Comparison of ATTEMPT and SIMPLE Protocols for Wireless Body Area Networks

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Abstract – *The data of the patients is of utmost important for his health monitoring therefore it must be kept very safely. The functioning of standard must take care of security and accuracy in data transferring. It is quite necessary that the data must be transferred in a secure way to the WBAN system coordinator. We must also take care of the fact that the data of one patient must not get mixed up with another one's. The patient's data is highly private and it must have limited access and must be highly secure. This paper compares the two recently proposed protocols ATTEMPT and SIMPLE along with simulation results.*

Key Words: WBAN, SIMPLE, Throughput

1. INTRODUCTION

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]. 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.

2. DESCRIPTION OF PROTOCOLS

ATTEMPT PROTOCOL

A. Initialization Phase
In this phase Hello messages is broadcasted by each node. Aforesaid Hello message comprise the information of the neighbours along with the sink nodes distance in form of hop counts. Each node is updated in this manner with their neighbours, position of the sink node and routes that are available to the sink node.

B. Routing Phase
In the routing phase, selection of the routes with fewer hopes to sink node is made from the routes that are available. At this point, we assume that nodes consist of information of each node and also the location of the sink nodes. Therefore, less energy is consumed by the selected routes and they are steadfast also. The proposed routing protocol also defines the emergency services. In important scenarios, all procedures are slacked till effective reception of important data at the sink node. All of the nodes that are implanted on the body can make the direct communication with the base station in the event of any emergency.

In addition to this, it is possible for each sensor nodes to make a direct communication with the sink node when there is need from sink node. Delay is quite less in the event of direct communication in comparison to multi-hop communication. This is due to the fact that in multi-hop communication, the process takes place in a lengthy way i.e. each intermediate node receives, make processing and then transfer data to next node. In the whole process of receiving, processing and then transmission of the received data on each intermediate node causes delay. This delay is also increased because of the sometime congestion. This delay must be overcome especially in the case of critical situations. To minimize this delay, data could be sent through single-hop communication. We make the calculation of energy consumed in the case of single-hop communication E_{S-HOP} as:

$$E_{S-HOP} = E_{Transmit} \qquad (1)$$

And transmission energy $E_{Transmit}$ is calculated as:

$$E_{Transmit} = E_{elec} + E_{amp} \qquad (2)$$

where, E_{elec} is the energy consumed for processing and E_{amp} is energy consumed by transmit amplifier.

A linear network is supposed in which each node is embedded at same distance from each other. To transmit b bits up to n hops, the transmission energy is provided as:

$$E_{Transmit} = n\left(bE_{elec} + bE_{amp}\right)d^2 \qquad (3)$$

In the case of our single-hop/multi-hop traffic control algorithm 1, if a node uses single-hop communication is used by a node when sensed critical position or on-demand data. The sensor node makes use of maximum power of battery in single-hop communication in order to transfer its data whereas for receiving normal data, the multi-hop communication is utilized to transfer data to sink node. Subsequently, considering all the things power consumption is low without making any kind of effect on the reliability in view of delay. With the increases in the distance, the consumption of energy also increases to send data. Hence, consumption of energy is quite low in multi-hop communication.

Algorithm 1 : Single hop/multi-hop traffic control algorithm

1:    **for** $i = 1:1:n \, do$

2   **Initialization Phase**

3    $T_r \leftarrow Transmission\,range\,of\,node\,i$

4   **if** $(Node_i <= T_r)\,then$

5   Direct communication with Sink node

6   **Else**

7   I**f**$(Critical\,Data == 1 \mid On-demand == 1)\,then$

8   Send data to sink node

9   **if** $(L_{i,j} > C_T)\,then$

10   Send data to other node

11   end if

12   end if

13   end if

14   end for

In WBASNs, the preservation of energy is given the utmost priority as the implanted sensor nodes do not have much sources of energy. Therefore, nodes that are implanted required sensible battery use so that the life-time of the network extents. Deployed sensor nodes provide few heating effects on the human body.
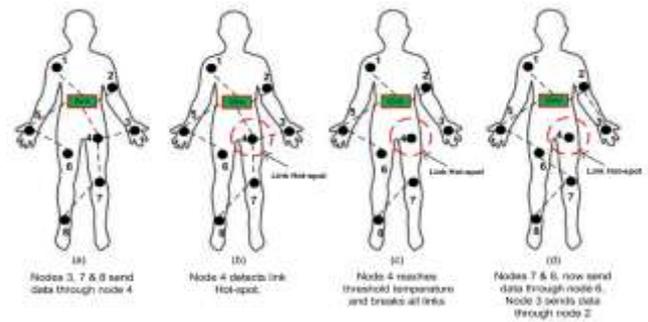

Figure 3.1: WBAN Body Area Network path selection

In the event of dealing or working with wireless communication around the person, we must pay attention on the effects made by these sensors on human body. The factor that is considered with utmost importance for this intention is Specific Absorption Rate (SAR) and effects made by the heating of the implanted sensor nodes.

The purpose routing protocol is developed to operate as per the SAR and heating effects on the body of the person. Due to the fact that nodes deployed nearer to sink node are sending data of their follower nodes. At whatever point these nodes achieve their temperature threshold, link is broken by these nodes with their neighbour nodes for some rounds. As soon as their temperature goes down and reach at normal temperature, these sensor nodes build up their past routes. Though, in the case a sensor node gets a data packet and reaches its threshold of temperature at this point it sends packet back to previous node and that node will identify this link as Hot-spot as illustrated in Fig. 1.

In order to make the calculation of the energy consumed at the time of a multi-hop communication, we consider a linear network in which the distance between all implanted nodes is equal.

The energy loss while making multi-hop communication can be evaluated using the below given equations:

$$E_{M-HOP} = E_{Transmit} + E_{Received} \qquad (4)$$

where, $E_{received}$ is the energy loss for receiving data. If we are transmitting b-bits to a distance of n-hops then the transmission energy will be $nbE_{Transmit}$ and receiving energy will be $(n-1)bE_{Received}$. As the first node transmit only and intermediate nodes first receive n- bits and then transmit these received bits. Therefore, the energy consumed for multi-hop is:

$$E_{M-HOP} = nbE_{Transmit} + (n-1)bE_{Received}$$
$$E_{M-HOP} = nb(E_{elec} + E_{amp}d^2) + (n-1)bE_{elec} \qquad (5)$$

Algorithm 2 explains the ATTEMPT routing. In the case two routes are available the selection of hop-count route is less. Moreover if two routes have identical hop-count, the route with less consumption of energy to the sink node is selected.

Algorithm 2 : ATTEMPT Routing

1:   **Routing Phase**
2   **if** $(route\_1 < route\_2) then$
3     $route\_1 = selected\ route$
4   **Else**
5     $route\_2 = selected\ route$
6    $If\ (route\ 2 < route\_1) then$
7     $route\_2 = selected\ route$
8   **Else**
9     $route\_1 = selected\ route$
10   **if** $(route\_1 = route\_2) then$
11    $E_{hop-count} \leftarrow Energy\ consumption\ for\ a\ route$
12    $If\ (E_{hop-count}\_1 < \leftarrow E_{hop-count}\_2) then$
13     $route\_1 = selected\ route$
14   **Else**
15    $route\_2 = selected\ route$
16   **End if**
17   **End if**
18   **End if**
19   **End if**

C. Scheduling Phase
After the completion of the phase of route selection, the sink node begins channel assignment is started by the sink node with the help of Time Division Multiple Access (TDMA) schedule for making the communication with root nodes. Sink node makes the allotment of time-slots to the root nodes for normal delivery of data.

D. Data Transmission Phase
After the assignment of time slots to the root nodes is over, root nodes transmit their data to sink node in the time slot that was allocated to them. After the receiving of data by the sink node, it will take a small measure of time to collect the data which is received. After this, sink node then send this collected data to the out body server by means of wireless link.

E. Mobility support in ATTEMPT
The nature of WASNs is mobile and the reason behind this is due to the movements in human body. To deal with this, the scheme proposed by us supports mobility. To accomplish the same, we propose a prototype for setting nodes on the person and termed it as Mobile-ATTEMPT (MATTEMPT). Nodes are placed on the person's body according to their with high data rate. Nodes with high data rate are planted at less mobile body parts. These are parent nodes and are in

direct connection with the sink node. Parent nodes with 10J develop 10Kbytes of data.

3.3 SIMPLE PROTOCOL

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 [41]. Following subsections throws a light on the features of the system model along with the detail of SIMPLE protocol.

A. 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 which is around heart area is ECG sensor while node 2 in waist is Glucose sensor node. Data is transmitted directly to sink by these two nodes. The deployment of nodes and sink on the human body is shown by the fig. 2. The typical sensor node parameters are detailed in Table 3.1.

Table 3.1: Radio Parameters

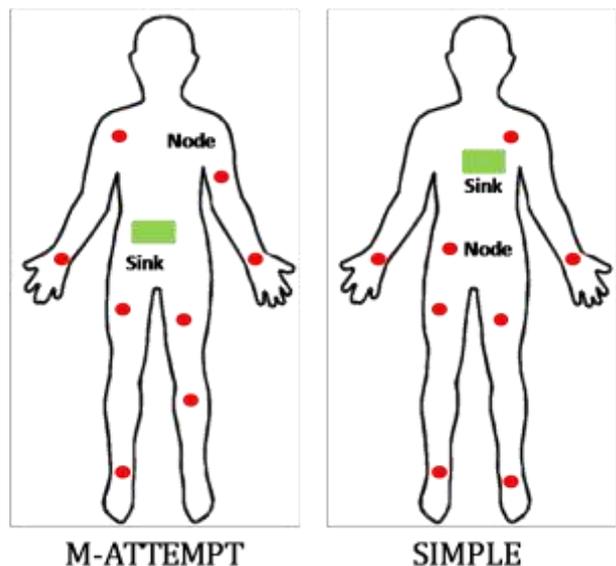| Parameters	nRF 2401A	CC2420	Units
DC Current (Tx)	10.5	17.4	mA
DC Current (Rx)	18	19.7	mA
Supply Voltage (min)	1.9	2.1	V
$E_{TX-elec}$	16.7	96.9	nJ/bit
$E_{RX-elec}$	36.1	172.8	nJ/bit
E_{amp}	1.97×10^{-9}	2.71×10^{-7}	J/bit

Figure 2: WBAN Body Area Network with Eight Nodes

B. 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 neighbours and sink.

C. Selection of next hop

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:

$$C.F(i) = \frac{d(i)}{R.E(i)} \tag{6}$$

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 neighbour node get affixed together with forwarder node and transfer their data to forwarder. This data is collected and forwarded to sink by the forwarder. This (forwarder) node has highest residual energy and least distance to sink; hence, minimum energy is consumed by it in the process of forwarding data to sink. Nodes for Glucose and ECG monitoring establish direct communication with sink and do not get indulge in forwarding data.

D. Scheduling

As far as this phase is concerned, a Time Division Multiple Access (TDMA) is assigned by forwarder node to its children nodes on the basis of the time slots. Each one of these children nodes transmit the data which is sensed by them to forwarder node in its particular predefined time slot. In the case when a node does not contain any data to be sent, it switches to idle mode. Nodes wake up just at the time of its transmission. The dissipation of energy of particular sensor node could be minimized by scheduling of sensor nodes.

4. RADIO MODEL

In past various radio model is proposed for WSN. In general first order radio is found suitable for WBAN as detailed in [6].
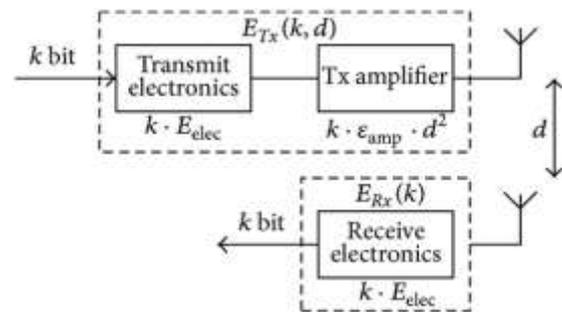

Figure 1: First order radio model

This radio model assume that d, is the separation between transmitter and receiver and d^2, the loss of energy due to transmission channel. First order radio model equations can be summarized as

$$E_{TX}(k,d) = E_{TX-elec}(k) + E_{TX-amp}(k,d) \tag{1}$$

$$E_{TX}(k,d) = E_{TX-elec} \times k + E_{TX-amp} \times k \times d^2 \tag{2}$$

$$E_{RX}(k,d) = E_{RX-elec}(k)E_{RX}(k) = E_{RX-elec}(k) \times k \tag{3}$$

where E_{TX} is the energy consumed at the time of transmission, E_{RX} is the energy consumed during reception, $E_{TX-elec}$ and $E_{RX-elec}$ are the energies needed for the operation of the electronic circuit of transmitter and receiver, respectively. E_{amp} is termed as the measure of energy needed for the amplifier circuit, while k denotes the size of the packet.

The medium that is used for the communication in WBAN is human body which provides its contribution of attenuation to radio signal. Hence, path loss coefficient parameter is added by us in radio model. Equation 27 of transmitter can be rewritten as

$$E_{TX}(k,d) = E_{elec} \times k + E_{amp} \times n \times k \times d^n \tag{4}$$

The parameters of energy provided in equation 6 rely on the hardware. In WBAN technology, two transceivers that are generally used for the analysis are Nordic nRF 2401A is a single chip, low power and Chipcon CC2420 transceivers. Both have the same bandwidth i.e. 2.4GHz.

The reason behind the use of the energy parameter of The Nordic nRF 2401A transceiver is its less consumption of power as compared to Chipcon CC2420. The energy parameters for this transceiver are given in Table 1.

Table 1: Network Parameters

Parameter	Value
E_0	0.5 Joule
E_{elec}	5 nJ/bit
E_{fs}	10pJ/bit/m^2
E_{amp}	0.0013 pJ/bit/m^4
E_{da}	5 pJ/bit
Packet Size	4000 bits

3 PERFORMANCE METRICS

The protocol is discussed in terms of the following parameters.

1) *Throughput:* Throughput is a fractional value and it is the total number of generated packets that are correctly received at sink. This is also equal to the difference of total generated packets and loss packets.

2) *Residual Energy:* Residual energy represents the energy left with the nodes with each subsequent round. This is helpful in evaluating the energy consumption in the network.

5. **SIMULATION RESULTS AND ANALYSIS**

With keeping in mind the end goal of evaluation of the proposed protocol, we have carried out an extensive set of experiments using MATLAB R2010a. In the first set of results we studied the performance of the SIMPLE [7] protocol by comparisons with the existing protocol M-ATTEMPT [6]. In the second part of the result SIMPLE protocol is compared with proposed one.

1 Comparison of SIMPLE and ATTEMPT Protocol

In figure 2, number of dead nodes vs. Number of rounds is plotted. In ATTEMPT protocol at the round 2161, all of sudden 3 nodes become dead. However in case of SIMPLE protocol till round 4436 number of dead node remains as zero. From round 4436 to 5390 rounds dead node is one thereafter, number of dead node rises and crosses the ATTEMPT curve at the round 5546.
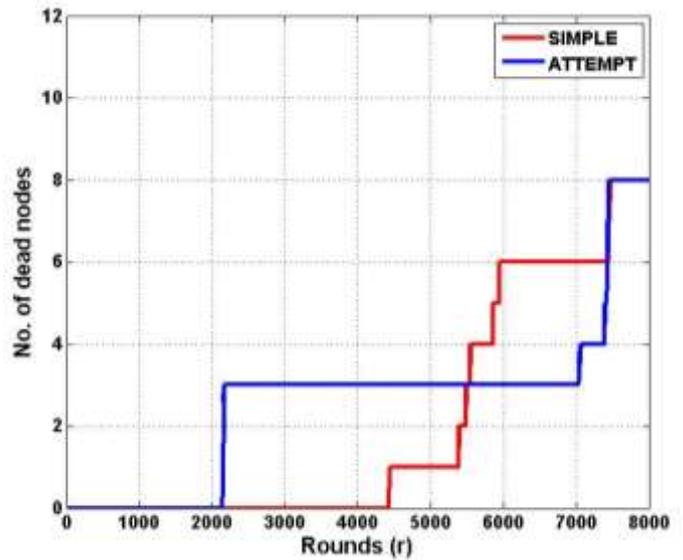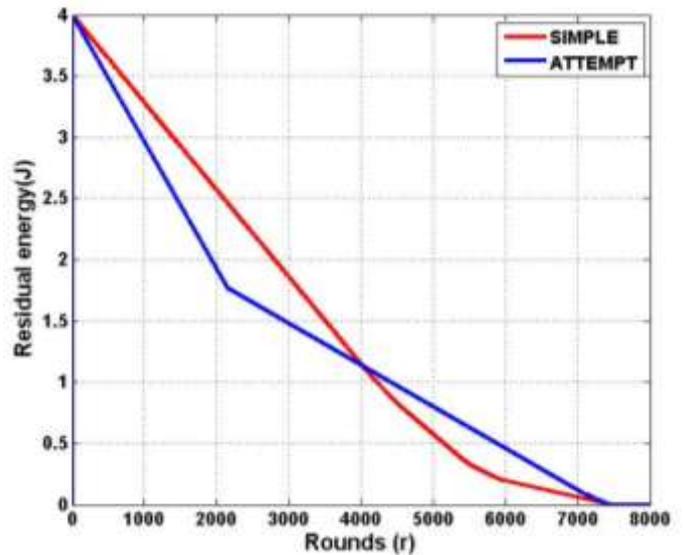

Figure 2: No. of dead nodes vs. rounds

Figure 3: Residual Energy vs. Rounds

Number of dead nodes remains two till round 7047 for ATTEMPT; however number of dead nodes increases and at the round 7445 number of dead nodes becomes 8. Thus the stability of period of the SIMPLE protocol is larger in comparison to ATTEMPT protocol. In ATTEMPT protocol for a large number of rounds number of dead nodes remains as three thus it performance is expected to be poor in terms of throughput.

In figure 3, residual energy vs. Round is plotted. Over here till 4000 round the residual energy of SIMPLE protocol nodes is higher. Thereafter, residual energy decreases with number of rounds. This curve has relation with curve 3, where numbers of dead nodes are shown with respect to number of rounds. As in ATTEMPT, till 2161, number of dead nodes is zero and thereafter number of dead nodes becomes three. Thus a shift in residual energy can be expected as

shown in graph. However in case of SIMPLE protocol form round 4500 to 6000 numbers of dead nodes increases from 1 to 6 with crossover with ATTEMPT curve at 5390. Thus residual energy shown variations in the curve and as well as it comes down below to ATTEMPT curve due to the larger number of dead nodes, and finally residual energy goes to zero at 7445 rounds.

In figure 4 packet dropped vs. Round is plotted. Here, a huge difference can be observed in the packet dropped. In case of ATTEMPT protocol the total packets dropped are 7435, while for SIMPLE protocol, the number of dropped packets are 1.204×10^4.
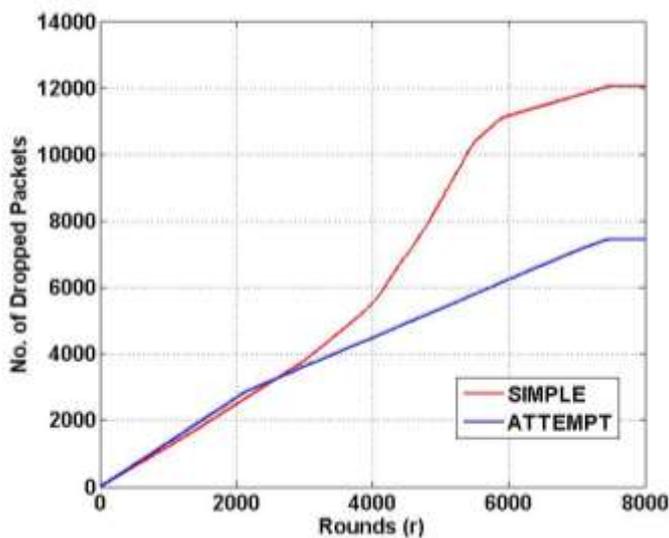

Figure 4: Packet Dropped at the Sink vs. Rounds
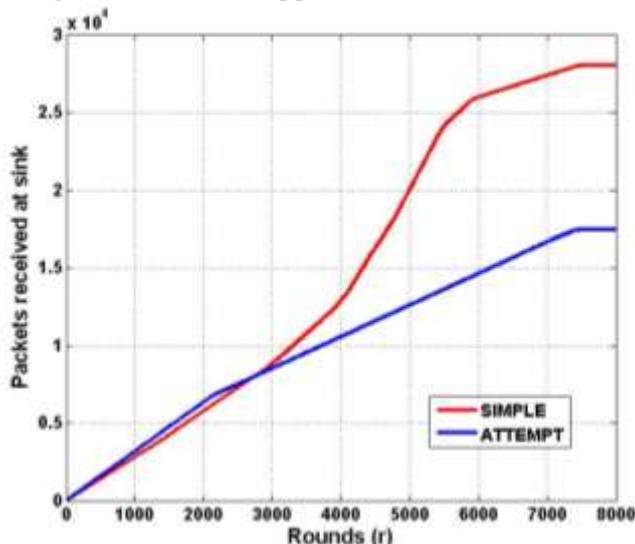

Figure 5: Packet Received at the Sink vs. Rounds

In figure 5 packet received at the sink vs. Round is plotted, till 3000 rounds the packets received remain the same for both the protocol. Thereafter a huge difference can be observed in the packet received. In case of ATTEMPT protocol the total packet received are 1.745×10^4, while for

SIMPLE protocol, the number of received packets are 2.8×10^4. Therefore, a huge rise in the packets received and in terms of percentage it is more than 60%.

6. CONCLUSION

In this work an energy efficient wireless body area network protocols are presented. The selection of forwarding nodes is based on the cost function which is dependent on the distance and energy. It is found that the performance of SIMPLE protocol is much better in comparison to ATTEMPT protocol.

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