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IMPLEMENTATION OF E-HARP ROUTING PROTOCOL IN WIRELESS BODY AREA NETWORKS USING MATLAB

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Abstract

Wireless Sensor Networks (WSN) are an advanced communication technology. One of the unique branches of WSN is the Wireless Body Brea Network (WBAN). WBAN is in charge of the tiny sensors that are attached to or implanted within the human body to monitor critical body parameters. Today, there is a growing desire to enhance people's life expectancy. Disease identification and diagnosis have emerged as the most crucial aspects of this procedure. This includes real-time health monitoring, which leads to remote patient monitoring. In the current world, remote patient monitoring is a large study topic that necessitates patient mobility, which may also be accomplished using WBAN. This paper gives a brief introduction to WBAN, implementation of E-HARP routing protocol in MATLAB and results of implementation of this protocol for a few performance measures.

Keywords:

WBAN, Routing Protocols, Remote Patient Monitoring, MATLAB

1. INTRODUCTION

Wireless Sensor Network is an important field of communications engineering. Over time, the scale of equipment used in this technology has continued to increase. Vigorous development in the field of micro-electro-mechanical systems (MEMS) has made it possible to manufacture smaller, low-power sensors and actuators, spawning a new field called the Wireless Body Area Network, or WBAN [1].

It can be defined as the interconnection of portable computing devices deployed in the human body to detect different parameters, such as blood sugar, heart rate, lactate formation, and human fatigue. Since the devices will be implanted in the human body with minimal invasion there is a need for microsensors fabrication technology such as MEMS and NEMS. Ease of insertion and removal will be easier due to sensor node miniaturization

In a short period of time, WBAN has attracted widespread attention in various fields such as medical, military, fitness, and sports [2]. The simplest example of a WBAN sensor may be the fit bits that people use to track their calorie consumption and pulse rate. In contrast to wired sensors that do not allow users to move freely, the main advantage of using WBAN technology is that it provides mobility to its users [3].

There are also few limitations to WBAN as the nodes in WBANs are required to operate under strict resource constraints. WBANs are highly affected by the energy dissipation of the nodes [4]. Energy capacity of batteries in WSN is limited. It is impossible or non-profitable to replace batteries of nodes on a regular basis. Frequent recharging procedure is one of the main obstacles in WBAN.

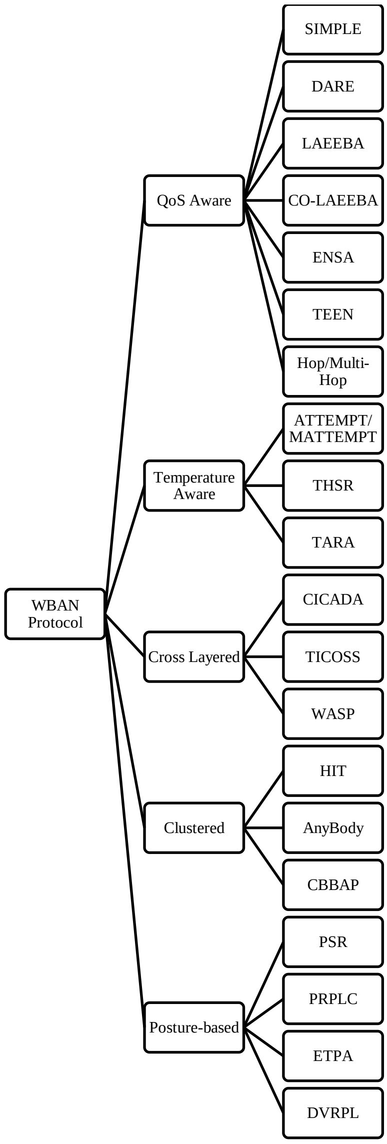

Fig.1. Classification of Routing protocols

2. ROUTING PROTOCOLS IN WBAN

A protocol is a set of rules for the management of any system. The routing protocol in WBAN determines the process by which sensor nodes communicate with each other to effectively consume power. The routing protocol also ensures that all the energy of an interconnected node given that it forms the network is distributed evenly among all the nodes according to their function, that is, the advanced nodes will have more energy than the normal mode, because the advanced nodes need to transmit more data and require a large computational power.

There are several routing protocols on WBAN [5]. Its use depends on the requirements of human conditions. Quite a large number of routing protocols inheriting robustness, security, sustainability etc. have been developed and tested by researchers in the past few years. Reliability of the sensor nodes is very crucial for the success of WBAN.

Nadeem et al. [6] observed that the sensor nodes are alive for a longer period of time in the SIMPLE protocol as continuous patient monitoring is possible. Linear programming is adopted in the M-ATTEMPT protocol to find the minimum energy consumed along with the maximization of data exchange between the sensor nodes. Simulation results proved that this protocol is more reliable as compared to the multi hop protocol [7].

Another energy efficient protocol, namely Co-LAEEBA is proposed by Ahmed et al. [8] which shows an enhancement of the stability period, residual energy, and redundancy in data transmission and cooperative learning is affected. Coexistence issue and signal interference are discussed by Hayajneh et al. [9]. It is observed from their OPNET simulation results that the WiFi interference disrupts the WBAN performance. The Fig.1 shows the detailed WBAN classification for various routing protocols based on type of protocol [10].

The Fig.2 shows the detailed WBAN classification for various routing protocols based on energy level of the nodes.

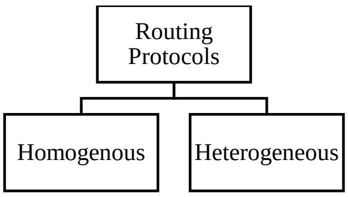

Fig.2. Classification of Rotuing protocols

A basic implementation of the WBAN module using NS-2 is carried out by Gu et al.. [11]. Delay is observed for different transmitting rate and packet size. Also, there is no need of the ARP packets as the hub contains all the data and it can solely resolve the data exchange. Yuce [12] lists the different wireless connectivity technologies in the medical domain. MICS, WMTS and 433 ISM bands with different frequencies are used to get signals from different nodes. UWB technology is also utilized to get multiple channel signals in case of EEG, ECG etc. GATEWAY software is used which communicates with the CCU and is able to get the data of sensor nodes and transmit it through the network to the destination PC.

3. IMPLEMENTATION

3.1 GENERATE COORDINATES

In each WSN or WBAN network, location of coordinates plays a vital role in routing as routing is highly affected by distance between a node and sink or base station.

Generally, while creating a routing protocol researchers tend to use symbol '*N*' or '*n*' to represent total number of nodes in a network. To simplify the analysis of network, *N* is generally taken as 100 for routing protocols in WSN but *N* may vary depending on each of the routing protocol. Sometimes, *N* or *n* is given by developer in the research paper.

Here, it is shown how coordinate generation takes place while developing a routing protocol for WSN or WBAN in MATLAB.

1: Define number of nodes in the network i.e. *N*.

2: Determine the size of deployment i.e. the maximum *x* and *y* coordinates to be taken into consideration.

3: Assign *x*-coordinate and *y*-coordinate values to each node one by one. Using a FOR loop makes the task much easier. The coordinates can be random or specific depending on the developer.

4: Plot the coordinates using plot function in the Matlab and the result for above task is shown is Fig.4.

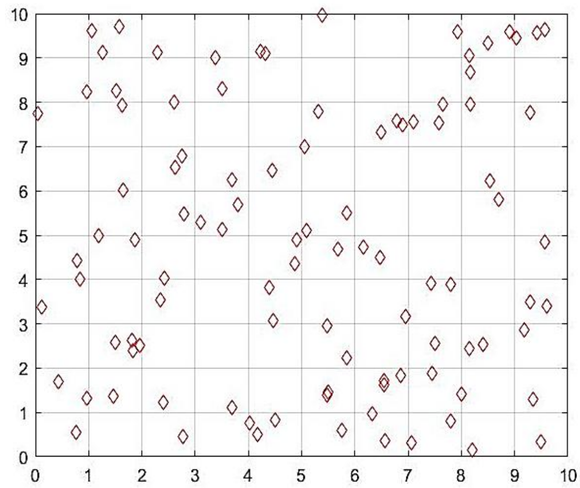

Fig.3. Random coordinates

3.2 MAKE SINK AWARE OF ALL NODES

The sink or base station must have the knowledge of all the nodes in the network which includes nodes' coordinates, nodes' ID, nodes' distance from sink, nodes' energy, nodes' type etc. This information is required by the node to carry out all the calculations i.e. computing cost factor, energy and path loss calculation etc. This process is also called as initialization.

The routing protocol which is chosen for simulation purpose is EHARP [1]. The characteristics of EHARP are as follows:

- Total number of sensor nodes deployed is 14
- The network is homogenous
- 2 sinks are present
- 2 clusters are formed with each cluster having 1 sink
- CF is calculated is for each round based on distance and residual energy for each cluster
- Node with minimum CF is selected as cluster

In Fig.4, the random coordinates generated after initialization is shown. The nodes are shown as black circles with corresponding node ID. The 2 sinks can be seen with blue and red asterisks. Each node transfers its data to one the sinks based on the distance between the sink and the node.

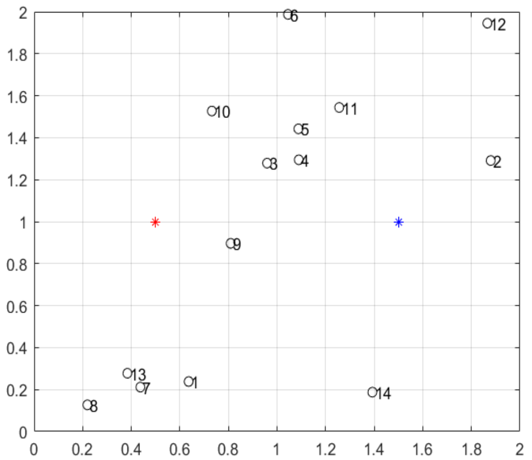

Fig.4. Random coordinates for E-HARP

3.3 COST FUNCTION AND SELECTION OF CLUSTER HEAD

The node does not directly send their data to the base station unless the information is critical to balance the energy consumption among all the nodes. The information is transmitted to the base station through a node referred to as cluster head. The cluster head collects data from all the neighboring nodes and so forwards it to the base station.

To pick the cluster head among the nodes a parameter called Cost Function is defined. The computation of the CF is done by the base station for every node in a very cluster and therefore the node with a minimum value of CF is chosen as cluster head.

Fields	x	y	id	E	type	dist_sink	sink	CF
1	0.6361	0.2384	1	0.5000	"Normal"	0.7736	'sink1'	0.0279
2	1.8797	1.2911	2	0.5000	"Normal"	0.4784	'sink2'	0.0282
3	0.9589	1.2786	3	0.5000	"Normal"	0.5369	'sink1'	0.0285
4	1.0894	1.2946	4	0.5000	"Normal"	0.5053	'sink2'	0.0279
5	1.0878	1.4421	5	0.5000	"Normal"	0.6045	'sink2'	0.0279
6	1.0450	1.9874	6	0.5000	"Normal"	1.0872	'sink2'	0.0286
7	0.4374	0.2116	7	0.5000	"Normal"	0.7909	'sink1'	0.0280
8	0.2194	0.1272	8	0.5000	"Normal"	0.9168	'sink1'	0.0283
9	0.8092	0.8967	9	0.5000	"Normal"	0.3259	'sink1'	0.0278
10	0.7316	1.5270	10	0.5000	"Normal"	0.5757	'sink1'	0.0289
11	1.2558	1.5440	11	0.5000	"Normal"	0.5963	'sink2'	0.0278
12	1.8657	1.9455	12	0.5000	"Normal"	1.0137	'sink2'	0.0287
13	0.3841	0.2777	13	0.5000	"Normal"	0.7315	'sink1'	0.0280
14	1.3925	0.1876	14	0.5000	"Normal"	0.8194	'sink2'	0.0301
15	0.5000	1	[]	[]	[]	[]	[]	[]
16	1.5000	1	[]	[]	[]	[]	[]	[]

Fig.5. MATLAB Structure for EHARP

The Fig.5 shows the MATLAB structure obtained after the execution of code. The structure consists of *x* and *y* coordinates of the nodes, node ID, node energy, sink to which the node will report and CF of the particular node.

The cluster head is selected based on CF. The node with minimum value of CF is selected as cluster head. For example, in Fig.8 for sink 1 the minimum value for CF is 0.0278 with corresponding node ID 9. Therefore, the cluster head for sink 1 for this particular round is node 9.

3.4 ANALYSIS

The analysis of a routing protocol is done on the basis of different performance parameters which are mentioned below:

3.4.1 Stability period:

The time lapse from the beginning of the network till the demise of the very first node while the network is in operational mode is known as stability period. In Fig.6, the stability period is around 7000 rounds.

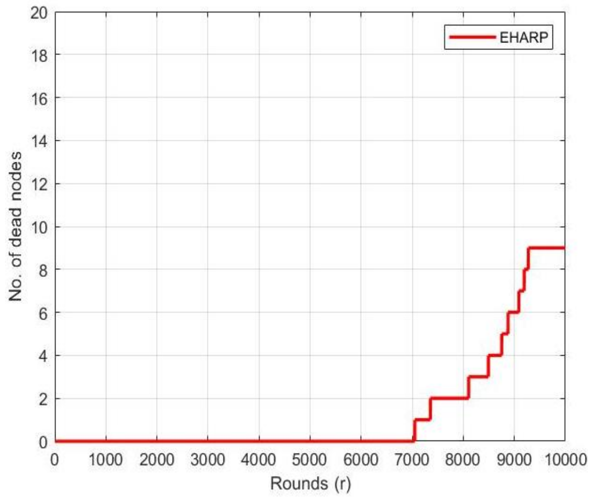

Fig.6. Number of Dead nodes for E-HARP

3.4.2 Residual Energy:

During network operation, it is the difference between initial energy of nodes and energy utilized by nodes. The Fig.7 shows the depletion of initial network energy with number of rounds.

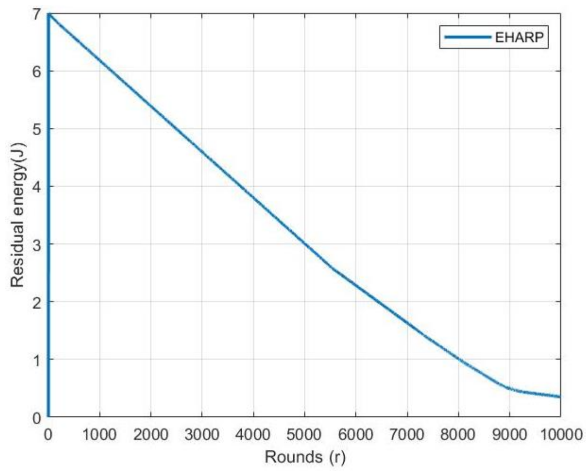

Fig.7. Residual energy of the network for E-HARP

3.4.3 Throughput:

It represents the number of packets received at the sink after successful transmission of the packets via nodes. In Fig.8, the throughput is nearly $3.25*10^8$.

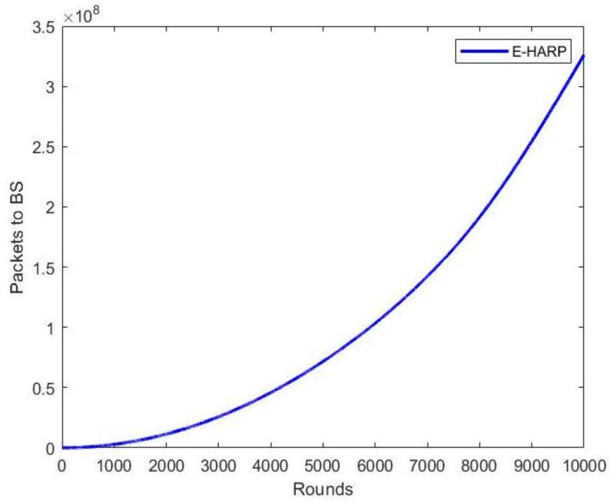

Fig.8. Packets received at sink for E-HARP

4. CONCLUSIONS

The simulation and analysis of routing protocol can be done using MATLAB. In this paper, EHARP routing protocol is considered for simulation purpose and is successfully implemented. The performance of this protocol as compared to the Co-LAEEBA, SIMPLE and ATTEMPT is as follows: i) The stability period is 7000r and it is the highest for the protocols simulated. ii) Residual energy for E-HARP is 7 J and iii) Throughput for the protocol is nearly $3.25*10^8$. A number of other performance measures for the protocols can be ascertained using MATLAB simulation.

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