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Joar: Jaya Based Optimized and Reliable Protocol for Wireless Body Area Network

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Abstract: Wireless body area network (WBAN) is most useful network due to its healthcare applications. The reliability is the major issue of concern in WBAN as highly prioritized signals are sent by using this network. The WBAN must cover the maximum body with minimum number of nodes for the efficient processing of the data sensed. This paper discusses a reliable optimized WBAN protocol named as Jaya based Optimized And Reliable protocol (JOAR) which covers the maximum body with minimum nodes and route the data in an efficient manner. The proposed protocol uses the JAYA algorithm for the optimization process. The comparison of the routing protocol with other existing state of art techniques like anthocnet, AODV and DSDV proves its significance.

Keywords: JAYA, optimization, WBAN, MAC, reliability.

I. INTRODUCTION

Wireless Body area network (WBAN) is an area restricted sensor network in which nodes can be placed on or inside the body. The sensor nodes in the WBAN basically access the body parameters which can be used for the healthcare applications [1]. Normally each sensor is responsible to read different parameter like temperature, heart rate etc. The WBAN topology generally uses a coordinator node, all the other nodes communicate [2] with this node as shown in figure 1.

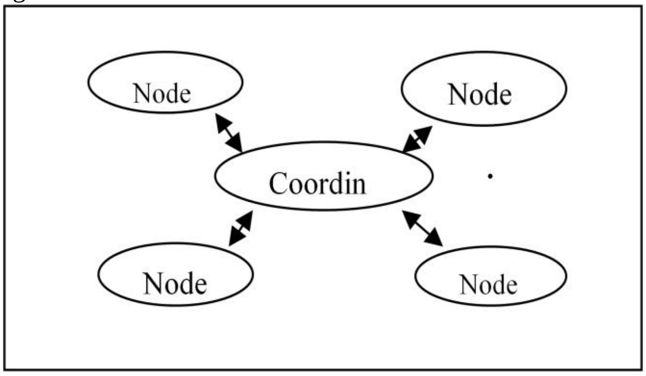

Fig:1 WBAN Topology

The coordinator node is responsible for the communication with the third party to transfer the data. The sensor node placed on the body may affect the health of person due to the radiation emitted by the sensor node.

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This limits the number of sensor nodes to be placed on the body of a person. Moreover, each sensor node is a battery operated device so the lifetime of the node must be large as the replacement of node of changing battery is a difficult task.

The duty cycle of each node must be minimized to enhance the life of each node. It leads to a scenario, where minimum number of nodes with limiting duty life cycle must be placed around the body to cover maximum (required) parameters.

The implementation of the WBAN requires the physical layer implementation which includes the transceiver and sensory interface. The heterogeneity of devices at this layer is denoted by different usable devices i.e. sensors, peripherals (ECG, EEG) and actuators. Moreover, the increase in the number of nodes enhances the parameters to be covered, which is a favorable scenario but it affects the body health. So the optimized number of nodes must be placed around the body such that maximum parameters covered without affecting the health of person. Moreover, the decrease in duty cycle leads enhance in the life time of the node but degradation in the reliability so the duty cycle must be optimized to balance the life time and reliability. Optimization is a usually experienced different issue in all disciplines of engineering; these issues are mainly concerned with finding the most ideal/alluring arrangement. Optimization issues are far reaching and various, thus strategies for taking care of these issues should be a dynamic research point. Optimization calculations can be either deterministic or stochastic in nature [3]. Previous techniques to tackle improvement issues require colossal computational endeavors, which have a tendency to bomb as the issue estimate increments. This is the inspiration for utilizing bio propelled stochastic improvement calculations as computationally proficient other options to deterministic approach. There are various algorithms which are inspired from bio a list of some of the algorithms like Ant Colony Optimization (ACO) [4], Particle Swarm Optimization (PSO) [5], Differential Evolution (DE)[6] , Genetic algorithm (GA)[7] etc. This paper uses optimization algorithm to design an optimized and reliable protocol for the WBAN. The remaining paper has been divided into 4 sections. The section 2(next section) describes the various work done by different researchers in the related field. The section 3 describes the Jaya algorithm which is implemented in WBAN for the optimization. The proposed algorithm (JOAR) along with the fitness function is described in section 4. The implementation details along with the results are given in the section 5. Then the paper summarizes the conclusion.

II. RELATED WORK

Various solutions specific to reliability in WSNs are proposed by many researchers previously.

But little efforts have been shown by researchers for QoS solutions for BANs. Reliability of BANs is highly important since they deal with human and lives can be endangered in case of communication failure. QoS provisioning in emergency telemedicine exhibited a review of the e-health observing innovation with QoS Provisioning. NGL03-6 talked about various QoS prerequisites for transmission of therapeutic information over broadband systems utilizing the remote Diffsery innovation. Distinctive sorts of biomedical sensors require diverse testing rates and in addition administration time which prompts the need of Qos provisioning in BAN. BodyQoS concentrated on three primary testing qualities: i) utilization of a hilter kilter engineering when the greater part of the handling is at the focal gadget, ii) support for various MACs and iii) versatile asset planning procedure used to give measurable transmission capacity and dependable information correspondence in BANs. PNP-MAC broke down QoS as indicated by the need of activity. It gives preemptive space distribution and non-preemptive transmission system to manage QoS prerequisites. IEEE 802.15.4[8] utilizes IEEE 802.15.4 for QoS in BAN. It proposes a QoS Provisioning system by utilizing IEEE 802.15.4 super edge structure in reference point empowered mode. It distinguishes four QoS prerequisite parameters i.e. need of the applications, delay imperatives, landing rate and accessible burst size. QoS for IEEE 802.15.4 based BANs[9] characterizes QoS provisioning plans with administration separation and prioritization [10]. AFTCS [11] proposed a versatile and adaptable shortcoming tolerant correspondence plan for BANs. AFTCS takes a shot at a channel transmission capacity reservation technique for dependable correspondence if there should arise an occurrence of channel debilitations. U-MAC[12] proposed a desperation based MAC convention for BAN. It characterizes a need access instrument that permits sensor hub with earnest wellbeing data to battle the correspondence channel more than the hub with non-critical data. The author of [13] has discussed a model for the WBAN scheduling with different concerned issues. A cross layer based optimized energy efficient model for WBAN is described in [14]. The author of [14] basically optimizes the packet length while the packet size is optimized by the author of [15]. The author of [16] has used the ACO for dissemination of data in WBAN scenario. The author proves that ACO is most useful optimization technique to improve the performance of WBAN routing. The Jaya algorithm used for routing optimization in this work has been described in next section.

III. JAYA ALGORITHM

Swarm Intelligence based algorithms are probabilistic algorithms and need controlling parameters for performance optimization like population size, number of generation etc. Some algorithm specific controlling parameters are also needed like crossover and mutation probability in genetic algorithm, inertia weight in the particle swarm optimization. The improper tuning of such parameters leads to performance degradation of the algorithm. The performance of various swarm intelligence based algorithms like particle swarm optimization, ACO, ABC, GA, DE etc. is controlled by these controlled by these controlling parameters. Recent development results in few parameters-less algorithms like teacher learning based algorithm (TLBO), Jaya algorithm which needs only common parameters (no algorithm specific parameter needed). Jaya algorithm is simple as compared to the TLBO as it needs only one phase to complete its processing. This work will use the Jaya algorithm [17] described below.

Suppose O(p) is an objective function to be optimized (minimized or maximized). At any particular moment (say a^{th} iteration), s is the population size with each population consisting of m members. The population member obtaining the best value of O(p) say $O(p)_{best}$ is the best member while the member having lowest value is the worst member say $O(p)_{worst}$. Then,

$$p^m_{b,c,a} = p_{b,c,a} + r_{1,b,a}\left(p_{b,best,a} - |p_{b,c,a}|\right) - r_{2,b,a}\left(p_{b,worst,a} - pb,c,a \right. \quad (1)$$

Where $p_{b,c,a}$ and $p^m_{b,c,a}$ are the original and modified value of b^{th} member of c^{th} population at a^{th} iteration respectively. $r_{1,b,a}$ and $r_{2,b,a}$ are variables having random value between 0 and 1. $p_{b,best,a}$ and $p_{b,worst,a}$ are best and worst b^{th} member at a^{th} iteration. The $r_{1,b,a}\left(p_{b,best,a} - |p_{b,c,a}|\right)$ coefficient of equation (1) moves the value of $p_{b,c,a}$ towards best member while the coefficient $-r_{2,b,a}\left(p_{b,worst,a} - |p_{b,c,a}|\right)$ moves the value of $p_{b,c,a}$ away from the worst value. The value of $p^m_{b,c,a}$ is accepted only if $O(p^m_{b,c,a}) > O(p_{b,c,a})$ for maximization problem and $O(p^m_{b,c,a}) < O(p_{b,c,a})$ for minimization problem. This process is applied to whole population to generate better solution until stopping criteria achieved. The procedure of Jaya algorithm is given as:

JAYA ALGORITHM:

1. Initiate population size(s), each population member(m), stopping criteria
2. Identify the best and worst population member say best and worst.
3. Modify current solution

$$p^m_{b,c,a} = p_{b,c,a} + r_{1,b,a}\left(p_{b,best,a} - |p_{b,c,a}|\right) - r_{2,b,a}\left(p_{b,worst,a} - |p_{b,c,a}|\right)$$

4. if $O(p^m_{b,c,a}) < O(p_{b,c,a})$ for minimization problem and $O(p^m_{b,c,a}) > O\left(p_{b,c,a}\right)$ for maximization problem then

$$p_{b,c,a} = p^m_{b,c,a}$$

endif

5. if stopping criteria achieved then

Optimized solution found

else

Go to step 2.

endif

The above described procedure can be used to optimize any objective function. The optimization is on the basis of moving towards the best and avoiding the worst solution.

The current solution of the population is modified on the basis of the best and worst population evaluated values as shown in above algorithm.
The above process is repeated until the stopping criterion is achieved. This algorithm has been implemented for the WBAN optimization discussed in next section.

IV. PROPOSED PROTOCOL: JOAR

This work designs a **J**aya based **O**ptimized **A**nd**R**eliable protocol by using the jaya algorithm for the WBAN scenario. In this algorithm the routing path for transferring the data to the coordinator node is selected by using the duty cycle. The current routing path is altered on the basis of best(with minimum duty cycle) and the worst(with maximum duty cycle) path available. The algorithm broadcast the hello packet to get the information of all available path in the network towards the destination along the required duty cycle. Then the path with minimum duty cycle is marked as the best path while the path with maximum duty cycle is marked as worst. For each other node these best and worst path are used to optimize the performance by using following formulae:

$$RP^{m}_{s,d,c} = RP_{s,d,c} + r_{1,s,d}\left(RP_{s,d,best} - \left|RP_{s,d,c}\right|\right) - r_{2,s,d}\left(RP_{s,d,worst} - \left|RP_{s,d,c}\right|\right) \quad (2)$$

Here , $RP_{s,d,c}$ represents the number of hops in the **R**outing **P**ath from s(source) to destination via current node(c), while the $RP^{m}_{s,d,c}$ shows the number of hopes in the modified path. $RP_{s,d,best}$ represents the number of hops through the neighbor of c available in the best path while $RP_{s,d,worst}$ represents the number of hops through the neighbor node of c available in the worst path. It means the route is optimized to select the nodes available in the best path and avoiding the worst path nodes. The $RP^{m}_{s,d,c}$ is accepted only if the duty cycle of corresponding routing path is lower than the $RP_{s,d,c}$. The duty cycle of each route is evaluated by using the fitness function with SAR as constraint is discussed in next section. This fitness function is used to optimize the process based on the SAR and duty cycle, corresponding details are available in next section.

a. Fitness Function

We are considering the reliability as a multi objective optimization problem i.e. specific absorption rate (SAR) and duty cycle must be minimized.
The fitness function for the problem is:

$$F = \alpha_1 * SAR + \alpha_2 * duty\_cycle \quad (3)$$

Such that $\alpha_1 + \alpha_2 = 1$
Here, the objective function for the reliability is designed using the parameter i.e. SAR. The SAR is a vital parameter when discussing the presentation of the human body to electromagnetic fields and it quantifies the amount of vitality that the human body ingests each second per kilo (W/kg) [18].
SAR is shown in (4):

$$SAR = \sigma|E|^2/\rho \ (W/kg) \quad (4)$$

Here, E is the electric field induced by radiation, σ is the electrical conductivity of the tissue, and ρ is the density of tissue. The study shows that the sensing effect of 8 W/kg for 15 minutes has appeared to bring about extreme tissue harm. In this manner, WBAN directing conventions need to effectively diminish radiation outflow and temperature. Likewise, even courses with light movement and short postpone won't not be effective as far as temperature, which makes directing and sending infeasible. The SAR total depends upon the parameter selected for the node. The equation (4) already shows that the SAR is directly proportional to the electric field induced. The electric field induced depends the transmitting range of the node. The transmitting range of the sensor is selected $1/10^{th}$ of the normal sensor node(exact value specified in table 1) to reduce the SAR.
Duty cycle is figured as the part of time that a framework is in a "dynamic" state. For the sensor handset, this is the time the handset is ON (RF action time), in any case in the event that it is transmitting information, getting information, or without moving listening to an unmistakable channel [19]. Complete RF action is the entirety of time required for sending information and synchronization, and is figured as T_{active}as given in (5) below.

$$T_{active} = T_{on} + T_{data} + T_{oh} + T_{ack} + T_{sync}/N_R \quad (5)$$

The duty cycle is computed as given in (6)

$$D = T_{active}/T_{frame}(1 + PER) \quad (6)$$

Here PER is packet error rate while N_R is TDMA frame resynchronization rate. The algorithm which describes the whole process is as follow:

JOAR Algorithm(n, C, M)

Here n is the number of sensor nodes along a coordinator node C and a mobile node M. The algorithm will transfer the data from source to coordinator node in an efficient manner

1. Initialize the network, select a source node say S.
2. Broadcast the HELLO packet from S to C.
3. Calculate F for each path

$$F = \alpha_1 * SAR + \alpha_2 * duty\_cycle$$

Where, $SAR = \sigma|E|^2/\rho$

and $duty\_cycle = T_{active}/T_{frame}(1 + PER)$

4. Select the path with minimum value of F as best path and maximum value of F as worst path.
5. For any node in the network say N to transfer the data follow step 6 to 10 untill data reaches coordinator node
6. Select N as C_N(current node)
7. Select the neighbor of the node
8. $RP_{s,d,c}$ = number of hops through the selected neighbor of C_N
9. $RP^{m}_{s,d,c} = RP_{s,d,c} + r_{1,s,d}\left(RP_{s,d,best} - \left|RP_{s,d,c}\right|\right) - r_{2,s,d}\left(RP_{s,d,worst} - \left|RP_{s,d,c}\right|\right)$
10. Calculate F for $RP_{s,d,c}$ and $RP^{m}_{s,d,c}$ say f and f1 repectively.

11. If f1<f
Then $RP_{s,d,c} = RP_{s,d,c}^{m}$
End
12. Update C_N
13. End

The above algorithm transfers the data in any WBAN scenario. The corresponding implementation and results are discussed in next section.

V. RESULT AND DISCUSSION

The JOAR algorithm described in the previous section has been implemented using the network simulator. The performance of the algorithm is compared with the existing state of art techniques AODV [20][21], DSDV [20][22] and ANTHOCNET [16] by using the E2Edelay, Remaining Energy, PDR , Routing load and throughput [23][24]. The AODV, DSDV and the ANTHOCNET protocols are selected to show the comparison of proposed protocol (JOAR) with on-demand, table –driven as well as the optimization algorithm respectively. The optimization algorithm showing better performance in WBAN is based on ACO [16], so selected for the comparison. The protocol performance has been verified for theIntra Ban scenario shown in figure 3. The scenario shows a room consisting of a patient. The scenario consists of Mobile node , coordinator node and the 7 other sensing nodes (1 EEG, 1 ECG, 1 BP, 1 Glucose, 1 Toxin, 1 Hearing, 1 Vision). The parameter name along with their values is shown in the table 1.

Table 1: Network Scenario Parameter

Parameter	Value
Area	$5*4m^2$
Number of Sensing nodes	7(1 EEG, 1 ECG, 1 BP, 1 Glucose, 1 Toxin, 1 Hearing, 1 Vision)
Coordinator Node	1
Mobile Node	1
Area Covered by Sensing Nodes	$0.4*0.4m^2$
Range of Node	5m

The corresponding implementation scenario is shown in figure 2. The network scenario consists of maximum 9 nodes including the mobile and the coordinator node and 7 sensor nodes. The analysis has been done on 7 different scenarios by changing the number of sensing nodes. Each scenario consist of 1 mobile and 1 coordinator node, the remaining nodes are sensing nodes. The performance of the protocols over the scenario discussed is described in following subsection.

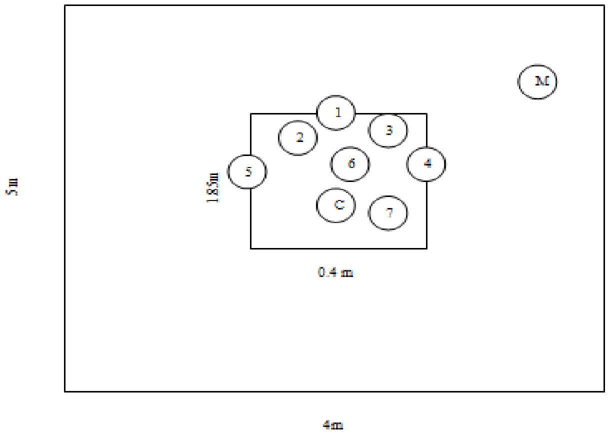

Fig 2: WBAN Scenario for Analysis

The position of the nodes shown in the figure 2 is described in the table 2.

Table 2: Location of the Nodes

Node Id	X coordinate	Y Coordinate
1	2.00	1.575
2	1.99	1.585
3	2.01	1.585
4	2.2	2.085
5	1.8	2.185
6	2	2.057
7	2.1	2.65
C	2	2.5

a. Performance Evaluation

The figure 3 compares the end 2 end delay for the different network scenario between the AODV, DSDV ,Anthocnet and the Jaya algorithm. The comparison clearly shows that the performance of the Jaya algorithm is better than the other algorithms as the e2edelay is lowered in each scenario as compared to other state of art techniques.

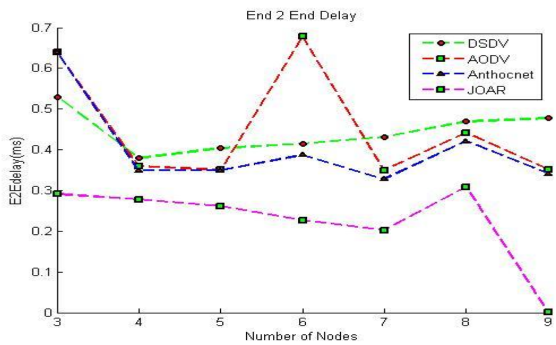

Fig 3: Comparison of End 2 End delay

The figure 3 clearly signifies that the e2edelay of Anthocnet is lower than the AODV and DSDV in each scenario while the e2edelay of AODV is lower than the DSDV except for 3 and 6 node scenarios. While the JAYA algorithm exhibits lower delay in each scenario as compared to other techniques**.** This is due to the selection of the path with optimized duty cycle in the JAYA algorithm.

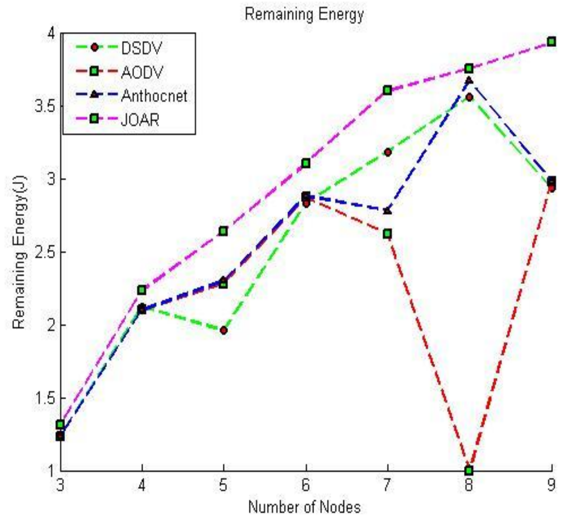

Fig 4: Comparison of Remaining Energy

The figure 4 shows that the Remaining Energy of Anthocnet is higher than the AODV and DSDV in each scenario except 7 node scenario while the remaining energy of AODV is higher than the DSDV except for 7 and 8 node scenarios. While the JAYA algorithm exhibits higher remaining energy in each scenario as compared to other techniques. It means the Jaya algorithm consumes less amount of energy resulting enhanced network lifetime, due to the SAR factor considered in the fitness function.

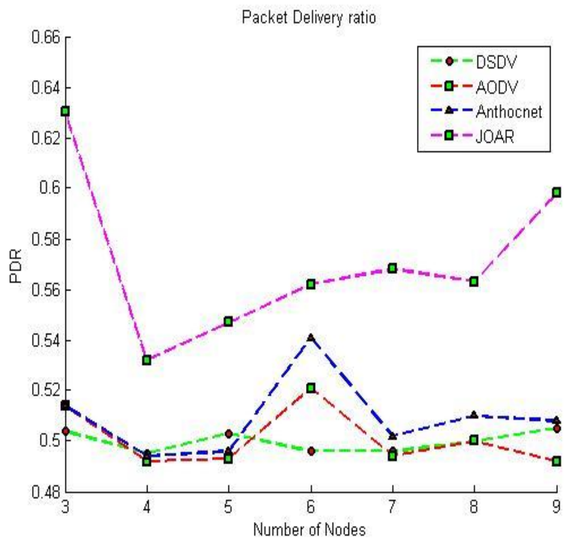

Fig 5: Comparison of Packet Delivery Ratio

The figure 5 represents the PDR of Anthocnet is slightly higher than the AODV and DSDV in each scenario while the remaining PDR of AODV is higher than the DSDV except for 4, 5 and 9 node scenarios. While the JAYA algorithm exhibits higher PDR in each scenario as compared to other techniques due to dynamic path selection with minimum cost.

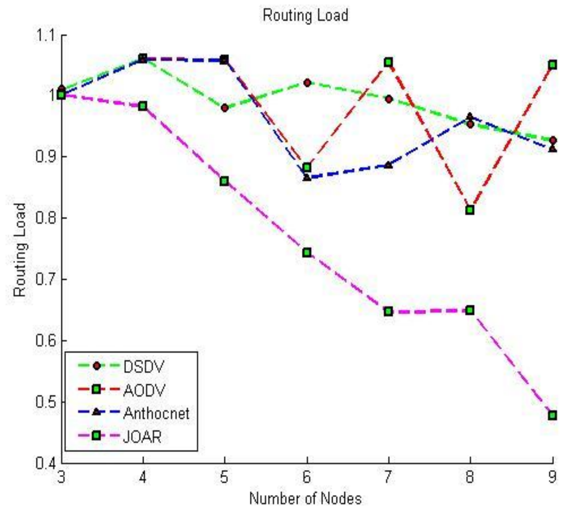

Fig 6: Comparison of Routing Load

The figure 6 signifies that the routing load of Anthocnet is lower than the AODV and DSDV in each scenario except 5 and 8 node scenario while the routing load of AODV is lower than the DSDV except for 5, 7 and 9 node scenarios. While the JAYA algorithm shows lower routing load in each scenario as compared to other techniques as the path with minimum duty cycle has been selected.

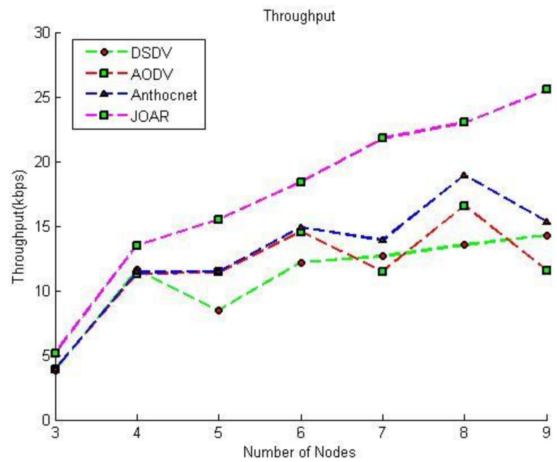

Fig 7: Comparison of Throughput

The figure 7 represents the throughput of Anthocnet is slightly higher than the AODV and DSDV in each scenario while the remaining PDR of AODV is higher than the DSDV except for 7 and 9 node scenarios. While the JAYA algorithm exhibits higher throughput in each scenario as compared to other techniques. The throughput is higher due to the data transfer through the path with low duty cycle. It means the performance of the JOAR algorithm is better than the existing state of art algorithms.

VI. CONCLUSION

The meta-heuristic techniques are useful for the efficient performance in application fields. The paper designs JOAR a Jaya based routing for WBAN. The algorithm shows the better performance of the JOAR algorithm as compared to AODV, DSDV, and Anthocnet protocols in each scenario in terms of remaining energy, delay, throughput, routing load and PDR. The algorithm is reliable as the stable optimized performance is analyzed in each scenario. In future, the other meta-heuristic algorithms can be used to check the further improvement of performance.

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