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DTMP: Energy Conception Reduction in Body Area Networks Using a Dynamic Traffic Management Protocol

Mona Alimardani[1]; Amir Masoud Rahmani[2]; Houman Zarrabi[3]

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Abstract — **Advances in medical sciences with other fields of science and technology is closely casual profound mutations in different branches of science and methods for providing medical services affect the lives of its descriptor. Wireless Body Area Network (WBAN) represents such a leap. Those networks excite new branches in the world of telemedicine. Small wireless sensors, to be quite precise and calculated, are installed in or on the body and create a WBAN that various vital statistics or environmental parameters sampling, processing and radio. These nodes allow independent monitoring of a person's location, in typical environments and for long periods and provide for the user and the medical, offer real-time feedback from the patient's health status. In this article, the introduction of WBAN and review issues and applications of medical sensor networks, to offer a protocol has been established that the threshold for data transmission reduces power consumption on sensor nodes, increasing the lifetime of the network and motion phase to increase the dynamics of the network. The proposed protocol in the network been compared with the SIMPLE and ATTEMPT protocols. Results indicate a significant reduction in energy consumption of sensors to reduce energy consumption the entire network.**

Keyword: **Body Area Network; Network Lifetime; Energy Consumption; Traffic Management.**

1- Islamic Azad University, Science and Research Branch of Tehran, Iran. (mona_alimardani@yahoo.com)
2- Department of Computer Engineering, Islamic Azad University Science and Research Branch of Tehran, Tehran, Iran.
3- Houman Zarrabi is with Communication Technologies Department, Iran ICT Research Center, Tehran, IRAN (h.zarrabi@itrc.ac.ir)

I. INTRODUCTION

Wireless Body Area Network (WBAN) is one of the types WSN that are associated with the human body. Set of wireless sensor nodes that communicate with each other in real time by radio transmitters sent data to the sink. WBAN is one of the newest phenomena WSN. One of the key applications WBAN is healthcare medical. Wireless sensors on (wearable) or in (implants) the human body placed and transmitted to the sink the person's vital signs such as blood pressure, blood sugar, heart rate, etc. In WBANs the sensor nodes are facing energy supply limitation. The sensors require that the lowest energy consumption data to send to the sink. WBAN and WSN in terms of architecture and applied are significant differences with each other. Protocols in a WBAN should have the ability to monitor patients in a long time.

WBAN protocols can be divided into different clusters routing protocols. Researchers divided protocols into clusters such as thermal-aware routing protocols, the based routing protocols, postural movement based routing protocols, and cross layered based routing protocols [1]. In this study, we've developed a protocol for WBAN that increase Throughput, reduce energy consumption and increase the network lifetime. We have considered a number of nodes on the body human, each node sensor have the task of collecting vital data from the body. According to their task these nodes are placed in different places of the body. For example, nodes measuring blood sugar levels and heart rate on the chest, blood pressure and body temperature on the wrist nodes, the nodes EMG is located on the legs. Sink is in the middle of the chest. Send data the threshold and mobility

will move the body in two phases.

This article, description and results of this study are Offers. In the second section, providing a summary of the related works, in the third section explain the purpose of the study, in the fourth section the system model, in the fifth section details the proposed protocol DTMP. The sixth section simulation results, in the seventh section path loss model, eighth section Comparison of protocols and in the ninth section conclusions of the study will be presented.

II. RELATED WORK

In this section we offer a number WBAN routing protocol that is specific to particular issues. A routing protocol introduced in [2] is a protocol improve energy efficiency, thus acts nodes its data in a spanning tree, a child node to other child node sends to reach the sink. If nodes haven't any vital data, send its data to neighbor node and then send to the sink but if node has emergency data send its data for single-hop connection to the sink. Another protocol, the protocol presented in [3]. The multi-hop communications is between nodes. The protocol mentioned in the article is the hot spot link detection. Along with the movement of the body, adjacent nodes communicate with the nearest node. The protocol detects link hotspot, its connection with neighboring nodes breaks and after reaching a normal status, re-connects with neighboring nodes.

In [4] routing protocol provided that with multi-hop and single-hop communication, has tried to conception energy efficiency. In the each rand, calculation a cost-function for nodes then each nodes that its cost-function is lower, selected for send data to the sink. Nodes submit their data to the forwarder node (selected nodes) then the node data collected to send to the sink. In [5] multi-hop routing protocol are proposed. This protocol uses a HOME-signal to select the optimal route. That provided a home system that receive conditional message from node that whether the data to be sent to the sink or HOME-signal. By selecting an optimal path and priorities for emergency data, optimizes the energy consumption.

In [6] CICADA protocol Time Division Multiple Access (TDMA) is used for timing nodes. Parent or forwarder nodes that are near to the root collect data the child nodes and send to the sink. Due to high traffic load child nodes, parent nodes energy goes out quickly.

III. THE AIM OF THE SUDY

WSNs with the diversity of their applications have the ability to change their lifestyle. One of these applications is the medical healthcare that can be an example is Capsule Endoscopy that in-body to on-body network be mentioned. A Capsule Endoscopy, white a camera is that Diagnosis bowel disease. Capsule Endoscopy these have demonstrated the ability to detect small bowel diseases, while other technologies are not able to detect it [7-9]The network of UWB due to low power consumption and anti-multipath also being used [10], in 802.15.6 IEEE standard width 499 MHz is allocated to channel UWB [11]. Other applications include Artificial retina implant is to help increase the visibility of blind people mentioned. The chip is an artificial retina of the eye which can be implanted in the human eye [12].

Recent technological advances in wireless sensors has led to examples of sensor nodes with low cost and small size and used in the human body. This feature allows remote on human health can be monitored continuously. Therefore, the sensor network application in medical environment creates a unique opportunity to medical healthcare outside the clinic setting can be done by installing sensors on the patient's body. But given the nature of the wireless network congestion and packet loss probability in the network is more than wired networks. Also in the wireless sensor network because the data are sent from the sensor nodes to the sink, the possibility of congestion and packet loss, especially nodes near the sink increases.

One of the main problems facing the implementation of WBAN network operations in real-world environments (such as major hospitals) and support the mobility of patients. In the networks used send and receive low-power modules. For this reason, the range of send and receive data is very small which cover environmental issue in these networks, mobility challenged patients.

Reliability, latency time, and Jitter should be considered for applications BAN required by the networks. In medical applications latency time should be less than 125 milliseconds, as well as non-medical applications is less than 250 milliseconds. The jitter must be less than 50 milliseconds [13]. With regard to traffic

management for WBAN, with a comprehensive monitoring the send data reduce to wasted energy. Nodes their energy when it is not required to send data store and residual energy will be used in an emergency. With this technique, avoid sending unnecessary data and reduce early unnecessary the battery nodes. The average energy consumption, optimize energy consumption and increase performance significantly for the network will be.

With the aim of reducing energy consumption and increasing mobility and network performance, the proposed protocol, the following results was achieved:

- Our proposed scheme, by creating a threshold for nodes to send the data to the sink, the nodes power consumption was reduced.
- Reduce the energy consumption of nodes in the network, achieve increased network lifetime (stability) resulted.
- Reduce energy consumption of nodes and increase the stability of the network, increasing network performance.

IV. SYSTEM MODEL

In this study, the radio model [4] have used. The radio version includes d from node to sink, d^"2" is wasted energy because the transmission. The following formula shows to calculate the energy consumption of the network:

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

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

At the top, E_{Tx} energy consumed when transmitting data, E_{Rx} energy consumed for receiving the data, $E_{Tx\text{-}elec}$ and $E_{Rx\text{-}elec}$ energy to electrical current transmitter and receiver. E_{amp} Energy for the amplifier and k is the package size. In WBAN there is always some attenuation in the human body communication is path-loss that it must be considered in the calculations. The following formula can be equation 1 by adding n path-loss coefficient wrote as follows:

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

Parameters in the equation 3 depends on the type of hardware is used. WBAN technology often use in two types of transmitter. One of these transmitters is A2401 Nordic nRF a single chip with low power transmitter and the other ChipconCC2420. In this study, the energy parameters were used A2401 Nordic nRF [4].

V. DETAILS OF THE PROPOSED PROTOCOL

In this section we introduce the proposed protocol. For emergency applications, have quick access to channel MAC protocol (less than one second) and fast sending data to coordinator for in-body or on-body nodes provide. For example, irregular heartbeat, high or low blood pressure, high temperature or low blood sugar levels in diabetics. Other examples when the node dies. Reporting of medical events should be priority more of non-medical events (such as battery) [14]. By applying traffic restrictions in the protocol for sending data could have a significant reduction in energy consumption and increase network stability and lifetime. We were able by creating a movement phase, the dynamics and network performance to improve.

The system model is consists of eight nodes. As in Figure 1 you can see the nodes are on specific areas of the body to measure the vital parameter.

1.Timing Phase

There are usually two types of channel model for WBAN: static and dynamic channels. In resources, these channel models for WBAN are achieved by using a vector network analyzer (VNA). WBAN channel conditions constantly changing due to movement of the body. Therefore, static channel model is not a proper display for the network properties because of a WBAN not provide complete operating scenario [15]. In this phase, after the broadcasting of information by nodes such as location on the body and initial energy, sink sends a package containing addresses to all nodes and nodes store the information. This networks runs in five times phase and two phase motion. Body experience different state such as running, stand, walk and run fast. In Figure 2 shows three-dimensional motion phases.

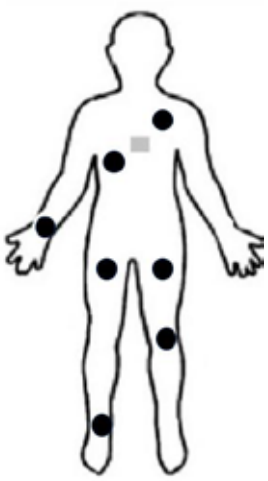

Fig. 1 The location of nodes on the body

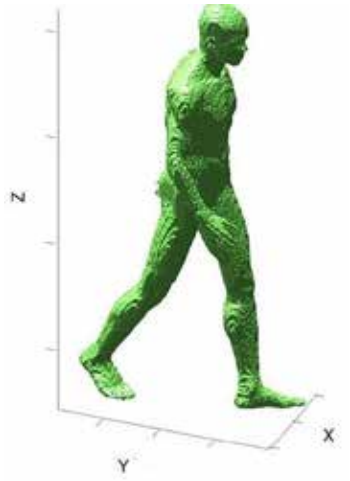

Fig. 2 Three-dimensional view of DTMP protocol [16]

2.Data Transmission Phase

Due to reduced energy consumption, in this phase, a node, the candidate will send data to the sink. In each round, the sink introduces the candidate node with the function D.F in Equation 4 to nodes.

$$D.F(i) = \frac{d_j(i)}{R.E_j(i)}, j = 1,2 \qquad (4)$$

Parameter d_j distance node i from the sink in motion phases j, $R.E_j$ residual energy of node i in the motion phases j. Except ECG and Glucose sensors all nodes will be chosen as a candidate. Information of selected node whit lower function sent to other nodes by the sink. Node send data to the sink by comparing its distance to the sink and its distance from the candidate node, select the optimal path and sends data.

After determining the candidate node, each node when sending data that is in the threshold. As Table 1 shows, the allowable range of each node that measures the critical parameters has been determined.

As in Table 1 the three-stage are normal, warning and danger for each node is considered. Ninety if the column is a normal stage of his data in this area is not allowed. If data is normal, node is not allowed to send data. Node in warning and danger states is allowed send data to the sink. In the warning state, node sends one data packet to the sink and in the danger state sends two packets to the sink. Figure 3 shows implementation of the Protocol in the network.

Table 1. Thresholds for sending data

Node	Normal	warning	Danger
Node1: ECG	0.005-18 km/h [60-100*]	18-20 km/h [100-120*]	20-40 km/h [120-140*]
Node2: G	70-140 mg/dl	140-250 mg/dl	250-500 mg/dl
Node3: BP	110-120 MmHg	120-140 MmHg	140-200 MmHg
Node4: T	36.1-38 C	38.1-39 C	39.1-42.2 C
Nodes 5,6,7,8: EMG	-90_-70 Mv	-70_-50 Mv	-50_-30 Mv

**Beats per minute*
ECG=Electro Cardio Graph, G=Glucose, P=Blood Pressure, T=Temperature, EMG= Electromyography, km=kilometer, h=hour, mg=milligram, dl=deciliter, MmHg= Millimeters of mercury, C= Centigrade, Mv= Millivolts

VI. SIMULATION RESULTS

The network is simulated with MATLAB R2011a. The output of the simulation is described in the following.

1.Network Lifetime

In figure 4, the average network life is shown whit DTMP proposed protocol. There node forwarder and threshold cause is a significant reduction in energy consumption and energy storage. As Figure 4 shows, output ATTMPT and SIMPLE protocol for sending too much data in each round, causing early death of nodes, the death network and ultimately reduce network stability. But the measures proposed protocol by

taking the threshold for all 8 nodes, the energy losses prevent and use of the stored energy in an emergency. Blue graph in the Figure 4 , DTMP protocol that network stability than the SIMPLE and ATTMPT protocols respectively 0.16 and 2.66 increased and DTMP protocol achieves, 3.01 more than SIMPLE and 2.59 longer than ATTEMPT network lifetime.

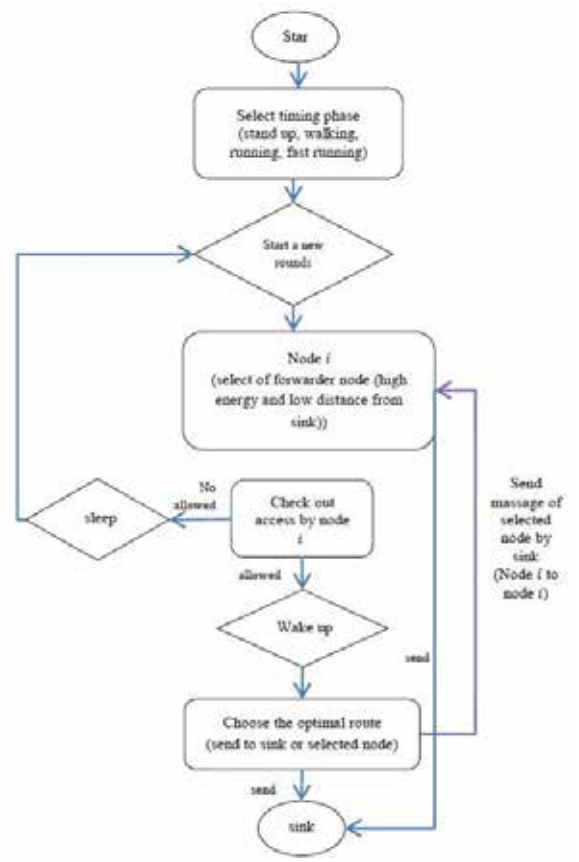

Fig. 3 The flowchart of a node using DTMP protocol

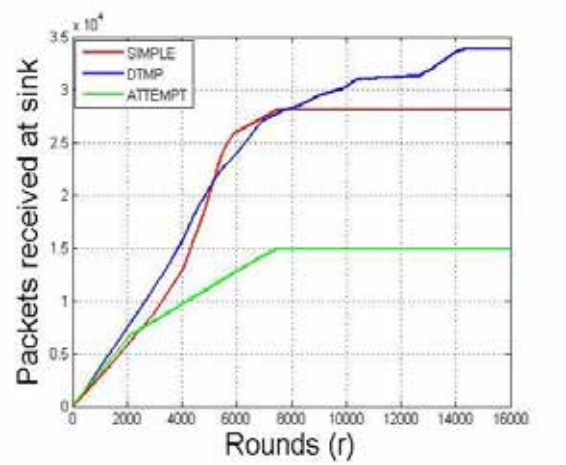

Fig 5. The analysis of network throughput

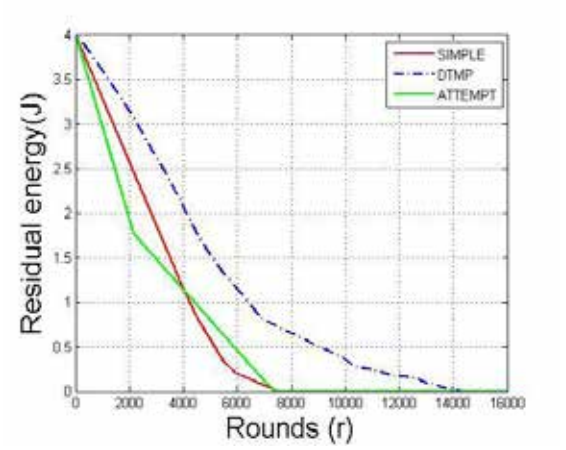

Fig 6. The analysis of remaining energy

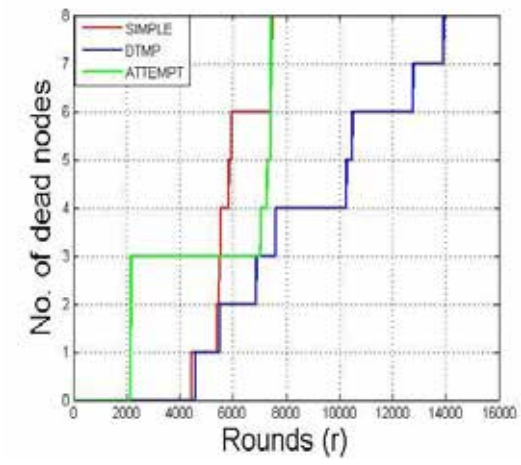

Fig 4. The analysis of network lifetime

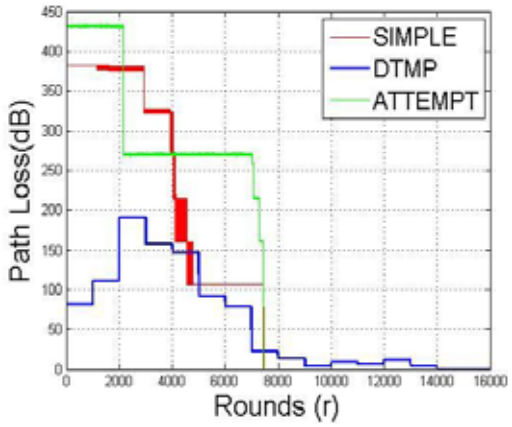

Fig 7. The network path loss

2. Throughput

Network throughput is the total number of packets successfully received at sink. In WBAN because critical data, sent with confidence, quality and quantity of data and reaching to the sink or desired medical databases, it is important. Figure 5 shows the throughput of three protocols DTMP, SIMPLE and ATTEMPT. The proposed protocol, due to increased lifetime of the network, makes the network more rounds (6000 rounds more) to 14,000 rounds will continue and send more packages to the sink.

Thus, throughput DTMP protocol to SIMPLE protocols and ATTEMPT respectively 0.16 and 2.04 increased.

3. Residual Energy

Small sensors are designed with the limitations and challenges associated energy consumption. In this case, radio waves to make energy consumer, should be cut off. After computing and information exchange, node should be able to go to rest state and return in time to be determined, hibernate mode [17]. Figure 6 shows the average energy remaining in the program. As mentioned earlier, in the WBANs, energy challenge is very important. Extensive research in the field shows the importance of this issue. The aim of this study is to provide a solution to reduce energy consumption in WBANs. Thus, energy conception of DTMP protocol to SIMPLE protocols and ATTEMPT respectively 1.5 % and 1.8 % decreased.

4. Path Loss

Attenuation in networks is path loss. Path loss is the difference between the transmitted power of transmitting node and received power receiving node. It is measured in decibels (dB). Path loss shown in the Figure 7 is dependent on the distance and the frequency is 2.4 GH. Path loss correlation coefficient in this article is 3.38 and the standard variance is 4.1, which has been used from Article [4].

Path loss in DTMP protocol to SIMPLE protocols and ATTEMPT respectively 48.6 % and 59.8 % decreased.

VII. PATH LOSS MODEL

Path Loss in on-body communications is less than in-body communication, because is on-body communication in the air, resulting Path Loss is less in air [18].

Path Lass usually due to issues such as open space, refraction, diffraction, reflection, and Coupling occurs. Outdoor, Path Loss by secret areas, environment, emissions, the distance between the transceiver and receiver and the location and antenna height penetrates[19].

The difference between the muscle tissues that have more water and fat tissues that have less water, the cause is changes in the electromagnetic interactions. The difference between tissues such as muscles that have more water and tissues that have less water, such as fats caused electromagnetic interactions [20].

Signal lost between transmitter and receiver nodes say Shadowing, that's the most important challenges in the networking of WBAN. The problems of shadowing is due to millimeter waves communication in the range of 60 GHz that can be seen in the communications NLOS [21].The channel models in medical sensor networks, because Scatterer that there are around antennas, communications, Indoor and Outdoor environments are very different [22].

Formula 5 shows the direct relation path loss whit distance and frequency [4]:

$$PL(f,d) = PL(f) \times PL(d), \sqrt{PL(f)}\,\alpha\, f^{k} \qquad (5)$$

In the above formula, k factor is dependent on the frequency and the characteristics of the human body. Distance relationship with path loss shown below.

$$PL(f,d) = P_{o} + 10n \log_{10} \frac{d}{d_{o}} \qquad (6)$$

Multi-path topology reduces the path loss. Because multipath reduces the distance, thus reducing the path loss [4].

VIII. COMPARISON OF PROTOCOLS

Because of the similarity of structure SIMPLE Protocol and DTMP and M2E2 [5] whit the Protocol ATTEMPT, the following Table 2 has been provided.

IX. CONCLUSIONS

By applying traffic management in the DTMP protocol, energy storage, due to not sending unnecessary data and use of energy when necessary, acceptable improvements in energy consumption reduction was. In this protocol, with increasing data transmission speed (sending the package at the time of emergency), the sensitivity of the patient's condition, with the rapid notification and on time to medical control center, improvements patient and diagnostics and treatment was catalyzed. WBAN in medicine and medical healthcare isn't just for on bed or sedentary patients at home. When a networking system shows high performance it can have more flexibility. The proposed protocol to create dynamic conditions, can the patient data at the time of driving, work, sports and any activity that brings a patient to the emergency situation, record and monitor. While traditional network aims to provide high quality services and provide solutions to the possibility of recharging the battery, body heat and vibration are an important factor in providing this energy will be required for a WBAN [23].

Table 2: Comparison of three ATTEMPT, SIMPLE, M2E2 and DTMP protocols

Characteristics	Protocols			
	M-ATTEMPT	SIMPLE	M^2E^2	DTMP
Network lifetime	Low	Low	Medium	High
Energy conception	Normal	Low	Low	Very Low
Mobility support	Poor	-	-	Good
Network stability	Low	Medium	Medium	Medium
Emergency support	-	-	Yes	Yes

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