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Chaos Reptile Search Algorithm Based Clustering and Routing for Internet of Things assisted Wireless Sensor Network

Narasimha Murthy Madiwala Satyanarayana Rao[1]* **Kannughatta Narasimhamurthy Shreenath[2]**
Udayakumar Nittur Lakshminarayanachar[3] **Thirthe Gowda Mallinathapura Thimmegowda[4]**
Atur Venkateshmurthy Krishna Mohan[2]

[1]*Department of Information Science & Engineering,*
BMS Institute of Technology & Management, Bengaluru, India
[2]*Department of Computer Science & Engineering, Siddaganga Institute of Technology, Tumkur, India*
[3]*Department of Computer Science & Engineering, Shridevi Institute of Engineering and Technology, Tumkur, India*
[4]*Department of Computer Science & Engineering, Government Engineering College, Hassan, India*
* Corresponding author's Email: narasimhamurthyms@bmsit.in

Abstract: Wireless sensor network (WSN) is a self-organizing network that contains numerous small sensor nodes for monitoring applications in a broad range. However, energy consumption and trust are considered two prominent issues, due to the limited energy sources and open medium. In this research, the Chaos Reptile Search Algorithm (CRSA) is proposed to perform clustering and routing in Internet of Things (IoT) based WSN. The CRSA is utilized to ensure the Cluster Head (CH) and route path for attain reliable data transmission. Main objective of CRSA is to achieve efficient data transmission to enhance the lifespan of WSNs. The CRSA is utilized to perform better exploitation and avoid local optima issues because of the efficient stability between exploration and exploitation. The CRSA performance is assessed through Packet Delivery Ratio (PDR), throughput, delay and energy consumption. The CRSA achieved PDR of 99.75%, 99.24% and 98.51% for 100, 200 and 300 nodes which is better when compared to Improved Metaheuristic-Driven Energy-Aware Cluster-Based Routing Scheme (IMD-EACBR), Energy Aware Clustering and Multihop Routing Protocol with mobile sink (EACMRP-MS), Improved Duck and Traveller Optimization enabled cluster-based Multi-Hop Routing (IDTOMHR).

Keywords: Data transmission, Energy consumption, Internet of things, Packet delivery ratio, Reptile search algorithm, Wireless sensor network.

1. Introduction

In recent years, the IoT-assisted Wireless Sensor Network (WSN) has played a prominent role in Industry that links the digital environment to the physical world [1]. IoT-assisted WSN provides accessible communication through various Sensor Nodes (SNs) which are initialized in a target monitoring region [2]. The WSN are generally tiny in size, low expensive devices, restricted bandwidth, memory and battery [3]. The IoT-assisted WSN can be performed in several functions like sensing, computation, monitoring, storage, and communication [4]. The incorporation of IoT with WSN is utilized at application levels such as smart healthcare, smart cities, remote surveillance and environmental monitoring [5]. The impairments of WSN stimulate the necessary activities in an IoT such as finding the shortest route into a sink, WSN node deployment, hierarchical structure creation, and huge payload [6, 7]. The different impairments are measured and employ the limited resources by developing an effective protocol at every layer for enhance the Quality of Service (QoS) in WSN [8].

The WSN has been utilized in different applications like health monitoring, civil, military, target tracking, forage, and so on [9]. The WSN performs in an efficient form and supports energy consumption within the network lifetime [10]. The

Cluster Head (CH) nodes are responsible for gathering data from Cluster Members (CMs) and transmitting it to the Base Station (BS) [11]. In WSN, several features are examined such as low computational complexity, interoperability, limited memory, localization, and manageable sensors. According to these features, WSN-assisted applications are low maintenance and robust [12]. The network lifetime is considered a prominent feature for viability and it is a constraint to define how the system works without the maintenance [13]. The SN lifespan is represented through the battery, so energy is efficiently required in the whole network [14]. Security is a primary issue in WSN because of the unattended operation and unreliable channels that reveal the sensors exposed to malicious attacks [15]. The contributions of the paper are designated below:

- The CRSA is utilized to achieve efficient data transmission while enhancing the lifespan of WSNs which has efficient stability among exploration and exploitation.
- The fitness functions like trust, residual energy, delay, communication cost, and node degree are utilized for selecting CH and route paths in WSN.
- The CRSA is employed to ensure CH and route path to achieve efficient data transmission while enhancing the lifespan of WSN. The CRSA performance is examined through PDR, throughput, delay, and energy consumption.

Rest of the paper is as follows: Section 2 designates literature review; section 3 describes proposed method; section 4 describes results and discussion and section 5 describes conclusion.

2. Literature review

This section describes some recent literature work based on clustering and routing using metaheuristic optimization algorithms for IoT-based WSNs.

Kuruva Lakshmanna [16] implemented an IMD-EACBR for IoT-based WSNs. The Improved Archimedes Optimization Algorithm-based Clustering (IAOAC) for CH selection and cluster organization. The IAOAC calculated a fitness that connected numerous structures for node degree, energy efficiency, inter-cluster distance, and detachment. The implemented model extends WSN lifetime, diminishes energy, and manages path length. However, it required restricted communications for transmitting data through sensor nodes.

Neelakandan Subramani [17] developed an EACMRP-MS for IoT-based WSNs. The EACMRP-MS was utilized to reduce energy consumption in sensor nodes which enhanced the network efficiency. It primarily depends on Tunicate Swarm Algorithm (TSA) for CH selection and cluster generation. Then, Type-II Fuzzy Logic (T2FL) was employed for optimum selection of route through numerous input parameters. The T2FL has disseminated the data packets over a short path which is utilized to reduce latency. However, this model has limited resources such as inadequate memory, processing, and small battery capability.

Mashael M. Asiri [18] introduced IDTOMHR protocol for energy-efficient clustering and routing protocol for WSN. Initially, the IDTO algorithm was used to choose Cluster Heads (CHs) and cluster constructions. The artificial Gorilla Troops Optimization (ATGO) method was utilized to originate the optimum group of routes for an endpoint. The IDTOMHR-based CH and path selection were employed for attain better energy balancing in WSN. However, it examined only less number of sensor nodes.

Ravi Kumar Sanapala and Sreenivasa Rao Duggirala [19] developed a Low Energy Adaptive Clustering Hierarchy-Improved Spider Monkey Optimization (LEACH-ISMO) for routing in WSN. The LEACH algorithm was utilized to designate optimum CH from the network. The ICMO is employed to create optimum route by CHs to BS and fitness functions like energy, distance, and route traffic are considered for enhance ISMO. The LEACH-ISMO helps to diminish the nodes energy consumption. However, the performances of WSN are mostly pretentious because of unsuitable fitness function selection and it diminishes WSN lifetime.

Mohanadevi and Selvakumar [20] presented a Quality of Service-aware Multipath Routing (QMR) method for clustering and routing in WSN. The hybrid Cuckoo Search and Particle Swarm Optimization (PSO) was utilized for clustering SNs and choosing CHs to ensure sure reliability of data delivery. The introduced protocol utilized various paths to deliver data packets and contained highly manageable over-data traffic in a network. The introduced model minimized the consumption of energy with a network. However, it failed to consider the fitness function of energy and distance which caused a packet drop in the network.

Udaya Suriya Rajkumar D [21] implemented a Hierarchical Secured Energy Efficient Routing Protocol (HSEERP) for cluster-based routing in WSN. The implemented model has designated a best route between two nodes to enabling extension for selecting network route. It was sufficiently resistance for small particular threats that contains entire traffic attributes through malicious nodes. The HSEERP has optimized energy consumption however this method

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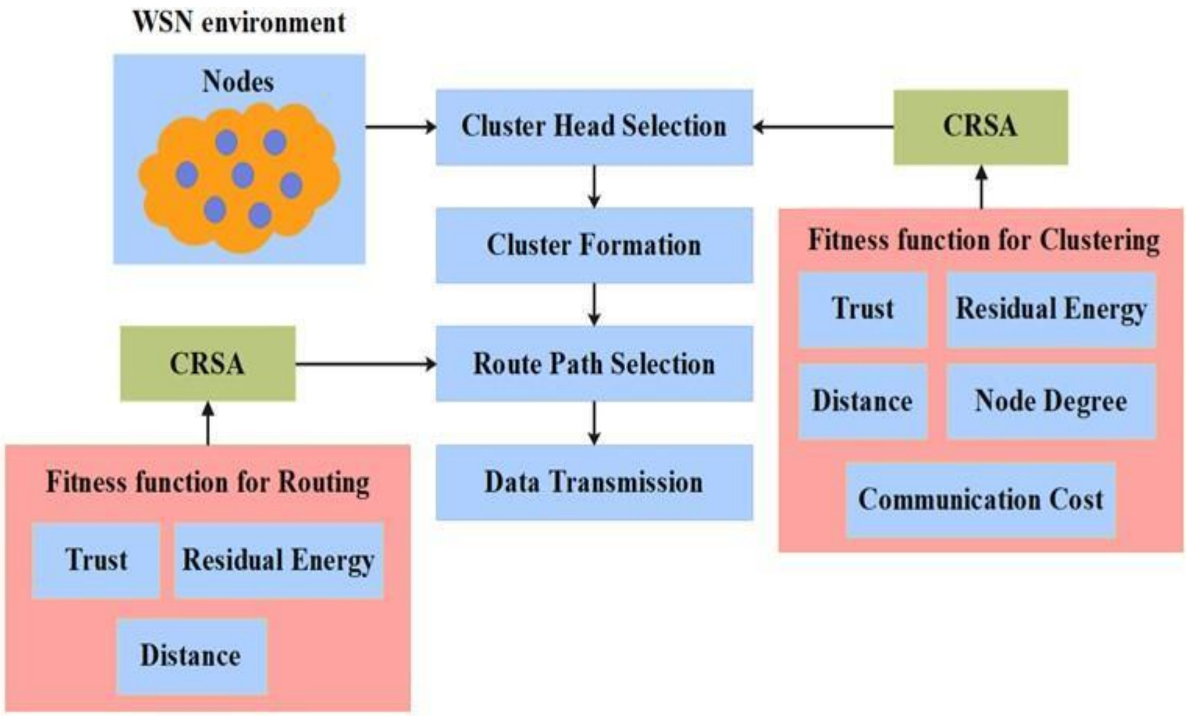

Figure. 1 The process of CRSA in IoT based WSN

fails to consider the network lifetime.

3. Proposed methodology

In this research, secure and reliable communication is made by utilizing Chaos Reptile Search Algorithm (CRSA). The CRSA has four phases like SNs deployment, CH selection, cluster formation, and path selection. To evade malicious attacks while transmitting data packets, the CH and path selection is employed. Therefore, the unwanted data packets and energy consumption are diminished by CRSA. Fig. 1 presents overall process of CRSA in IoT-based WSNs.

3.1. Sensor deployment

Firstly, nodes are positioned in WSN randomly, and then optimal CHs and routes are designated through CRSA that helps to attain secure and reliable data transmission in a network.

3.2. CH selection using CRSA

The CH from normal nodes is recognized through the Chaos Reptile Search Algorithm (CRSA) with various fitness measures. The CH selection is important for optimizing energy utilization and enhancing data transmission and reliability which impacts overall performance. The optimization algorithm is utilized to find the most suitable nodes to act as CH for enhancing model performance. The RSA is a metaheuristic optimization algorithm [22] that is inspired by the encircling and hunting behaviour of Crocodiles in nature. Crocodiles are semi-aquatic reptiles with exclusive characteristics like lined body shape, swimming, capability to lift their legs to a side when walking, and belly walking which enables them to become a dominant hunter in the wild. The CRSA is utilized to overcome issues of inefficient search processes and local optima issues. The random numbers are generated by iterating a special chaotic map in RSA. When the random number generation is required in the RSA from the first iteration, the designated chaotic map is innovative from the designated primary point. The CRSA work is based on two stages such as encircling (exploration) and hunting (exploitation).

3.2.1. Initialization

The RSA is initialized through stochastically producing a set of primary solution candidates by Eq. (1),

$$x_{ij} = rand \times (U_b - L_b) + L_b \quad j = 1,2,\dots,n \quad (1)$$

Where, x_{ij} is an initialization matrix, $i = 1,2,\dots,P$. The n is a dimension of an optimization problem and P is the size of the population. The $rand$, U_b and L_b are the random number, upper and lower bound limits respectively.

3.2.2. Exploration stage

In an exploration, the two strategies of Crocodiles are performed such as high and belly walking. These activities denote various techniques that are committed to present an exploration ability of an algorithm. The activities prevent catching the prey because of the noise until it utilizes another search mechanism, but the exploration stage determines the wide search space. At the exploration stage, the location is updated through Eqs. (2) and (3),

$$x_{ij}(\tau+1) = Best_j(\tau) \times \left(-\mu_{(i,j)}(\tau)\right) \times \beta\left(R_{i,j}(\tau) \times rand\right), \qquad \tau \leq \frac{T}{4} \tag{2}$$

$$x_{ij}(\tau+1) = Best_j(\tau) \times x_{(r1,j)} \times ES(\tau) \times rand, \qquad \tau \leq 2\frac{T}{4} and\ \tau > \frac{T}{4} \tag{3}$$

Where, $Best_j(\tau)$ is an optimum solution obtained at position j, $rand$ is a random number, β is a critical parameter, τ and T is a current and maximum number of iterations, $r1$ is a random number within the range of 1 and N, ES is an Evolutionary Sense, $\mu_{(i,j)}$ is a hunting operator value of solution i at position j. The value of $\mu_{(i,j)}$ is discovered by Eq. (4), the $R_{(i,j)}$ is utilized to minimize a search space area which is estimated through Eq. (5), and the ES is designed by Eq. (6),

$$\mu_{(i,j)} = Best_j(\tau) \times \mu_{(i,j)} > 2\frac{T}{4} \tag{4}$$

$$R_{(i,j)} = \frac{Best_j(\tau) - P_{(r2,j)}}{Best_j(\tau) + \varepsilon} \tag{5}$$

$$ES(\tau) = 2 \times r3 \times \left(1 - \frac{1}{T}\right) \tag{6}$$

Where, r2, $r3$ are random numbers within 1 and N, N is a number of candidate solutions, ε is a small magnitude value. The $P_{(i,j)}$ is calculated through Eqs. (7) and (8),

$$P_{(i,j)} = \alpha + \frac{x_{(i,j)-M(x_i)}}{Best_j(\tau)x\left(U_{b(j)} - L_{b(j)}\right) + \epsilon} \tag{7}$$

$$M(x_i) = \frac{1}{n}\sum_{k=1}^{n} x_{(i,j)} \tag{8}$$

Where, α is a sensitive limit that manages the exploration accuracy, $M(x_i)$ is an average position of solution i, $U_{b(j)}$ and $L_{b(j)}$ is an upper and lower boundary at position j, and the ϵ is a small magnitude value.

3.2.3. Exploitation stage

In an exploitation, the two strategies such as hunting coordination and cooperation are utilized to locally traverse search space and assist in finding an optimal solution. The coordination is accomplished for iterations within the range of $\tau \leq 3\frac{T}{4} and\ \tau > 2\frac{T}{4}$, whereas the cooperation is accomplished within $\tau \leq T\ and\ \tau > 3\frac{T}{4}$. The stochastic coefficients are utilized to transverse the local search space for producing an optimum solution. At the exploitation stage, the location is updated through Eqs. (9) and (10),

$$x_{ij}(\tau+1) = Best_j(\tau) \times \left(P_{(i,j)}(\tau) \times rand\right), \qquad \tau \leq 3\frac{T}{4} and\ \tau > 2\frac{T}{4} \tag{9}$$

$$x_{ij}(\tau+1) = Best_j(\tau) - \mu_{(i,j)}(\tau) \times \varepsilon - R_{i,j}(\tau) \times rand, \qquad \tau \leq T\ and\ \tau > 3\frac{T}{4} \tag{10}$$

Where, $Best_j(\tau)$ is the best solution for the present iteration at position j, $\mu_{(i,j)}$ is a hunting operator, ε is a small magnitude value and $rand$ is a random number. here, the $rand$ of Eqs. (2) and (3) are taken as R^0 and Y^0 correspondingly. $R^{t+1} = CM_{type}(R^t)$ and $y^{t+1} = CM_{type}(Y^t)$. The CM is the chaotic map which produces a chaotic number concerning the designated random number ($R^0 and\ Y^0$) and an iteration. The $type$ denotes the chaotic map type. Hence, the R^{t+1} and Y^{t+1} generates the chaotic sequences based on the designated chaotic map. The reptile in the RSA will be utilized to set a food-seeking for food and the respective chaotic map is utilized rather than a random number generator. The chaotic map is utilized to improve the primary data values that output in different system behaviors. The RSA utilizes the chaotic map in every iteration when an agent is far away from a search space. The CRSA enhances the algorithm performance to perform better exploitation and avoid local optima issues. After the CH selection, fitness functions are utilized to determine the CHs from a network which is presented in the following section.

3.3. Fitness function estimation

The fitness function of CH and route path discovers the extent to which the energy consumption is reduced and coverage is enhanced. It enables the quantification of enhancing network lifetime, optimizing coverage and reducing energy consumption which provides conditions for measuring the performance of various solutions. The fitness function utilized to select CH through CRSO is trust (ff_1), residual energy (ff_2), distance (ff_3), communication cost (ff_4) and node degree (ff_5). The fitness function is changed into one objective function (F) and it is mathematically presented in Eq. (11),

$$F = \gamma_1 \times ff_1 + \gamma_2 \times ff_2 + \gamma_3 \times ff_3 + \gamma_4 \times ff_4 + \gamma_5 \times ff_5 \quad (11)$$

Where, F denotes the overall fitness function, $\gamma_1, \gamma_2, \gamma_3, \gamma_4$ and γ_5 are the weight metrics utilized for each fitness function. The fitness functions for CRSO are described in the following subsections:

3.3.1. Trust

Trust is an important factor to stronger the trust against malicious actions in CH selection and discussion is accomplished through trust. It is measured depending on the behaviour of the packet forwarder ratio which is the ratio between a number of forwarded and received packets. The trust value (ff_1) is estimated through Eq. (12),

$$ff_1 = \frac{FP_{i,j}}{RP_{i,j}} \quad (12)$$

Where, $FP_{i,j}$ and $RP_{i,j}$ are presents the number of forwarded and received packets among nodes i and j.

3.3.2. Residual energy

The CH utilizes high energy for data collection, processing, transmission, and path selection due to a node by huge energy being considered for route path. The residual energy (ff_2) is estimated through Eq. (13),

$$ff_2 = \sum_{i=1}^{D} \frac{1}{E_{CH_i}} \quad (13)$$

Where, E_{CH_i} is a remaining energy of ith CH.

3.3.3. Distance

The WSN consumes high energy when transmitting data into CH and BS, the energy consumption is directly proportional to transmitted energy. So, it required to select CH with less distance from BS. The distance (ff_3) is estimated through Eq. (14),

$$ff_3 = \sum_{i=1}^{D} dis(CH_i, BS) \quad (14)$$

Where, $dis(CH_i, BS)$ is the distance between ith CH and BS.

3.3.4. Communication cost

The data is transmitted by power that is directly proportional to a square of distance between source and candidate nodes. The communication cost (ff_4) is estimated through Eq. (15),

$$ff_4 = \frac{d_{avg}^2}{d_0^2} \quad (15)$$

Where, d_0 is a distribution radius of the node, d_{avg} is an average distance among nodes and its neighbours.

3.3.5. Node degree

The node degree is an essential element in the next-hop selection. The performance of nodes is stable for a long time when less node degree is selected as the next hop and it has fewer data from its members. The node degree (ff_5) is estimated through Eq. (16),

$$ff_5 = \frac{1}{\sum_{i=1}^{m} l_i} \quad (16)$$

Where, l_i is a number of nodes in ith cluster. The trust is utilized to reduce the packet drop and unnecessary energy consumption. The residual energy is employed to avoid node failure and the distance is utilized to reduce the transmission distance. In communication cost, the minimum energy SNs progresses a node failure. The distance among CH and BS is utilized to obtain short path that diminishes energy consumption. Additionally, node failure is utilized to enhance energy efficiency when improving network security against malicious attacks. By utilizing these fitness functions, CH and route path are selected. After selecting CH, the cluster formation process is initialized which is given in the next section.

3.4. Cluster formation

In cluster formation, all the active nodes transfer the control packet to the sink node to be part of the cluster. In the process of cluster formation, the SNs are utilized for choosing CH. It is formed by residual energy and distance, the sensor potential is considered during cluster generation which is given in Eq. (17),

$$Sensor\ potential\ (s_i) = \frac{E_{CH}}{dis(s_i, CH)} \quad (17)$$

Table 1. Parameters for simulation

Parameters	Values
Area	1000m × 1000m
Simulation time	100s
Initial energy	50J
Packet size	512 bytes
Number of Nodes	100, 200, 300, 400 and 500

Table 2. PDR (%) vs No. of nodes

No. of Nodes	PDR (%)				
	HSA	GOA	SSA	RSA	CRSA
100	96.87	97.53	98.67	99.26	99.75
200	96.28	97.12	98.35	98.68	99.24
300	95.71	96.43	97.61	98.15	98.51
400	95.19	96.35	97.18	97.44	97.86
500	94.64	95.82	96.47	96.76	97.12

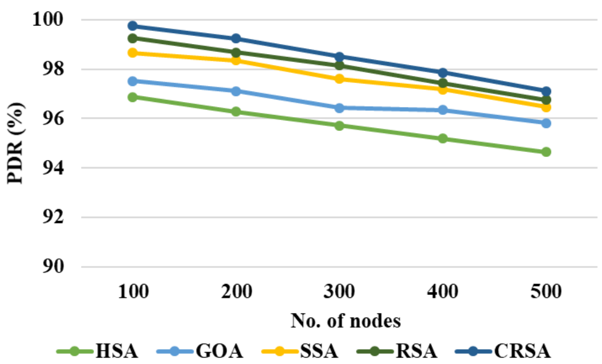

Figure. 2 PDR (%) vs No. of nodes

Where, E_{CH} is a CH energy and $dis(s_i, CH)$ is a distance among ith sensor and CH.

3.5. Route path selection using CRSA

After the cluster formation, the route path selection process is initialized which is a process for selecting a suitable path for transmitting data into source to destination. The route path is chosen by CRSA, in which path formation of CH to BS is considered as final gateway. The fitness like trust, residual energy and distance are considered for path formation. Therefore, the CRSA is effective for data transmission, diminished energy consumption, and maximizes WSN lifetime. The route path selection steps are given below:

- The paths from CH to BS are considered as the initial solution for designate route paths. Each result dimension is equivalent to several CHs in the route path.
- Additionally, the fitness like trust, residual energy, and distance are considered to update a position which is presented in Eq. (18). The location update of path selection is accomplished depending on CRSA iterations.

$$fitness = \delta_1 \times \frac{FP_{i,j}}{RP_{i,j}} + \delta_2 \times \sum_{i=1}^{D} \frac{1}{E_{CH_i}} + \delta_3 \times \sum_{i=1}^{D} dis(CH_i, BS) \quad (18)$$

Where, δ_1, δ_2 and δ_3 are weighted parameters given for each route path generation. It aids in recognizing a path through huge energy by minimum distance and communication cost. Thus, SNs consumes less energy by CRSA-based routing which assists in prolonging a network lifespan.

4. Experimental result

The performance of CRSA is stimulated through MATLAB R2020a with a system requirement of the Windows 10 operating system, 6GB RAM, and i5 processor. The CRSA comprises 100-500 nodes disseminated in $1000m \times 1000m$ area. Table 1 shows simulation parameters of the CRSA algorithm.

4.1. Performance analysis

The CRSA performance is assessed by metrics like PDR, throughput, delay, and energy consumption. The existing algorithms utilized to evaluate the proposed CRSA are the Harmony Search Algorithm (HSA), Grasshopper Optimization Algorithm (GOA), and Sparrow Search Algorithm (SSA) which is developed for a similar specification to the proposed CMFO algorithm.

4.1.1. Packet delivery ratio

It is an amount of received packets at a destination which is divided by no. of packets transmitted to source. The numerical expression is presented as Eq. (19).

$$PDR = \frac{\sum Packet\ received}{\sum Packet\ transmitted} \quad (19)$$

Table 2 and Fig. 2 presents CRSA performance with the metrics of PDR. The CRSA achieved high PDR of 99.75%, 99.24%, 98.51%, 97.86% and 97.12% for 100-500 nodes. The CRSA achieves better when compared to existing algorithms like HAS, GOA, SSA and RSA that achieves less PDR for different nodes.

4.1.2. Throughput

It is demarcated as an amount of delivered packets into destination node from source. Numerical expression is presented as Eq. (20),

Table 3. Throughput (Mbps) vs No. of nodes

No. of Nodes	Throughput (Mbps)				
	HSA	GOA	SSA	RSA	CRSA
100	0.926	0.947	0.968	0.975	0.983
200	0.918	0.933	0.945	0.963	0.976
300	0.907	0.925	0.931	0.958	0.967
400	0.892	0.918	0.924	0.937	0.951
500	0.881	0.894	0.916	0.921	0.935

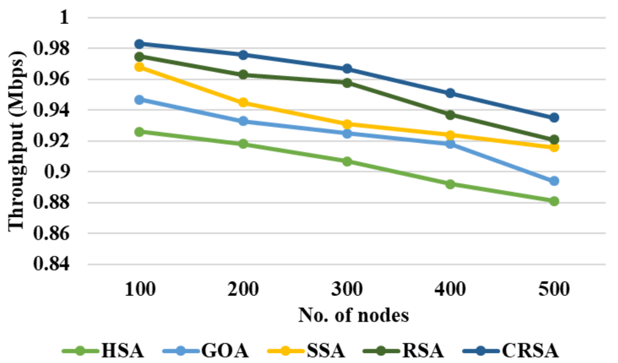

Figure. 3 Throughput (Mbps) vs No. of nodes

Table 4. Delay (ms) vs No. of nodes

No. of Nodes	Delay (ms)				
	HSA	GOA	SSA	RSA	CRSA
100	6.53	5.84	4.76	3.51	2.59
200	7.46	6.51	5.42	4.65	3.17
300	8.71	7.63	6.71	5.12	3.68
400	9.62	8.42	7.64	6.43	4.35
500	11.14	9.76	8.15	7.59	5.61

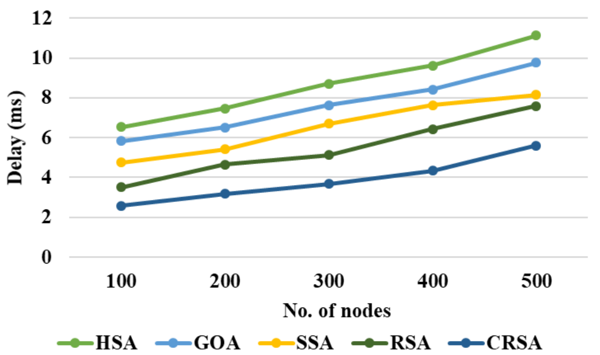

Figure. 4 Delay (ms) vs No. of nodes

$$Throughput = \frac{Delivered\ Packets}{Simulation\ Time} \quad (20)$$

For $0\ to\ 50$ rounds a single model reaches mean throughput values.

Table 3 and Fig. 3 presents CRSA performance with the metrics of throughput. The CRSA achieved high throughput of 0.983Mbps, 0.976Mbps, 0.967Mbps, 0.951Mbps, and 0.935Mbps for 100-500 nodes. The CRSA achieves better when compared to existing algorithms like HAS, GOA, SSA and RSA that attains less throughput for different nodes.

Table 5. Energy Consumption (mJ) vs No. of nodes

No. of Nodes	Energy Consumption (mJ)				
	HSA	GOA	SSA	RSA	CRSA
100	39.65	35.51	31.63	28.71	26.68
200	42.86	37.42	34.56	31.54	29.51
300	45.71	41.28	37.38	34.69	31.46
400	47.38	45.73	40.52	37.51	35.73
500	51.29	48.61	44.12	40.82	38.16

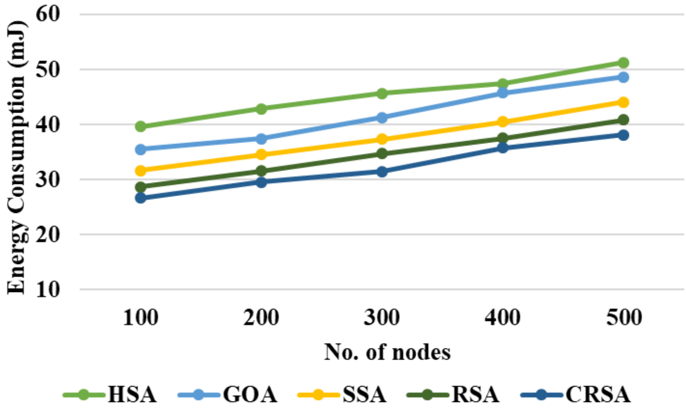

Figure. 5 Energy Consumption (mJ) vs No. of nodes

4.1.3. Delay

It is specified as time considered to sending data packets from source to destination. The numerical expression is presented as Eq. (21),

$$Delay = \frac{\sum Transaction\ time - Receiving\ time}{F} \quad (21)$$

Where, F is a number of nodes in network.

Table 4 and Fig. 4 presents CRSA performance with the metrics of delay. The CRSA achieved less delay of 2.59ms, 3.17ms, 3.68ms, 4.35ms and 5.61ms for 100-500 nodes. The CRSA achieves better when compared to other existing algorithms like HAS, GOA, SSA, and RSA that attain high delay for different nodes.

4.1.4. Energy consumption

It is an amount of energy consumed for data transmission through nodes. It is estimated through each set of transmissions at a certain time.

Table 5 and Fig. 5 presents CRSA performance with the metrics of energy consumption. The CRSA achieved a less energy consumption of 26.68mJ, 29.51mJ, 31.46mJ, 35.73mJ, and 38.16mJ for 100-

Table 6. Comparative Analysis

Performance Metrics	Methods	No. of nodes		
		100	200	300
PDR (%)	IMD-EACBR [16]	98.83	98.46	98.03
	EACMRP-MS [17]	99.68	98.96	98.24
	IDTOMHR [18]	96.28	95.90	94.78
	LEACH-ISMO [19]	98.9	96.7	95.2
	QMR [20]	94.51	91.87	89.65
	HSEERP [21]	97.7	96.5	95.3
	Proposed CRSA	**99.75**	**99.24**	**98.51**
Throughput (Mbps)	IMD-EACBR [16]	0.975	0.958	0.945
	EACMRP-MS [17]	0.97	0.89	0.78
	HSEERP [21]	0.961	0.957	0.936
	Proposed CRSA	**0.983**	**0.976**	**0.967**
Network Lifetime (rounds)	IMD-EACBR [16]	1719	2135	2590
	EACMRP-MS [17]	5535	5487	5165
	Proposed CRSA	**5867**	**5673**	**5539**
Energy consumption (mJ)	EACMRP-MS [17]	29.70	54.76	76.70
	Proposed CRSA	**26.68**	**29.51**	**31.46**

500 nodes. The CRSA achieves better when compared to existing algorithms like HAS, GOA, SSA and RSA that consumes high energy for different nodes.

4.2. Comparative analysis

The CRSA performance is compared with existing algorithms like IMD-EACBR [16], EACMRP-MS [17], IDTOMHR [18], LEACH-ISMO [19], QMR [20] and HSEERP [21] that is given in table 6. The CRSA obtained high PDR of 98.83%, 98.46%, 98.51% and throughput of 0.975Mbps, 0.958Mbps and 0.967Mbps for 100-300 nodes respectively. The CRSA is employed to enhance the robustness against malicious attacks, which improves data delivery and life span of WSN.

4.3. Discussion

The advantages of CRSA and limitations of existing algorithms are deliberated in this section. The existing algorithms has feq limitations such as IMD-EACBR [16] utilizing a huge number of control packets in route path selection which leads to an increase in the delay. In EACMRP-MS [17], the CH selection mostly depends on the energy, distance, and delay only. The IDTOMHR [18] examined only a smaller number of sensor nodes. The LEACH-ISMO [19] does not consider delay and communication costs when data broadcasting. The QMR [20] failed to consider the fitness function of energy and distance which caused a packet drop in the network. The HSEERP [21] failed to consider the network lifetime which affects the model performance. The CRSA tackles these existing algorithm limitations. The CMSA obtained less delay because of less usage of data packets and short path generation in route path selection.

5. Conclusion

The Chaos Reptile Search Algorithm (CRSA) is proposed in this research to perform clustering and routing in IoT based WSN. The CRSA is employed to ensure CH and route path to attain reliable data transmission over WSN. Main objective of CRSA is to achieve efficient data transmission when enhancing the lifespan of WSNs. The CMSA attained less delay because of the less usage of data packets and short path generation in route path selection. The fitness like trust, residual energy, delay, communication cost, and node degree are utilized for selecting CH and route paths in WSN. The CRSA performance is assessed through PDR, throughput, delay and energy consumption. The CRSA obtained high PDR of 99.75%, 99.24% and 98.51% for 100, 200 and 300 nodes which is better when compared to IMD-EACBR, EACMRP-MS, IDTOMHR, and LEACH-ISMO. In future, hybrid optimization algorithms will be used to improve the performance of IoT-based WSNs.

Notation

Notation	Description
x_{ij}	Initialization matrix
n	dimension of an optimization problem
P	Population size
$rand$	Random number
U_b	Upper bound limits

L_b	Lower bound limits
$Best_j(\tau)$	Optimum solution obtained at position j
β	Critical parameter
τ	Current number of iterations
T	Maximum number of iterations
ES	Evolutionary Sense
$\mu_{(i,j)}$	Hunting operator value of solution i at position j
$r1, r2$ and $r3$	Random numbers within the range of 1 and N
N	Number of candidate solutions
ε	Small magnitude value
α	Sensitive limit
$M(x_i)$	Average position of solution i
$U_{b(j)}$ and $L_{b(j)}$	upper and lower boundary at position j
CM	Chaotic map
$type$	Chaotic map type
$\gamma_1, \gamma_2, \gamma_3, \gamma_4$ and γ_5	Weight metrics
$FP_{i,j}$ and $RP_{i,j}$	Number of forwarded and received packets among nodes i and j
E_{CH_i}	Remaining energy of ith CH
$dis(CH_i, BS)$	Distance between ith CH and BS
d_0	Distribution radius of the node
d_{avg}	Average distance between nodes and neighbors
l_i	Number of nodes in ith cluster
δ_1, δ_2 and δ_3	Weight parameters

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

The paper conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, have been done by 1st and 3rd author. The supervision and project administration, have been done by 2nd, 4th, and 5th author.

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