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Novel BOA protocol for Optimal Energy-Delay scheduling in Energy Harvesting Wireless sensor network

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Abstract: In this manuscript, an optimal Energy-Delay Scheduling using Billiards-inspired optimization algorithm (BOA) for Energy-Harvesting WSNs is proposed. Network resource allocation is a major issue for the design of Energy Harvesting Wireless Sensor Networks (EH-WSN). Here, the problem of capacity allocation in EH-WSN among interference channels for fixed data and power flow topologies. To optimize the data rates, power allocations and energy transfers, total network delay. Initially describe the data flow is fixed on every data link and optimize the transmit power on every sensor node for a single energy harvest in a time interval. Here the optimization issue is not convex and it is hard to get the optimal solution. So here consider the signal-to- interference-pulse-noise- ratio (SINR). Then joint optimization issue for EH-WSN using Billiards-Inspired Optimization Algorithm (BOA). The Proposed EDS-Billiards-inspired optimization algorithm (BOA) provide lower delay 50.13%,54.04%, higher delay ratio 34.83%,53.91%, lower node drop 60.50%,25.79%, lower energy drop 33.12%,48.76%, higher life time 1.414%,2.52%, lower overhead 31.284%,19.82%, higher throughput 62.33%,11.748%.for different nodes compared with the existing algorithm like Negatively Correlated Search(NCS),Ant Colony Optimization, and Convex approximation respectively.

Keywords: Optimization, Energy Detection, Billiards-inspired optimization algorithm (BOA) Energy Harvesting wireless sensor (EH-WSNs).

1. INTRODUCTION

Energy consumption is the main problem in Wireless Sensor Networks (WSN) [1]. It is used to remove energy from the surrounding environment and deliver it to particular region through wireless sensor networks. It is extensively utilized on large number of areas like environmental monitoring, smart construction, remote surveillance, intelligent transportation based on its low cost, self-sustainability and ease of operation [2, 3]. In this capacity allocation problem is one of the major problems to design EH-WSN [4]. It uses sensor nodes to place them in a two-dimensional (2D) area of interest. The sensing node gathers the sensing data and transmits the sink in a multi-hop style. Based on noise signals, channel interference can occur, thus limiting the performance of EH-WSNs [5].

Energy harvesting may use different energy sources, like solar power, wind, mechanical vibrations, temperature variations, magnetic fields. While providing energy incessantly and storing for future exploit [6]. To avoid the allocation of network resources, use energy harvesting wireless sensor networks. Next, calculate the optimum data rates, power allocation energy, energy transfers, and total network delay [7]. Finally, to diminish the delay of EH-WSN network by optimizing data rates, power allocation and power transfers through interference channel. An optimization problem is typically not convex and hard for solving directly due to complicated interference. When considering the signal-to-noise ratio, the non-convex optimization issue is converted into a convex one in the form "log-sum-exp" by convex approximation [8, 9].

A convex optimization problem is suitable for high SINR and also provides high network performance. The optimal energy delay schedule for capacity allocation problems on EH-WSN can be derived for fixed data streams and power topologies [10]. Then create the optimization issue for a multiple time interval. The main concept of these derivations is used for diminishing network delay [11 Solve the original non-convex formula using a billiard-inspired optimization algorithm. It will find the optimum solution efficiently and also provides a sufficiently good solution to an optimization problem [12, 13].

The aim of EH-WSN is to collect energy from the surrounding environment and incessantly offer energy and store it for future use [14]. It has a great number of sensor nodes to collect energy from various sources and transmit it to the sink of multi-hop fashion [15, 16]. While sending the energy through various sources noise will occur in the channel and interfere the data, to limit this we have to use EH-WSNs performance [17, 18]. Capacity allocation, optimal data rates, power allocation, power transfers, and total network lag are the main issues. [19]. To overcome these issues, we propose an optimal Energy-delay scheduling (EDS) using a Billiards – inspired optimization algorithm.

The main contribution of this paper is summarizes as follows:

- In this manuscript Billiards – inspired optimization algorithm [20] is proposed for optimal power allocation and network delay problem, non-convex capacity assignment problem.
- Fixed data flows and energy obtainable on EH-WSNs through interference channel, to assume the capacity allocation issue in single time and multi-time slots.
- Then create the optimization issue for multi-time intervals and find out that may be solved independently on every time interval to find the characteristics.
- Then transform the restricted optimization (objective function) into the unrestricted optimization issues. (Minimizing the objective function) using the exterior penalty function method.
- To achieve near-optimal power allocation, energy transfer and minimal network delay, by using Billiards – inspired optimization algorithm modified energy delay scheduling (EDS).
- The result of Billiards – inspired optimization algorithm is better than the convex approximation method.

Remaining manuscript is mentioned as below. The Literature survey is described in section 2. Section 3 is about the Network model .Interference model, problem optimization, communication model. Section 4 is about the Proposed Method for optimal Energy-delay scheduling (EDS) using a Billiards – inspired optimization algorithm. Result and discussion are presented in section 5 and finally, Section 6 concludes the manuscript.

2. LITERATURE SURVEY

Among the numerous researches works on Energy harvesting wireless sensor networks, some of the most recent research works were reviewed here in this section.

In 2019, Vieeralingaam, et al [21] have presented a modified Newton's system for the solution obtained. The problem of minimizing interference and distortion was solved from joint optimization issue on EH-WSN with resource allocation restrictions. This issue was primarily a non-convex issue involving a quadratic sum of ratios. Then transform the convex problems posed as a difference sum problem. Wireless Power Transfer (WPT) was utilized to collect enough energy. After collecting an enough amount of energy, wireless information transfer (WIT) system was utilized for transmitting information. The major cause for the diminution in variance was that beam forming cannot be enhanced on sensor side.

In 2019, Sarkar, et al [22] have presented a utilized cluster-head approach used for effectual transmission of data with minimum energy. The firefly algorithm was evolved to maximize the energy efficiency of network and lifetime of nodes through the optimal selection of cluster head. The cluster head was selected so that spatially nearer with base station on sensor nodes. Therefore, the delay may be decreased. The data packet transmission speed may be maximized. Running and merging the cluster-based topology together with grid-based topology was a big problem. Capacity, performance, end-to-end delay, coverage, real-time delay, and collision are certain requirements that support multi-target routing.

In 2019, Tao, et al [23] have presented efficient algorithms to dynamically program the MS to collect data from sensors with dissimilar data generation rates. It consists of an optimization framework that has three phases. Initial stage deals with the reliable allocation of energy and stability for the sensors. Then find a closed path for MS sensory data collection, which covers the aggregation nodes, and devise a decentralized algorithm and determine the generation rate of every sensor and the data flow rate of every link optimizing the performance of network.

In 2019, Jiao, et al [24] have proposed that the problem of capacity allocations on energy harvesting wireless sensor networks (WSN) through interference channels were investigated. For fixed energy and data topologies, the optimization issue was formulated while the low level of data leftovers stable on entire data links and every sensor node collects the energy in the time interval. The optimization issue was not convex and hard to solve directly through the network with high signal-to-interference-to-noise ratio (SINR).

In 2018, Koufoudakis et al [25] have presented a modified version of the probabilistic flooding algorithm that uses this process named Robust Probabilistic Flooding, which is able to deal with the nodes that are depleted in the batteries to recommence its operation after the collection of environmental energy. The Markov chain is also introduced for capturing the energy harvesting environments behaviour was analyzed and simplified.

In 2018, Xu et al [26] introduced a secure resource allocation for Energy Harvesting Cognitive Radio Sensor Networks (EHCRSN) underlying a small cell network and base station for power of adaptive or fixed transmission of cooperative interference and also to serve mobile users and select an arbitrary pair channels follow block fade and match a single frame.

In 2019, Taherpour, et al [27] have presented a collaborative data aggregation by multi-antenna sensors and fusion Cebter with EH-WSN. The optimization issue is created for enhancing the data transfer rate, using sensors to estimate the energy harvesting and store the data. It uses battery to store the energy and maintain the network connectivity. It deals with all three scenarios depend on number of antennas to transfer, collect and share the sensor and HR data. In this optimization problem was not convex and solve this problem, the objective function was transformed to convex function by relaxation process.

In 2019, Xie et al. [28] introduced a predictive ship collision avoidance scheme depends on enhanced search algorithm for beetle search antennas. To improve the real-time performance and reliability of the existing ship collision prevention method by forecasting collision risk, a predictive collision prevention process depends on enhanced Beetle Antenna Search (BAS) algorithm. The optimization strategy for real-time collisions creates risk and delay. For solving the optimization issue, an enhanced BAS algorithm is used to improve the optimization performance of original BAS algorithm to solve the predictive collision avoidance problem.

3. NETWORK MODEL FOR BILLIARDS – INSPIRED OPTIMIZATION ALGORITHM

Network model describes the interconnection between the two or more nodes present in the network. Let V be the wireless sensor nodes placed randomly on some area. It is explained in graph $M = (n, s)$ Where $N = \{N_{0,} N_1 N_{2,} \ldots\ldots.. N_n\}$ is composed of sink node and N sensor nodes. A data collection tree $R = (N_{r,} S_r)$ is build to EH-WSNs. This network is the acyclic spanning sub graph of $M = (n, s)$ where $N_{S=n}$ and$S_T \in S$. Where the data collection trees N_i, N_j are nodes used the sensor data network. The sensor node V_n may sometimes pass the detected data to the sensor data to sink N_o. The sensor node z needs energy to operate.

3.1. Interference model for Billiards–inspired optimization algorithm

The physical interference is used modify a signal in a disruptive manner, as it travels with communication channel among their source and receiver and also used to describe the performance of tree based EH-WSNs. For each signals $\nabla l \in S_{r,} let Hz \in \ (0, Hx^{max})$ it is the transmit power of l. Then, $H = \{Hl | x \in SR\}$ as the power allocation vector of entire real links in every time interval.

$$SINR_{X(H)} = \frac{M_{XX\ hX}}{\sum_{X \neq 1} M_{XX\ hx + \theta 1}} \tag{1}$$

Where M_{xx}denotes the channel gain as transmitter l to receiver x. it depends on numerous factors like path loss, shadowing and fading effects.M_{xx} is channel gain of data link K, and Hx^t are channel gain of data link K and also noise power on data link K.

3.2 Communication Model

When there is a delay in data link l go behind $G/G/$ 1queueing model and the time interval is great sufficient also defined as

$$F_1 = \frac{f_1}{v_{1-f_1}} \tag{2}$$

Where f_1 implies amount of data flow, and $v_i$implies communication link l data rate which $f_1 \leq v_i, \forall \in S_r$.

The data rate v_i of data link l obtained according to Shannon formula

$$v_i = \frac{1}{2} \log(1 + SINR_{x(h)}) \tag{3}$$

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In each sensor node v, the total power exhausted on the transmit data link K and energy link Q noted as

$$\sum_{x\in o_{f(l)}} Hx \leq S_l + \sum_{Q\in X_{Q(l)}} \beta\vartheta_{Q-} I_Q \quad (4)$$

Where $\beta\vartheta$ implies energy transfer efficiency,E_n implies energy collected as sensing node n and x_q implies amount of energy transferred in energy link q. Let L and A are the outgoing data links and energy links. It can written as

$$L_h + A_i \leq S \quad (5)$$

3.3 Capacity allocation problem on EH-WSNS for fixed data streams

For minimizing the total delay of network and improve the network performance on EH-WSN through interference channel. Capacity allocation contains the beginning of extra multicast services on existing unicast networks. First, the issue is formalized by describing a cost function for assessing the goodness of a provided capacity allocation configuration. For create the capacity allocation problems on single and multi-time interval.

3.4 Single time interval case

For single energy harvesting on every time interval, the total delay on EH-WSNs with interference channel is

$$F = \sum_{z\in sR} \frac{f_x}{v_{x-f_x}} \quad (6)$$

The problem with reducing total delay on network is

$$\min_{si-fi} \sum_{x\in sr} \frac{f_x}{v_{x-f_x}} \quad (7)$$

$$e.r. Lh + Ai \leq S$$

$$fx \leq vx, \forall Sr$$

$$\min_{hx,ix} \sum_{x\in Sr} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq 1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (8)$$

Where the SINR constraint in above equations

$$e.r. Lh + Ai \leq S \quad (9)$$

$$fx \leq vx, \forall Sr$$

$$h_x \geq \frac{\sum_{x=1} M_{xx}H_x+\theta_x}{M_{xx}}(e^{2d1}-1) \quad (10)$$

$$\frac{M_{xx}H_x+\theta_x}{\sum_{x\neq 1} M_{xx}H_x+\theta_x} \geq \gamma_{min} \quad (11)$$

The optimization problem in eqn (8) may assumed as $w^{-}$for real data links in the network on every time interval. The detailed equations are in the case1 and case 2

Case 1: No energy Transfer

In this case energy transfer do not occur, here lq and eq are used

$$\min_{hx,ix} \sum_{x=1}^{w^-} \sum_{x\in Sf(n)} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq 1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (12)$$

$$\text{v.n.} hx \leq S_v + \sum_{x\in Sf(n)} \delta_Q I_Q \quad (13)$$

Case 2:Energy Transfer

In this case energy transfer is assumed as xq≥ 0 ∝

$$\min_{hx,ix} \sum_{x=1}^{w^-} \sum_{x\in Sf(n)} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq 1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (14)$$

$$\text{v.n}\sum_{\boldsymbol{i=1}} hs \leq st + \sum_{q\in od} hriQ, \forall \text{ s} \quad (15)$$

$$0 \leq iQ \leq so(r)$$

3.5 Multiple Time interval case

In this sensor, the node may change over time. In this time an interval is established, and every time interval contain equal length and the sensor node n may harvest E_{nt} units of energy at every time interval t, here t=1,2,…..T and T implies total number of time interval at data collection. The variables $d_{ii}, c_{ii,}s_{ii}$ $and\ x_{qt}$ indicate the data flow, data rate, power, noise power, and energy transferred on time interval t. The channel noise powers does not change the over time interval it denotes for $dii = di, gii = gi, and\ sii = si\ for\ \wedge l\ and\ \wedge t$in ths the approximation also responsible for the M/M/1 and ever time interval is efficiently greater to average delay. Therefore the eq (16) becomes

$$F_{xx} = \frac{f_{xx}}{v_{xx}-f_{xx}}$$

Where $v_{xx} = \frac{1}{2}\log(1+\frac{M_{xx}}{\sum_{x\neq 1} M_{xx}h_{xx}+exx})$

The energy collected on time interval t may be utilized while the energy has reached. Thus, the energetic causality of every sensor node n on time may be explained as

$$\sum_{r=1}^{g} \sum_{x\in 0f(v)} h_{xx} \leq \sum_{r=1}(S_{vr} + \sum_{Q\in IQ(v)} \gamma qsIqs), \forall m \in \{1,2.\ldots\ldots T\} \quad (18)$$

For fixed data streams on EH-WHNs through the interference channel, the capacity allocation issue to diminish the total delay on entire data links in one round of data collection may be written as

$$\min_{hxx,iQx} \sum_{r=1}^{R} \sum_{x\in Sf(n)} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (19)$$

$$\boldsymbol{v.n.} \sum_{r=1}^{g} \sum_{x\in Of(v)} h_{xx} \leq \sum_{r=1}(S_{vr} + \sum_{Q\in IQ(v)} \gamma qsIqs) (20)$$

$$h_x \geq \frac{\sum_{x=1} M_{xx}H_x+\theta_x}{M_{xx}}(e^{2d1}-1), \forall k \in S/R \quad (21)$$

$$\frac{M_{xx}H_x+\theta_x}{\sum_{x\neq1} M_{xx}H_x+\theta_x} \geq \gamma_{min} \quad (22)$$

$$0 \leq X_{Qr} \leq So(t) \quad (23)$$

Equation 23 indicates the size of transferred energy cannot be exceeding their energy at time interval $r, r \in \{1,2....R\}$. Equation 14 is the optimization issue is also solved separately with energy transfer and without energy.

Case 3: No-Energy Transfer
In this $X_{Qr} = 0, \forall q, \forall r$, the optimization problem (14) becomes

$$\min_{hxr} \sum_{r=1}^{R} \sum_{x=1}^{K} \sum_{x\in Sf(n)} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (24)$$

$$0 \leq iQ \leq so(r) \quad (25)$$

Case 4: Energy Transfer
In this $X_{Qr} = 0, \forall q, \forall r$, the optimization problem (14) becomes

$$\min_{hxr,Iqt} \sum_{r=1}^{R} \sum_{x=1}^{K} \sum_{x\in Sf(n)} \frac{f_x}{\frac{1}{2}\log\left(1+\frac{M_{xx}H_x}{\sum_{x\neq1} M_{xx}H_x+\theta_x}\right)-f_x} \quad (26)$$

$$\boldsymbol{v.n} \sum_{r=1}^{g} \sum_{x\in Of(v)} h_{xx} \leq \sum_{r=1}(S_{vr} + \sum_{Q\in IQ(v)} \gamma qsIqs) \quad (27)$$

The optimization problems in cases 1 to 4 are non-convex optimization problems as both the objective functions and the constraints are not convex with respect to transmit power p.

4. PROPOSED METHOD FOR OPTIMAL ENERGY-DELAY SCHEDULING (EDS) USING BILLIARDS – INSPIRED OPTIMIZATION ALGORITHM

In this section, a new method is proposed to solve energy delay in the Energy Harvesting Wireless Sensor Method. The proposed algorithm is used to decrease the energy delay in EH-WSNs using Billiards – inspired optimization algorithm (BOA). Billiards – inspired optimization algorithm (BOA) consists of small computation, rapid convergence, and strong global optimization capability. Energy Harvesting (EH) in the wireless sensor network is real strategy to get power as surrounding sources that deliberately transfer energy. EH-WSNs are used in several applications like environmental monitor, smart construction, remote surveillance, smart transportation based on its minimum cost, self-sustainability, and simple operation. Billiards-inspired optimization algorithm is a metaheuristic intelligent optimization algorithm depends on group optimization. The location of every billiard denotes an optimized solution reachable. The optimization process for this algorithm is based on the game of billiards. In this solution, it assumed as a multidimensional billiard ball and solutions from packets. While the balls meet the other balls, vector algebra and conservation laws are used to decide the last locations of balls on optimization. The problem of minimizing interference and distortion is solved from joint optimization issue on EH-WSN with resource allocation restrictions. This issue is primarily presented as a non-convex issue linking a quadratic sum of ratios. Next transform the convex problem posed as a difference sum issue. Wireless Power Transfer (WPT) is utilized to collect enough energy. Then collect an enough amount of energy, wireless information transfer (WIT) method is employed for transmitting information. The major reason behind the reduction on variance is beam forming may not be enhanced on sensor side since beam forming needs channel information on sensor side and needs memory for storing the beam forming matrix. From the above cases 1, 2, 3, 4 the energy delay can be showed as to connect the vector, $\overrightarrow{g_1 g_2}$ from the starting point to the middle of the initial crashing ball to the middle of the second ball, to the flash of the crash. The component vectors to connect the vector with radii t_1 and t_2 are radii of balls.

$$\overrightarrow{v_1} = \frac{\overrightarrow{g_1 g_2}}{t_1 t_2} \quad (28)$$

Considering the crash is fully elas$\longrightarrow$tic, then the kinetic energy and moment conservations becomes

$$\frac{1}{2}g_1 c_{1.\alpha}^2 + \frac{1}{2}g_2 c_{1..\alpha}^2 + \frac{1}{2}g_1 c_{1..\tau}^2 + \frac{1}{2}g_2 c_{1..\tau}^2 = \frac{1}{2}g_1 c_{1.\alpha}^2 + \frac{1}{2}g_2 c_{1.\alpha}^2 + \frac{1}{2}g_1 c_{1..\tau}^2 + \frac{1}{2}g_2 c_{1..\tau}^2 \quad (29)$$

where c_1 and c_2 are the velocity of initial ball and second ball, and the symbol α and $.\tau$ denote the parallel and perpendicular components. The parameter, g_1 and g_2 are the mass of balls.

$$g_1 \overrightarrow{c_{1.\tau}} = \overrightarrow{g_1 c'_{1.\tau}} \quad (30)$$

$$g_1 \overrightarrow{c_{1.\tau}} = \overrightarrow{g_1 c'_{1.\tau}} \quad (31)$$

The above equation shows the perpendicular moments of the ball and the velocity became unchanged. Then the parallel component moments are derived from below equations and the velocity also conserved.

$$\frac{1}{2}g_1c_{1.\alpha}^2 + \frac{1}{2}g_2c_{2..\alpha}^2 = \frac{1}{2}g_1c_{1.\alpha}^{2} + \frac{1}{2}g_2c_{2..\alpha}^{2} \quad (32)$$

$$\frac{1}{2}g_1c_{1.\alpha} + \frac{1}{2}g_2c_{1..\alpha} = \frac{1}{2}g_1c_{1.\alpha}^{'} + \frac{1}{2}g_2c_{1..\alpha}^{'} \quad (33)$$

An equation (32) and (33) shows the utilization and then rearrangement of the velocity and gives the final equations for both parallel and perpendicular components remains unchanged.

$$\overrightarrow{c_{1..\alpha}^{'}} = c_{1..\alpha}.c_{1..\tau}^{'} \quad (34)$$

$$\overrightarrow{c_{2..\alpha}^{'}} = c_{21..\alpha}.c_{2..\tau}^{'} \quad (35)$$

When the perpendicular and parallel balls collide to gather, the force is generated and new energy is produced to reduce the energy delay in the wireless sensor network.

1 Step by Step procedure

In this section, to discuss power allocation, power transfer and minimal network delay, propose an optimization algorithm inspired by billiards, Modified Energy Delay Scheduling (EDS) The Billiards-inspired optimization algorithm is extremely efficient optimization algorithm. The proposed meta- heuristic intelligent optimization process is based on the Billiards – inspired optimization algorithm is as follows:

$$D(x) = \sum_{x=1}^{2} |s_x^2 - 10\cos(2ss) + 10| \quad (36)$$

In this algorithm every solution has a series of variables that are assumed billiard balls. Such balls are optimization problems agent and the dimension denotes the variables. To consume the energy from the wireless sensor network then want to minimize the optimization problem using Billiards-inspired optimization algorithm. The following steps are as follows;

Step 1: Initialization:
Initialize the initial size of Balls is v and the solution gives every probable power allocation vector. The dimension of the number of active links in the network in the time interval *r*. Every power allocation vector pt is created arbitrarily in the functional energy restriction.

$$A_{v..z}^{0} = var_g^{min} + rand_{[0,1]}\left(var_g^{max} - var_g^{min}\right) \quad v = 1,2,3 \dots .... \quad (37)$$

where $A_{v..z}^{0}$ decides the first value of v and m variables in the ball. var_g^{max} and var_g^{min} V implies maximal and minimal variable. $rand_{[0,1]}$ implies random number by uniform distribution on slot [0,1], and g is the number of variables.

Step 2: Random generation:
In power iteration a new power allocation vectors generated from the Gaussian mutation operator and evaluated in delay ∂.It is evaluated using objective function.

Step 3: Fitness function:
The optimal power allocation vectors Pt' is updated in case of multiple time slots from the above equations the energy can be slotted in time slot r, where r=1,2….R. For the joint optimization problem of capacity and flow allocation in the EH-WSNs with interference channel, the capacity assignment problem to minimize the total delay over all data link in a data collection Initialize 2v balls and L pockets.

Step 4: Updating the position of using BOA:
The optimization problems in energy transfer can be solved by the EDS -BOA algorithm. In each solution, the power allocation vector is denoted in the right half of the solution n and the energy transfer vector is denoted in the left half of the solution. The output of corresponding solution is optimal power allocation and energy transfer.

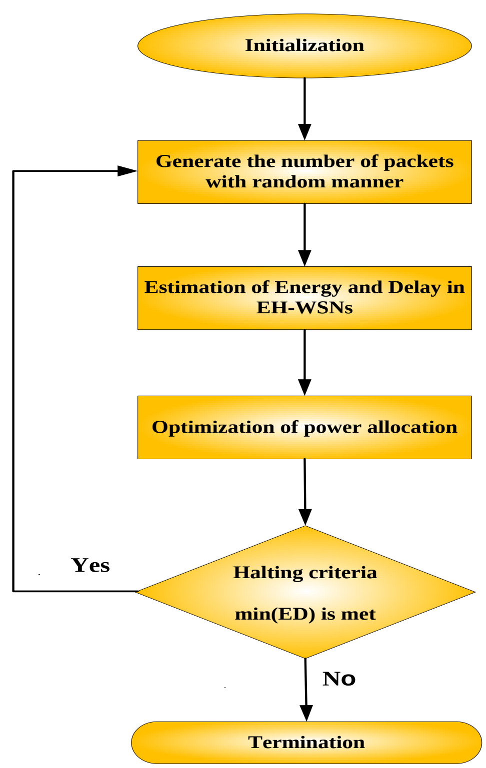

Figure 1: Flow chart for optimal EDS using BOA algorithm

Step 5: Minimization of energy delay:
In the exploration phase, the optimization for best solution can be obtained by randomly searching and change their position according to the position of the primary user constraint. The optimization solution can be obtained by the following equation, where the vector coefficient H with values >1 or <1.The energy delay can be minimized by the following equations,

$$\sum_{x=1}^{L} f_i(r) = \emptyset \sum_{v=1}^{V} vn \quad (38)$$

$$Minimize\ D_{cos}(i) = \sum_{x=1}^{vj} Ix \sum_{g=1}^{vn(x)} \partial Hx \quad (39)$$

Step 6: Termination
The optimization problems in above equations are also non convex optimization problems, here both the objective functions and constraint functions are non convex in terms of the transmission power and the data flow D. Finally, the outputs of Billiards-inspired optimization algorithm are achieved by minimizing the energy delay based on optimization problem in wireless sensor network with the help of network model, communication model.

5. RESULT AND DISCUSSION

In this section, the simulation performance of the proposed EDS - Billards-Inspired Optimization Algorithm (BOA) for the optimal energy delay programming issue. Here, explore the performance of EH-Billards inspired optimization network through interference channel in fixed data stream and joint optimization of capacity and stream, etc. The simulations are carried out on a PC with Intel Core, 2.50 GHz CPU, 8GB of RAM and Windows 8. The entire simulation programs are performed. Here the optimal given rates, power allocations and power transfers, and the minimization of total network delay and performance is also discussed. Then the performance of the proposed EH-WSN method using Billards-inspired optimization algorithm is compared with the existing method like EH-WSN using NCS algorithm. The simulation parameters of the proposed algorithm are shown on Table 1.

Table 1: Simulation parameter

Parameter	Value
Simulation area	1000m
No of nodes	20,40,60,80,100
Size of packet	1024 bytes
Population size	50
Total number of time periods in a data collection round.	300s
Range of transmission	300m
Number of node	250

5.1: Simulation Phase 1: Performance Comparison of various methods

Figure 2 to 8 shows the simulation result for the network performance of EDS- Billards-inspired optimization algorithm with interference channel in fixed data and joint optimization of capacity. The various evaluation metrics such as network lag, energy, performance, power consumption, are discussed in this segment. Here, the performance of the EDS-Billards-inspired optimization algorithm (BOA) method is analyzed and compared with the EH-WSN and EDS-NCS method by varying number of nodes with a fixed data of 50 Mbps on network. From figure 2 shows the node delay performance, at node 20, the proposed BOA shows the 44.57%, 55.69% lower than the existing NCS algorithm and CA algorithm. At node 40 ,The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 32.42%,43.24% lower than the existing NCS algorithm and CA algorithm , At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 34.77% ,43.37% lower than the existing NCS algorithm and CA algorithm, At node 80 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 32.35% ,41.12% lower than the existing NCS algorithm and CA algorithm, At node 100 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 21.54%,33.67% lower than the existing NCS algorithm and CA algorithm respectively

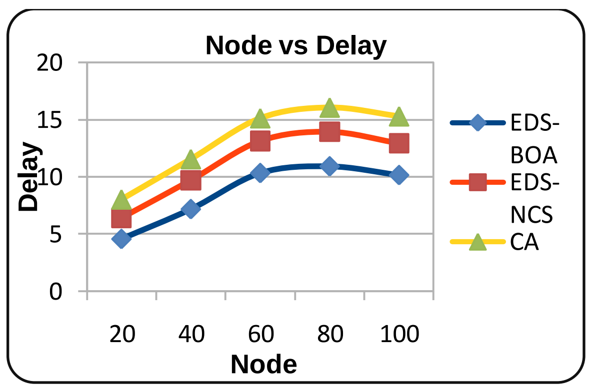

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Figure 2: Performance analysis of Node delay

From figure 3 shows the node delivery ratio performance, at node 20, the proposed Billards-inspired optimization algorithm (BOA) shows 29.23%, 39.57% is higher than the existing NCS algorithm and CA algorithm. At node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 42.31%, 39.57% is higher than the existing NCS algorithm and CA algorithm. At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 46.18%, 70.97% is higher than the existing NCS algorithm and CA algorithm. At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 20.03%, 39.17% is higher than the existing NCS algorithm and CA algorithm. At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 36.41%, 60.66% is higher than the existing NCS algorithm and CA algorithm respectively.

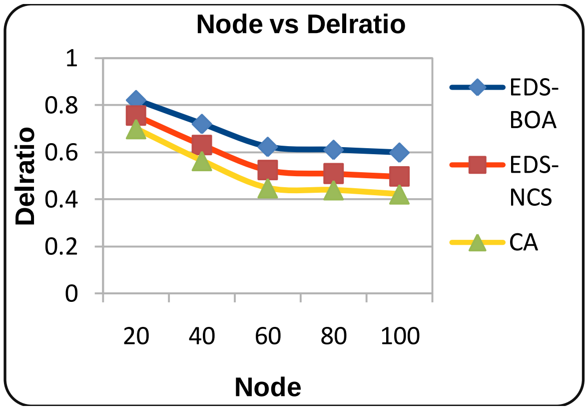

Figure 3: Performance analysis of Node delivery ratio

From figure 4 shows the node energy performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 30.80%, 47.56% lower than the existing NCS algorithm and CA algorithm. At node 40 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 31.75%,48.07% lower than the existing NCS algorithm and CA algorithm , At node 60 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 37.75%,50.33% lower than the existing NCS algorithm and CA algorithm, At node 80 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 34.25%,50.34% lower than the existing NCS algorithm and CA algorithm, At node 100 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 30.93%,47.50% lower than the existing NCS algorithm and CA algorithm respectively.

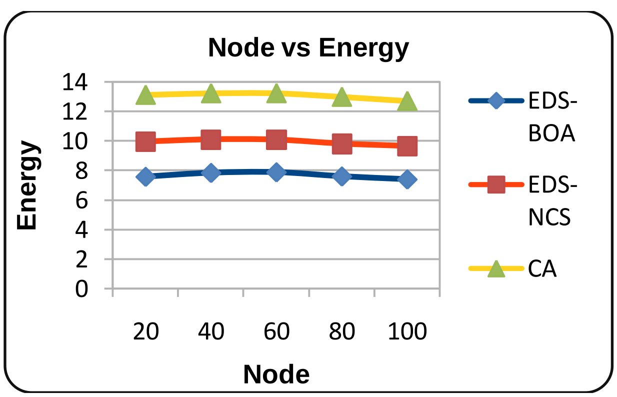

Figure 4: Performance analysis of Node Energy

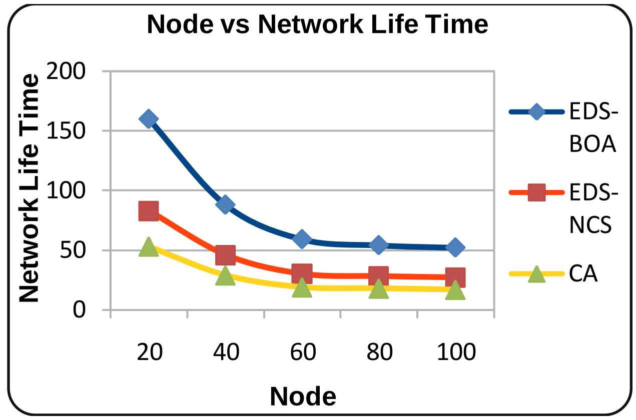

Figure 5: Performance analysis of Node Network life time

From figure 5 shows the node network life time performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 1.04%, 2.20% is higher than the existing NCS algorithm and CA algorithm. At node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 1.17%, 2.44% is higher than the existing NCS algorithm and CA algorithm. At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 1.93%, 3.63% is higher than the existing NCS algorithm and CA algorithm. At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 1.71%, 3.22% is higher than the existing NCS algorithm and CA algorithm. At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 1.22%, 2.52% is higher than the existing NCS algorithm and CA algorithm respectively.

From figure 6 shows the node drop performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) drop shows the 70%, 40% lower than the existing NCS algorithm and CA algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 65%,25% lower than the existing NCS algorithm and CA algorithm , At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 39.2%,13.3% lower than the existing NCS algorithm and CA algorithm, At node 80 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 71%,85.4% lower than the existing NCS algorithm and CA algorithm, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 57.14%,41.17% lower than the existing NCS algorithm and CA algorithm respectively.

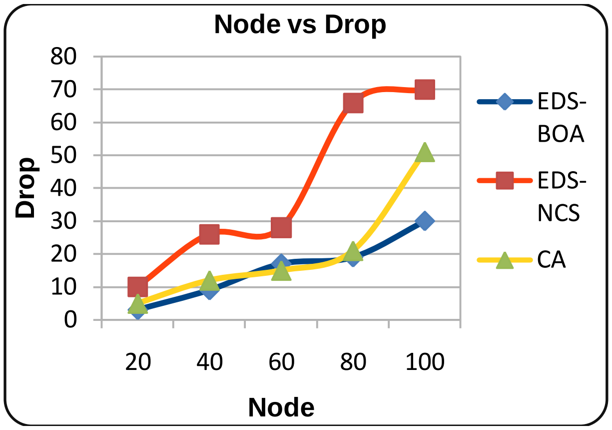

Figure 6: Performance analysis of Node Drop

From figure 7 shows the node overhead performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) overhead shows the 31.34%, 15.32% lower than the existing NCS algorithm and CA algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 36.01%,23.87% lower than the existing NCS algorithm and CA algorithm , At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 28.43%,18.62%lower than the existing NCS algorithm and CA algorithm, At node 80 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 34.12%,24.35% lower than the existing NCS algorithm and CA algorithm, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 26.52%,16.96% lower than the existing NCS algorithm and CA algorithm respectively.

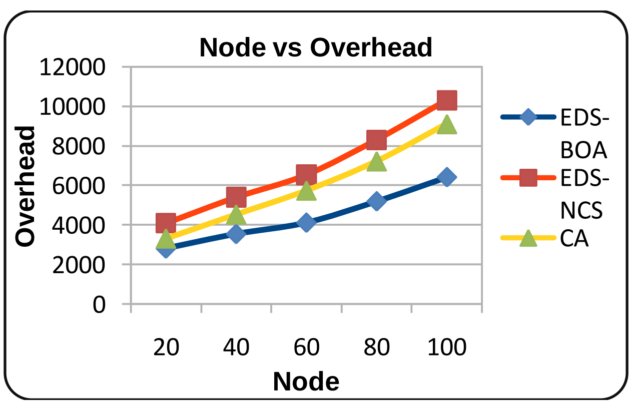

Figure 7: Performance analysis of Node overhead

From figure 8 shows the node delivery through put performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 60.78%, 11.42% is higher than the existing NCS algorithm and CA algorithm. At node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 53.73%, 10.48% is higher than the existing NCS algorithm and CA algorithm. At node 60, the Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 74.70%, 13.25% is higher than the existing NCS algorithm and CA algorithm. at node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 68.55%,12.43% is higher than the existing NCS algorithm and CA algorithm. At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 58.92%, 11.16% is higher than the existing NCS algorithm and CA algorithm respectively.

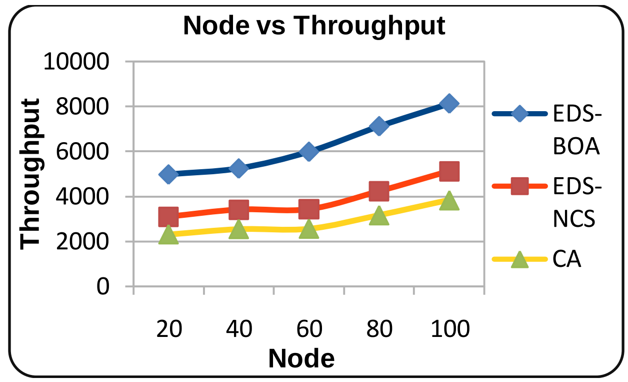

Figure 8: Performance analysis of Node Throughput

From figure 9 shows the node delay performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 45.17% is lower than the existing ACO algorithm. at node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 43.56% is lower than the existing ACO algorithm. At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 42.09% is lower than the existing ACO algorithm. at node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 21.91% is lower than the existing ACO algorithm. At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 14.87% is lower than the existing ACO algorithm respectively.

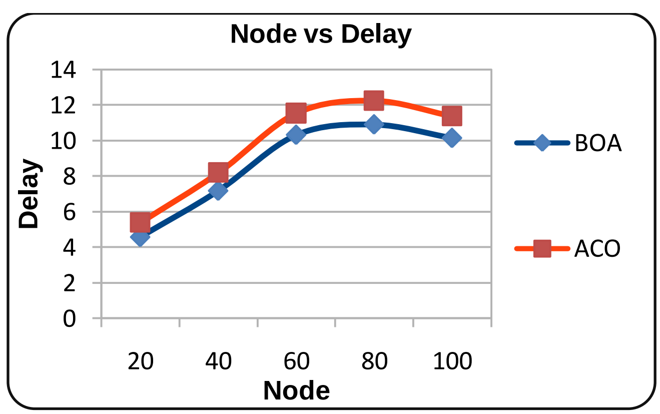

Figure 9: Performance analysis of Node Delay

From figure 10 shows the node drop, at node 20, The Proposed EDS- Billards-inspired optimization algorithm

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(BOA) shows the 1.5% lower than the existing ACO algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 0.5% lower than the existing ACO algorithm, At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 0.31% lower than the existing ACO algorithm, At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 0.48% lower than the existing ACO algorithm, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 0.12% lower than the existing ACO algorithm respectively.

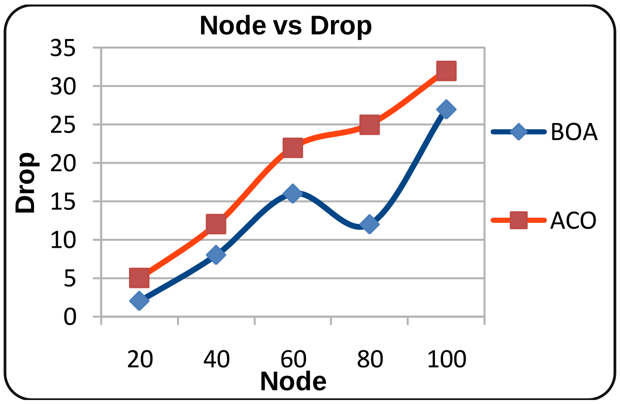

Figure 10: Performance analysis of Node Drop

From figure 11 shows the node energy performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 27.10% lower than the existing ACO algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 10.64% lower than the existing ACO algorithm , At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 11.38% lower than the existing ACO algorithm, At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 12.72% lower than the existing ACO algorithm, At node 100,The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 15.89% lower than the existing ACO algorithm respectively.

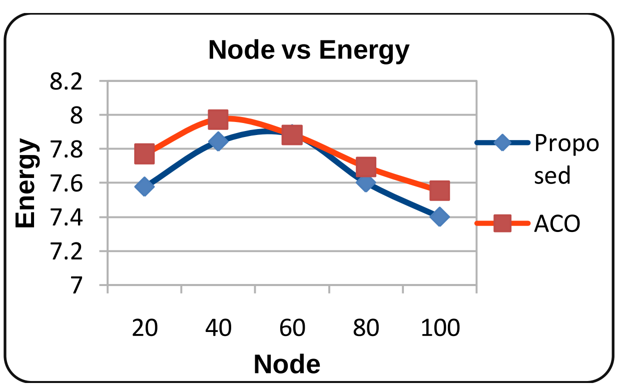

Figure 11: Performance analysis of Node energy

From figure 12 shows the node delivery ratio performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 12.95%higher than the existing ACO algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 28.91% higher than the existing ACO algorithm , At node 60 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 30.34% higher than the existing ACO algorithm, At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 23.10% higher than the existing ACO, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 11.06% higher than the existing ACO algorithm respectively.

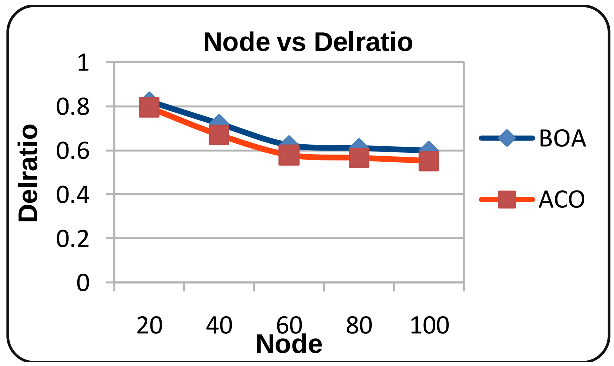

Figure 12: Performance analysis of Node Delivery ratio

From figure 13 shows the node network lifetime performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 46.55%higher than the existing ACO algorithm. At node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 31.57% higher than the existing ACO algorithm, At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 10.714% higher than the existing ACO algorithm, At node 80 shows the 74.35% higher than the existing ACO, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 31.57% higher than the existing ACO algorithm respectively.

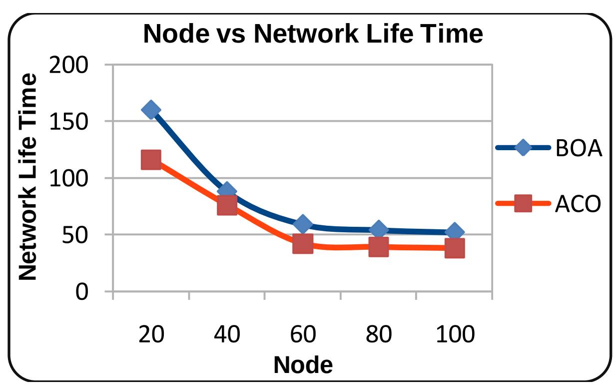

Figure 13: Performance analysis of Node Network life time

From figure 14 shows the overhead performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 42.13% lower than the existing ACO algorithm. At node 40, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 51.20% lower than the existing ACO algorithm, At node 60 The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 34.19% lower than the existing ACO algorithm, At node 80 shows the 37.08% lower than the existing ACO algorithm, At node 100 The Proposed EDS-Billards-inspired optimization algorithm (BOA) shows 34.58% lower than the existing ACO algorithm respectively.

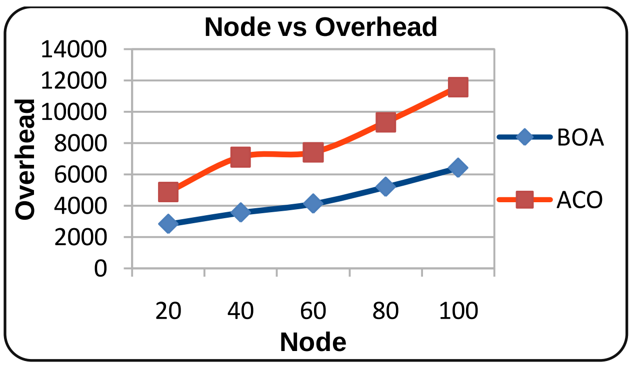

Figure 14: Performance analysis of Node overhead

From figure 15 shows the node through put performance, at node 20, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 28.49% higher than the existing ACO algorithm. At node 40 , The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 27.36% higher than the existing ACO algorithm , At node 60, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 34.26% higher than the existing ACO algorithm, At node 80, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows the 14.98% higher than the existing ACO algorithm, At node 100, The Proposed EDS- Billards-inspired optimization algorithm (BOA) shows 22.76% higher than the existing ACO algorithm respectively.

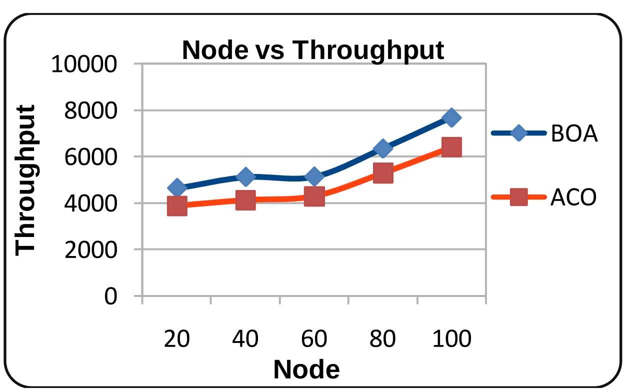

Figure 15: Performance analysis of Throughput

6. CONCLUSION

In this paper, optimal energy delay for Energy Harvesting WSNs is proposed using Billards-inspired optimization algorithm (BOA) proposed research work is based on non-convex capacity assignment problem, Energy delay detection capacity assignment problem under both single and multiple time slots. Then have to transform the constrained optimization problems(in objective the function) using in to the unconstrained optimization problems (minimizing the objective function). To attain close-to - optimal power allocation, energy transfer and minimum network delay implies the Billards-inspired optimization algorithm (BOA) and energy delay Scheduling is modified. The experimental results show that the proposed method is performed better in terms of delay, delivery ratio, throughput, network lifetime, Energy, drop, overhead. The Proposed EDS- Billards-inspired optimization algorithm (BOA) provide lower delay 33.52%, higher delivery ratio 21.272%,lower node drop 0.58% lower energy 16.946%, higher life time 38.95% lower overhead 39.836%, higher throughput 25.57%. For different nodes compared with the existing algorithm like Negatively Correlated Search (NCS) and Ant Colony Optimization, Convex approximation respectively.

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