# A Novel Hybrid Beluga Whale and Jellyfish Optimization for EEIICR Based Algorithm for WSN

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**ABSTRACT**: Based on the monitoring environment, the frequent generation of extensive amounts of redundant sensing data is processed in the WSN applications. Aggregating all of these data using effective data aggregation techniques is essential for lowering the energy usage in a network. Numerous clustering approaches have been employed to aggregate the copious amounts of data supplied by sensor nodes. Due to the inefficiency of the clustering and CH selection algorithms, the CH nodes in the majority of clustering environments are compelled to send the sink node, which is located far from the CHs. Therefore a novel framework for energy-aware clustering was proposed. Phases including Data Aggregation, Routing, and Optimal Clustering are included in the model. The first stage, known as optimal clustering and it involves the introduction of the new Jelly Customized Beluga Whale optimization algorithm (JC-BWOA) to complete the clustering process while taking trust, energy, delay, and intra- and inter-cluster distance into account. By taking link quality and distance into account, the JC-BWOA algorithm performs optimal routing. Based on the investigation, the suggested methods produced the best outcomes for WSN clustering that is energy-efficient.

**INDEX TERMS**: CH- Cluster Heads, WSN- Wireless Sensor Networks,.

## I. INTRODUCTION

WSNs are unmatched in tasks related to network security, environmental monitoring, and other related areas. The principal duty of nodes is to generate diverse types of data and transmit them to the sink node through either single-hop or multi-hop data transmission techniques. A WSN deploys a large number of wireless nodes into sensor networks in order to gather information. It's possible that the sensor hardware in those nodes lacks the processing capacity or range needed for efficient data gathering and transmission. The greatest solution for monitoring the surroundings and ensuring public safety is to use wireless sensor networks, or WSNs. Nodes are mostly in charge of producing different types of data to be distributed to sinking nodes, whether by multi-hop or single-hop data transmission. Due to a lack of resources, sensor nodes rapidly run out of juice. Maximizing the amount of time this mechanism is in operation is what is meant by energy efficiency. A useful method for increasing energy efficiency is clustering, which lowers or balances the energy consumption of sensor nodes. In the great majority of cluster-based systems, the nodes nearest to the cluster's epicenter have historically been chosen as Cluster Heads (CH). Additionally, MNs and CH frequently use the direct data transmission method for intra-cluster routing, which results in unequal energy utilization. This is due to the fact that nodes farther away from CH need more energy to send data packets because the amount of energy required varies with the distance to the destination. The unequal depletion of MNs' power supplies results in coverage gaps and decreased network uptime overall. The time frame following the initial MN's battery is referred to as the coverage time. In most existing cluster based WSNs, balancing energy consumption of CHs has been primary design problem. However, addressing MNs' inefficient use of energy has received far less attention.

In Figure 1 we see overarching design of WSN.

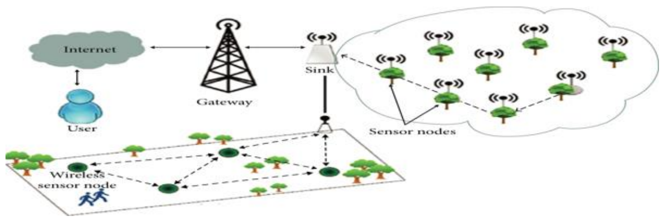


**Figure 1: Wireless Sensor Network**

**Research gaps and challenges:**

To increase the sensor network's longevity, further research on energy-aware protocols is required. Despite the widespread use of WSN-based methods such as EIR, ICGW-PSOGA, Data Aggregation Technique, and EEICS, more research is required to make the approach suitable for protected networks by summing the trust value. A fault tolerance mechanism is required to improve the dependability of the sensor nodes, which plays a crucial role. In order to improve energy conservations and network longevity in WSN, it is necessary to improve data aggregation algorithms at the cluster head level. For evaluating new model, it is required for increasing number of nodes in the network, since this affects clustering, data aggregation, and routing. To improve data aggregation, it's essential to present a reliable clustering & CH selection process that can choose CHs that are free of congestion. To lengthen the service life of networks, it is necessary to devise plethora of clustering techniques.

**System model of EEIICR:**

The EEIICR includes BS and $T$ SNs. The SNs are represented by a set $T = T_1, T_2, \ldots T_m$. These SNs were sorted in clusters, and each cluster contains MNs and CH. It is believed that $T$ uniform sensors is dispersed consistently all through the network area. The below assumptions are considered during the performance assessment phase of EEIICR scheme.

i. In EIR, static and mobile sinks are employed, which reduces data delivery delay and boosts PDR.

ii. Sinks are high-resource gadgets that include a GPS unit.

iii. Each connection channel has enough capability to send data packets over it.

iv. It is not needed to take account of energy utilization as every node generate data at similar amount and the energy lost during data gathering is evenly distributed amongst every node.

v. MNs use direct data transfer to send sensory data to CH or MS.

vi. Because of the information that they all offer the similar services, employ the similar wireless technologies, and are tethered to the similar backbone network, all nodules is identical.

EEIICR model is shown in figure 2 below.

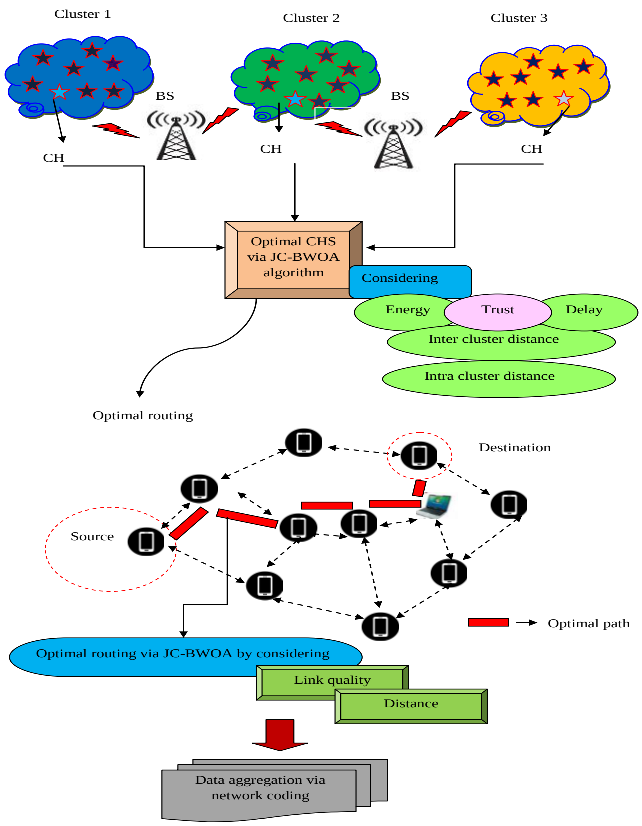


**Figure 2: EEIICR scheme in WSN.**

## Optimal CHS via JC-BWOA Optimization:

This work chooses optimal Cluster Head by means of JC-BWOA. Eq. (1) shows the objective for CHS, which will indicate that trust and energy are desired to be high, whereas, the intra and inter cluster distances and the delay should be very small. In Eq. (1), the summing up of weights $\omega_1$- $\omega_4$ is 1, i.e. $\sum \omega_i = 1$

$$Fit = Min\left[\omega_1 * Dl + \omega_2 * (1-E) + \omega_3 * (1-Tr) + \omega_4 * IAD + \omega_5 * ICD\right] \quad (1)$$

Energy Model

It is evaluated by using the mean of residual energy of CH as expressed in Eq. (2), wherein, $(En_{CH})$ represents the residual energy of CH.

$$E = Mean\left(En_{CH}\right) \qquad (2)$$

Intra cluster Distance

The distance of every node in cluster to CH is known as total CH.

$$IAD = \sum_{i=1}^{i=T} Dt\left(i, CH\right) \qquad (3)$$

Here, $Dt\left(i, CH\right)$ refers to distance of node to CH & $T$ refers to count of nodes in a cluster.

Inter cluster Distance

The distance among the respective CHs of clusters is known as Inter cluster Distance. In Eq. (4), $k$ implies cluster count, $y_i$ and $y_j$ implies cluster centre.

$$ICD = Min\left(\left\|y_i - y_j\right\|\right)^2 \qquad (4)$$

Here, $i = 1,2...k-1$ and $j = i+1,....k$.

This study chooses CH optimally via a new JC-BWOA algorithm.

| ***Algorithm 1: Proposed JC-BWOA*** |
|---|
| *Initializing population* $T$ *and compute fitness and get finest solution* |
| *while* $T \le T_{\max}$ *do* |
| *Accomplish* $W_f$ *and* $B_f$ |
| *for* $X_i$ *(every whale) do* |
| *if* $B_f\left(i\right) \succ 0.5$ |
| *Calculate the dimension arbitrarily* $p_j\left(j = 1,2,...,d\right)$ |
| *Elect the whale randomly* $X_r$ |
| *Update position of exploration phase as in Eq. (5.15)* |
| *else if* $B_f\left(i\right) \le 0.5$ |
| *Update* $LF$ *and* $C_1$ |
| *Update position of proposed exploitation using JFO update* |
| *end if* |
| *Search for novel position limit and calculate fitness* |
| *end for* |
| *for every* $X_i$ *do* |
| *if* $B_f\left(i\right) \le W_f$ |
| *Notify* $C_2$ *(step factor)* |
| *Calculate* $X_{step}$ |
| *Update whale fall position* |
| *Search for novel position limit and calculate fitness* |
| *end if* |
| *end for* |
| *Get optimal solution* $\left(k^*\right)$ |
| $T = T + 1$ |
| *end while* |

**I. Data Aggregation via Network Coding:**

It is done by Network coding scheme: It is a network technology, where transferred data is encoded and decoded to improve the throughput, decrease the delay and to increase the robust of network. The received transmissions are decoded at their destinations. Network coding is alienated into 3 parts:

1. Source node encoding
2. Re-encoding at intermediate node
3. Decoding at receiver node

Network coding is expressed by Eq. (5).

$$\left(tg\right)^{-1} tgp = p \qquad (5)$$

In Eq. (5), $p$ refers to data matrix, $g$ refers to generator matrix and $t$ refers to transfer matrix. After deploying network coding, $p$ experiences transforms for 3 times. Initially, $gp$ refers to encoding at source node, subsequently, multiplying the resultant of $gp$ by matrix $t$ indicates the re-encoding function at intermediate nodes and at last, multiplying the resultant of $(t(gp))$ by matrix $(tg)^{-1}$ indicates the decoding function at receivers.

Beluga whale behaviors like foraging, gliding, and whale falls are imitated by the JC-BWOA algorithm. Due to the JC-BWOA populace, beluga whales are considered as search agents, and each whale is considered as feasible solution throughout the optimization method. Eq. (6) demonstrates the matrix of search agent position.

$$X = \begin{bmatrix} x_{1,1} & x_{1,2} & \ldots\ldots x_{1,d} \\ . \\ . \\ . \\ x_{n,1} & x_{n,2} & \ldots\ldots x_{n,d} \end{bmatrix} \quad (6)$$

Results and Discussions:

Developed JC-BWOA based EEIICR in WSN was done in NS2. Here, analysis was done under varied rounds from 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800 and 2000. Additionally, the JC-BWOA based EEIICR in WSN was examined for varied nodes from 100 to 300. The JC-BWOA based EEIICR in WSN was assessed over JFO, BWO, ACO, MFO, RHSO and WOA. The parameter set was specified in Table 1.

**Table 1: Simulation Parameter**

| Parameters | Values |
|---|---|
| "Initial nodal energy | 0.5J |
| Network area | 100×100 |
| Total node count | 300 nodes |
| Energy dispersed per bit | 100nJ/bit |
| Predetermined percentage of CH | 0.05" |

**Analysis on Inter cluster & Intra cluster distance:**

Study on inter & intra cluster distances for JC-BWOA based EEIICR in WSN over JFO, BWO, ACO, MFO, RHSO and WOA for 300 nodes is displayed in figure 3 and figure 4. The distance amongst nodes should be less, so that it could be chosen as CH. In assessment over JFO, BWO, ACO, MFO, RHSO and WOA, the suggested JC-BWOA model includes lesser distances. In case of 100 nodes, at beginning rounds, inter cluster, intra cluster spaces are less. That is, in figure 5.4(a) at 0th round, inter cluster distance is less. After 0th round, inter cluster distance is high and when the round is 1900, high inter cluster distance is obtained. At 1900th round, inter cluster distance for JC-BWOA is around 690. The inter distance using JFO is high around 790 for 100 nodes at 1800th round. In case of figure 5.5, the distance is less at beginning rounds for 200 nodes. As rounds increases, the intra cluster distance also increases. At 1800th round, the intra distance using MFO is high around 730 for 200 nodes. However, when evaluated over JFO, BWO, ACO, MFO, RHSO and WOA, the distances for JC-BWOA is less. Similarly, for 300 nodes, the distances are less using JC-BWOA over JFO, BWO, ACO, MFO, RHSO and WOA. The distances for proposed work are less as the suggested EEIICR in WSN model uses optimal routing via JC-BWOA. In addition, JC-BWOA aids in CHS that lessened the cluster distances during transmission.

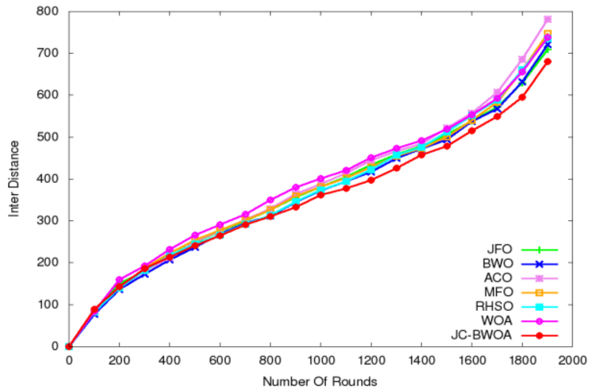


**Figure a 100 nodes**

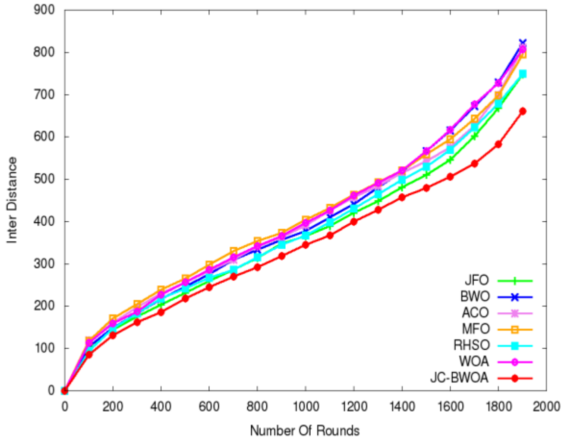


**Figure b 200 nodes**

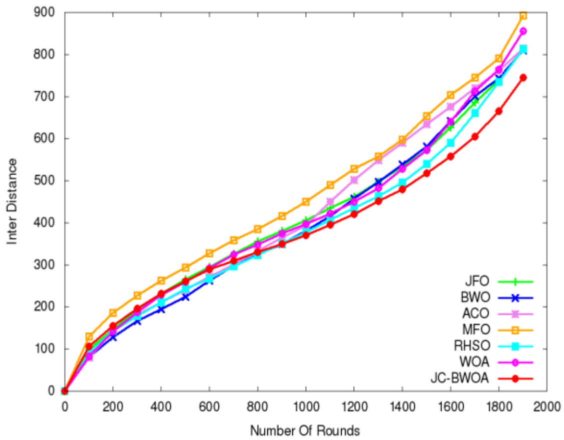


**Figure c 300 nodes**

**Figure 3: Inter cluster distance analysis for EEIICR in WSN for nodes (a) 100 (b) 200 and (c) 300**

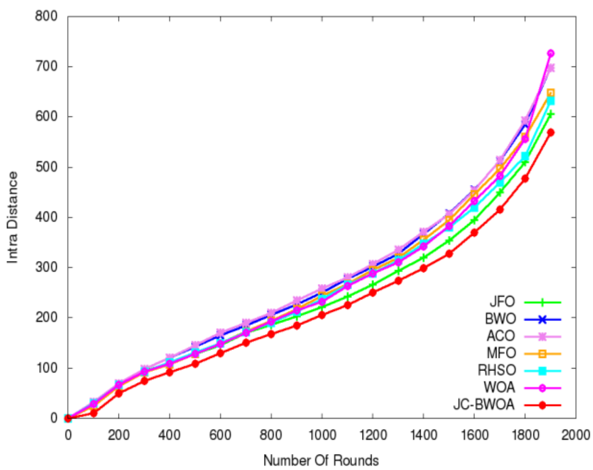


**Figure a 100 nodes**

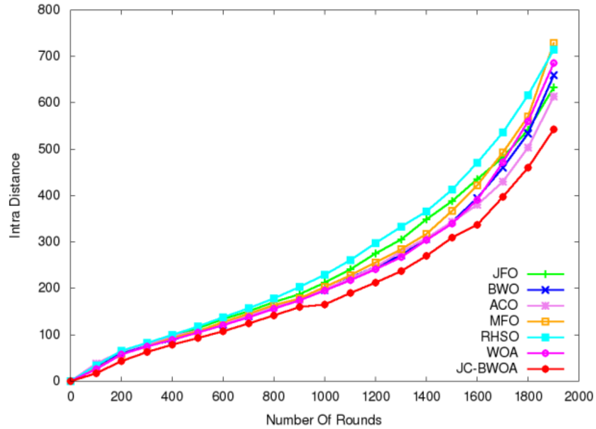


**Figure b 200 nodes**

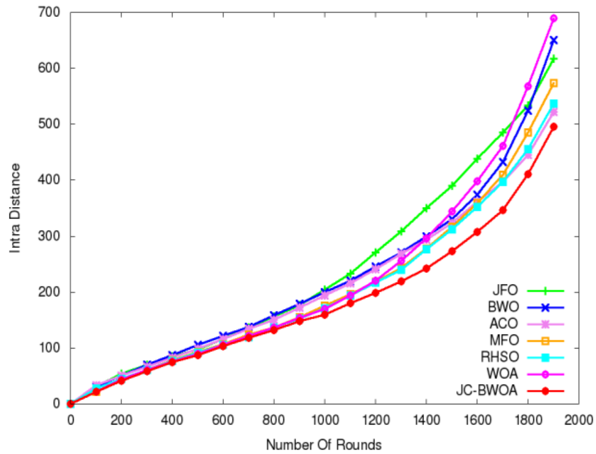


**Figure c 300 nodes**

**Figure 4: Intra cluster distance analysis for EEIICR in WSN for nodes (a) 100 (b) 200 and (c) 300**

**Analysis on Energy and throughput:**

Figure 5 and 6 describe the energy and throughput examination of JC-BWOA based EEIICR in WSN over JFO, BWO, ACO, MFO, RHSO and WOA for 300 nodes. Energy and throughput are crucial parameters for transmission of data. The throughput as well as residual energy should be higher. The suggested JC-BWOA model includes higher energy and throughput. The residual energy lessens with increase in rounds, however, In case of 100 nodes, at beginning rounds, the energy is high. That is, in figure 6(a) at 0th round, the energy is high, after 0th round, the energy is less and when the round is 1900, less energy is obtained. At 1900th round, the energy for JC-BWOA is around 2.4.

However, when evaluated over JFO, BWO, ACO, MFO, RHSO and WOA, the energy for JC-BWOA is less. The throughput is less at beginning rounds; however, with increase in rounds, throughput is high due to optimal routing via JC-BWOA.

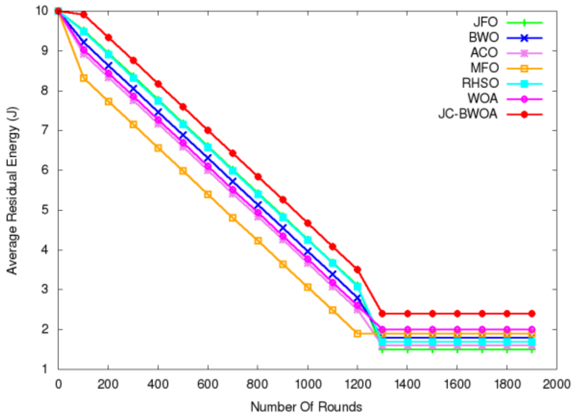


**Figure a 100 nodes**

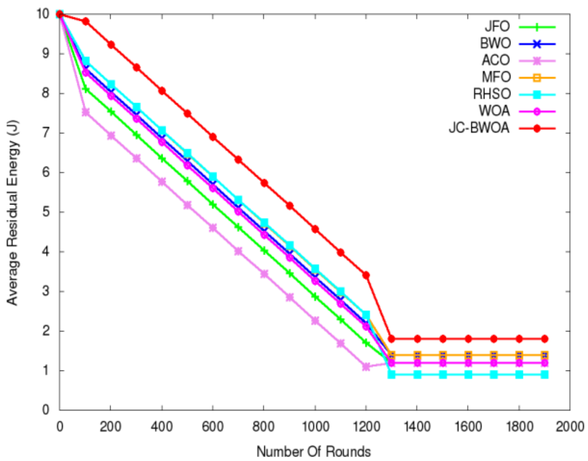


**Figure b 200 nodes**

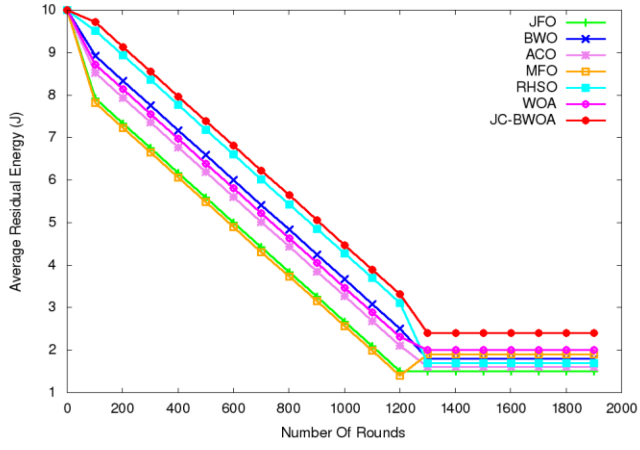


***Fig. c 300 nodes***

**Figure 5: Energy analysis for EEIICR in WSN for nodes (a) 100 (b) 200 and (c) 300**

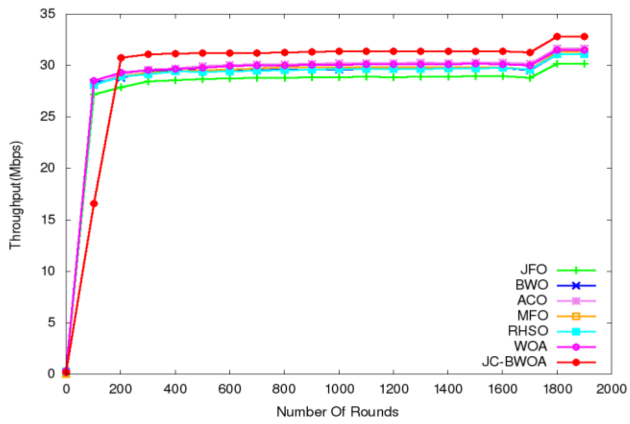


**Figure a 100 nodes**

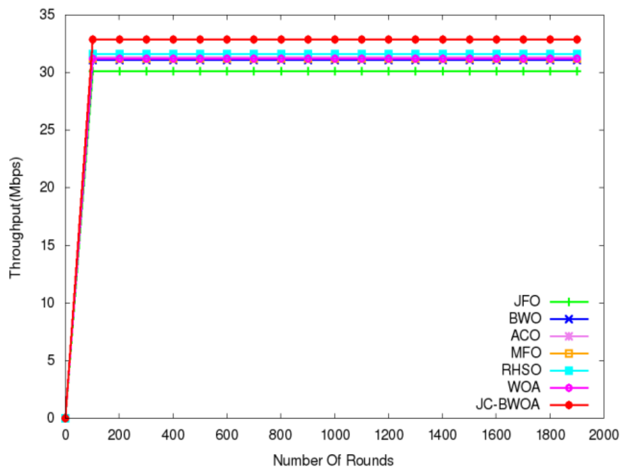


**Figure b 200 nodes**

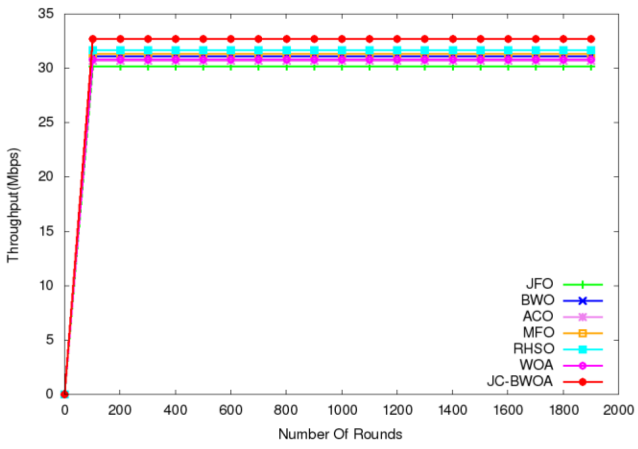


**Figure c 300 nodes**

Figure 6: Throughput analysis for EEIICR in WSN for nodes (a) 100 (b) 200 and (c) 300

**Statistical study:**

Table 2 shows statistical study of presented JC-BWOA based EEIICR in WSN over JFO, BWO, ACO, MFO, RHSO and WOA. The analysis is done for 300nodes. The adopted scheme for maximum case scored a lesser value of 0.823805. The fitness of JC-BWOA based EEIICR in WSN is less, whereas, the existing models have exposed high fitness. As optimum CHS is done based upon suggested JC-BWOA.

**Table 2: Statistical analysis of EEIICR in WSN**

| Methods | Maximum | SD | Mean | Minimum | Median |
|---|---|---|---|---|---|
| JFO | 2.01193 | 0.164411 | 1.06945 | 0.175554 | 1.00137 |
| BWO | 0.92077 | 0.181836 | 0.51106 | 0.174082 | 0.497103 |
| ACO | 1.29945 | 0.133272 | 0.970433 | 0.15 | 0.901702 |
| MFO | 1.47414 | 0.154083 | 0.574682 | 0.15 | 0.502895 |
| RHSO | 0.99938 | 0.136605 | 0.631228 | 0.165015 | 0.577636 |
| WOA | 0.991861 | 0.149076 | 0.578328 | 0.179248 | 0.508402 |
| JC-BWOA | 0.823805 | 0.126145 | 0.216476 | 0.138396 | 0.154648 |

**Conclusion**

This work has introduced a novel method of EEIICR framework. The model incorporated the phases like: Optimal Clustering, Routing and Data Aggregation. Optimal Clustering was the preliminary phase, where, JC-BWOA optimization has introduced to perform clustering process on considering the parameters like delay, energy, trust, intra, inter cluster distance. Optimal routing was also done via JC-BWOA algorithm by considering link quality and the distance. From analysis, at 0th round, inter cluster distance was less. After 0th round, inter cluster space was high and when the round is 1900, high inter group distance was obtained. At 1900th round, the inter group distance for JC-BWOA was around 690. The inter group distance using JFO was high around 790 for 100 nodes at 1800th round. In instance of intra cluster distance, the distance was less at the beginning rounds for 200 nodes. At 1800th round, the distance using MFO was high around 730 for 200 nodes. In future, life span of network should be analysed.

**Future Scope**

The suggested system has potential in the fields of smart cities, precision agriculture, healthcare, home mechanization; further development might include adding a fault tolerance mechanism to further increase the scheme's dependability.

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