for WBANs has been displayed [22]. Different situations, for example, health services, crisis case, game, and battlefield are being noted as important area of applications for WBAN. Observing developments of expecting mothers, individuals with mental issues can be noted as cases of social insurance situation. Moreover, continuous information exchange is vital for crisis cases, for example, fire and disaster management events. In this situation, BAN system can provide important information as state, area, and damage of casualties and soldiers. Gaming frameworks have been transformed by utilizing wearable sensors. These days, players are more interfaced with games, a portion of the amusements enable clients to regulate and control their character with their own body parts with the help of wearable

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sensors. Gamer drives its control instructions to framework over BAN. In the Battle filed situation, officer insurance is finished by observing fighter's crucial signs and sends that readied information to medicinal individual via BAN.

In light of the perception that prerequisites of each BAN application is not quite the same as the other, the proposed design consists of 3 parts that are essential, particular parts, and specific parts. Essential parts incorporate context-aware data part, QoS part, directing part, error-free conveyance part, security and fragmentation role and protection part. Then again, applications, which are under a similar situation, share the particular parts and the specific parts, independently. Part information of use is put into the part headers and can be utilized by alternate applications. In this way, different parts don't should be embedded and the system stack diminishes with the part determination. Moreover, throughput proficiency of error control plans, for example, ARQ, BCH (127, 20, 1), and convolutional code Rc=1/2, are assessed to implement role-based engineering.

Ideal package measures used for every one of these inaccuracy control strategies are additionally establish to build the throughput execution. Example of which is the ideal packet estimate, that expands throughput effectiveness of 211 bits for ARQ plot with 10-3 BER. Assessments demonstrated that suggested design which is role-based beats conventional layered design as far as throughput productivity is concerned. Moreover, the throughput productivity execution of the anticipated role-based design conspires and additionally assessed with a similar error control plot in different BER esteems (i.e., 0.001 and 0.00001) as the payload increases its length. After validation it has been proven that throughput effectiveness and the ideal payload length increment with the diminishing of BER. Also, throughput proficiency with a smaller length of payload, for example, 350-2000 bits are estimated as the separation increments with a similar error control plans for both implanted and mounted sensors networks by means of LOS network model and attached body sensor systems by means of NLOS network display.

Observation was made that the bigger loads gives more throughput productivity (e.g., throughput increases to 12.8% as the payload length reaches 2000 as compare to 350 bits). Additionally, it has been demonstrated that proficiency of throughput for the error control plans is great as the load estimate increments. This is also experienced that FEC square codes joined by means of hop-length expansion procedure and BPSK regulation accomplishes most elevated throughput by means of the ideal packet size estimation.

The way out of keeping overcrowding issue in BANs is displayed via indicating ideal package measure that limits retransmission endeavors when fault circumstances occur [13]. In BANs, sensor hubs are implanted in body of human beings for medicinal services or battle field uses. Crucial signs are gathered from the body of human with the help of these implanted nodes which are then sent to the base station In any case, high BERs happen in BANs due to lossy connections, clamor, impedance, and blurring. Moreover, congestion happens amid the crisis circumstances when the system stack is high, that diminishes a quality of a network and vitality proficiency which results in expanded communication suspensions. Those issues are ought to be tackled by means of taking care of the clog issue for productive information transmission in a crisis circumstance. By way of solution for those situations, impacts of shifting pack magnitudes for the execution of BANs in various BERs are explored and assessed by reproductions via considering package conveyance proportion, deferral at each end, total retransmissions, overhead, add up to package delivered, and got after some period.

Outcomes demonstrated that package transfer ratio weakens, delay at both ends and the amount of retransmissions grows as soon as elongated package measure are utilized in high BER conditions due to conflict happening at high movement. Then again, utilizing the packets of small size can result in immense measure of overheads in low BER circumstances. The ideal packet measure of 640bits is come to be good for such issues. To this end, the execution of armed services and medicinal services, utilizing BANs stands expanded in anticipating congestion.

Table 1: Packet size optimization practices in BANs.

Environment	Study	Energy efficiency	Reliability	Network lifespan	Latency
BANs	[18]	Yes	Yes	No	No
	[23]	Yes	Yes	No	No
	[22]	No	Yes	No	No
	[8]	No	Yes	No	Yes

Table 2: Comparison of packet size optimization techniques based on their environments.

Environment	Technique	Purpose	Performance metrics
BASNs	Study of package measure to optimize the BANs and using hop-length extension scheme for FEC block codes [18]	Finding the most legitimate error regulating plan to Increment vitality adequacy with the perfect payload package measure.	Vitality Proficiency
	An adaptable non-layered and application-oriented based design for BANs [22]	Expanding the vitality productivity with the error control plans for an ideal bundle estimate.	Vitality Proficiency
	Preventing overcrowding issue in BANs [13]	Reducing re-transmission efforts via defining ideal pack size.	typical delay, Packet delivery ratio, no. of re-transmissions and overhead

WBANs application

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Table 3: Optimal package measure conferring to BAN applications.

WBANs application	Requirement	Optimum packet size
Battle field and medicinal area	Greater vitality competence & faultless communication	640 bits 69
combat zone observing, mechanical process control, environmental and safety purposes.	combat zone observing, mechanical process control, environmental and safety purposes.	50 bits 31
Battlefield, industrials uses, and environment defense uses & industrial process control, security	Greater vitality proficiency	456 bits with no use of BCH codes&1888 bits with the use of BCH codes 34
Automation systems, logistics, environment, and fiasco situations and unavoidable database frameworks	Greater throughput	2048 bits 27

In view of these current investigations, which are outlined, and thought about in Tables 1 & 2, from BANs viewpoint, it has been noted that ideal package measure altogether alterations as indicated by BAN application prerequisites and furthermore differs between the topology and the strategy. Hence, application prerequisites (e.g. high throughput, high vitality effectiveness, or little delay at both ends) need to be take care of before determining ideal package measure. As per a brief outline, ideal package sizes in light of prerequisites of particular WBAN applications are presented in Table 3.

Key Undeveloped Research Problems

The greater part of this study is in the direction of deciding perfect package measure in BANs for the vitality effectiveness, low latency, and high throughput. Though, such investigations confront numerous difficulties as a result of particular application prerequisites and proliferation attributes of organization situations. In forthcoming section, we feature these research problems which are still open for researchers for deciding the ideal package measure for BANs.

Service provisioning

QoS prerequisite for every BAN area differs application to application. Subsequently, the packet size optimization strategy must fulfill the particular application area necessities (e.g. vitality efficiency, little delay). Although indicating ideal package measure, remote network settings essentially well-thought-out to create sensible arrangements. Besides, the ideal packet size can be balanced by the type of traffic; this may be real and non-real time. Real-time packages require shorter delay, along these lines; little packet size can be utilized. Then again, packet sizes of greater length can be favored for non-real-time and best effort packets.

Transmission power control

Power utilization is an essential issue because of restricted battery for sensor nodes. Numerous investigations outline space to decide ideal packet size to expand the energy effectiveness. The wide are of works in literature utilize the little package measure for diminishing communication control. In any case, if the transmission is controlled by the network condition, the ultimate package measure can be discovered precisely.

Cross-layer design

Outline of a total cross-layer come closer commencing the physical layer to the application layer for optimization of packet size in BAN which hasn't been addressed in literature for various BAN areas. For instance, different antenna models e.g. omni-directional or directional radio wires at physical layer or diverse MAC conventions (e.g. TDMA, CSMA, and half and half) at the connection layer be reflected to decide the ideal package measure.

Reliable communication

Error control is a basic problem in WBANs, as the quantity of retransmission diminishes once the error free communication is accomplished. In literature discussed earlier, some error control components, for example, ARQ, FEC, and half and half strategies, are applied to get the ideal packet size. But, the performance measurement of these systems hasn't been fully compared for various WBAN applications to get the comparing ideal packet size.

Energy-harvesting wbans

Energy Harvesting (EH) might improve execution of WBANs by means of its own charging ability. Accessible vitality from surroundings, for example energy from sun, thermal, magnetic can be rummaged to control remote sensors. Though, current package measure methods for WBANs can't be straightforwardly applicable to EH-BANs. This is on account of the existing vitality that changes with time, rather than monotonically diminishing in energy-harvesting WBANs. To this end, ideal packet size arrangements are required for energy-harvesting WBANs to adjust the trade-off between energy utilization and QoS.

Conclusion

Packet measure is a vital constraint to expand the execution of BANs. Several optimization methods are anticipated by the specialists to enhance the system execution as far as the energy effectiveness, throughput, and delay are concern (among other execution measurements). These methodologies are grouped into various scientific categorizations.

Meanwhile several of these suggest using the package of fixed length or the dynamic package length, whereas others suggest utilizing different package arrangements or optimization systems. Optimization methods for package length are investigated in terms of WBANs. We reviewed the latest optimization schemes for package length to meet the necessities of particular application area to decide the ultimate package length. At last, we expressed the primary undeveloped research issues in the zone of package length optimization for forthcoming studies.

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