An Enhanced SIMPLE Protocol for Wireless Body Area Sensor Network

Narendra Kumar Yadav
Rameshwaram Institute of Technology & Management
Lucknow, U.P. (227202)
Dr.A.P.J.A.K.T.U, Lucknow
narendradelhi@gmail.com

Pushpendra Dwivedi
Pranveer Singh Institute of Technology
Kanpur, U.P. (208020)
Dr.A.P.J.A.K.T.U, Lucknow
pushpendradwivedi10@gmail.com

Abstract

The above mentioned small sensing devices are known as nodes and consist of battery (for energy), CPU (for data processing), transceiver (for receiving and sending signals or data from one node to another) and memory (for data storage). The size of each sensor node changes with the change in applications. For example, in some surveillance or military applications it might be microscopically small. Its expense relies on its parameters such as battery, memory size and processing speed [1].

In the present time, wireless sensor networks are mostly utilized as a vital part of commercial and industrial areas like for e.g. habitat monitoring, environmental monitoring, healthcare, process surveillance and monitoring. For example, in a military zone, wireless sensor networks are generally used to monitor any kind of activity. In the case an event is triggered, these sensor nodes sense it and information is send to the base station (called sink) with the communication with other nodes.

Key Words: *Wireless Body Area Sensor Networks, Distance-aware, Threshold-based, Thermal-aware, Multi-hop, Single-hop.*

1. INTRODUCTION

With the time, the application of wireless sensor networks is expanding day by day and in the meantime it goes through the issue of energy constraints in terms of limited battery lifetime. As for activities, each node relies on its energy; this has turned into a big problem in wireless sensor networks. The malfunctioning of one node can affect the application or entire system. Each sensing node can be in idle, sleep and active (for receiving and transmission activities) modes. Nodes consume energy in active mode at the time of receiving or transmitting data. In idle mode, the nodes consume approximately the same amount of energy as in active mode, while, the nodes shutdown the radio in sleep mode to save the energy.

The steps given below can be considered to save energy caused by communication in wireless sensor networks [2].

.To schedules the state of the nodes (i.e. transmitting, receiving, idle or sleep). Changing the transmission range between the sensing nodes.

· Using efficient routing and data collecting methods.

· Avoiding the handling of unwanted data as in the case of overhearing.

The battery is the only source of life for the nodes in WSNs. A great deal of energy is consumed by sensing activities or communicating with other nodes in processing the data and transmitting the collected data to the sink. In mostly cases (e.g. surveillance applications), it is not desirable to change the batteries that are depleted or drained of energy. A number of researchers are hence attempting to discover power-aware protocols for wireless sensor networks with a specific end goal to overcome such energy efficiency issues as those mentioned above.

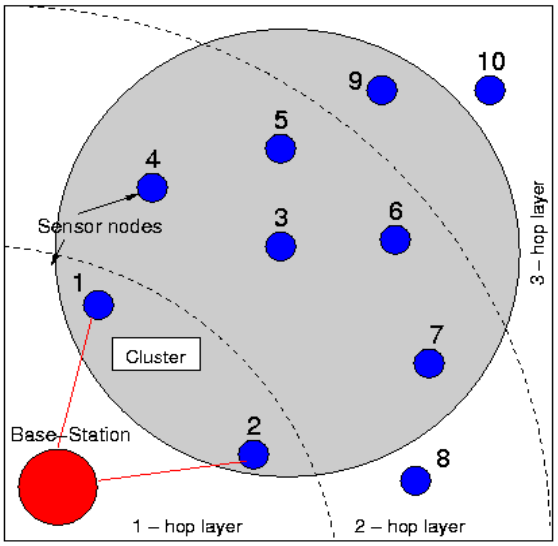

Fig 1: Schematic of wireless Sensor Network

A great numbers of Sensor nodes deployed in collaborate to design a network efficient of reporting to data collection and deployment can be random deployment or self organization [3].

2. CHALLANNGES IN WSBN

Development of a WBSN requires considering numerous things that can result in less communication flaws, network longevity and turn the network safe and sound for the purpose of communication [4]. The factors mentioned below must be taken into consideration at the time of while making a WBSN:

2.1 Energy

It is very difficult or almost impossible to make the replacement of the battery after a short interval in WBSN particularly if there should be an occurrence of implanted nodes. Therefore considering the use of power in the network so as to enhance the life of the network is of most extreme significance.

2.2 QoS and Reliability

It is essential that WBSN should have the ability of transmitting flawless data that too consistently in real time. BAN applications that are used in the field of medical conditions particularly need data to be sent without making

any kind of delay and loss. These kinds of important applications needs reliability and QoS as corrupted or false information can result in the critical and may be even deadly consequences.

2.3 Co-Existence

Standards like Zigbee [6] and Bluetooth are used to transfer the data from one network to the other. Therefore, it is needful that WBSN should be that much effective so that it can operate across various networks without creating any sort of interference from the other networks in the vicinity.

2.4 Security and Privacy

As per the application WBSN consist data which is extremely important and kind of tampering with it can result in a perilous situation such as death. Therefore, there must be appropriate procurements for carrying out authorization checks to verify whether the user is authorised to accesses the information or not. We should also maintain the integrity of data as to make sure that data remains unchanged at sender and receiver side [7].

2.5 Data Validation

Due to the defective links over the network or because of the interference from different networks, there can be errors in the information sent over the network [8]. This may result in getting wrong data at the receiver side. Such kind of wrong data in case of health applications can cause serious effects or may result in someone's death. So, each data should be validated in a proper way at the receiver's end to check for its correctness.

3. BACKGROUND AND MOTIVATION

In order to make uninterrupted monitoring of the persons or patients, wireless body area sensors are used with energy constraints. A number of energy efficient routing algorithms are being proposed. These algorithms were used to transfer data from body sensors to far located medical server. We must pay attention on the fact that the sensed data of person should be transferred in time and with proper reliably to the concerned person or server so that appropriate action or analysis could be done.

In an opportunistic protocol ATTEMPT is proposed and studied [40-51]. This scheme provides mobility of some of the nodes at cost of low throughput and an extra expense of relay node. At any time, sink node moves far from nodes transmission range (due to movement of body parts), it relies on a relay node which is applied for making the collection of data from sensor nodes.

In the work sink node is deployed at wrist. Due to the fact that hands move now and then, sink becomes mobile for a major part of the time and lie far from the sensors for a long duration. This will result in the more consumption of power of relay nodes and sensor node. More packets will drop because of the mobility of the sink on hands that in turn results into the loss of important and critical data. One of the major problems in WBANs is high throughput with limited source of energy.

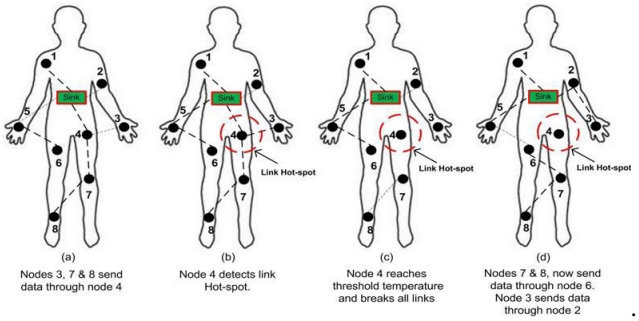

Fig 2: Link Hot-spot Detection

The constant quantities of nodes in WBANs offer chance to relax limitations in routing protocols. With the inspiration of routing constrains, we enhance the period of stability and throughput of the network. Following subsections throws a light on the features of the system model along with the detail of SIMPLE protocol [4-9].

4. SIMPLE PROTOCOL

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4.1 INITIAL PHASE

In this phase, Sink broadcast a small information packet in this phase which comprises the position of the sink on the person's body. Each sensor node, after getting this control packet, stores the position of sink. An information packet is broadcasted by each sensor node which has the following information: position of node on body, node ID and its energy status. Thus, each sensor node is updated with the information about the location of neighbors and sinks.

4.2 SELECTION OF FORWARDER

In order to save energy and to enhance network throughput, a multi hop scheme is proposed for WBAN. In this part, we explain the criteria of selection for a node to turn out parent node or forwarder. With the end goal of balancing consumption of energy among sensor nodes and trimming down energy consumption of network, new forwarder is being selected by SIMPLE protocol in each round. Sink node is aware of the information of the nodes such as distance, ID and residual energy status. Sink processes the cost function of each node and this cost function is transmitted to all nodes by sink.

Each node makes the decision on the basis of this cost function whether to be a forwarder node or not. If i is number of nodes than cost function of i nodes is evaluated as:

$$C.F(i) = \frac{d(i)}{R.E(i)}$$

Where the distance between the node i and sink is represented by $d(i)$, $R.E(i)$ is the residual energy of node i and is estimated by extracting out the present energy of node from initial total

energy in the initial. We prefer a node with least cost function as a forwarder. Each one of the neighbor node get affixed together with forwarder node and transfer their data to forwarder.

4.3 SYSTEM MODEL

Eight sensor nodes are placed on the body of the person in this scheme. Each sensor node consists of same power and computation capabilities. Sink node is deployed at waist. Node 1 is ECG sensor while node 2 is Glucose sensor node. Data is transmitted directly to sink by these two nodes [10-12]. The deployment of nodes and sink on the human body. The forwarder node is selected on the basis of cost function.

Parameters	nRF 2401A	CC2420	Units
DC Current (Tx)	10.5	17.4	mA
DC Current (Rx)	18	19.7	mA
Supply Voltage (min)	1.9	2.1	V
$E_{TX\text{-}elec}$	16.7	96.9	nJ/bit
$E_{RX\text{-}elec}$	36.1	172.8	nJ/bit
E_{amp}	1.97×10^{-9}	2.71×10^{-7}	J/bit

Table 1: Radio Parameters

5. PERFORMANCE METRICS

We evaluated key performance metrics for proposed protocol. Definition of performance metrics is given in following subsections [13].

1) ***Network lifetime:*** It represents the total network operation time till the last node die.

2) ***Stability period:*** Stability period is the time span of network operation till the first node die. The time period after the death of first node is termed as unstable period.

3) ***Throughput:*** Throughput is the total number of packets successfully received at sink.

4) ***Residual Energy:*** In order to investigate the energy consumption of nodes per round, we consider residual energy parameter to analyze energy consumption of network.

5) ***Path Loss:*** Path loss is the difference between the transmitted power of transmitting node and received power at receiving node. It is measured in decibels (dB).

Path loss represents the signal attenuation and is measured in decibels (dB). Signal power is also degraded by Additive White Gaussian Noise (AWGN) [15]. Path loss is the difference between the transmitted power and received power whereas antenna gain may or may not be considered. Path loss occurs due to the increasing surface area of propagating wave front. Transmitting antenna radiates power outward and any object between transmitter and receiver causes destruction of radiated signal. In WBAN, different human postures, movement of body, hands and cloths, affects the transmitted signal. Path loss is related to the distance and frequency and expressed as [16].

Transmitting antenna radiates power outward and any object between transmitter and receiver causes destruction of radiated signal. In WBAN, different human postures, movement of body, hands and cloths, affects the transmitted signal. Path loss is related to the distance and frequency and expressed as [20].

$$PL(f,d)=PL(f)\times PL(d) \qquad (1)$$

The relation of frequency with path loss is expressed as

$$\sqrt{PL(f)}\propto f^{k} \qquad (2)$$

Where k is frequency dependent factor and it is related to the geometry of the body. The relation of distance with path loss is given as

$$PL(f,d)=PL_0+10n\log_{10}\frac{d}{d_0}+X\sigma \qquad (3)$$

Where PL is received power, d is the distance between transmitter and receiver, do is the reference distance, n is the path loss coefficient and its value depends on the propagation environment. In free space its value is 2, for WBAN, n varies from 3-4 for line of sight (LOS) communication and 5-7.4 for non line of sight (NLOS) communication. X is Gaussian random variable and σ is standard deviation [13,14]. PL_o is received power at reference distance d_o and it is expressed as:

$$PL_0=10\log_{10}\frac{(4\pi df)^2}{c}$$

Where f is frequency, c speed of light and d is distance between transmitter and receiver. The value of reference distance do is 10cm. In reality it is difficult to predict strength of signal between transmitter and receiver boundary. To solve this issue, we use a deviation variable $X\sigma$.

6. PROPOSED MODEL

To increase the throughput and reliable communication between sensors and sink, we propose a new scheme. Main advantages of our proposed protocol are as follow:

Our proposed scheme achieve a longer stability time. Nodes stay alive for longer period and consume less energy. The large stability period and less energy consumption of nodes, contribute to a high throughput. The proposed model is very much similar to the simple protocol with following changes:

In our model the forwarding node is decided on the basis of following cost function it is better to call is forwarding function as such no cost involve

$$FF(i)=\frac{1}{d(i)}$$

As it is useless to select to forwarding node which is far away from the data sending node, and as the most of the nodes (as in SIMPLE and ATTEMPT) have same energy E_0, thus residual energy consideration is not necessary.

Moreover we also assume that ECG and glucose monitoring sensor nodes carry higher energy than other nodes by a fraction α .

7. SIMULATION RESULTS AND ANALYSIS

In this section, results of proposed model are compared with SIMPLE protocol. In figure 4.6, number of dead nodes vs. Number of rounds is plotted. However, with proposed model; till 2803 rounds number of dead node is zero, which becomes 1 and remains one till 7215 rounds. In case of SIMPLE protocol, from round 4436 to 5390 rounds dead node is one thereafter, number of dead node rises. With SIMPLE protocol, the numbers of dead nodes become 6, around the round 5917.

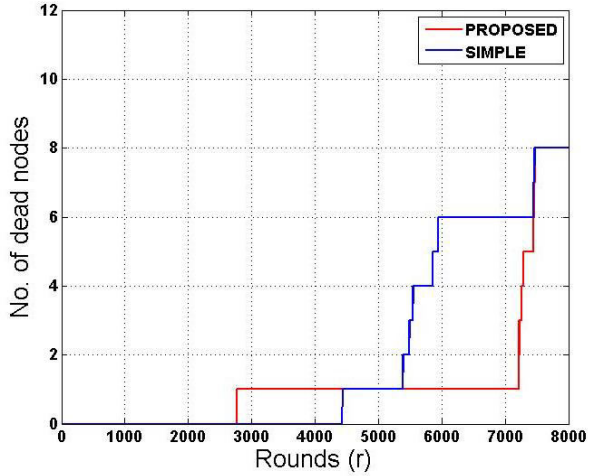

Fig 3: No of Dead Node vs. Rounds

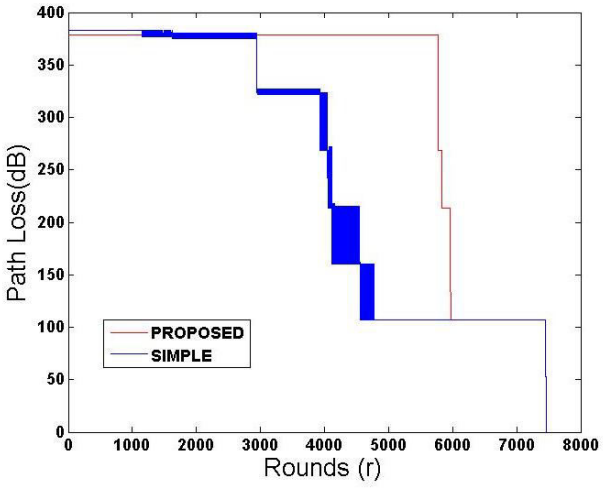

Fig 4: Path Loss vs. Rounds

In figure 5, residual energy vs. Round is plotted. Over here till 1753 rounds the residual energy of SIMPLE protocol and proposed protocol is same i.e., 2.744 Joules. Thereafter, residual energy decreases with number of rounds. However in case of SIMPLE protocol form round 4500 to 6000 numbers of dead nodes increases from 1 to 6. Thus residual energy shown variations in the curve and as well as it comes down below to proposed curve due to the larger number of dead nodes, and finally residual energy goes to zero at 7445 rounds.

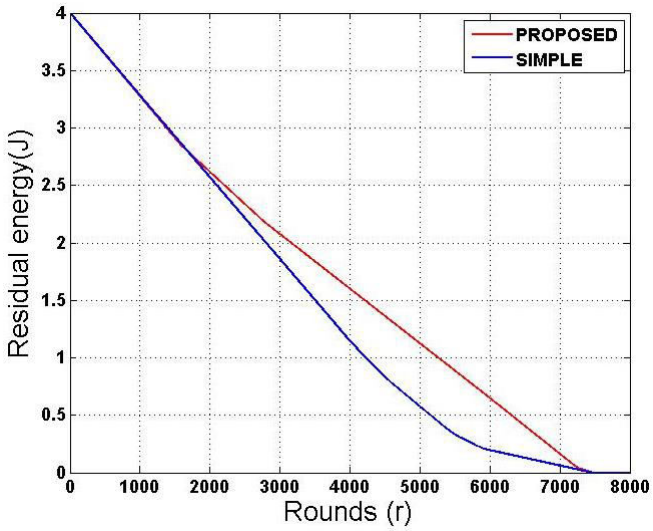

Fig 5: Residual Energy vs. Rounds

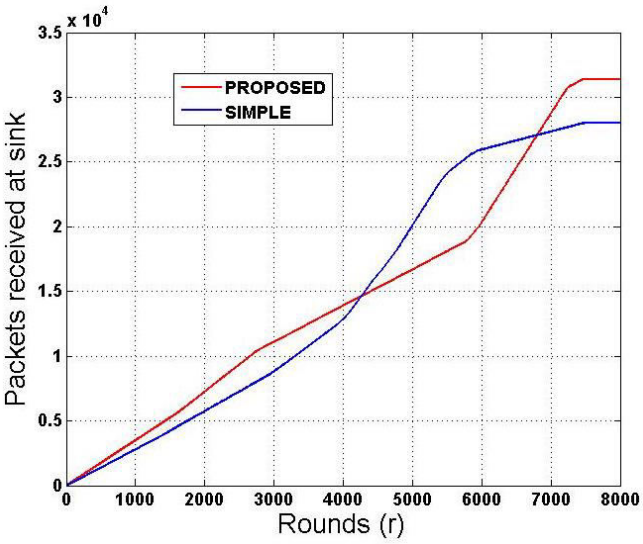

Fig 6: Packet Received at Sink vs. Rounds

. In case of PROPOSED protocol the total packets received are 3.13×10^4, while for SIMPLE protocol, the number of received packets are 2.8×10^4. Therefore, a rise in the packets received and in terms of percentage it is 11.78%.

8. Future Work

1. Delay can also be calculated during transmission.

2. Topology optimization can also be done to enhance the throughput.

3. Cost function can be further modified to further enhance the results.

4. Clustering based method can be used to further enhance the results.

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