ERM: Efficient Routing Mechanism to route data in wireless body sensor networks

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ABSTRACT

Wireless body sensor networks (WBSN) is an extension of Wireless sensor networks basically used in medical field for monitoring patients vital data.WBSNs works for collecting the health related data such as ECG,EEG, Glucose values, temperature etc. from human body and route the data towards the destination so that the patients information can be sent to the concerned person. In the health monitoring system routing has an important role. The data sensed by the sensors need to be routed to the destination effectively. In this work we have proposed a routing algorithm which can be used to transfer the data to destination efficiently. To route the data to the sink multi hop process is used and the cost function is used to find the node next closest node in the route from source to destination. The node with minimum cast function will be selected as a forwarder node. The experiments are done in MATLAB environment and simulation result shows that the proposed scheme provides the better network stability period as well as good throughput.

Keywords: WBSN (Wireless Body Sensor Networks), EEG signal (Electroencephalogram), ECG signal (Electrocardiogram)

1. INTRODUCTION

Wireless sensor networks is a network of sensors working in a cooperative network. The sensors will communicate with each other without wires. These types of networks can be used in different fields like monitoring the traffic, Battle field, Medical field etc. Recently use of sensors for health monitoring has got very much importance .Use of the sensors in health monitoring is denoted as Wireless body Area Networks or Wireless sensor Networks (WBSN).WBSN is an extension of the wireless sensor networks. In WBSN the nodes (sensors) may be embedded inside the body, may be placed on the body in a fixed position or may be go with devices that humans can take with them, in pockets, by hand or in various bags. The sensors which are placed in/on the human body will collect various kind of health data to observe the patient's health status irrespective of their location. The information will be transmitted wirelessly to an external processing unit. This devices can transfer all information in real time immediately to the concerned person. If an emergency is detected, the doctors will immediately advise the patient by sending appropriate messages or alarms through the computer system. The architecture of the system used in hospitals or by doctors/experts can be referred as 3-tier architecture:

Tier-1: Intra WBSN: - This is very important part of the system architecture as the intelligent sensors nodes collect various physiological signals from the human body and each and every node is capable of sensing, sampling, processing and finally communicating. In this tier, there are different modules like ECG module, Blood oxygen module and for these modules there is node called coordinator which is used to process and transmit sensed data wirelessly.

Tier-2: Inter WBSN: - In this part the base station/sink node/link sensor receives the data from coordinator from Tier-1 either and forward it Tier-3

Tier-3: Extra WBSN: This part of architecture provides different functions to WBAN users, medical personnel (doctors), and informal caregivers. There is a database in which all relevant data related registered patients are stored or signals collected from body are stored in the database. Only the authenticated doctor can access the database and as per physiological signals collected, doctors prescribe medicines or tips or prevention from risks to their respective patients. In case any emergency detected, then the doctors or caregivers through the internet access the health summary reports so that they provide prescription their patients.

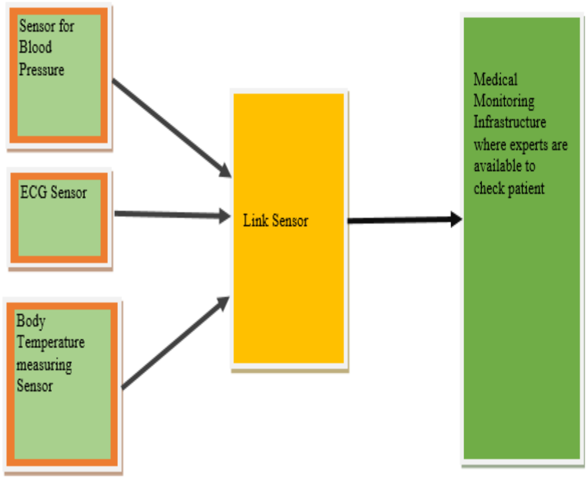

Figure 1: Architecture of WBSN

2. ROUTING:

Routing is a way of finding the efficient route form one node to another node with specified metric of consideration. In case of WBSN routing plays a very vital role as the system performance is depending on the working of routing as the data sensed and processed by the sensor node has to reach the destination node properly.
There are number of routing protocols mentioned in literature like Adaptive Threshold-based Thermal-aware Energy-efficient Multi-hop Protocol (ATTEMPT), LTR, and TARA etc.
While designing the routing protocols for WBSN some issues has to be considered, some of them are stated below.

Topology of the Network: The arrangement of a network that includes its nodes and connecting lines will be indicated by the topology of network .The network geometry can be shown in two ways: the physical topology and the logical (or signal) topology.

Network partitioning: Disconnection among the nodes in the network or network partition can happen in WBSN because of frequent changes in the body position of patient due to body movements. So the nodes in the network will keep stirring in and out of range of communication .The proposed routing protocols should be designed by keeping in mind these topology changes.

Scarcity of Resources: Due to minute size of the sensor nodes used in WBSN all nodes will have having limited resources such as node energy, bandwidth, range for communication etc.

Need of varying data: Different types of data can be controlled/examined by using WBSN for health monitoring. The service quality required for each type of data will be diverse in nature. Quick attention is the necessity for some kind of data so that has be delivered instantly whereas some kind of data can be sent a bit late and delayed. The patients data information can be considered for several types for example critical data like EEG, ECG etc., reliability-essential data e.g. PH monitor, important data signals for monitoring, respiration monitoring and data like heartbeat, temperature, etc[6,7]. The WBSN applications where data is having more importance cannot have increased packet loss and increase in waiting time. The proposed protocols should be conscious about quality of service requirements for different kinds of signals associated to the patient's body.

Path Loss: When the electromagnetic wave travels through the wireless medium the power density of the wave decreases. Path loss is the ratio of the power of the transmitted signal to the power of received signal [3]. In WBSN human body is the medium of communication. Path loss value for human body ranges from four to seven which is high and [9] whereas for free space the path loss value is two which is low. Hence the researcher must bear in mind the parameter path loss values that is critical for proposing routing protocols for WBSNs.

Heterogeneous Environment: In WBSNs different kind of medical data need to be collected from human body so it needs different types of nodes for collection of various types of medical data so the nature WBSNs are heterogeneous. The functions of every node is different, while some nodes may have the intelligence of reading body temperature, some others may intelligence of measuring blood pressure etc. The sensor nodes have different storage capabilities, different working processes and varied energy utilization. So heterogeneity in a network is an issue for concern.

3. ROUTING PROTOCOLS

In literature routing protocols have been categorized in different types [1].Here concise description of some of the existing types is given:

3.1 Temperature-Aware Routing Protocols:

In human body the temperature rise can happen because of several reasons such as circuits in node consume power while processing (Tang et al., 2005), intake of radiation from antenna. If this rise in temperature continues for long time, it can damage human tissues. To trim down the rise in temperature of sensor nodes Temperature aware routing protocols have been started. Some of the protocols belonging this category are Routing Algorithm for Network of Homogeneous and ID-Less Bio-Medical Sensor Nodes (RAIN) [7], Thermal-Aware Shortest Hop Routing (TSHR) [7] reduce increase in temperature and decrease packet delay to provide improved packet delivery ratio.

3.2 Qos–Aware Routing Protocols:

The different types of modules can be used by the protocols based on QoS requirements of the application .Some of the protocols of this type are QoS-Aware Peering Routing for Delay-Sensitive Data (QPRD) [5] gives a smaller amount delay, QoS-Aware Peering Routing for Reliability- (QPRR) [2] enhances the accuracy. These two protocols are improved processing to minimize the energy consumption.

3.3 Postural-Movement-Based Routing Protocols:

Partitioning is one of the issues of concern in WBSNs topology. These types of protocols use cost function with the aim of resolving the problem caused due to disconnections because of movements of human body. The path having the suitable cost function value is used for sending the data from the node to the destination. On-Body Store and Flood Routing (OBSFR) is an example of this type it provides less delay in packet delivery, whereas decreased end to end delay is provided by Probabilistic Routing (PRPLC) [8].

3.4 Cluster Based Routing Protocols:

In this type clusters are formed amongst all the sensor nodes are and one node amongst all nodes in the cluster is selected as cluster head by using some methods. To minimize the direct communication between individual node and destination, the data from each node in the cluster is send to the sink using this cluster. Some examples of this type are Hybrid Indirect Transmission (HIT) and Anybody [12] which improves packet delivery ratio and energy utilization where as in Anybody latency is decreased and packet delivery ratio improved.

3.5 Cross-Layered Routing Protocols: This type of protocols works to provide the way out to the problems s experienced by network layer and MAC layer at the same time which helps to enhance the overall network performance. Some examples are; Wireless Autonomous Spanning Tree Protocol (WASP) [11] works to reduce energy utilization and end to end delay, Timezone Coordinated Sleeping Scheduling (TICOSS) decreases the delay in packet delivery and Biocomm [6] provides decrease in the packet loss and enhancement network throughput. These are the few protocols that come under this category.

In the proposed work Efficient routing algorithm is implemented. And the working of the protocol is compared with ATTEMPT.

4. PROTOCOL DETAILS

The first order radio model proposed in [18] is used in this work. First order radio model equations are given as.

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx}-amp(k,d)$$

$$E_{Tx}(k,d) = E_{Tx-elec} \times k + Eamp \times k \times d^2 \quad (1)$$

$$E_{Rx}(k) = E_{Rx-elec(k)} E_{Rx}(k) = E_{Rx-elec} \times k \quad (2)$$

where

d: separation between transmitter and receiver

d^2: the loss of energy due to transmission channel

E_{Tx}: the energy consumed in transmission
E_{Rx}:the energy consumed by receiver
$E_{Tx-elec}$ and $E_{Rx-elec}$ are the energies required to run the electronic circuit of transmitter and receiver, respectively.
Eamp: the energy required for amplifier circuit,
k : the packet size.
Human body is the medium through which communication occurs In WBAN because of which there will be attenuation to radio signal. Therefore, we add path loss coefficient parameter n in radio model. Equation 2 of transmitter can be rewritten as.

$$E_{Tx}(k,d) = E_{elec} \times k + E_{amp} \times n \times k \times d^{n} \quad (3)$$

The energy parameters given in equation 3 depend on the hardware. In this the Nordic nRF 2401A transreciver is considered. It is a single chip, low power transceiver and the bandwidth of the transceiver is 2.4GHz. The energy parameters for this transceiver are given in Table 1.

Table 1: Energy Parameters for nRF2401A

Parameters	nRF2401A	Units
DC Current(Tx)	10.5	mA
DC Current(Rx)	18	mA
Supply Voltage(min)	1.9	V
Etx-elec	16.7	nJ/bit
Erx-elec	36.1	nJ/bit
Eamp	1.97e-9	j/b

Protocol Details:

Efficient routing protocol is the routing protocol can be used in WBANs. This protocol tries toenhance the stability time of the network and throughput of the network.
Algorithm:

1. Firstly, at a definite location on human body the sink is fixed and then other nodes used for collecting different data information are placed on precise area on different parts of body such as chest, abdomen, legs, hands etc.
2. A packet containing the information about the position of Sink placed on human body will be broad casted by SINK. When the node in the network receives this information packet each sensor node save the information about the position of sink.
3. Every sensor node broadcast a message containing details of node identification i.e. node id , position of the node and energy of the node. In this way all sensor nodes will acquire the information about the position of neighboring node and sink.
4. With the objective of increasing throughput of the network and to save energy multihop routing mechanism is used. The parent/forwarded node will be selected on basis of cost function value. The parent node will be selected for forwarding the data towards sink
   The forwarder node will be selected depending on the value of the cost function. If x is node number then cost function of x node is computed as :
   Cost Function(node x)=(distance between node x and sink) / (Residual Energy of node x) (4)
   Residual energy of node i is calculated by subtracting the current energy of node from initial energy.
   The ideal forwarder is the node with minimum cost function. All the neighbor nodes send their respective data information to selected forwarder node. The selected forwarder node clusters the data and forward to sink. Forwarder node will be having highest residual energy and shortest distance to sink; therefore, it consumes least amount energy to forward data to sink.
5. The time slots will be allocated based on Time Division Multiple Access method by the forwarder node to the nodes attached to it. The nodes transfer the data collected/sensed by them to forwarder node in its own scheduled time slot. When there is no information to transfer the node turns to ideal mode. Nodes awake during its transmission turn. There is minimum utilization of energy by sensor node because of use of scheduling mechanism.

5.STANDARDS CONSIDERED FOR MEASURING THE NETWORK PERFORMANCE

The following subsection defines some of the performance metrics

1) Network lifetime: It indicates the time duration of network operation from initial state i.e starting of the network till death of last node in the network.
2) Stability period: It is the time span of network operation till the first node die. After the death of first node rest of the time period is termed as unstable period.
3) Throughput: Throughput can be given as the number of packets successfully received at sink.
4) Residual Energy: To find out the energy utilized by the nodes per round, residual energy is considered as a metric. It is basically used to consider energy consumption of network.
5) Path Loss: Path loss is the difference of transmitted power of the node which is transmitting and power received at receiver.

6. SIMULATION RESULTS AND ANALYSIS

To evaluate proposed protocol, we have done the experiments using MATLAB R2013a. The implementation of the ERP protocol is studied by doing comparisons with the existing protocol.

6.1 .Network lifetime and stability

Following figure shows the average network lifetime of proposed scheme. The results show that the stability period of proposed protocol is
more. It is happened because of selection of suitable new forwarder in each round.

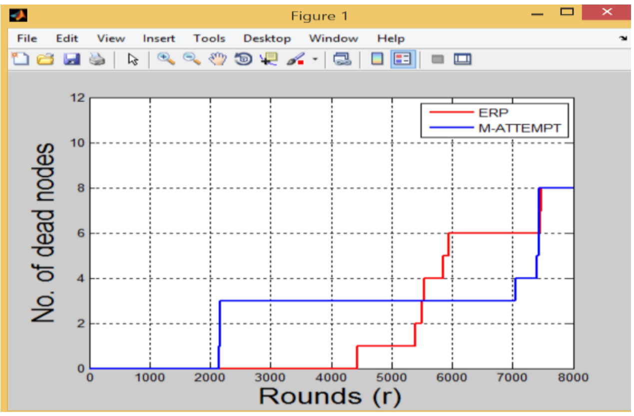

Figure 2 Graph for Network stability

6. 2. Throughput:

Throughput is the total number of packet received at the sink. The result shows that the Proposed protocol throughput is better compared to existing protocol, as shown in figure 3

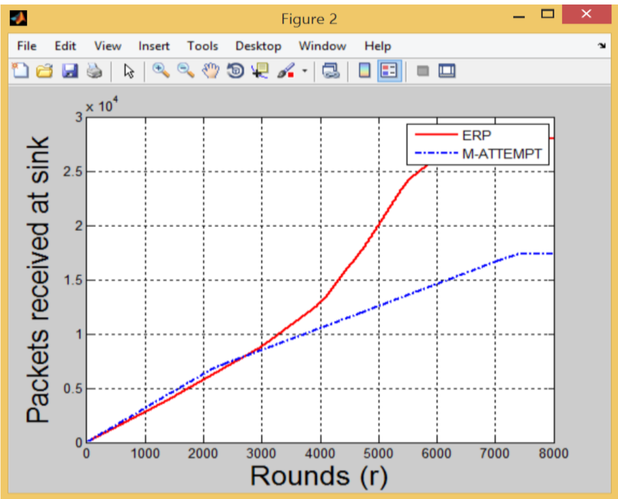

Figure 3 Graph for Throughput of Network

6.3 . Residual Energy:

In each round whatever the amount of average energy of network consumed is shown in figure 4 d. Simulation results show that for 70% of simulation time ,proposed protocol uses less energy . It indicates that , during the stable network time, more nodes have sufficient energy and they transmit more data packet to sink.

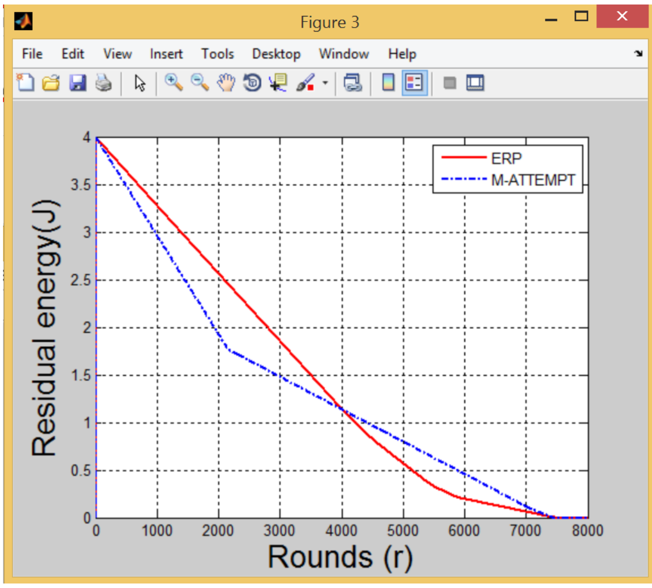

Figure 4 Graph showing Residual energy

6.4. Path loss:

Path loss function considers frequency and separation between the source node and sink. figure 5 depicts the path loss value of proposed scheme is less compared to other one. It is calculated with the help of nodes distance to sink with constant frequency which is 2.4GHz.

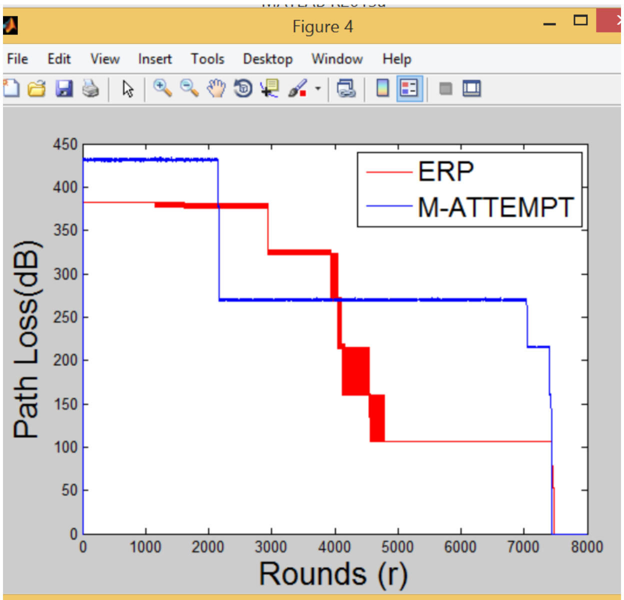

Figure 5 Graph for Path loss

7 . CONCLUSION

A routing mechanism to route data in WBANs is presented in this work. Cost function is used to choose the appropriate route to the destination. Residual energy of node and its separation distance from sink is considered to find the value of the cost function. Ideal forwarder node is the node with less cost function value. Other nodes are the nodes attached to the forwarder node to send their data to sink node. The simulation results shows that proposed routing scheme enhance the stability time of the network and packet carried to sink and decreased Path loss.

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