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Performance evaluation of non-hierarchical routing protocols for healthcare applications

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ABSTRACT

All wireless sensor network (WSN) is a network of spatially distributed sensors that monitor physical or environmental characteristics. Wireless Body Area Network (WBAN) is a subset of WSN. WBAN is a new technology that is gaining popularity these days, WBAN devices are critical in the process of health monitoring and patient monitoring. Routing protocols will play a critical role in improving the effectiveness of communication between nodes and increasing the lifetime of a WBAN. The development and study of WBAN routing protocols has become a popular research area in recent years, particularly for medical monitoring applications. The energy aware and high life time of network is important parameters in the patient monitoring, For Health care application requires a unique routing protocol to transmit the data to their intended destination. The different non-hierarchical routing protocols like RPL, CTP presented in this context, The existing algorithms cannot fully satisfy the application requirements. In this paper energy efficient and reliable routing protocol is proposed for healthcare applications, our proposed routing protocol improves the network lifetime and reduce the energy consumption by using a weighted method, we evaluated the performance of proposed routing protocol in various routing parameter and comparing with RPL, CTP routing scheme. the Experimental results shows that proposed routing protocol performs better when compare to other two routing scheme. It is the best replacement with existing methods.

Keywords: *Wireless body area network, efficiency, Residual energy, Routing protocol, reliability*

1. INTRODUCTION

WBAN (Wireless Body Area Network) is emerging as a distinct application of this technology. In several aspects, WBAN differs from existing wireless sensor networks (WSNs). The first distinction between a WBAN and a WSN is mobility. WBAN allows users to transition between sensor nodes with the same mobility pattern, whereas WSN is often utilized to remain stationary. WBAN uses a lot less energy than other WSN configurations. WBAN sensor sensors are also less expensive than WSNs. WBAN nodes, on the other hand, are conventional in terms of reliability, network complexity, and density. WSNs are not designed to address special criteria relating to the network's interaction with the human body. There are wireless technologies available, such as Bluetooth, low-power Wi-Fi, IEEE 802.15.6 and ZigBee.

WBANs' most significant design problem is to ensure reliable data transmission and extend the life of the network under the constraints of a limited energy supply. A proper and well-designed routing scheme offers prolong network life-time with high quality of services by efficient resource management strategies. As WBANs operating conditions and its architecture are different than other traditional sensor networks, therefore the routing schemes designed for those networks, are not suitable to be implemented in WBANs applications.

A wireless sensor network routing protocol could be a set of rules that sensor nodes follow to determine the optimum path for delivering data to its intended destinations. a particular routing protocol is required for a healthcare application that consists of little, wireless sensor nodes with minimal power consumption inserted within the bodies of patients so the nodes can securely and efficiently transfer all of the required data. In order for the network to have a long-life lifetime, the energy level must also be considered. The routing protocol is a collection of rules used by routers (in WSN nodes) to find the best path for sending data packets to their destinations.

In this paper different non-hierarchical routing protocol for healthcare applications is presented, the energy efficient and reliable routing protocol is proposed in this work the main goal of proposed routing protocols to improve maximum throughput and high reliability as well as maximum life time of the network [3]. This protocol selects the best route which has a highest residual energy and expected transmission count as apart of weight and it use as a routing metrics for routing process.

The rest of this paper is organized as follows. In Section II, the WBAN architecture and standards explains in detail. Section III present a node placement algorithm, Section IV discuss the RPL and CTP routing protocols and Section V & VI we have presented routing protocol and performance evaluation by simulation, Section VII we summarize the conclusion.

2. WIRELESS BODY AREA NETWORK

WBAN (Wireless Body Area Network) is a collection of low-power, small, implanted or wearable lightweight wireless sensor nodes which help in the frequent monitoring of human body activities and the surrounding environment. The WBAN is made up of a collection of intelligent sensors and biosensors that work together to enhance health tracking, healthcare and diagnostic monitoring, and medical operations.

A. Architecture of WBAN

WBAN is designed with a different sensors and devices that is independent a human body's insides and outsides [2]. the simple WBAN architecture divided into 4 sections as shown in the below fig.1.

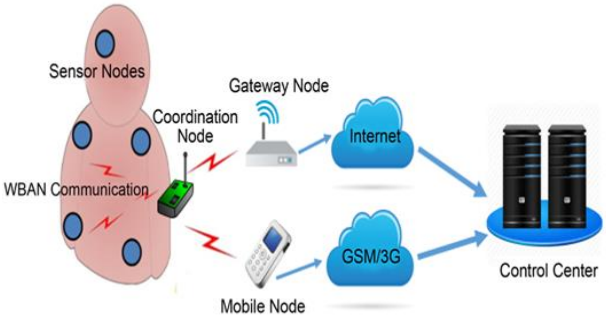

Fig 1: WBAN architecture

The WBAN component, which is made up of many sensor nodes, is the first. They are low-cost, high-power nodes that are strategically placed on the human body and contain inertial or physiological sensors. All sensors may be utilized to continuously monitor movement, vital factors such as heart rate, ECG, blood pressure, and the environment. Vast monitoring systems based on wired connections are already being used. in patient monitoring system the wired connections are always difficult, uncomfortable and restrict to mobility of patient. The second component, known as the Central Control Unit (CCU), links all of the sensor nodes and is responsible for gathering and delivering all of the data to the next segment. There is no wireless technology that can be used to target WBAN for monitoring human bodily activity. GSM, 3G, 4G, WPAN, Wi-Fi (Bluetooth, ZigBee) etc. are the most widely used wireless medical monitoring technology.

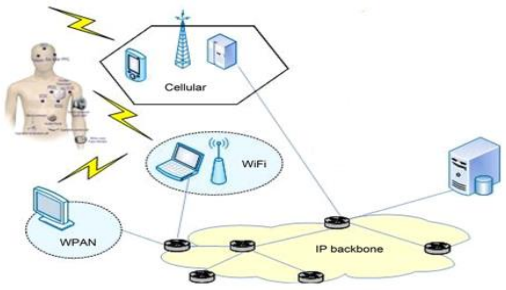

Fig 2: A Typical WBAN communication

All of these technologies, with the exception of the traditional cellular network, are commonly utilized for short-distance communication.

Other technologies that could be used for body monitoring systems while using minimum transmission power are WMTS (Wireless Medical Telemetry Service) and Ultra-Wide Band. WBAN communication is the third component, and it acts as a channel for data transfer to the destination. A mobile node can act as a gateway for a remote station, allowing it to send a mobile message to a mobile network through GSM/3G/4G. To engage via email or other services, a remote node, such as an Ethernet router or a PC, can be used as shown in Fig 2.

At last section all database storage server information is stored it consists of control devices with end node devices i.e., personal computers, email, mobile telephone.

B. WBAN standards

The WBAN standard IEEE 802.15.6 defined 2 layers PHY and MAC layers [2]. The IEEE 802.15.6 defines three separate layers:

a) Physical layer:
   1. Narrow Band: The Clear Channel Assessment, CCA within the present channel and data transmission/receipt are the responsible for activate/deactivate the radio transceiver. The standard employs differential phase shifting keying technique (DPSK) except the Gaussian Minimum Shift Keying technology (GMSK) 420 MHz per 450 MHz band.
   2. Ultra-Wideband: This layer works in low and high frequency bands. Each frequency band is divided into channels with a bandwidth of 499.2 MHz
   3. Human Body Communications: It covers the whole WBAN protocol, including packet structure, modulation, and so on. This layer works in two frequency bands of 16 MHz and 27 MHz, each with a bandwidth of 4 MHz

b) MAC Layer: The coordinator is responsible for the channel access coordination it has a 3-access mode:
   1. Beacon mode with beacon period super frame boundaries: In this mode, except in inactive super frames or where regulations preclude it, the hub transmits beacons during each beacon cycle.
   2. non-beacon mode with super frame boundaries: In this mode, the entire super frame length is converted by either a type I or a type II but not both.
   3. non-beacon mode without super frame boundaries: In this access mode, the coordinator only provides unscheduled Type II polled allocation, which means that each node must determine its own time schedule.

3. NODE PLACEMENT IN AN AREA

The Node placement algorithm randomly places the nodes in non-hierarchical network in such way All nodes will fall within an x*y meter radius., Number of sensing point, Minimum x & y position, Maximum x & y position, Generate the sensing point id starting with '1', Create x and y coordinates. Repeat the procedure until all sensing points are placed in the non-hierarchical network. Randomly store the information in the format of a set, increment the sensing point id, and repeat the process until all sensing points are placed in the non-hierarchical network. The Node Placement algorithm provides an order matrix known as the Node Deployment Matrix in addition to positioning the nodes in the network. N is the total number of nodes in the network. The Node ID will be the first column, the x location of the node will be the second column, and the y position of the node will be the third column.

4. WBAN ROUTING PROTOCOLS

A node's collected information must be shared with the rest of the network's nodes. Routing is crucial in WBAN because with the proper path, node communication may be improved. A routing protocol describes how routers interact with one another, allowing them to choose routes between any two nodes in a computer network. The two non-hierarchal routing discussed below.

a) RPL protocol

The Internet Engineering Task Force (IETF) introduced the Routing Protocol for Low-Power and Lossy Networks (RPL) is one of the most extensively used protocols in the world today [7]. It's a routing protocol that uses distance vectors. The main purpose of the routing protocol for low power and lossy Network (RPL) algorithm is to prevent loops in the network. It uses a routing metric called Expected Transmission Count (ETX) to determine the routing path. The expected number of transmissions required to send a data packet is known as ETX [3]. This protocol finds a multiple path form source to destination computes ETX for all individual route the route which has highest ETX will be selected a best route for routing This protocol is ideal for point-to-multipoint and multipoint-to-point communication, but not for two-way communication. RPL have a feature that able to work in any other application using a proper routing metrics.

The RPL algorithm will find the 2Tx neighbors where Tx represents the transmission range for the node in the network. For each of the node in the transmission range to destination the route formation is done using individual RPL algorithm. In the Individual path formation, the initiator node will find the neighbors, it will pick one of the neighbors as the next forward node based on computation of expected transmission count. This procedure is repeated until the desired destination is reached. Once multiple paths are found then the path which has maximum Expected Transmission Count is chosen as the best path.

b) CTP protocol

The Connection Tree Protocol (CTP) is developed to ensure the efficiency, robustness and reliability of routing path selection [7]. This protocol finds a multiple path form source to destination computes RE for all individual route the route which has highest RE will be selected a best route for routing, unlike other routing protocols, this protocol prioritizes route reliability over energy constraints when selecting a routing path, by avoiding less secure paths, CTP reduces the number of transmission of packets in a WSN network. CTP, on the other hand, cannot be used in some applications where reliability is not needed.

The CTP algorithm will find the 2Tx neighbors where Tx represents the transmission range for the node in the network. For each of the node in the transmission range to destination the route formation is done using individual CTP algorithm. In the Individual path formation, the initiator node will find the neighbors, it will pick one of the neighbors as the next forward node based on computation of reply time. This procedure is repeated until the desired destination is reached. Once multiple paths are found then the path which has maximum total residual energy is chosen as the best path.

5. PROPOSED PROTOCOL

The proposed algorithm discovers multiple routes from source to destination it computes weight for each individual routes, the path which has a highest weight will be selected as best route for routing process. Every piece of data in a healthcare application is really important. Any data that does not reach its intended recipient can cause significant harm to both the individual and the healthcare system. This protocol provides high reliability and energy efficient path to send the data information from source node to destination node.

The Proposed algorithm as shown in fig 3 will find the Tx neighbors where Tx represents the transmission range for the node in the network. For each of the node in the transmission range to destination the route formation is done using individual proposed algorithm. In the Individual path formation, the initiator node will find the neighbors, it will pick one of the neighbors as the next forward node based on computation of weight which is combination of expected transmission count and residual energy. This procedure is repeated until the desired destination is reached. Once multiple paths are found then the path which has maximum weight is chosen as the best path.

6. PERFORMANCE EVALUATION

Now we are going to discuss about evaluation of our proposed routing protocol based on different parameters and comparing with existing algorithms. To perform the Proposed Method first we have to place the nodes in non-hierarchical network by using the node placement algorithm. The input to the algorithm can be given as follows.

Nodes in the Network	100
Transmission Range for Neighbors	40
Battery Power	2000
Source node Id	67
Destination Id	57
Energy Required for Amplification in mJ	10
Energy Required for Transmission in mJ	20
Attenuation Factor [0.1 to 1]	0.5

We can observe from fig. 4. that 100 nodes were randomly placed in the network in a 100*100 area.

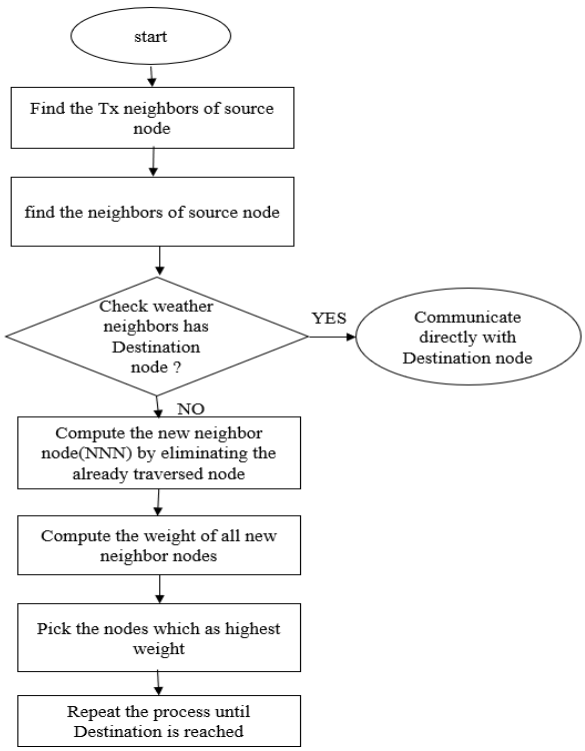

Fig 3: Flowchart of Individual route discovery of Proposed algorithm

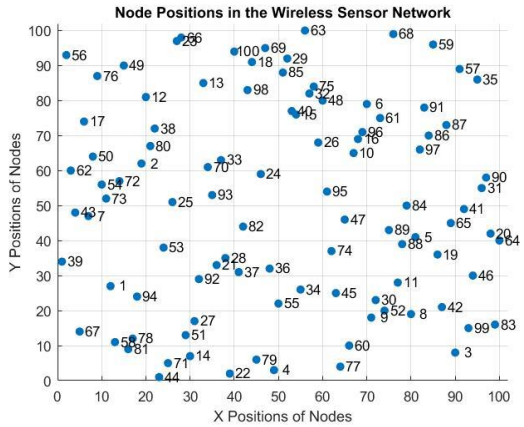

Fig 4: Node placement in the area

The fig 5 shows that all the nodes in the network will have a same amount of energy when the network is formed before routing process plotting a graph Residual Energy on Y- axis and Node Ids on X-axis, here we are setting initially 2000J of energy to all the nodes in the network.

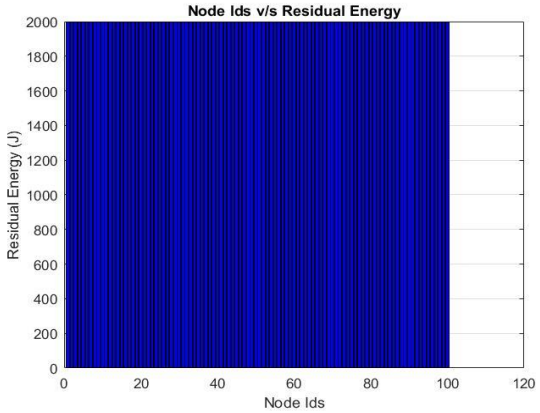

Fig 5: Initial energy of all the nodes before routing

Select a Source node of 67 and a Destination node of 57 in fig 4.16., Transmission range as 40, According to RPL algorithm nodes which are falls within the transmission region i.e., Tx=40m selected as initiators by using this initiator finds the multiple path form source destination, each individual paths calculates the Weight (ETX+RE) between the nodes as shown on the below fig 6. describes a total Weight value for each multiple paths by plotting a ETX value on Y-axis and multiple route numbers on X-axis. Proposed method selects the route which has a highest total weight value as a best route for routing process to send the data form source to destination the Route No 3 has highest weight value i.e., $2.9*10^4$ among all the remaining routes so Route no 3 selected as best route as shown in the fig 7.

Fig 6: Total Weight of multiple routes

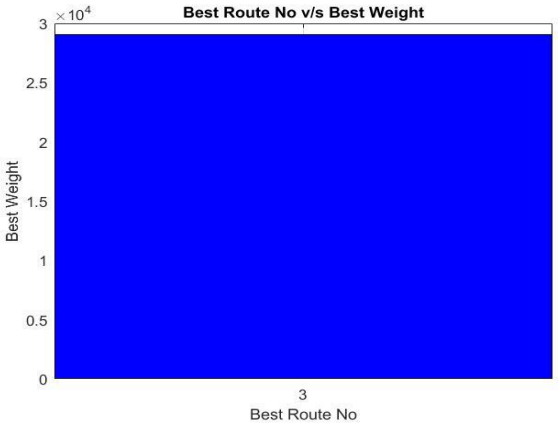

Fig 7: Best route selection

Once after the best path is found the path is traced form source to destination as shown in the fig 8.

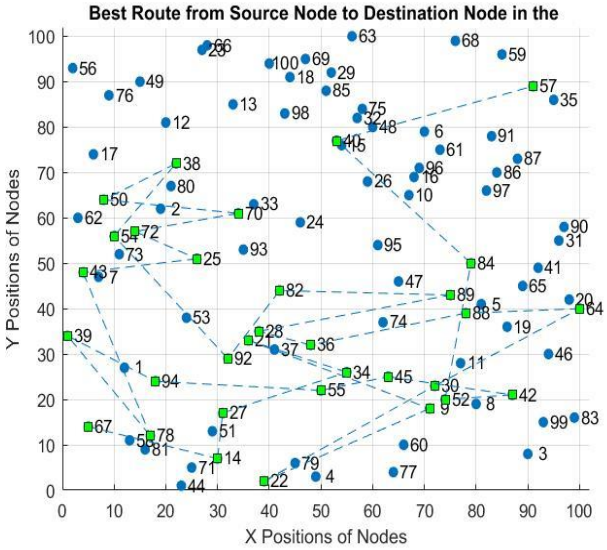

Fig 8: Best route trace form source to destination node

The nodes which are participated in the routing process whose energy decreases otherwise remains same amount of initial Energy when the network is formed as shown in the fig 9.

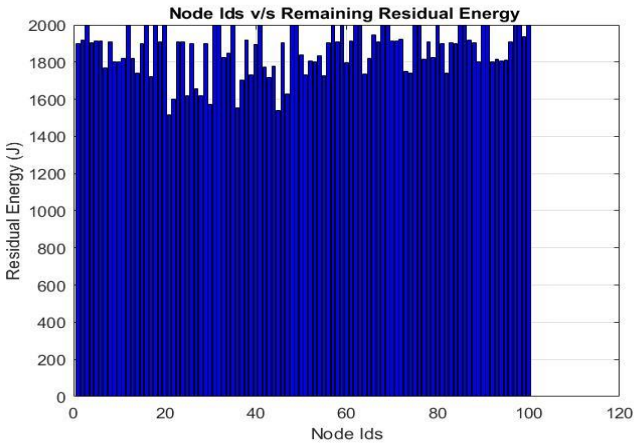

Fig 9: Remaining energy of all the nodes after routing

Comparison of RPL, CTP and Proposed Algorithms

The RPL, CTP & Proposed algorithms are compared in terms of different routing parameters up to 5 iterations as shown in the Fig 10.

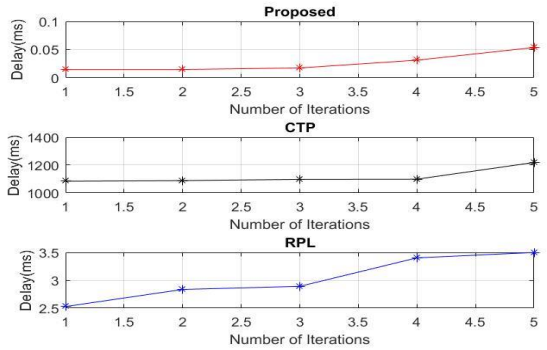

Fig 10: Delay Comparison

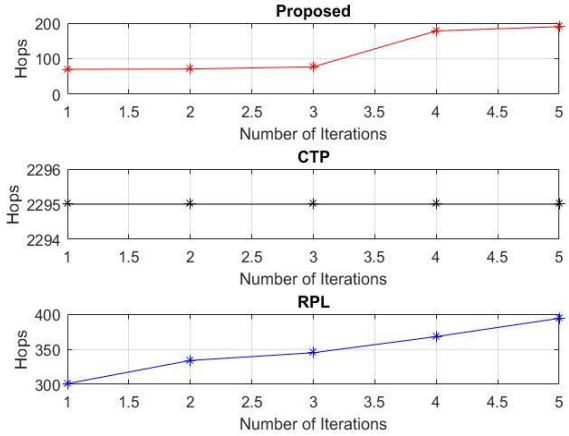

Fig 11: Hops Comparison

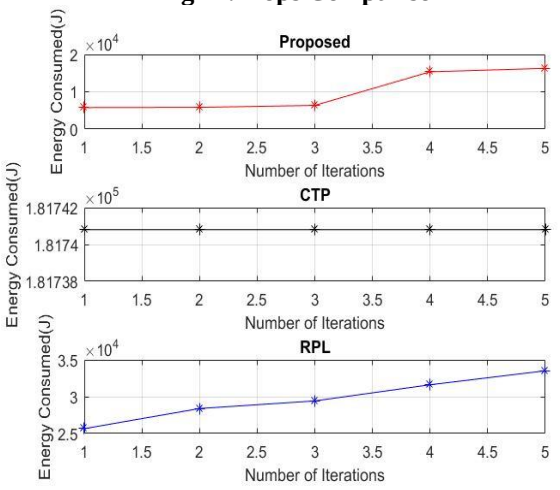

Fig 12: Energy consumption Comparison

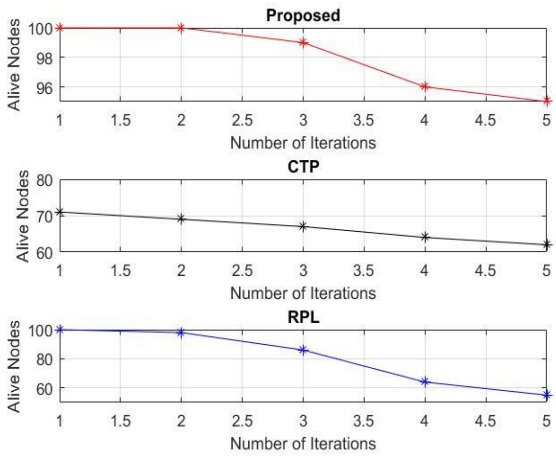

Fig 13: Number of Alive nodes Comparison

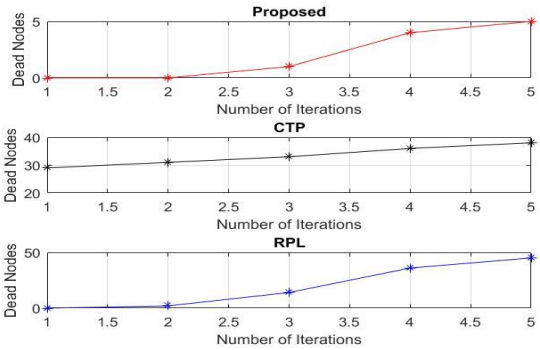

Fig 14: Number of Dead nodes Comparison

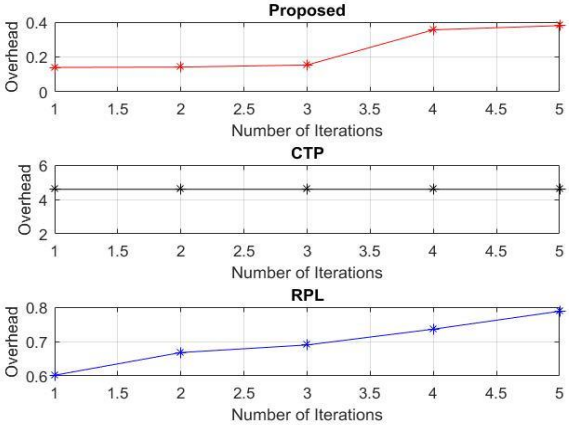

Fig 15: Overhead comparison

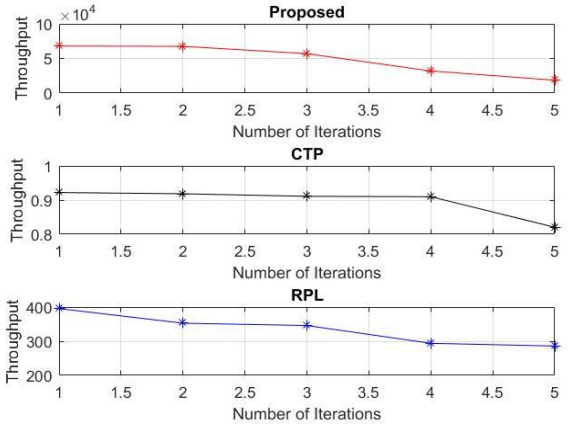

Fig 16: Throughput comparison

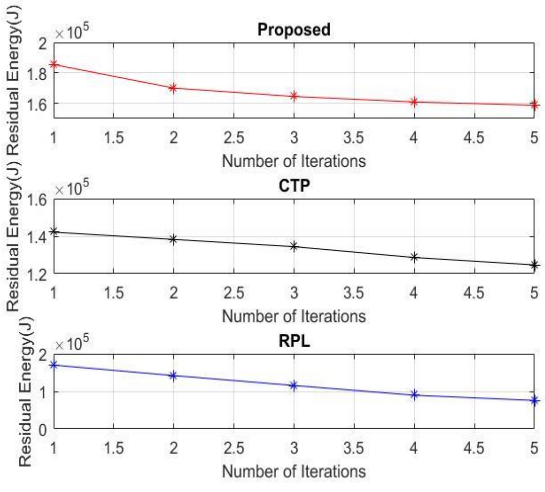

Fig 17: Residual energy comparison

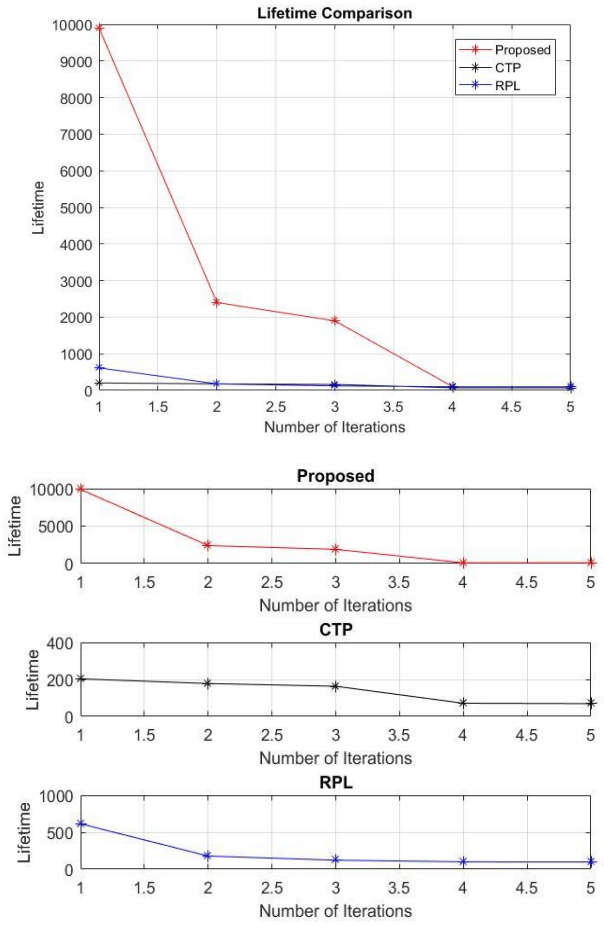

Fig 18: Life time ratio comparison and subplots

By observing analysis of all the parameters, we can say that the proposed algorithm performs better when compare to other two algorithm i.e., RPL and CTP algorithm. The proposed algorithm is the best replacement in WBAN network it satisfies all requirement in healthcare applications.

7. CONCLUSIONS

A specific routing protocol is required to monitor the patients in healthcare application, which consists of lightweight, low-power wireless sensor nodes that are implanted in patients' bodies, so that the nodes may reliably and efficiently convey all of the necessary data. In this work 3 different non-hierarchical routing protocols for WBAN network presented. An Improved Energy aware and high lifetime ratio algorithm based on weight computation for patient monitoring is proposed the main goal this research work is to enhance the network life-time, Energy consumption, throughput and end-to-end delay. The performance of the healthcare application may be greatly improved using our proposed routing scheme. In terms of various characteristics, we examined and compared the performance of three energy efficient routing protocols. The comparison of RPL, CTP and Proposed routing protocols has been done by simulations in MATLAB. According to the results, the proposed protocol outperforms the other two protocols in terms of many parameters, making it a promising choice for WBAN routing.

4. REFERENCES

[1] Z. Ullah et al., "Energy-Efficient Harvested-Aware Clustering and Cooperative Routing Protocol for WBAN (E-HARP)," in IEEE Access, vol. 7, pp. 100036-100050, 2019, doi: 10.1109/ACCESS.2019.2930652.

[2]https://file.scirp.org/Html/61730598_76200.htm#:~:text=WBAN%20is%20designed%20with%20special,is%20divided%20into%20several%20sections.

[3] M. R. Rahman, M. M. Islam, E. A. Shahaz and Y. Alsaawy, "Application Specific Energy Aware and Reliable Routing Protocol for Wireless Sensor Network," 2019 7th International Conference on Smart Computing & Communications (ICSCC), 2019, pp. 1-5, doi: 10.1109/ICSCC.2019.8843687.

[4] N. K. Samra, R. Kaur and B. P. Kaur, "A Novel Approach for Energy Efficiency and Congestion Control in WBAN," 2019 6th International Conference on Computing for Sustainable Global Development (INDIACom), 2019, pp. 719-723.

[5] D. Divya Bharathi and R. Jayaparvathy, "Efficient Node Distribution Strategies for Minimizing Energy Hole Problem in WSN,"2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, 2018, pp. 0858-0862, doi: 10.1109/ICCSP.2018.8524568.

[6] P. Kaur and S. S. Kang, "Trust Aware Routing Protocols in Wireless Body Area Networks," 2019 6th International Conference on Computing for Sustainable Global Development (INDIACom), 2019, pp. 1106-1112.

[7] P. Janani, V. C. Diniesh and M. J. Auxilius Jude, "Impact of Path Metrics on RPL's Performance in Low Power and Lossy Networks," 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, 2018, pp. 0835-0839, doi: 10.1109/ICCSP.2018.8524141.

[8] J. Mao, "Investigating on the Interferences on Human Body Communication System Induced by Other Wearable Devices," 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 4044-4047, doi: 10.1109/EMBC.2019.8857102.

[9] E. Caballero, V. C. Ferreira, R. A. Lima, C. Albuquerque and D. C. Muchaluat-Saade, "LATOR: Link-Quality Aware and Thermal Aware On-Demand Routing Protocol for WBAN,"2020 International Conference on Systems, Signals and Image Processing (IWSSIP), 2020, pp. 337-342, doi: 10.1109/IWSSIP48289.2020.9145292.

