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Efficient Load Balancing in WSN Using Quasi – oppositional Based Jaya Optimization with Cluster Head Selection

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Abstract: Researchers have been paying close attention to the wireless sensor (WSN) networks area because of its variety of applications, including industrial management, human detection, and health care management. In Wireless Sensor (WSN) Network, consumption of efficient energy is a challenging problem. Many clustering techniques were used for balancing the load of WSN network. In clustering, the cluster head (CH) is selected as a relay node with greater power which is compared with the nodes of non-CH. In the existing system, it uses LBC-COFL algorithm to reduce the energy consumption problem. To overcome this problem, the proposed system uses Quasi oppositional based Jaya load balancing strategy with cluster head (QOJ-LCH) selection protocol to boost the lifespan of network and energy consumption. The QOJ-LCH method improves the relay nodes life and shares the load on relay nodes equitably across the network to enhance the lifespan. It also reduces the load-balancing problems in Wireless Sensor networks. It uses two routing methods single-hop and multiple-hop. The proposed QOJ-LCH with cluster head selection method enhances the network's lifespan, total amount of power utilization and the active sensor devices present in the Single-hop routing ,it worked with 1600 rounds in network and 300 sensor nodes, for Multiple-hop routing, it worked with 1800 rounds in network and 350 sensor nodes. It achieves better performance, scalability and reliability.

Index Terms: Wireless Sensor Networks, Load Balancing, Energy Consumption, Cluster Head (CH), Active Nodes, and Relay Nodes, Quasi Oppositional, Jaya Load Balancing.

1. Introduction

WSNs are the foremost highly developed area in numerous information assortment and communication applications. WSNs encompass small, controlled, battery homeward device nodes for watching the area. Sensor nodes are organized haphazardly otherwise physically within the objective area. It has a variety of components, as well as major ones resembling sensors, transceivers and batteries. The sensor nodes could have the Global Position System (GPS) so as to understand the precise position of the sensor node. WSN is loosely utilized in a spread of areas such as physical condition care, security detection and surveillance [1].

The sensor nodes gather surrounding data and transfer to the sink. The sink is an internet-connected join that receives information on occurrences in the target zone. It has limited communication capabilities, which are further constrained by the battery, resulting in nodes which cannot transmit data straight to the sink. As a result, effective power management of network devices is a critical WSN design factor. To get better network duration of WSNs, the idea of cluster-based WSN is realized by establishing different group of sensor nodes. The lifespan of network is described in the novel as the total number of years that a network has been operational [2,3]. The WSNs are a set of small, self-aware, minimum energy based nodes that are dispersed across a specific area. These nodes gather the local available data at target region regularly. Also, nodes transfer information to mobile base station (MBS) [2]. A sensor node clustering is regarded to be an effective strategy for node energy conservation. This method completes the grouping of networks into clusters. The task of the CH is to receive data from sensor node called cluster member, data is gathered and transferred to MBS through link or CH [4].

In some instances, the network period is delineating in expressions of node survival, property and exposure [5-7]. Therefore, it varies the lifespan of WSNs supported by the appliance necessities and network topology groups. In cluster-primarily adopted totally WSNs, groups which is planned to split sensor nodes into several set cluster incorporates CH inside the organization of nodes of the sensor for statistics series commencing its related sensor nodes. It collects statistics from the related sensor node, aggregate data and in the end communication statistics to the immediate sink or by different CH. Therefore, CH desires to perform extra load of the work than non-CH node within side of network [8].

The author [9-13] has planned power well-organized cluster procedure to improve the system period of WSNs. within the previous decade; algorithms which are inspired by naturally are used for varied problem at WSN. For example, Ant Colony algorithm[14] is employed for information gathering in WSN, Genetic algorithmic rule (GA-rule) [15] works in huge amount of observation application and honeybee based swarm intelligence techniques [16] helps to improve the competence of power. The predominant goal of those is the development of clusters within side the sensor network in a way this is dynamic, to deliver the power aid intake in the network that may lengthen the network's lifespan. The proposed QOJ-LCH with cluster head (CH) method help to improve the enhanced load-balanced network and develop the WSN lifetime. The research helps to identify the solutions for:

1. How Cluster head selection method resolves the load-balance problem?
2. How the least lifespan relay node is enhanced?
3. How do the routing methods use to improve the life span?

In the existing method, [17,18] does not work using routers of single hop and multi-hop methods. It also does not provide reliability and energy consumption. The proposed Quasi oppositional based Jaya load balancing strategy with cluster head (QOJ-LCH) selection protocol to increase the network lifespan and energy consumption. The major contribution of this study is given:

1. The QOJ-LCH clustering process with cluster head selection and fitness function reduces the balancing of load issues in Wireless Sensor Networks.
2. Initial population is generated by using Quasi-oppositional (QO) population which helps to boost up the rate of convergence in QOJ-LCH.
3. It enhances the lifespan of the WSN system and also improves the power consumption of WSN.

The remaining section of our research article is written as given: The 2nd section consists of brief study of existing Wireless Sensor Networks, Cluster Head (CH) and Various Clustering methods. 3rd Section describes the working strategy of the proposed work. 4th Section evaluates the result and gives a comparison of different algorithms. To carry out the research work, the simulator (ns-2) is used for a wireless sensor network, which is a discrete event network simulator. Section 5conclusion of the research work.

2. Related Works

Numerous researchers have studied energy-efficient problem using clustering algorithm [19] to increase WSN lifespan under constraint of less power of battery and communication details. This research looks at some of different strategies to have a better grasp of clustering protocols. In the subsections below, the heuristic as well as meta-heuristic strategies for solving the clustering issue are presented in depth.

Heuristic algorithms: The most admired cluster-based routing protocol is Low Energy based Adaptive Clustering Hierarchy [20] – (LEACH). The CH range in LEACH is adopted on a set chance. The CHs in the network are dynamically selected by LEACH. For the next round, the CHs may be updated. Many researchers devised improved algorithms to address LEACH's shortcomings, including PEGAS [21], Hybrid Energy-Efficient Distributed [22], I-LEACH, E-LEACH [23,24] and others. PEGASIS has a large lifespan for network than LEACH, requires active topology manage and has a more delay in the data, making it unsuitable for extensive WSNs. The CHs are chosen by HEED based on the node amount and outstanding entropy.

Usually, some WSN arranged arbitrarily with big amount of sensor node. In addition to routing, clustering protocol is all future for enhancing overall presentation of all those networks. The LEACH set of rules turned into proposing in [20]. This is a distinguished clustering set of rules wherein the sensor node picks out itself as a CH with fewer opportunities. The LEACH additionally offers a noteworthy stage of maintenance of electricity and prolongs the network's instance. Though, a chief demerit of this set of rules is with the purpose of readily available probabilities of choosing a CH that has small electricity and may expire quickly. So, some of algorithms are advanced for enhancing the

LEACH protocol. In [25] has proposed the LEACH-E protocol this is much like the unique.

In [26] have fostered a Genetic Algorithm based bunching concept in varied WSNs for further developing organization life expectancy. In this methodology, every chromosome addresses the network design or grouping arrangement. In [27] has carried out an improved PSO calculation for improving organization life expectancy of WSNs by thinking about broadcast detachment and power effectiveness, the transfer hubs be utilized for decreasing the abundance power use of CHs. In [28], scientists contain planned the Rearranged Complex Development (SCE) calculation for adjusting the heap of passages utilizing a clever wellness by concerning vigorously stacked passages. In [29], the creators have proposed a Worked on Rearranged Frag Jump Calculation (ISFLA) for adjusting the heap of the doors. The ISFLA insists the main heap of the passages to gauge the nature of the arrangement.

Other research has looked into the load balancing problem in order to increase energy efficiency by managing network congestion and data redundancy. When multiple sensor nodes linked to the similar source send data at the identical occasion, the data received by the source becomes clogged or fails, resulting in the reception of delay sensitive data. To overcome the problem of data reception delay and reduce network power consumption, load balancing techniques are used [30, 31]. WSN networks benefit from cluster routing protocols because they reduce power consumption and improve energy efficiency. This categorization of routing protocols yields four basic categories: a traditional, metaheuristic, and fuzzy and hybrid algorithms.

In WSN, the power utilization is the big problem. In the existing system uses traditional clustering algorithm [32, 33]. It does not work with single and multi-hop Wireless sensor networks; therefore, it provides reliability and energy consumption problem. In [33] proposed an Adjacent Exponentially Distributed Route Maintenance mechanism technique to improve the energy consumption by consider the power and distance during route selection in its calculations. In [34] proposed a Statistical Markov Model Based Natural Inspired Glowworm Multi-Objective Optimization (SMM-NIGMO) Technique is used to maximize throughput as well as helps to slow down the energy consumption for efficient data transmission in MANET. To overcome this problem, the proposed system, QOJ-LCH with cluster head (CH) selection algorithm is used. It improves the lifespan and memory utilization of the network.

3. Proposed Methodologies

In WSN, consumption of power/energy is the major challenge. Many clustering techniques were used for balancing the load of WSN network. In clustering, the CH is selected as relay node with higher energy compared with the nodes of non-CH. In the existing system, it uses LBC-COFL algorithm to reduce the energy consumption problem. To overcome this problem, the proposed system uses Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head selection protocol to develop the network's lifespan and energy consumption. The architecture of QOJ-LCH with cluster head (CH) selection is show in figure 1.

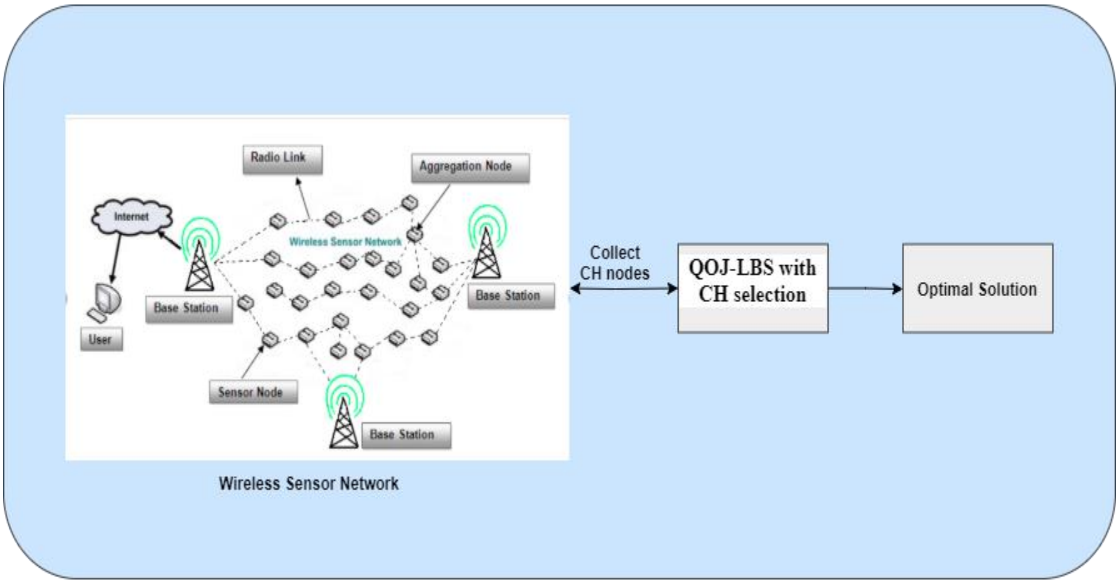

Fig.1. Architecture of QOJ-LCH with Cluster Head Selection.

Figure 1 show architecture process of QOJ-LCH with selection of cluster head. Initially the node of cluster head is collected from the WSN, and then the algorithm is applied; it provides the optimal solution. It consists of Energy model, System model and Mathematical Model.

3.1. Energy Model

This model similar to energy model in the communication channel. It consists of two channels that are free space and multi-path. The transmitter and receiver used by energy model are represented by DE as in (1) - (3) [18]. The threshold value is represented as Dh_0 and then the free-space and multi-path channel is selected.

$$EN_{tx}(k_b, DE) = \begin{cases} Kb * EN_{elec} + Kb * \epsilon_{FS} * D^2, DE < Dh_0 \\ Kb * EN_{elec} + Kb * \epsilon_{MP} * D^4, DE \geq Dh_0 \end{cases} \quad (1)$$

where EN_{elec} is represented as the amount of usage consumed by the electric circuit, $\epsilon_{FS}$and $\epsilon_{MP}$is denoted as energy taken by transmitters is spacious and multi-path channel.

$$EN_{rx}(Kb) = kb * EN_{elec} \quad (2)$$

$$D_0 = \sqrt{\frac{\epsilon_{FS}}{\epsilon_{MP}}} \quad (3)$$

D_0 denotes the threshold value Kb is a data bit is used above the distance of D.

3.2. System Model

The system model has the subsequent important premise regarding the WSNs are thought-about within the model of network.

1. Target regions are randomly generated it also contains relay nodes, sensor nodes and sink nodes.
2. The setup is static while giving sensor, relay and sink nodes to the system.
3. For energy consumption, the proposed work uses Euclidean distance among the nodes and the energy model is used for measuring the node's energy utilization.
4. The sensor node detects the accurate place of the nodes which is already known and also the sensor node intellect the event within its range.
5. The initial stage of node batteries in the networks is heterogeneous.
6. The sink node battery is countless, when it is in initial quantity.

3.3. Mathematical Model of Proposed Work

To find the solution for balancing the load issues and also improves the network's lifetime is the major intention. To develop the network's lifetime, the appropriate power of nodes should be used. The entire instance until the initial relay node dissipates its entire power is used to characterize network longevity in this study. As a result, non-CHs load can be dispersed evenly across the network, the network lifespan can be enhanced. Now, the load balancing difficulty is the main reason for cluster-based WSNs is shown below, together with parameters to measure the created clustered system. The goal of the study is to discover the best way to allocate each node of sensor to precisely one relay node. There are Mr relay nodes and Ns sensor nodes in the system. The sensor node to the relay node is assigned and then it is given to the network by the matrix As_{NM}.as in (4).

$$As_{NM} = \begin{pmatrix} \alpha_{11}\alpha_{12} & \cdots & \alpha_{1Mr} \\ \vdots & \ddots & \vdots \\ \alpha_{N1}\alpha_{N2} & \cdots & \alpha_{NsMr} \end{pmatrix} \quad (4)$$

Here, α_{XY} is defined as Boolean variable, it represents whether the communication link is present or not between the node of sensor S_X and the node of relay R_Y. If $\alpha_{XY=1}$ it denotes that the sensor node S_X is selected to the relay node $R_{Y;}$ or else α_{XY}=0.

$$\alpha_{XY} = \begin{cases} 1, if\ sensor\ node\ S_X\ is\ alloted\ to\ relay\ node\ R_Y \\ \forall_{X,Y} : 1 \leq X \leq N, 1 \leq Y \leq M. \\ 0, Otherwise \end{cases} \quad (5)$$

The proposed work is given below:

- Increase the value of the minimum lifetime relay node amongst the network's relay nodes.

Increase: L_{MIN}

- L_{MIN} is represented as minimum lifetime value of the relay node i is determined as network.

  L_{MIN}= MIN {Lifespan (R_i)|$\forall i: 1 \leq i \leq M$}

- Entropy (h) is reduced and the value is given to the load.

  Increase: Entropy (h)

3.4. Quasi-oppositional Based Jaya Algorithm

It is easily implemented and there is no require for algorithmic parameters. The size of the initial population IS, are randomly generated with upper and lower limits. The original population of the decision variables of QO-Jaya is given below as in (6)-(9):

$$Q^4(T, I, J) = rand\ (X, Y) \quad (6)$$

$$X = \frac{Q_I^{lower} + Q_I^{upper}}{2} \quad (7)$$

T represents the current iteration number; I denote the size of variable and J represents the amount of the population.

$$Q(T+1, I, J) = Q(T, I, J) + R\ (T, I, J)\ (Q\ (T, I, best) - |Q(T, I, J)|) - R(T, I, 2)\ (Q\ (T, I, worst) - |Q(T, I, J)|) \quad (8)$$

The candidates are selected by best and worst case ad it is denoted by S. The randomly produced numbers are R (T, I, 1) and R (T, I, 2). The process will continue until it reaches the conditions.

3.5. Proposed QOJ-LCH with Cluster Head (CH) Selection

In the existing systems, (31, 32) there is an issue in getting better of the lifespan and power utilization of the network. To overcome the issues, the proposed method QOJ-LCH with CH selection protocol works with fitness value, helps to improve the lifespan of the network. Figure 2 shows the in general workflow of the proposed system. It contains two steps. Bootstrapping is the primary step; the clusters are formed in the second step.

A. QOJ-LCH Algorithm

In advance, population's candidate solution is precise. In load-balancing problem, every candidate solution gives an absolute solution to the network. Initially the population size S, dimension D and the number of iterations is initialized. Then the Initial size of the random population S is generated. By using equation 5 Quasi-opposite populations is created. The fitness value and the cluster head (CH) selections are generated by the equation 12 and 14. From the 2S population, the best candidate solution is selected by fitness value. Then it is store best and worst candidate solutions in S and the solution is updated in the equation 8. In case it met the stopping condition, the best nodes are selected from cluster head (CH) along the population. Once the cluster head is selected, then the node is chosen to the CH based on their space between the Sensor nodes and cluster head. If the value of the fitness is improved, it replaces with the previous solution. If the answer is not better, the earlier solution is maintained. When the maximum iterations get reached, the optimal candidate solution is stored. Otherwise, it again follows the equation 5 and starts the iteration process until reaches the optimal solution.

B. Generation of Random Population

Initially, it generates a size of the populations S with random candidate solutions. The random candidate solutions are given below. Where D represents the dimensions of the candidate solution.

$$C_{sj} = \{p_{j1,}p_{j2}, p_{j3} \dots \dots \dots \dots \dots .. p_{jD}\}, j = \{1,2,3, \dots \dots .. S\} \quad (9)$$

where Cs_j is the candidate result and p_{j1} is the initial part of the candidate solution. In this stage, there is s dimension D for each candidate solution population with random solutions. The mapping process of a node of sensor to the node of relay is given as in (10).

$$R_k = Map\ (com\ (S_D), N) \quad (10)$$

where, com (S_D) denotes, set of relay nodes inside the range of the sensor node in communication is S_D. Where Map (com (S_D), N) is the mapping function.

C. Cluster Head (CH) Selection with Fitness Value Evaluation

The performance of the candidate result is determined by the fitness rate and cluster head (CH) selection. To assess the individual candidate, the fitness function is developed. It helps to minimize the load balancing problems in the proposed work. For several activities, the relay node takes energy such as from connected sensor nodes, the data is collected, data is moved to the sink, with the help of relay nodes or it directly transmits. For cluster head selection the following equation is given below (11):

$$F_1 = \sum_{K-1}^{M} \frac{1}{L_j} \left(\sum_{j=1}^{L_j} dist\ (S_j, ch_K) \right) \tag{11}$$

$$F_3 = \frac{\frac{1}{M} \sum_{j=1}^{M} dist(ch_j, bs)}{N} \tag{12}$$

where, F_1 represents the cluster heads, intra cluster distance ad L_1 represents the nodes belonging to the ch_k. F_3 denotes the average sink ratio for the total nodes in the network. There are some objectives used for the calculation of fitness function. The objectives are given below

$$Fitness\ (F) = w_1 * F_1 + w_2 * F_2 \tag{13}$$

$$F = w_1 * \left(\frac{l_{min}}{a + l_{min}} \right) + \ (1 - w_1) * (-\sum_{i=1}^{M} P_i log_M\ (P_i)) \tag{14}$$

Here w_1 and w_2 are fitness functions weight. P_i is the probability value of i^{th} relay node in the network.

4. Algorithm 1 Pseudo-code of QOJ-LCH with CH Selection

Algorithm 1 Pseudo-Code Of Qoj-Lch With Ch Selection

Input: S_N, R_M, com(s_i), S, T_{MAX}
Output: Assigning C: $S_N \rightarrow R_M$
begin
\\ Generation of random population\\
for candidate solution j=1 to S do
for dimension i=1 to D do
randomly positions are initialized.
end for
end for
\\Generation of Quasi opposite population\\
for candidate solution j=1 to S do
for dimension i=1 to D do
QO is generated by using (5)
end for
end for
\\ Cluster head selection with fitness value \\
Cluster head selection is verified by using (10)
Fitness value is evaluated by using (12)
Choose the candidate solution S among the QO population
Best and worst solutions are stored
\\Updating the position \\
for candidate solution j=1 to S do
for dimension i=1 to D do
candidate solution is updated by using (5)
end for
fitness function of the candidate solution is calculated by using (12)
end for
if F(present)> F(prior) then
newly generated position values are restored.
else
Previous position values are continued.
end if
end for
if the criteria is met then
stop
else
repeat the step 3
end if

Algorithm 1 shows the QOJ-LSB with cluster head selection process.

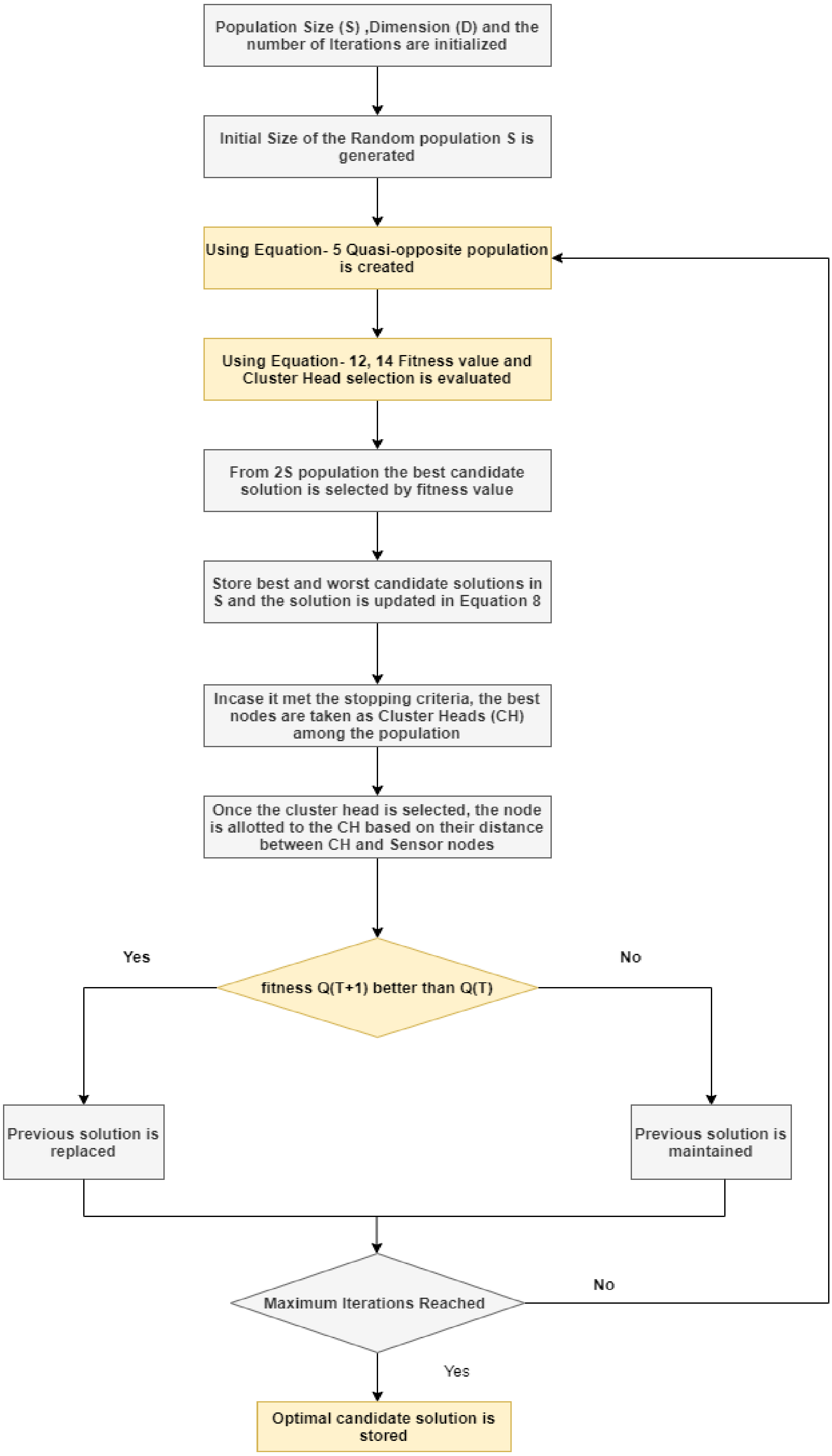

Fig.2. Overall workflow of QOJ-LCH with CH selection.

5. Result Evaluation

The evaluation result of the proposed Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head (CH) selection protocol method uses many comparative parameter metrics such as active sensor nodes, network energy consumption, lifespan of the network, lifetime of relay nodes in each circle. It works in 2 different phases, single –hop and multiple-hop. The clustering approach is significantly important in this research work because the main concern is to extend the battery life and network lifetime of the individual sensor as well as ensure the utilization of energy is one of the main characteristics when compared to the non-clustering algorithms. The proposed method decreases the power consumption and improves the lifespan of the network. To carry out the research work, the simulator (ns-2) is used for a wireless sensor network, which is a discrete event network simulator.

5.1. Evaluation of Single-hop Routing

This segment illustrates the Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head (CH) selection protocol, when the relay nodes transmit data straight forwardly to the sink. The main anxiety is to permit the sensor nodes on the transfer nodes to decrease the highest power utilization of the transfer nodes. It works with 15 and 20 relay nodes.

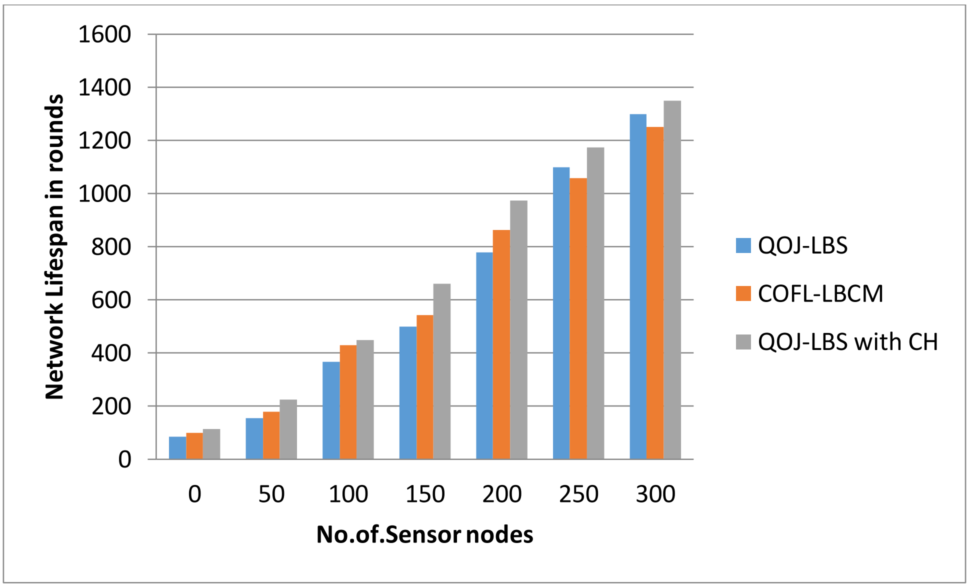

Fig.3. Network lifespan for Single-hop.

Figure 3, shows the proposed QOJ-LCH with CH selection improves the lifespan in Single-hop routing. It worked with 1600 rounds in network and 300 sensor nodes. It achieves better performance compared with the existing algorithms such as QOJ-LCH [30], COFL-LBCM [17]. The result revealed that the network lifespan for single-hop of QOJ-LBS with CH is 3.70% and 7.41% higher than the QOJ-LBS and COFL-LBCM for 300 sensor nodes.

5.2. Evaluation of Multiple- hop Routing

The evaluation of multiple-hop uses the Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head selection protocol, thus the relay node broadcast the information straight to the sink node. The main anxiety is to authorize the sensor node on the transfer node to decrease the greatest power utilization of the transfer node. It works with 15 and 20 relay nodes. It improves the lifespan of the networks. Each round it calculates the sensor node presents actively at networks.

Figure 4, shows the proposed QOJ-LCH with CH selection improves the lifespan in Multiple-hop routing. It worked with 1800 rounds in network and 350 sensor nodes. It achieves better performance compared with the existing algorithms such as QOJ-LCH, COFL-LBCM. Also compared with single-hop routing, the multi-hop routing achieves more lifespan of the network. It is found that the network lifespan for multiple -hop of QOJ-LBS with CH increases by 12.42% and 14.18% at 300 sensor nodes when compared to the QOJ-LBS and COFL-LBCM respectively.

5.3. Evaluation Based on Energy Consumption

The network nodes energy consumption is improved in all of the methods because the wide variety of turns improved. The end result suggests the strength intake of the QOJ-LCH with CH techniques is decrease than that of the diverse techniques. The proposed set of rules has decrease strength intake. Figure 5 shows that the proposed QOJ-LCH with CH selection algorithm consume 95.75% of energy in 4000 rounds; therefore, it has less energy consumption, compared with other algorithms. It is observed that the energy consumption of QOJ-LBS with CH is higher by 10.52 % and 11.8 % at a4000 rounds when compared to the COFL-LBCM and QOJ-LBS respectively.

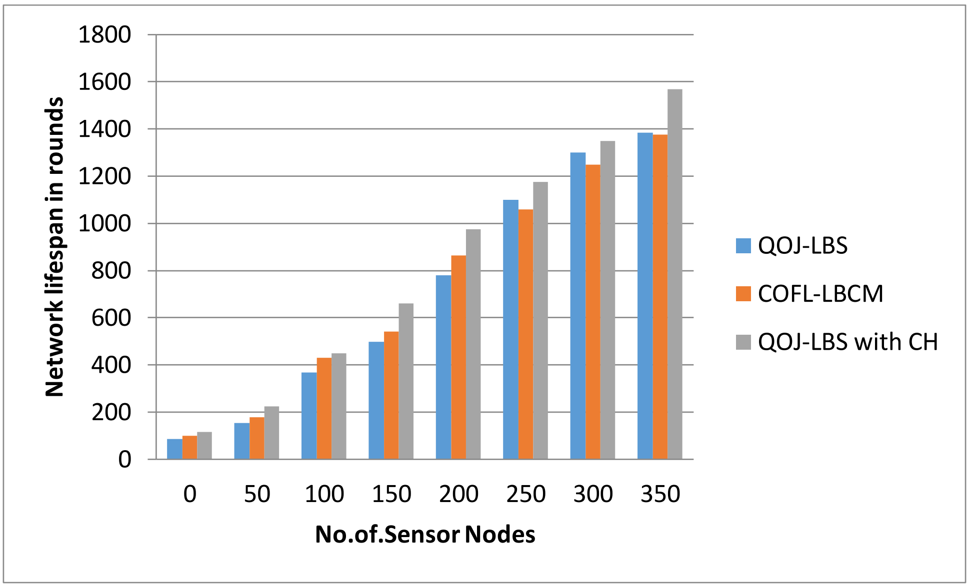

Fig.4. Network lifespan for Multiple-hop.

5.4. Standard Deviation of the Relay Nodes

The standard deviation of the relay node is determined by changing the amount of sensor nodes from 200 to 1000. The amount of relay nodes is fixed during the test, which are 10 in this case. Figure 6 show that the proposed system has increased standard deviation of load with sensors and relay nodes. The proposed method has more scalability and also has linear increase in the relay nodes. It is observed that the standard deviation of QOJ-LBS with CH is higher by 31.57 % and 46.15 % at 1000 relay nodes when compared to the COFL-LBCM and QOJ-LBS respectively.

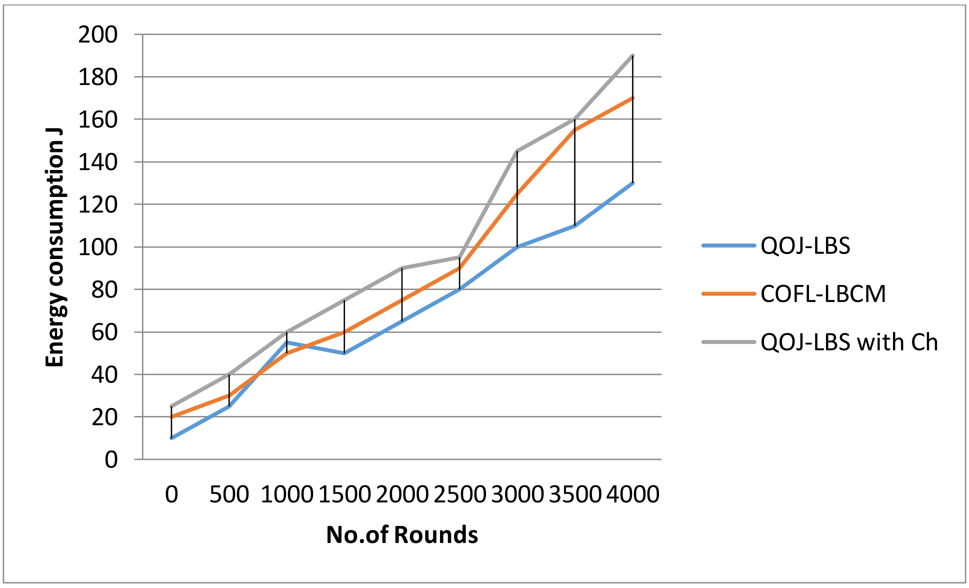

Fig.5. Energy Consumption.

5.5. ROC Curve

ROC is a graph which is used for showing the classification performance. It has two parameters True Positive Rate and False Positive Rate.

A. True Positive Rate (TPR)

It is also known as sensitivity, thus TPR is calculated by the probability of actual positive relay nodes using:

$$TRP = 1 - FNR \tag{15}$$

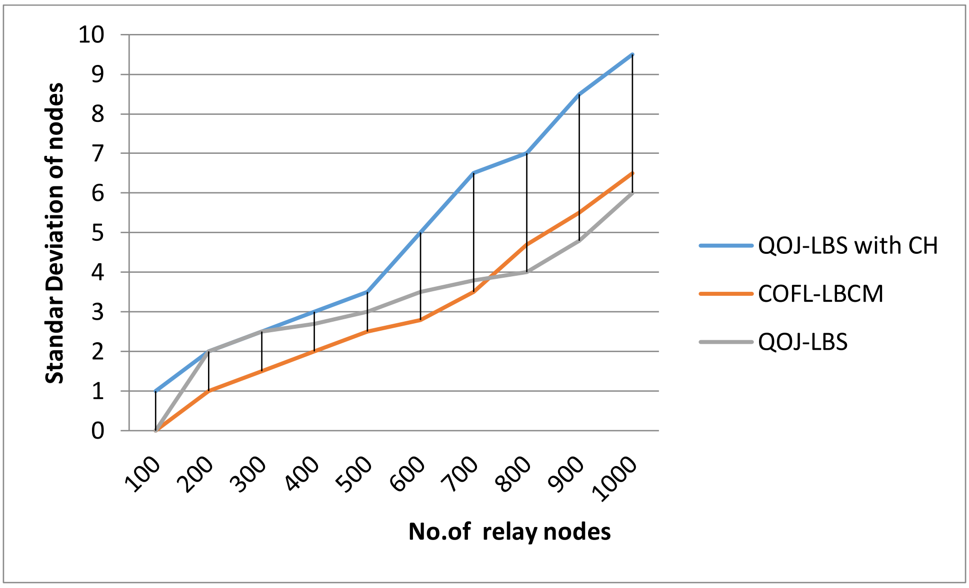

Fig.6. Standard Deviation.

B. *False Positive Rate (FPR)*

It is used to evaluate the ratio between correctly identified numbers of relay nodes to wrongly identified relay nodes using:

$$FPR = 1 - Specificty \tag{16}$$

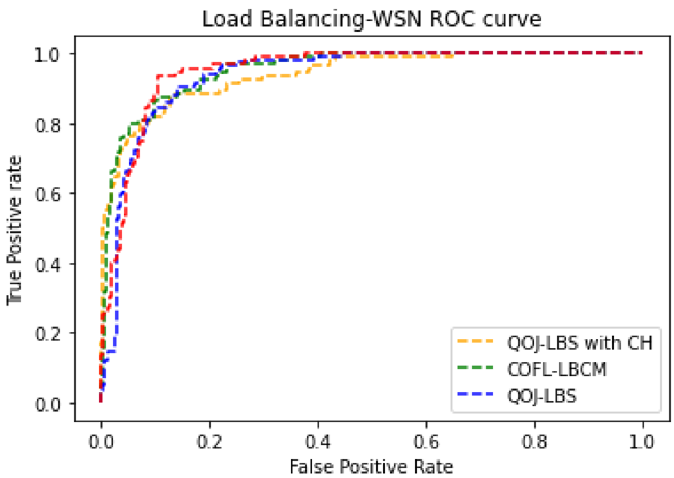

Fig.7. Load Balancing WSN ROC Curve.

Figure 7 shows the ROC curve of WSN, the correctly classified relay nodes and the false positive rate of the relay nodes in the WSN network. ROC curve is a graph plot between the X-axis (false positive rate) and the Y axis (true positive rate). It is very helpful to classify the positive cases and negative cases exactly. It is (0, 1) because the false positive rate is 0 (none), and the true positive rate is 1(all).

6. Conclusions

The proposed system uses Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head selection protocol to increase the network lifespan and energy consumption. The QOJ-LCH method improves the minimum lifetime relay node and shares the load on relay nodes equitably across the network to enhance the lifespan. It also reduces the load-balancing problems in Wireless Sensor networks. It uses two routing methods single-hop and multiple-hop. It works with fitness function and gives the best and worst candidate population over the network. The head selection at cluster helps to improve the lifespan of the network. The proposed QOJ-LCH with CH selection method enhances the lifespan of the network, total energy consumption, the standard deviation of the relay node and the entire amount of active sensor nodes present in the WSN. The result revealed that the network lifespan for single-hop of QOJ-LBS with CH is 3.70% and 7.41% higher than the QOJ-LBS and COFL-LBCM for 300 sensor nodes. It is found that the network lifespan for multiple -hop of QOJ-LBS with CH increases by 12.42% and 14.18% at 300 sensor nodes when compared to the QOJ-LBS and COFL-LBCM respectively. It is observed that the energy consumption of QOJ-LBS with CH is higher by 10.52 % and 11.8 % at 4000 rounds when compared to the COFL-LBCM and QOJ-LBS respectively. It is observed that the standard deviation of QOJ-LBS with CH is higher by 31.57 % and 46.15 % at 1000 relay nodes when compared to the COFL-LBCM and QOJ-LBS respectively.

In future, for efficient load-balancing in WSN, several clustering algorithms with machine learning and neural networks will be used. Also, for improving the energy consumption, several protocols will used.

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