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Energy Efficiency in Wireless Body Area Networks Using Path Loss Model

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Abstract— Wireless Body Area Networks (WBANs) represent one of the most promising approaches for improving the quality of life, allowing remote patient monitoring and other healthcare applications. The deployment of a wireless body area network is a critical issue that impacts both the network lifetime and the total energy consumed by the network. This work deploys the reduction of energy consumption in the Attempt model reduces the path loss ratio to enhance the multiple sensors in WBAN. It provides a good tradeoff between the energy consumption and the number of relays, wireless body area networks in short computing time, thus representing an interesting framework for the dynamic network. Low power devices attached to the body have limited battery life. It is desirable to have energy efficient routing protocols that maintain the required reliability value for sending the data from a given node to the sink. In addition to the processing energy, sensor sensing, transient energy and transmission/reception on/off energy have also been taken into account. The results show improved performance of the routing protocols in terms of energy efficiency.

Keywords— Wireless body area networks, Energy consumption, Network lifetime, Energy parameters

I. INTRODUCTION

As healthcare costs are rapidly increasing with the world's population, there has been a need to monitor a patient health status anywhere both in and out of the hospital. This demand and advancement in technology, mobile electronic devices, wireless communication, portable batteries, and sensors caused the development of wireless body area network (WBANS). Wireless body area network is a system that is able to monitor the health conditions of patients and early risk detection constantly by sharing information with physicians. Based on the operating environments this can be classified into two various groups, one is called wearable body area network which is operated on the surface of the body, and another is implantable body area network which is operated inside the human body [2].

Generally, two sorts of devices can be differentiated sensors and actuators. The sensors can be used to measure internal or external certain parameters of the human body. Body temperature, measuring the heartbeat or recording a prolonged electrocardiogram (ECG) are some examples of sensors (Swamy, 2017). On the other hand, the actuators (or actors) take some spectacular actions according to the data they receive from the sensors or through interaction with the user. For instance, an actuator equipped with a built-in reservoir and pump administers the correct dose of insulin to give to diabetics according to the glucose level measurements.

Interaction with the user or other person is usually handled by a personal device such as a smartphone which acts as a sink for data of the wireless devices. The amount of energy consumed by a sensor node depends on the role it serves, as well as the workload it handles. To analyze hard network lifetime for guaranteed schedulability, the energy consumption analysis is used and the minimum energy consumed for a cluster head, and a regular node in respectively [7].

II. REVIEW LITERATURE

Wireless body area networks and their various applications in healthcare to various sections mainly focusing on the aspect to reduce the need for categories and to help the elderly and chronically people live an independent life. Body area network modeling, the model below does not produce good results [5]. The use an option that is given by Castalia simulator that is to explicitly set a path loss map for all nodes in a file. This means that the file will contain the path loss experienced between every two nodes.

This model is used together with the physical environmental model in order to define the path loss between two nodes. These papers consider the indoor environment and the dependent path loss model. This is one of the most commonly used path loss models that define the behavior of signal strength in an indoor area [1]. The path loss behavior is dependent on the distance between nodes and the attenuation factor added by the objects. The attenuation can vary based on several factors such as the construction materials and the object size [6].

Path loss is the reduction in the power density of an electromagnetic wave as it propagates through space. Path loss is a major component in the analysis and design of the link budget of a telecommunication system. This term is commonly used in wireless communications and signal propagation. Path loss may be due to many effects, such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption [9].

Path loss is also influenced by terrain contours, environment, propagation medium, the distance between the transmitter and the receiver, the height and location of antennas. Both theoretical and measurement based propagation models indicate that average received signal power decreases logarithmically with distance, whether in outdoor or indoor radio channels.

Body area network requires a shorter communication range, and important data rate, has extremely low power cost in its standby mode, and can provide enough power at its active mode, compare to this will benefit the device's lifetime and its work performance. Body area network meets certain safety and bio-friendly requirement since the working environment is related to human body health [4].

III. PROPOSED WORK

The sinks are mobile, most of the time and keep away from the sensors for a longer time. It will consume more power of sensor nodes and the relay node. Due to the mobility of the sink on hands, more packets will drop, that causes important and critical data to lose. High throughput with limited energy source is one of the key issues in wireless body area networks. Body area network devices may be embedded in the body or may be mounted on the body or in a fixed position on the wearable technology or may be placed in mobile devices that people can carry in different situations, in clothing, pocket, hand or different bags. Gateway devices are used to connect wearable devices to the internet through the human body.

WBAN is a wireless network which enables communication among sensor nodes operating on the body surface (or) inside the human body to collect information on various parameters. Energy Consumption is very important for the key parameter in the deployment of WBAN, it is, therefore, vital for energy demands of WBAN should be as small as possible. WBAN consumes energy during sensing, communication, and data processing. A lot of energy is consumed during communication. WBAN consist of various components which work together to collect process, Store and transmit data from the body to specific points where the data is required for monitoring, interpretation (or) emergency response.

The problem statement of this work is to reduce the path loss ratio in the attempt routing protocol using multiple sensors before that the enhance of energy in the simple routing protocol that is the packet loss ratio only reduce in the previous model. The solution of this problem here is using multiple sensors at the attempt routing protocol in the WBAN to deploy the energy efficient at the point.

IV. METHODS AND MATERIAL

It should include important findings discussed briefly. Wherever necessary, elaborate on the tables and figures without repeating their contents. Interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. However, valid colored photographs can also be published.

Wireless body area network nodes communicate at an expense of a large amount of energy consumption. The total energy consumption is the sum of the processing energy, sensing energy, transient energy and transmission/reception on-time, radio transmission and receiving the energy consumption for all processes of every sensor node are same as all regular sensor nodes are assumed to be homogeneous.

1. Sensor Sensing

A Sensor node is able to connect to the physical world because of its sensing system. Considering I_{sens} as the total current needed for sensing and T_{sense} as the time taken for sensing the sensor node, the total energy consumption for sensing task for n bit packet, E_{sens_N} at the sensor node(n) per round is calculated as given in equation.

$E_{sens_N}(n) = nV_{sap}I_{sens}T_{sens}$, the total energy consumption for sensing task at the BC per round by $E_{sens_{BC}}(w_1,n) = w_1 E_{sens_N}(n)$ where V_{sap} is the supply voltage.

2. Radio Transmission and Receiving

If the energy dissipated by the radio in order to run the transmitter circuitry is represented by $E_{TX_{elec}}$,the energy dissipated by the receiver is represented by E_{TXelec} the energy for transmitter amplifier as E_{RXelec} , the distance between nodes i and j as D_{ij}. Then the energy consumption due to transmit of n bit packet from sensor node to BC per rothe und can be calculated as $E_{TXelec}(n, D_{ij}) = nE_{TXelec} + nE_{amp}D_{ij}^{p_{ij}}$. Energy dissipated when n bit packet is received from sensor node is given by $E_{TXelec}(n) = nE_{RXelec}$. Therefore, energy dissipated when n bit packet is transmitted to a distance D_{ijthe} from the BC round can be estimated by $E_{TXelec}(w_2, n, D_{ij}) = w_2 nE_{TXelec} + nE_{amp}D_{ij}^{p_{ij}}$

whereas the energy dissipated when n bit packet is received from BC is estimated by $E_{RXelec}(n) = w_2 nE_{RXelec}$ where n is the total number of bits transmitted /received and p is the distance based path loss exponent.

3. Processing Energy

Most of the energy consumed for processing and aggregation of data is accorded by the consumption of energy during switching and energy consumption due to leakage current E_{leak}.

Total energy consumed in data processing/aggregation of n bit packet by the sensor node, E_{procN}, per round is given by:

$$E_{procN}(n, N_{cyc}) = nN_{cyc}C_{avg}V_{sap}^2 + nV_{sap}\left(I_0 e^{\frac{V_{sap}}{k}}\right)\left(\frac{N_{cyc}}{f}\right)$$

,total energy dissipated by the body coordinator(BC), $E_{procN}(w_3, n, N_{cyc}) = w_3 E_{procN}(n, N_{cyc})$ where I_0 is the leakage current, V_t is the thermal voltage, f is sensor frequency, C_{avg} is the average capacitance switched per cycle, N_{cyc} is the number of clock cycles per task and K_p is the constant that depends on the processor. It is assumed that once during each round, sensor nodes sense data and transmits to their BC; the energy consumption due to data processing from normal sensor nodes has not been taken into account. It is considered that the sensing energy of BC is 10 % more than that of normal sensor nodes whereas the processing and communication energy of the BANC is 20 % more than normal sensor nodes. Hence, the weighting factor, w_i has been assumed as $(w_1, w_2, w_3) = (1.1, 1.2, 1.3)$

4. Transient Energy

Transitions between different modes (active, idle and sleep) of radio and micro-controller units consume a significant amount of power while accounting for the total energy consumption of the network. These are often not considered in the literature. Let the time taken for the transition from sleep-to-idle mode by T_{tranON} and the time needed for the transition from idle-to-sleep mode by $T_{tranOFF}$. A sensor node will listen to a busy channel, wake up for T_{α} and then sleep for T_s, then assuming $T_s \gg T_{\alpha}$. Similarly, BC wakes up for $T_{\alpha BC}$ duration, and then sleeps for T_{sBC}. Let time between corresponding packet transmission be T_{tr}. The BC will transmit every packet it receives in one batch after every T_{tr} seconds as given below.

5. Transmission/ Receiver on-time:

The time needed by a sensor node to attain a steady state after the power is switched on is known as the startup time (T_s).It is an established factor in the power management of sensors. The process will receive a wrong value, if the sensing activity does not wait for the (T_s) after the micro controller unit requests the sensor to turn on.

Characteristics of Wireless Body Area Networks include:

It is a small case wireless network for short distance communication within 3 meters (Liu & Kwak, 2010).

The range of data rate in WBAN is formed 10Kbps to 10Mbps.

The main structure in WBAN is Star topology and BN only communicates with BNC.

BNs are constrained in their power computation and communication capabilities, specifically for those implanted BNs (Baraka& Ammad-uddin, 2012).

Security should be energy efficient with minimal overhead and support at least authenticated and encryption operations.

It closely surrounds the body to consist of its own communication system.

The routing protocols have been evaluated based on comprehensive simulations using MATLAB in terms of energy consumption, throughput and number of packets forwarded. Results obtained demonstrate that the protocols are providing better results in terms of chosen parameters, optimizing multi-objective parameters to select the forwarder node has been instrumental in providing better results instead of direct selection.

Optimized Cost Effective Energy Efficient Routing Protocol:

The cost-effective and energy efficient routing protocol is explained below:

Initialization Phase

Which have considerably more energy than body area network nodes broadcast packets periodically and body area network broadcasts packets at the reception of other nodes' in a a packet containing information to construct and maintain a neighbour table and finally a routing table?. It is assumed that node k, the neighbour node of node s, is located between source node s and the the destination node. The packet fields of node K are $ID_d, L_d, ID_k, E_k, PL_k$ and $LinkR_k$.

Table 1. IEEE Specification for WBAN Technology

Distance/ operating space	2 m standard and 5 m special use; in, on, and around the body
Network Density	2-4 nets/m2
Network Size	Max : 100 devices/network, modest < 64 devices per BAN
Target lifetime	Up to 5 years for implants Up to 1 week for wearable Ultra-long for implants Long for wearable
Target frequency bands	Med Radio, ISM, WMTS, UWB Global Unlicensed and Medical bands
Power Consumption	~1mW/ Mbps, support for several power management and consumption scheme
Peak power consumption	Between 0.001–0.1mW in standby mode up to 30mW in fully active mode Scalable
Network Throughput	100 Mbps Max
Data rate	From sub kb/s up to 10 Mb/s Scalable
MAC	Low power listening, wake up, turn-around and Synchronization Scalable, reliable, versatile, self-forming
Topology	Self-forming, distributed with multi-hop support Star, Mesh or Tree
Very Low, Low, and High duty cycle Device Duty cycle,	From 0.001% up to 100% Adaptive, Scalable, Allows device driven degradation of services

When the node s receives hello packets from node k, it will record the information in its neighbour table. Furthermore, the node s adds its own information for broadcasting in the received packet. The $dist_{k,d}$ calculated by using equation 1.

$$dist_{k,d} = \sqrt{(x_k - x_d)^2 + (y_k - y_d)^2} \ldots\ldots (1)$$

The filters the neighbour's tables having many records for the same destination and only choose the one with the least value of communication cost. The routing table fields of sensor nodes are ID_d, L_d and nh_o. If the destination d and node s are one hop apart, the next hop (nh_o) will be the destination ID (ID_d). If they are far apart, then the neighbor node k having a minimum value of communication cost (C_k) will be selected as next hop.

Table 2 Difference between WSN and WBAN

Issues	**Wireless Body Area Network**	**Wireless Sensor network**
Node Size	Small is essential	Small is preferred, but not important
Scale	Human body (centimeters/ m)	Monitored Environment (meters/ km)
Node Tasks	Node performs multiple tasks	Node performs a special task
Network Topology	More variable because of body movement	Very likely to be fixed or static
Node Number	Fewer, limited in space	Many redundant nodes for wide area coverage
Energy-Scavenging Source	Most likely motion and thermal	Most likely solar and wind power
Node Lifetime	Several years/months, smaller battery capacity	Several years/months
Node Replacement	Replacement of implanted nodes difficult	Easily
Power Demand	Likely to be lower, energy supply more difficult	Likely to be large, energy supply easier
Wireless Technology	IEEE 802.15.6	Bluetooth, ZigBee, GPRS, WLAN
Result Accuracy	Through node accuracy and robustness	Through node redundancy
Security Level	High	Low
Biocompatibility	A must for implants and some external sensors	Not a consideration in most applications

V. SIMULATION AND RESULTS

Packet Received Ratio

To measure the useful work done by the system in the presence of an error recovery scheme. For a given link, we measure the useful work done over that link using an efficiency metric, which is defined as the ratio of the distinct packets received and the packets transmitted including retransmission. We intend to capture the efficiency of link layer retransmission, so our definition does not count the overhead from coding schemes or preamble for packets. Note that the efficiency metric does not measure channel utilization. Rather, because it measures the useful work done as a fraction of total work done, it gives us some indication of the energy wasted by the system in overcoming packet losses.

Simulation results show that SIMPLE protocol consumes minimum energy till 70% of simulation time. It means, a instability period, more nodes have enough energy and they transmit more data packet to sink. It also improves the throughput of the network. On the other hand, in M-ATTEMPT, some nodes exhaust early due to heavy traffic load. Figure 1 represents packet received ratio and simply refers proposed packet received ratio, it is increased than an attempt.

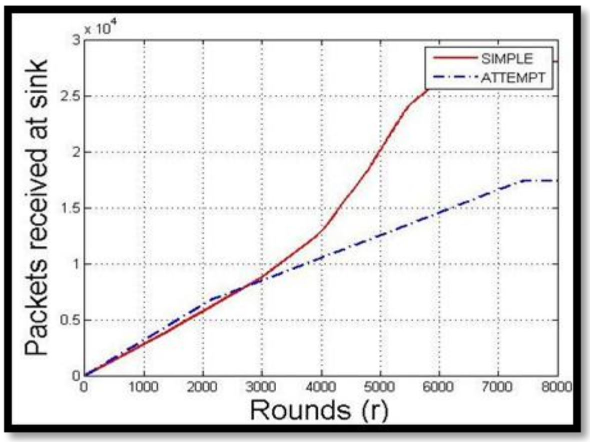

Figure 1. Packet received ratio

Path Loss

Path loss in the consequence of many effects such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Two separate path loss exponents are used to characterize the propagation.

PathLoss:

$$L = \begin{cases} 10n_1 log_{10}\, r + L_1 & for\, r \leq r_b \\ 10n_2 log_{10}\left(\frac{r}{r_b}\right) + 10n_1 log_{10} r_b + L_1 & for\, r > r_b \end{cases}$$

L1 = reference path loss at r=1m

rb = break point distance

n1 = path loss exponent for r<=rb

n2 = path loss exponent for r >rb

Path loss is also affected by other factors such as propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the frequency of the signal. When the effects of path loss are not considered, the evaluation of the underlying structure can become optimistic, since the problems associated, retransmissions and the way this phenomenon affects the energy consumption are taken into account. The multi-wall model gives the path loss as the free space loss added with losses introduced by the walls and floors penetrated by the direct path between the transmitter and the receiver. Figure 2 represents path Loss and simply refers proposed path loss, it can be reduced. Attempt refers old path loss model.

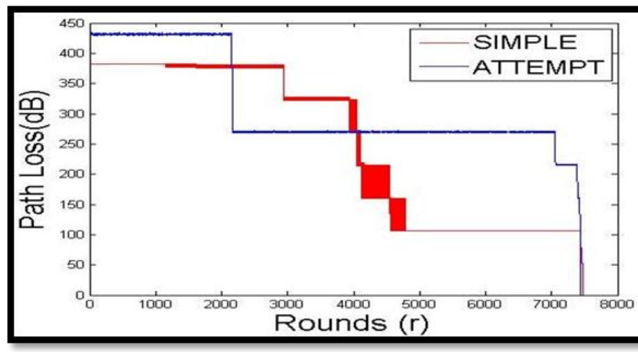

Figure 2. Path Loss

VI. CONCLUSION AND FUTURE WORK

The energy efficient routing scheme for wireless body area networks considering its continuous network operation so that wireless body area network sustains its functionality for the longest time. The function of node residual energy, path loss and link reliability model based energy efficient routing is provided on this work. The model can be used to minimize both the total energy consumption and the network installation cost while ensuring full coverage of all sensors. This paper to maximize the network lifetime while taking account of limitations such as the sensors, the reliability of sensors, and bandwidth. Path loss model for body area communication is described and from analytical simulations, it is observed that path loss is maximum in body area communication. The simple results show a great raise in sensors' lifetime compared to either single-hop or multi-hop transmission. To balance energy consumption among sensor nodes and to trim down the the energy consumption of network, SIMPLE protocol elects new forwarder in each round. It means, in a stability period, more nodes have enough energy and they transmit more data packet to sink. It also improves the throughput of the network. On the other hand, in M-ATTEMPT, some nodes exhaust early due to heavy traffic load.

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