Routing in a Wireless Multilayer Physical Network by Balanced Utilization Approach and Minimum Energy Using a Firefly Optimization Algorithm

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Abstract
Recent developments in the fields of electronic and digital telecommunications and creating low consumption compact circuits in nano dimensions have provided the ability to create sensors with low consumption power, small size, suitable cost, and various usages in the medical field. In past years, most of the researchers focused on sensor networks of the human body for designing wireless sensor, minimizing and matching them with live fibers of the body, lowering the consumption power, better signal processing, and communicational protocols and their security. Since the importance of sensor networks in the medical field, an entirely different method has been offered in this paper. It is based that we can manage nodes by changing the place of sensors, somehow that if the consumption powers of inside sensors are defined, then the power of all sensors will tend zero in a short period. Several various cost functions were offered based on the designed method, which created the most symmetrical kind of consumption and the lowest consumption in nodes. Then some optimality has been created in the selection of nodes in two modes of main and usual, by firefly ultra-complete algorithm. The offered method is better than the last methods because if the amounts nodes get increased, it will correctly keep its utility. After designing the costs function, the offered network has been implemented with software, and the results haves hown that in all fields, in terms of quality and consumption power form, the offered method has more utilization than other methods in the same terms.

Keywords
Wireless Sensor Network, Body Sensor Network, Meta-heuristic Methods, Glow Worm Algorithm, Medicine

1. Introduction

The sensor is something that recognizes the existence of an event or state or physical quantity and turns it to an electrical signal. These little sensors, which can do things like achieving various biological information's and processing and sending them, brought an idea for creating and developing networks, which are called physical sensors [1]. A network of the physical sensor is included of lots of sensor nodes that are implemented in a patient's body, and it collects and sends information. The place of nodes of sensors is not necessarily defined before and depends on the kind of disease. These sensors send information by achieving and processing them to the reception center, which usually is out of the patient's body, and after processing, the outer processor makes the decision. The history of sensor networks is related to the civil war, and the first idea of that is related to military designers of US defense industries. Due to the importance of networks of wireless medical sensors, which are related to the body, and their high usage in various diseases, the significant challenges for these networks are included of:

1- Power consumption needs to be optimal in sensors because sensors are in places which there is no possibility of changing or replacing for them, unless by surgery.
2- In order to using power optimally in sensor nodes, there is a need for optimized algorithm for sending and achieving information. These algorithms are included in location finding and sending data with minimum code length.
3- When the necessary minimum parameter code is being produced, in the compression algorithms, the amount of required processing is for less consumption. Hence it is the main challenge in creating the best mode for required processing for compressing. In another way, making the consumption less is because of the subtracting of code length. In other words, the sum of consumption power of compression algorithms and sending code must become a minimum.
4- Algorithms of routing must be designed somehow that deliver information to the primary node in less time. Algorithms of prevention from interference also must be evaluated. [2]

The quality of connection among nodes in the physical sensor network is different in a function of time because of the various body movements. So, the offered routing algorithms must be a comparative of movement various changes. In this way, the authors considered Network Tolerance Delay. Furthermore, some parts of the body and cloth block signal that increase mortality. In terms of available energy and computational power, the energy level of the node must be considered in the offered routing protocol. Also, in order to lessen the interference and preventing fiber heating, the power of node transformation must be very low. The life span of the network in the physical sensor network is much more important than medical sensor networks or wireless sensor network. A low range of signal transformation, in the physical sensor network, causes frequent partitioning and disconnection among sensors. In cases in which the transformation range of sensors is less than the threshold value, there are fewer options for routing adjacent sensors, which, with more transformation, cause an increment in power consumption. Therefore, delivering packages takes more time, which causes power consumption average increasing. Due to the standard draft IEEE 802.15.6 for the physical sensor network, the connection of the next step or next two steps in the physical sensor network is allowed. Many more steps bring much more energy consumption. However, the limitation of the amount of package in the next step is not considered in most of the routing protocols of the physical sensor network. Furthermore, semi-duplex machines in physical sensor networks, decrease bandwidth which is known as consecutive steps. Specific useful programs of physical sensor networks might need to collect heterogeneous data from various sensors with different sampling ratios; so, supporting the quality of suitable service in a physical sensor network might be challenging. Protocols of the physical sensor network divide into five parts:

- Cluster-based routing protocols
- Interlayer routing protocols
- Movement quality based routing protocols
- Minimum power routing protocols
- Informed service quality routing protocols

TARA is the first routing protocol of a physical sensor network that uses the power consumption circuit of biological sensors as a general factor in selecting the route. It works in 4 levels: launch phase, data sending phase, hotspot detection phase, and exit phase. The author (Balasingham, Liang), within the service of routing, offered informed service quality, which is a Modular interlayer architecture [3]. As they said, this architecture was formed to assure of the six below main functions:

- Creating informed service quality routing and maintaining
- Prioritizing the routing of the information package
- APIs
- Feedback on terms of the network for the user program
- Adaptive Network Traffic Balance
- Awareness of electricity providing level of sensor node

In a module-based protocol, distributed informed service quality has been presented, which helps the system to provide requirements of various services quality based on the nature of data [4]. The offered mechanism divides patient's information to regular traffic, reliability sensitive traffic, Delay, and critical traffic sensitive traffic. Synchronizer, which is known as a part of the physical sensor, collects raw data from medical-biological sensor nodes, and after processing required data and collecting data, sends them to the Sync nodes [5]. Each Sync node can cover more than one patient. The offered protocol has two kinds of Sync nodes for each patient: first Sync and second Sync, and Sync receive a separate copy of each massage.

Authors have offered QPRD which intends to divide patient's information packages to two parts to improve the usage:

Usual packages ((OP and delay-sensitive packages) (DSP routing architecture QPRD)) are divided into seven modules:

MAC receiver, Delay module, package classification, Hello module protocol, routing services module, informed service quality queuing module, and receiver. Authors have presented a routing protocol based on both focused and distributed methods, like informed energy to reduce the traffic of network and energy consumption. It is designed for the patient's information in real-time in a hospital [6]. In this design, they have used three communicational machines:

1- Nursing station synchronizer 2-Medical show synchronizer 3-physical network synchronizer [7]

Each node has chosen a short route to reach the Sync, and when the parent node becomes finished in power and energy; child nodes choose another optimal way. Span is a dependent protocol for connections that skillfully choose synchronizers from network nodes [8-11]. Synchronizers always stay active and do the routing for multipurpose transformations while other nodes are deactivated, and after a while, they check to see if they must be activated and become synchronized or not [12-15]. The main goal of this approach is that first: those nodes that have a higher life expectancy have more possibility for being chosen as synchronizer, and second: synchronizer nodes must be chosen somehow that have less amount [16]. Because of this, each node checks period to see and it can be synchronized or not. In [17], they had presented a protocol based on this attitude that a node can be activated when it wants to exchange information with its neighbor node. This plan makes energy consumption decrease to a minimum.

Furthermore, instant designs are more suitable for usage in sensor networks with a low-performance period. Jocelyne Elias et al. designed a new topology for physical wireless networks [18]. In this topology, it is using specific nodes, for collecting information, called Relay to connect to Sync. Therefore, physical wireless networks contain three types of nodes: Biosensor, Sensor node, and Relay that it is using multi-hubs from a multi-sparkles method for transferring information. Multi sparkles networks send their information to the server on several levels, and usually, it is not possible to send information from downstream nodes directly. The next single-step approach includes transferring all of the data directly from each sensor to the node, which causes energy consumption to decrease and make traffic least. A. Khan et al. presented a new BAN framework for hospital indoor environments [19]. They discovered a new mechanism of building routing tables, which causes a decrease in network traffic bar, energy consumption, and improve trustworthiness in BAN three scenarios with packages that have to be sent to the source node for analyzing. Static nodes are considered in first and second scenarios, while mobile nodes are being used in the third scenario. This method tries routing due to the closest neighbor; the purpose of this work is to decrease energy waste.

Liang ling et al. offered a focused method for tree-based routing as energy conscious for multi-stranded physical sensor networks [1]. Multi stranded networks or multi-hub sends their information on several levels. Usually, it is not possible to send information directly from downstream nodes. The main goal of this method is building reliability and high energy usage, which is one of the most critical features and is needed for physical sensor networks. In this paper, a routing mechanism has been offered based on connection quality among various nodes, which can support caused noise effects because of being in a network of the human body domain and make reliable communication by considering the energy waste among nodes. Klinalias has done a design for the physical network with low cost and conscious energy [20]. As was said, there is a need for very reliable performance, long lifetime, and high data transfer rates in the physical network.

Furthermore, due to high costs for sensors, the designed collection must be so suitable in cost and accurate, so the patient does not have to pay a lot. With these goals, a linearly programmed model as the conscious energy in the design of physical sensor networks is offered in this paper, which not only optimizes the amount and place of relays but also decreases the consumption power of the network in Relays and Sync nodes. The primary goal of this method, in addition to decreasing consumption power, is decreasing the cost of installation and hardware. The designed model has been implemented in various modes of physical sensor networks and general topologies, and usage of that has been compared with new usual methods. Finally, numerical results show that the offered model in this paper builds a very suitable compromise between the energy consumption and amount of Relays, and finally shows excellent performance of itself as cost and lifetime. Nadim et al. have offered a hardware-based method for a Multi-step technology post, to decrease energy consumption and increase network lifetime in a physical sensor network [21, 22]. The offered cost function has been chosen somehow that the importance of both the cluster head and the energy consumption is considered at the same time. Cluster heads have been chosen somehow that, in addition to having the required importance, must have the minimum distance to the Sync node. For balancing the residual energy in the common nodes in the network, their distance to the cluster heads and distance from cluster heads to Sync nodes have been arranged in each level adaptively.

Lili Wang et al. designed a model of physical sensor network which has three types of sensors that can be called like this: nodes which are implanted in the body, nodes which are implanted on the body and nodes which are implanted out of the body, that patient's monitoring system can be mentioned, the main goal of this method is decreasing the energy consumption and increasing transferring ratio [23]. In this reference, nodes collect the required information from the inside and surface of the body. For transferring it to Sync in the human body, first, they send the link into the body after collecting, and after turning on the Sync, they send the collected information to it. After transferring information from the inner Sync to monitoring or implanted Sync, outside the body, Sync becomes off again, which prevents energy waste.

As was mentioned, all of the physical networks are looking to increase quality, decrease consumption power, and increase the performance of the collection. The main challenge in all of the research was choosing the suitable cost function, which, with the considered approach in this paper, means consumption balance and finishing batteries in a period, and no research has been found. In the following paper, in the beginning, the third part of the approach theory is explained, and then in parts 4 and 5, we will study details of implementing, results, and concluding.

2. Materials and Methods

2.1 Model of System

In the assumed model, the sensor node is implanted in the body, and all of these sensor nodes have the same power and energy and use the same energy value. Sync bode or manager node and collector of information implants on the waist. The first node is the measuring node of ECG, and the second node is the Glucose sensor node. These two nodes transfer data directly to the Sync. The other six nodes can connect to the Sync by a secondary node or Relay or sending the data directly to the Sync. The place of sensors is shown in Figure 1.

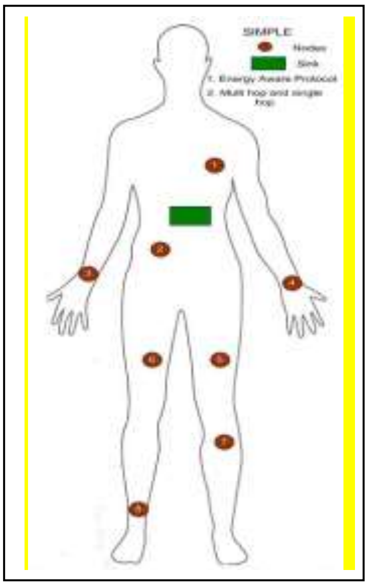

Figure1. Assumedmulti-model for placing the sensors

2.2 Suggested Protocol

2.2.1 First Phase

In this level, the Sync produces a small package of information that contains the place of Sync on the body. After receiving this controller package, each sensor node saves the position of Sync in itself. Each sensor node produces a data package that contains the IP of node and position of that in the body and energy value of that node. In this way, all of the sensor nodes meet their Sync position and adjacent nodes.

2.2.2 Choosing the Next Step

In order to save energy and maintaining the operational power of the network, a multi jump layout for networks of WBAN can be used. To balance the energy consumption among the sensor nodes and to edit energy consumption in the network, the protocol chooses a parent or a new transmitter at each level. Therefore, considering that the Sync node knows the IP of nodes and their distance, it computes the cost of all nodes. This function transfers the cost to all nodes. Based on this cost function, each node decides to be the transmitter or not. If we consider *I* as the number of nodes, cost function of *I* going to be like this:

$$C.F(I) = \frac{d(i)}{R.E(i)} \qquad (1)$$

Here, *d* is the distance between *i* and the Sync, and *R.Ei* is the remained energy of the *i* node, and it is obtained by subtracting the flowing energy of node from the consumption energy in each time.

A node with a minimum cost function is selected as the transmitter. All the adjacent nodes transfer data to the transmitter if their distance from the transmitter is less than the Sync. The transmitter node collects data and sends them to Sync. Based on cost Function (1), the transmitter node has the most remaining energy and the least distance to the Sync, so the transmitter node consumes the least energy for transmitting data to the Sync. Nodes that contain data of ECG and blood glucose, because of the importance and need of a network transmit data directly to the Sync and do not transfer them to the transmitter node. These two nodes also are not selected as the Relay or secondary node.

In relation 1, which is known as one of the newest and the most practical method, if all of the nodes send data directly to the primary node or Sync, two problems will happen:

1- Due to this point that wasting power in the collection of the body is $d^{3.8}$, the energy consumption of node for transferring data to the primary node or Sync is very high in each time, and it makes the power of node decreases so fast.
2- Possibility of interference or collision among data bits or in the route of transmitting bits is high because of high distance from the primary node, which increases the possibility of wasting bits. The challenges ahead of relation (1) are the weak point in the simple design of cost function. In the offered cost function, which is obtained by dividing the distance from the node by the remaining power in the node, the distance of other nodes from the interface node is not considered. For example, imagine a node that is placed between the interface node and the Sync with less power. Such node, if it is close enough to the interface node, must transmit its data to the interface node and interface must return data to the Sync again. It is clear that because of the higher distance of this node from the Sync, Sync would not be

the transmit candidate. The total transmission distance of this node from Sync is more than the node which used to send data directly. Decrement of power of nodes collection is much more impressive than the node which is directly connected to the Sync; therefore, designed cost function not only decrease the power consumption value, for evaluating that in the primary node or the Sync, but also decrease the performance of the method in some cases.

Furthermore, another critical parameter also was not implemented in the design of this cost function. Medically because of the high price of replacement, in a physical sensor network, the method must be designed somehow that by network lifetime being high, the collection of nodes dies in power. It means that nodes or all of them remain in the work circuit or a brief period; all of them decrease in power. Thus, a patient returns to the health center in a period given to him by a medic or technical team. Then, all of the sensors are reviewed and changed.

Another problem is its low speed because of increasing the number of nodes and cluster heads. For example, if we have forty nodes and want to find six cluster heads among them, we have to make about four million comparisons each time for all of the collection, which is not acceptable. In order to reduce this performance time, evolutionary methods like the firefly algorithm can be helpful and reduce the number of comparisons.

Possible candidates for replacing were:

-The average or total remaining energy in the network while using the interface node.

-A variance of the remaining power in the nodes.

Variance is a statistical parameter that points to data scattering. If the cost function is designed for decreasing the variance, we can assure that consumption power will be adjusted somehow that the collection of nodes uses the same power and power of collection of the network will homogeneously tend to zero.

-Factor of variation

This criterion, which is concluded by dividing variance root, or standard deviation, by an average of data, shows us scatter rate of data toward the middle point of the average. Practically, it can be so useful in the physical sensor network. If this value becomes the minimum, it means that numerator has a minimum value, and dominator has a maximum value. The minimum value of numerator means the most proximity in power consumption of sensors when choosing the interface and the maximum value of dominator means the most life span of the network.

2.3 Evaluation Criteria

-Timing and speed of transferring data

-Lifetime of network

-Operational power

-Residual energy

-Wasting the route

Wasting the route is a function of frequency and distance. This index has been computed by measuring the distance of the node from the Sync and the used static 2.4 GHrtz frequency in hardware. For the factor of wasting the route, due to human body existence, we use 3.38 and 4.1 value for standard deviation. Multi-jump topology decreases the possibility of destroying the data. It is based on the fact that multi-jump transferring decreases distance and causes route wasting decrease.

3. Modeling

In the physical networks, various modes of the human body, body movement, hands, and cloth will affect the transferred signals. Wasting the route depends on both distance and frequency factors.

$$PL(f,d) = PL(f) * PL(d) \qquad (2)$$

The relation between frequency and wasting the route is shown in the below relation.

$$\sqrt{PL(f)} \alpha f^{k} \qquad (3)$$

Here, *k* is the factor related to the frequency, and it depends on the geometry and position of the body. The relation between distance and route wasting is obtained from the below relation.

$$PL(f,d) = PL_0 + 10n \log_{10} \frac{d}{d_0} + X\sigma \qquad (4)$$

Here, *PL* of the obtained energy, *d* is the distance between receiver and transmitter, d_0 is resource distance, and *n* is the factor of route wasting and size of that depends on the producing area. In free space, its value is 2. In WBAN networks, *N* varies from 3 to 4 in the direct vision and from 5 to 7 for a connection out of vision. *X* is a magnetic field random variable and PL_0 is the obtained energy in distance of d_0 and is computed like this:

$$PL_0 = 10 \log_{10} \frac{(4\pi \times d \times f)^2}{c} \qquad (5)$$

Here, f is frequency, c is the speed of light, and d is the distance between receiver and transmitter. The resource distance value of d0 is 10cm here.

4. Firefly Algorithm

Firefly algorithm is an optimization algorithm which was designed in 2008 by Yang based on the optical behavior of firefly. This algorithm starts accidentally with placing n member's population of fireflies in various points of search space optimization. In the beginning, worms have the same amount of Luciferin in the amount of *I*. Each round of algorithm includes a phase to refresh the brightness, attraction, and a phase to updating the place of worms. During the phase of the movement, each worm moves possibly towards one of its neighbors, which has more attraction. In this way, worms move toward attractive neighbors. The general relationships of the firefly algorithm are like this:

$$\begin{aligned} I &= I_0 e^{-\gamma r} \\ \beta &= \beta_0 e^{-\gamma r} \\ r_{ij} &= \left\| x_i - x_j \right\| \\ \chi_{new\_i} &= \chi_{old\_i} + \beta_0 e^{-\gamma r_{ij}^2} (\chi_j - \chi_{old\_i}) + \alpha (rand - \frac{1}{2}) \end{aligned} \qquad (6)$$

The I is Lighting, $I_0$is primary lighting, β is attraction, β_0 is the primary attraction, γ is attraction factor, *r* is Euclidean distance of two worms, *x* is the position of the worm, *rand* is a random number between zero and one, and α is zero or one. The complete semi code of fireflies is brought in [24, 25]. The initial amount of worms was 64 worms. This algorithm only acts in cases in which the amount of nodes is more than 30 and unless it is not needed.

4.1 Used Hardware

The used hardware is AC CC2420 from Chipcon Company, which is one of the most critical standards IEEE Acs and is so useful. Specifications of it are brought in the Table (1).

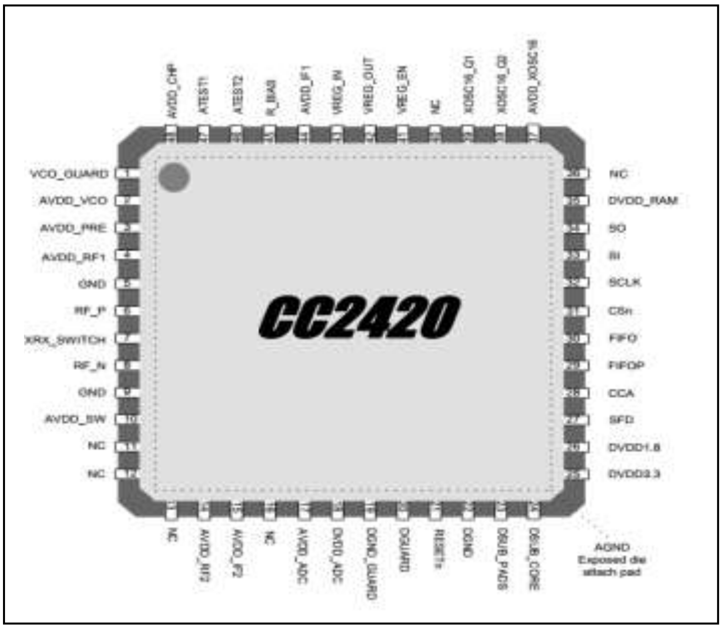

Figure2. AC CC2420

5. Results

In this part, the results of the offered method are compared with the results of [24] paper. The stability and power of the offered method have been shown toward the existing method and previous methods. In the first step, as regards that the goal of the offered method is making a lifetime of nodes maximum and finally was consuming their power in a short period, the number of dead nodes is computed based on the number of rounds. As it is shown in figure (3), the offered method, which is mentioned in the chart with a star sign and red color, had lost nodes in a short period. Almost in the 6500 rounds, all of the nodes had used their power. If we consider the number of useful nodes as 6, in an almost 300 rounds range, all of the live nodes become zero. It means that in the useful lifetime or without jump system, which there were 5300 rounds times, 95% of nodes energy had been used, and 5% remaining become zero in 300 rounds.

Table1. Hardware specifications of the sensors used in [22]

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
Etx−elec	16.7	96.9	nJ/bit
Erx−elec	36.1	172.8	nJ/bit
Eamp	1.97E-09	2.71E-07	j/b

It means that the designing team of a system can offer time to the patient for the first referral and changing all batteries. In this way, the patient will refer to the medical center in a period, and all of the nodes will be repaired. In comparison with the offered method, the related method with [24], which is specified with black color, in 2800 rounds nodes start to die, and then in 7000 rounds in a short period, remaining nodes are used. Therefore, if we want to compare the useful lifetime of network with a lifetime of our offered network, in this sense, our network maintains a useful lifetime, almost twice the offered network, which is higher primarily because of this. The blue method is the current physical network0 managing, which has been modeled based on results.

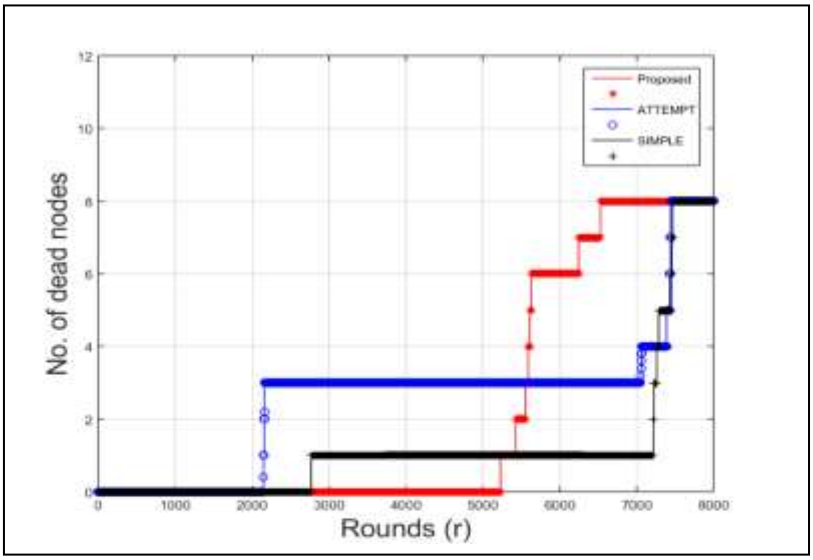

Figure3. Dead nodes based on round in the offered method

Finally, the previous method, which is based on saving and sending and is defined with blue color and “attempt” name, is not good enough to be compared with the offered method and is much weaker. From the point of some receiving packages which are defined in figure 4 and 5300th round or node, and the time of changing batteries in the offered method, we can compare that the provided method has better performance than the other. In the last nodes, because of the existence of more live nodes, it has much better performance. However, at the end of the timeline, because no packages are sending, [24] method will be better than that. Totally from the point of receiving the package, the offered method was better than [24] method in useful lifetime of the network, and in round 5300, that the last live node of the offered method is deleted, there is a 3 % improvement. This improvement can be seen in point 5300 in Figure 4.

The next benchmark comparison shows the residual energy in the network, which due to the charts; it is evident that offered method has more energy consumption than the previous methods because of trying to consume the same energy from batteries. However, due to the goal of this design, its performance is not that bad. This parameter was not an important one in this design.

The last evaluated criterion in Figure 6 was the amount of decrement of route in the offered and [24] methods and comparing these two, which is evident that the offered method, in the field of energy loss, has imposed fewer path drops than previous methods to the system. Death of the sensor causes this decrease, which is not acceptable.

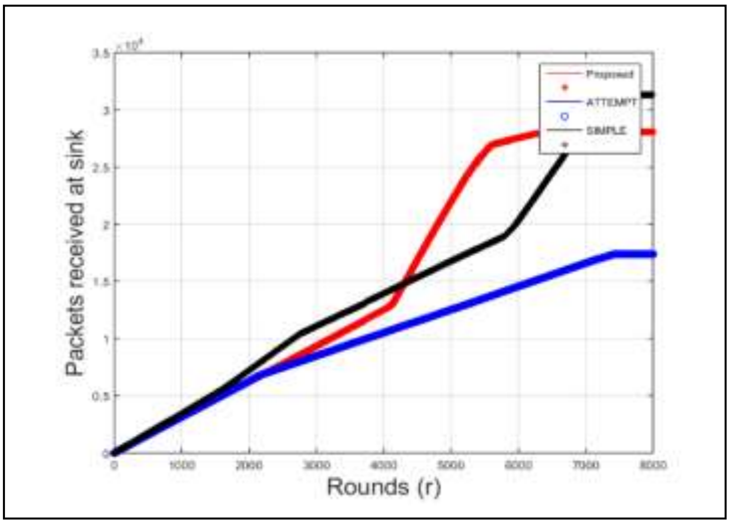

Figure4. Received package based on rounds in offered method and [24] method and saving and sending method

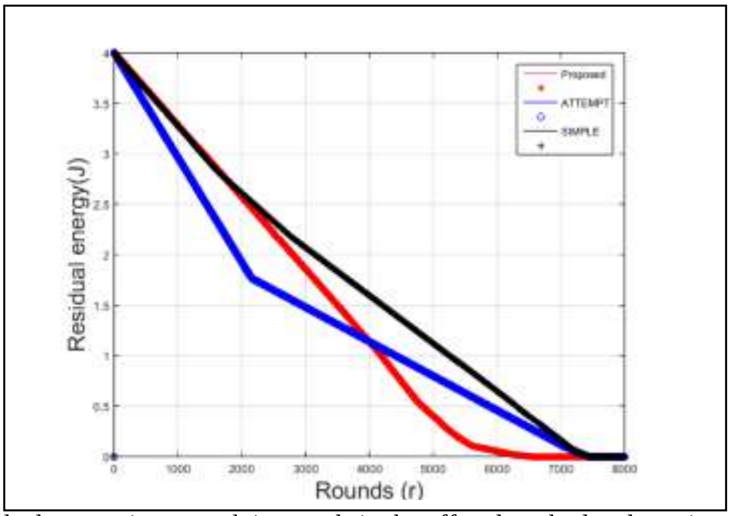

Figure5. Residual energy in-network in rounds in the offered method and previous methods

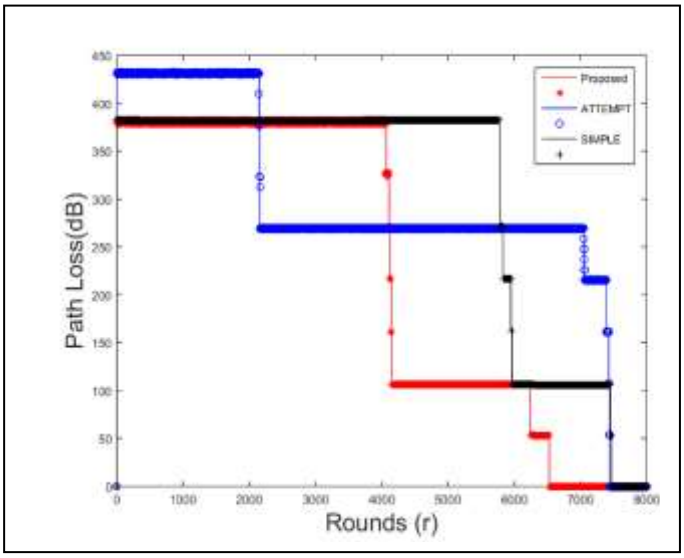

Figure6. Path drop in network based on round in offered and previous methods

According to all four charts in these figures, we can conclude that the offered cost function as a replacement for this network is better than the provided cost function in [24] method and from the point of the same switch and combined minimal energy consumption, it caused better stability in the network.

6. Conclusion

In this season, a beneficial method based on cost function by controlling all of the nodes, for choosing the interface node in a physical sensor network, using the firefly algorithm was offered. The offered network, based on our routing algorithm, can be managed somehow that all of the nodes or sensors consume power symmetrically, and finally, in a short period, all of the nodes achieved zero energy. It gives the user this possibility to change all of the sources of sensors at the same time by referring to medical centers or related technical center in accurate time intervals. From this point, it is so useful to increase the performance of the method from the patient's point of view, which needs the least pressure, least referring to medical centers, and the highest sensor efficiency. Other results have shown that, in the field of sustainability, the number of received packages and other cases of the offered method were so useful, and have no problems. Other advantages of this method are the need for the same nodes and no need to change the power supply in a different manner, which has decreased the cost of implanting and designing of the sensor. However, if the system is asymmetric, it will work correctly. All practical criteria, details of building and implementing, were chosen like [24] resources, so the offered method can be compared with the related method.

7. References

[1] Jian-Liang, G., Yong-Jun, X. and Xiao-Wei. L. 2007. Weighted-median based Distributed Fault Detection for Wireless Sensor Networks. Journal of Software. 18(5): 1208-1217.

[2] Moustapha, A. and Selmic, R. 2008. Wireless Sensor Network Modeling Using Modified Recurrent Neural Networks: Application to Fault Detection. IEEE International Conference on Networking, Sensing and Control. 57(5): 981-988.

[3] Liang, L., Yu, G., Gang, F., Wei, N. and Aung Aung, P. W. 2014. A Low Overhead Tree-based Energy-efficient Routing Scheme for Multi-hop Wireless Body Area Networks. Computer Networks. 70: 45-58.

[4] Lee, D., Lee, W. and Kim, J. 2007.Genetic Algorithmic Topology Control for Two-Tiered Wireless Sensor Networks. International Conference on Computational Science. 3: 385-392.

[5] Rezaei, F., Hempel, M. and Sharif, H. 2015. A Survey of Recent Trends in Wireless Communication Standards, Routing Protocols, and Energy Harvesting Techniques in E-Health Applications. International Journal of E-Health and Medical Communications. 6(1): 1-21.

[6] Djenouri, D. and Balasingham, I. 2009. New QoS and Geographical Routing in Wireless Biomedical Sensor Networks. In Proceedings of the Sixth International Conference on Broadband Communications, Madrid, Spain. 1: 1-8.

[7] Hsu, W. C., Kuo, C. W., Chang, W. W., Changb, J. J., Hou, Y. T., Lan, Y. C., Sung, T. J. and Yang, Y. J. 2010. A WSN Smart Medication System. Procedia Engineering. 5: 588-591.

[8] Liang, X. and Balasingham, I. 2007. A QoS-aware Routing Service Framework for Biomedical Sensor Networks. In Proceedings of the IEEE International Symposium on Wireless Communication Systems. 342-345.

[9] Elhadj, H. B., Chaari, L. and Kamoun, L. 2012. A Survey of Routing Protocols in Wireless Body Area Networks for Healthcare Applications. International Journal of E-Health and Medical Communications. 3(2): 1-18.

[10] Oey, C.H.W. and Moh, S. 2013. A Survey on Temperature-aware Routing Protocols in Wireless Body Sensor Networks. Sensors. 13: 9860-9877.

[11] Gao, T., Greenspan, D., Welsh, M., Juang, R. and Alm, A. 2006. Vital Signs Monitoring and Patient Tracking Over a Wireless Network. In Proceedings of IEEE-EMBS 27th Annual International Conference of the Engineering in Medicine and Biology Society. 17–18: 102-105.

[12] Javed Iqbal Bangash, J. I., Abdullah, A. H., Anisi, M. H. and Khan, A. W. 2014. A Survey of Routing Protocols in Wireless BodySensor Networks. 14: 1322-1357.

[13] Khan, Z., Sivakumar, S., Phillips, W. and Robertson, B. 2012. Aware Peering Routing Protocol for Delay Sensitive Data in Hospital Body Area Network Communication. In Proceedings of 7th International IEEE Conference on Broadband, Wireless Computing. Communication and Applications (BWCCA). 12–14: 178-185.

[14] Zahoor, A. Kh. , Sivakumar, Sh., Phillips, W. and Aslam, N. 2014. A New Patient Monitoring Framework and Energy-aware Peering Routing Protocol (EPR) for Body Area Network communication. Journal of Ambient Intelligence and Humanized Computing. 5(3): 409-423.

[15] Mohsin, A. H., Abu Bakar, K., Adekiigbe, A. and Ghafoor, K. Z. 2012. A Survey of Energy-Aware Routing and MAC Layer Protocols in MANETS: Trends and Challenges. 4(2): 82-107.

[16] Chen, B., Jamieson, K., Balakrishnan, H. and Morris, R. 2002. An Energy Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks. ACM Wireless Networks. 8(5): 481-464.

[17] Schurgers, C., Tsiatsis, V., Ganeriwal, S. and Srivastava, M. B. 2002. Optimizing Sensor Networks in the Energy-latency-density Design Space. IEEE Transactions on Mobile Computing. 1(1): 70-80.

[18] Elias, J. and Mehaoua, A. 2012. Energy-aware Topology Design for Wireless Body Area Networks. IEEE International Conference on Communications (ICC). Ottawa, Canada.

[19] Khan, Z., Sivakumar, S., Phillips, W. and Aslam, N. 2014. A New Patient Monitoring Framework and Energy-aware Peering Routing Protocol (EPR) for Body Area Network Communication. Journal of Ambient Intelligence and Humanized Computing. 5(3): 409-423.

[20] Yu, Ge., Gang, F., Wei, N. and Aung, W. 2014. A Low Overhead Tree-based Energy-Efficient Routing Scheme for Multi-hop Wireless Body Area Networks. Computer Networks: The International Journal of Computer and Telecommunications Networking archive. 7099): 45-58.

[21] Elias, J. 2014. Optimal Design of Energy-efficient and Cost-effective Wireless Body Area Networks. Ad Hoc Networks. 13(B): 560-574.

[22] Nadeem, Q., Javaid, N., Mohammad, S., Khan, M. Y., Sarfraz, S. and Gull, M. 2013. Stable Increased-throughput Multi-hop Protocol for Link Efficiency in Wireless Body Area Networks. Eighth International Conference on Broadband and Wireless Computing. Communication and Applications Compiegne. Compiegne. France.

[23] Latre, B., Braem, B., Moerman, I. Blondia, Ch. Reusens, E., Joseph, W. and Demeester, P. 2007. A Low-delay Protocol for Multihop Wireless Body Area Networks. Mobile and Ubiquitous Systems: Networking and Services. MobiQuitous. Fourth Annual International Conference on. IEEE.

[24] Elhadj, H. B., Elias, J., Chaari, L. and Kamoun, L. 2016. A Priority based Cross Layer Routing Protocol for Health Care Applications. Ad Hoc Networks. 42: 1-18.

[25] Nguyen, T. T., Quynh, N. V. and Van Dai, L. 2018. Improved Firefly Algorithm: A Novel Method for Optimal Operation of Thermal Generating Units. Complexity. 12: 1-23.