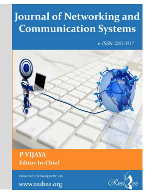
Vol.3 No.3 July 2020

Journal of Networking and Communication Systems

Received 20 June, Revised 6 July, Accepted 13 July



Hybrid Wolf Pack and Particle Swarm Optimization Algorithm for Multihop Routing Protocol in WSN

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Abstract: In the WSNs environment, the methodological development ensued in the process of gathering and forwarding the enormous data among the nodes that is the most important challenges in WSNs as it is related with high energy loss and delay. This ensued in establishment of a routing protocol for the optimally chosen of multipath to development of a routing in WSNs. Hence, this work presents an energy-effectual routing in WSNs utilizing the hybrid Wolf Pack approach with Particle Swarm Optimization (WP-PSO) approach that selects the optimal hops in succeeding the routing. Initially, the CHs are chosen by exploiting the LEACH protocol which reduces the traffic in the network. In the multihop routing, the CHs are engaged, and the selection of the optimal paths is based on the developed hybrid optimization that chooses optimal hops on basis of the energy constraints, namely energy, inter-intracluster distance, link lifetime, delay, and distance. The experimentation outcomes show that developed routing protocol obtained maximum energy, minimum delay, the maximum number of the alive nodes and average throughput.

Keywords: WSN; Clutser Head; Multihop Routing; LEACH; Optimization; Alive Nodes

Nomenclature

Abbreviations	Descriptions
WSN	Wireless Sensor Network
MH	Multihop
BS	Base Station
HABC-MBOA	Hybrid ABC and Monarchy BOA
DT	Direct Transmission
CL-GR	Cross- Layer Greedy Routing algorithm
SN	Sensor Nodes
MCDS-MI	Minimum Connected Dominating Set with Multi-hop Information
MDPSPL	Maximum Distance Forwarding Strategy and the PSPL
HQCA	High-Quality Clustering Algorithm
TDMA	Time Division Multiple Access
BG	Bi-Partite Graph
CHS	Cluster Head Selection
NEAHC	Novel Energy Aware Hierarchical Cluster-Based
AVL	Adelson-Velskii and Landis
WSNs	Wireless Sensor Networks
GPSR	Greedy Perimeter Stateless Routing protocol
LAN	Local Area Network
ABC	Artificial Bee Colony
LEACH	Low-Energy Adaptive Clustering Hierarchy
BOA	Butterfly Optimization Algorithm
GWO	Grey Wolf Optimization
ABC	Artificial Bee Colony
WOA	Whale Optimization Algorithm

1. Introduction

In the field of communications, WSN is obviously considered as the majority of fast-developing networks that lead to the progressions. The cause can be conferred and it depends on the growth of complicated,

https://doi.org/10.46253/jnacs.v3i3.a5

minimized and inexpensive sensor devices which show the capability to sense diverse kinds of environmental and physical parameters, dispensation it and data transmission wirelessly [1].

A WSN consist of spatially distributed individualistic sensors that is exploited to scrutinize environmental otherwise physical circumstances, namely, vibration, acoustic pressure, and parameters of temperature to synchronically allow their data during the main position that is the BS crosswise the network [12]. In general, WSNs comprises of the enormous count of nodes that are encompassing a power resource by means of restricted energy [13]. As energy required imparting sensed data packets to BS is high, consequently, a routing protocol that is energy competent is obligatory. The routing protocols are necessary to construct paths for communication among BS and SNs [5] [14]. Hence, too strongly and competently broadcast the data from nodes to BS turns out to be the maximum dangerous job of these sensor networks. Recently, several routing protocols were developed which employ the resources competently, decisively enhancing the network's lifetime [11].

The clustering methods use the probability value to structure CH that is able of communicating only with other nodes deceitful in a small range [15]. Hence, Multi-Hop routing helps to route in the network further than the communication range that is constrained by the energy factor. Conversely, minimization of delay, other than energy utilization is maximum; therefore, the routine stores the energy [3]. Hence, the researchers aspire towards raising an energy-competent routing protocol. Existing routing algorithms are categorized as Multi-Hop transmission and DT. The nodes converse directly with the Base Station in DT, while in Multi-Hop, communication distance is subcategorized and the communication engages intermediate nodes consequently that the least amount of energy, and delay, is definite. On the basis of the hop number, the transmissions of Multi-Hop are categorized as long-hop and short-hop routing [2] [10].

Motivation:

The CHS problem is considered to be a significant problem, as it is obligatory to balance energy utilization in the network. Also, the often CHS is one more problem that requires to be extremely concentrated, as frequently the CHS guide to energy imbalance and reduced network lifespan. The mass of Cluster Head Selection models is not able of behind in supporting the balance among the exploration and exploitation.

The most important intention of the work is to propose hybrid optimization named WP-PSO for multi-hop routing in Wireless Sensor Network. The developed method, WP-PSO which is the combination of the WP and PSO, aspires to decide the optimal hops to perform the multihop routing in Wireless Sensor Network. The optimal hop selection is on the basis of objective function based on constraints, like distance, inter-intracluster distance, energy, delay, and link lifetime.

2. Literature Review

In 2017, Wang Ke et al [1], developed a NEAHC routing protocol by means of two objectives such as reducing the total energy utilization and assuring the evenhandedness of energy utilization among nodes. The relay node selecting issue as a nonlinear programming issue was modeled; convex function property was used to discover the best solution. In 2017, Ramnik Singh and Anil Kumar Verma [2], presented a routing protocol for heterogeneous networks. The conception of weighted probability was exploited to allocate the CH of the network cluster. The developed method was experimented, verified, and evaluated with conventional routing protocols and has shown improved outcomes and extended the lifetime of the network. An integration of reactive and the proactive network was contemplated for effectual transmission of data in the developed protocol. In 2017, Ali Benzerbadj et al [3] developed a CL-GR that set up an accurate location-based routing on an N-UDG. It presents two novels greedy routing schemes, called correspondingly Progress towards the base station during Symmetrical links which set up the lowest Path Loss (PSPL) and improvement via symmetrical links, integrating the MDPSPL. A superior version of the Greedy approach of GPSR was compared and evaluated. In 2019, Amir AbbasBaradaran and KeivanNavi[4], developed an algorithm named the HQCA to generate extensive-quality clusters. The HQCA algorithm exploits a principle to measure the cluster quality that can progress intra and inter-cluster distances and the error rate was minimized in clustering. On the basis of the fuzzy logic, the optimal CH was chosen consistent with diverse criteria like the remaining energy, the least, and utmost energy in every cluster, and the least and utmost distances among the nodes in every cluster and the BS. Also, the strength of the clustering quality was measured on the basis of the internal and external criterion. In 2019, Bandi Rambabu et al [5], developed a HABC-MBOA-based CHS method for the principal CHS in the clustering procedure. This developed HABC-MBOA restores the employee bee stage of ABC with a mutated butterfly adjusting operator of MBOA to prevent the previous trapping of solutions. This developed method plays a fasten role to eliminate the insufficiency of the ABC method towards global search possible.

In 2018, R. Raj Priyadarshini and N. Sivakumar [6], simulated in the AVL tree rotation clustering method, which considers the cluster sensor node to achieve load balance. By exploiting the enhanced K-means clustering method a solitary LAN was separated into several clusters. Computational complexity was minimized during the building of MCDS-MI and cover as the BG model. CH variety technique was applied to discover the utmost set number of sensor nodes. Moreover, the performance of the prediction model was set up during experimentations in the scalable transmission of data in a WSN.

3 Developed Algorithm for Multi-Hop Routing in WSN

In WSNs, multihop routing assures the security for data transmission in the network and minimizes loss of information happening in transmission. Furthermore, to reduce the loss of energy through transmission and augment the network lifetime, work develops hybrid optimization approach exploited WP and PSO approaches. There are 2 main steps such as the initial step is the selection of CH exploiting the LEACH clustering approach which devises the optimal clusters, and in the next step, optimal hops are selected exploiting the adopted technique that functions on the basis of the objective function modeled, based upon the link lifetime energy, distance, delay, intercluster and intracluster distances. Fig. 1 exhibits the hybrid optimization-based multihop routing in WSNs. The hybrid algorithm to tune the optimal hops is a combination of the Wolf Pack Approach approach by means of the Particle Swarm Optimization hence the disadvantages of PSO concerning the convergence to the global optimal solution are solved via combing WPA which produces a global optimal solution by means of superior convergence rates.

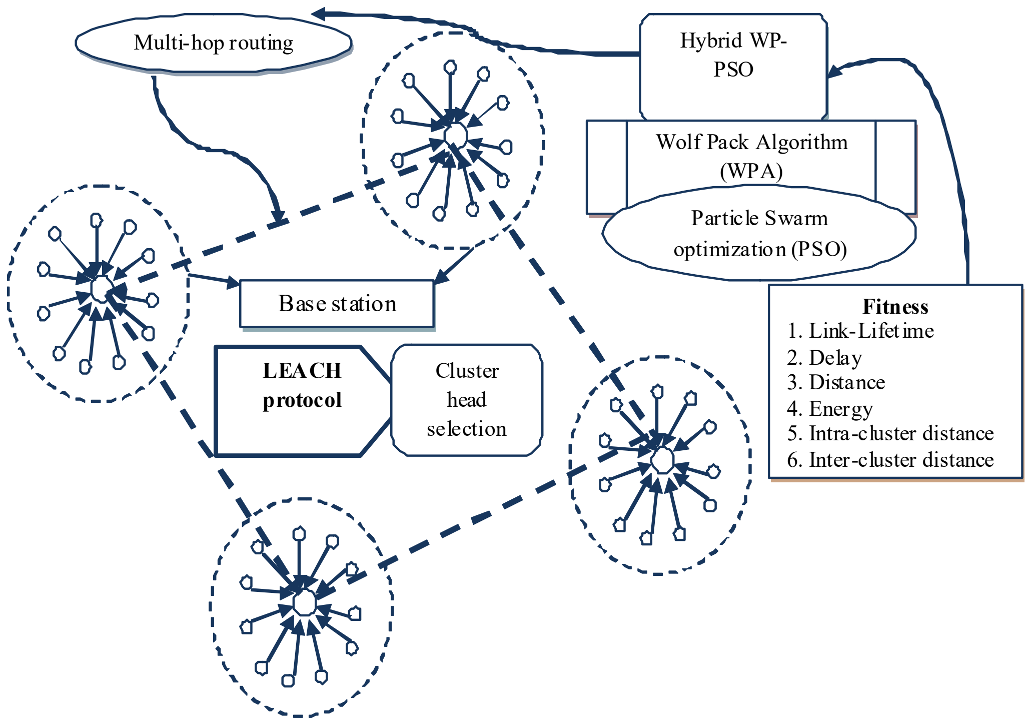

Fig. 1. *System model of the hybrid optimization algorithm for multihop routing*

3.1 LEACH Clustering Protocol for CHS

The LEACH protocol decides the cluster heads, and the benefits of exploiting LEACH: the lifetime of the network is concerted and augmented and there is no requirement for the information concerning the node location. The nodes are entirely distributed and for this reason, do not necessitate any control information from the base station and network global information in LEACH. Also, exploiting the LEACH makes easy the aggregation of gathered data in CH which reduces traffic in the network. LEACH is a MAC protocol that presumes a homogenous network of nodes that busy gathering data and transferring to the base station. As the nodes devour great number of energy, LEACH consistently gives out energy in nodes hence a load of energy is reduced. For few rounds, LEACH protocol is iterated till the best cluster head is decided and the rounds are restricted to $1/r$. For each round, individual cluster heads are selected, obtaining the size of $s\,r$. r indicates the best percentage of cluster heads, and s indicates to total nodes in the cluster. The rounds are categorized as 2 stages namely steady and setup stage. The main contribution of the setup phase is concerning cluster formation by choosing a cluster head for the individual clusters on the basis of the utmost energy accessible in the node. The cluster head selection is sustained so the exacting node not at all served as a CH before preceding iterations. Conversely, a node can take action as a cluster head merely after all nodes in the environment act as a cluster head for a minimum of no less than once in their lifespan. The circumstance for a node to turn out to be a cluster head is on basis of the threshold that ought to be higher than the number identifies update interval of the present topology.

The threshold is calculated exploiting the eq. (1).

$$Tr = \begin{cases} \dfrac{r}{1 - r \times \left(a \bmod \dfrac{1}{r} \right)}; \text{ if } s \in \tau \\ 0 \ ; \text{otherwise} \end{cases} \tag{1}$$

In eq. (1), r indicates the optimal percentage of Cluster head, τ denotes the nodes which not at all stayed as the cluster head and r indicates the necessary percentage of cluster heads. a indicates to number which represents the update interval of present topology. Next stage called steady stage, the data aggregation and transmission are deal that gets extended period evaluated by means of the setup stage. The succeeding steps of the LEACH clustering protocol are stated as below.

3.1.1 Advertisement stage

At first, every node in the environment determines whether to turn out to be the cluster head or not on the basis of the eq. (1), and based upon the number of rounds, the node is selected as cluster head. The choice is done during an assortment of the number that lies among 0 and 1. When chosen number lies under the threshold, subsequently node could turn out to be the cluster head. Hence, after the cluster head selection, the nodes are well-versed concerning the CH in an environment that can not at all turn out to be the cluster head for an exacting round, stating balance in energy utilization.

3.1.2 Cluster setup stage

Also, every node replies to the cluster head advertisement to inform their membership in the exacting cluster head in the environment. It is attractive to a reminder that cluster member controls off transmitter if not there is a requirement to data transmission to CHs to save energy. From all nodes in the setup stage, the receiver of the cluster heads is switched on to obtain the request message.

3.1.3 Broadcast schedule stage

From all nodes, messages are received in the cluster head concerning a request for membership in the exacting cluster. The cluster head produces a TDMA schedule based upon the total nodes in the cluster and transfers schedule to all nodes in the cluster. The schedule repeats node concerning time to transmit messages in exacting clusters.

3.1.4 Data transmission stage

After the setting up of TDMA, the transmission of data starts, and previous to the transmission, aggregation of data happens in CH. In a cluster, the aggregated data that owned by = individual nodes are transferred to BS during CH. Eventually, the steps are frequent. Consequently, the cluster heads are decided to exploit the LEACH approach, which aspires at selecting the node on the basis of the nodal energy. The cluster heads produced exploiting the LEACH clustering approach are stated as

$$C = \{C_1, C_2, ..., C_k, ..., C_v\} \tag{2}$$

In eq. (2), v denotes total cluster heads resulting using LEACH that enhances the network lifetime.

4. Hybrid Optimization Method for MH Routing

In WSN hybrid Wolf pack and Particle Swarm optimization method derives the optimal hops to development routing. The section states hybrid optimization, and the objective model, is exploited to determine optimal hops association in multihop routing.

4.1 WP Algorithm

To pact with function optimization issue, the Wolf Pack approach imitates the hunting wolves' behavior, and categorizes the wolves into three stages: the head, search, and fierce Wolf [8].

The complete hunting behavior of wolves is categorized as 3 types of intelligent behaviors as walking, siege, and summoning, behavior, ``strong survival'' wolf group regeneration and ``conqueror, is king'' head Wolf generation principle method.

4.1.1 Head Wolf Generation Principle

Initial from a preliminary prey pack in space to be searched, a wolf with the optimal value of fitness is chosen as head Wolf.

4.1.2 Walking Behavior

Apart from head Wolf, a total of $N - num$ optimal artificial wolves are chosen to carry out walking behavior as a search Wolf. $N - num$ arbitrarily obtains the integer among $[(\beta+1), n/\beta]$. β indicates the proportion factor of search Wolf, n indicates the total number of artificial wolves.

Initial, the attentiveness of prey smell (X_i) at the present location of the search Wolf (i) is computed. If $X_i > X_{lead}$, subsequently $X_i = X_{lead}$. To be exact, the search Wolf gets put of head Wolf and starts the behavior of summoning. If $X_i < X_{lead}$, subsequently the search Wolf moves forward in g directions independently (at this time step size is named $step_a$). After leaving in q -direction $(q = 1,2,3,.....g)$, location of search Wolf in d -dimensional space is

$$y_{id}^{q} = y_{id} + \sin(2\pi \times q / g) \times step_q^d \tag{3}$$

The search Wolf (i) walks gone awaiting smell attentiveness apparent by one of the search wolves is $X_i > X_{lead}$, otherwise the number of walks (T) is T_{max}.

In the prey search technique, there is dissimilarity for each search Wolf, namely, g value is diverse, and arbitrary integer among $[g_{min}, g_{max}]$ is taken in real circumstances.

4.1.3 Summoning Behavior

For summoning behavior, while head Wolf initiates to howl, inform the surrounding $S - num$

Fierce Wolf to rapidly congregate to head Wolf, whereas

$S - num = n - N - num - 1$; Whilst a fierce Wolf listens to a howl, it speedily moves toward head Wolf at a comparatively extended gallop step (named gallop $step_b$). After that, while the fierce Wolf (j) incidences number of $k+1$ iterations, its location in d dimensional space is stated in eq. (4).

$$y_{jd}^{k+1} = y_{jd}^{k} + step_b^d \cdot \frac{h_d^k - y_{jd}^k}{|h_d^k - y_{jd}^k|} \tag{4}$$

In eq. (4), h_d^k indicates the location of the head wolf in the d -dimensional space of k -generation population.

At some point in running procedure, if smell attentiveness apparent by fierce Wolf (j) is $X_i > X_{lead}$, subsequently $X_i = X_{lead}$, and the fierce Wolf, transforms into head Wolf and starts summoning behavior. If $X_i < X_{lead}$, subsequently fierce Wolf (j) carries on to run, and while the distance (d_{js}) among first Wolf (f) and fierce Wolf (j) is lesser than deciding distance (d_{near}), it refers to siege. The deciding distance (d_{near}) is calculated using eq. (5).

$$d_{near} = \frac{1}{D \cdot \omega} \cdot \sum_{d=1}^{D} |\max_d - \min_d| \tag{5}$$

In eq. (5), D indicates the variable space dimension to be optimized; max_d and min_d indicates the minimum and maximum d -dimensional space values to be optimized. df indicates the decision factor of distance, and its diverse values, will concern the convergence speed of the method. When df raises, the convergence speed of the method can be accelerated, however, if df is too huge, it will create it tricky for artificial Wolf to go into siege behavior and require a fine search for prey.

4.1.4 Siege Behavior

The wolves' manner siege behavior consistent by means of eq. (7). For k -generation of wolves, if a prey location in i -dimension is $H_d^k H_d^k$, subsequently siege wolves behavior stated using eq. (6).

$$y_{id}^{k+1} + \lambda \cdot step_c^d \cdot |H_d^k - y_{id}^k| \tag{6}$$

In eq. (6), $step_c^d$ indicates the attack step used by artificial Wolf (i) to perform siege behavior in the initial d -dimension λ indicates arbitrary number among [-1, 1].

The steps included in 3 types of intelligent behavior are walk step $(step_a^d)$, gallop step $(step_b^d)$, attack step $(step_c^d)$, and they encompass the subsequent association in d -dimensional space.

$$step_a^d = \frac{step_b^d}{2} = 2 \cdot step_c^d = | max_d - min_d | / N \tag{7}$$

In eq. (7), N indicates the step factor.

4.1.5 The Wolf Regeneration Method of Sturdy Survival'

The artificial wolves (A) with the worst objective model value are evaded and A are arbitrarily generated simultaneously. The value of A is an arbitrary integer among $[n/((2\times\alpha)), n/\alpha]$ and α indicates population regeneration scaling factor.

4.2 Algorithm Model

In this work, the hybrid algorithm refers to the WPA [8] and PSO [9]. In addition, the maximum likelihood algorithm is exploited to obtain a solution of l and m, which are GO model parameters [7]. The computation formulation of l is stated in eq. (8).

$$\begin{cases} l = \dfrac{n}{1 - e^{-mt_n}} \\ \dfrac{n}{m} = lt_n e^{-mt_n} \end{cases} \tag{8}$$

In eq. (8), t_i indicates failure time(i); $i = 1,2,3,....n$ n indicates recognized malfunction number. Here, a novel fitness model is designed consistent with the utmost likelihood estimation formulation of parameters l and m of GO technique. The specific technique is to alternate the primary phrase in eq. (8) into the next phrase and perform a mathematical transformation to build a formulation merely associated with the parameter m, as stated in eq. (9)

$$f = \left| m - \frac{n\left(1 - e^{-mt_n}\right)}{nt_n e^{-mt_n} + \left(1 - e^{-mt_n}\right)\sum_{i=1}^{n} t_i} \right| \tag{9}$$

f indicates a new fitness model, all the parameters in the formulation are identified apart from m. The less important f is superior to the consequence of parameter m estimation. In the proposed method iterative search, the best parameter m is obtained while the method stops principle is obtained, and subsequently the equivalent optimal parameter l is attained by alternating the utmost likelihood evaluation formulation of the parameter l. Fig 2 shows the flow chart of the proposed approach.

5. Result and Discussion

5.1 Simulation Model

In this section, outcomes of the multihop routing based on the proposed method besides by means of the relative analysis based on the performance measures to show the efficiency of the developed algorithm. The experimentation was performed with 50 and 100 nodes in the WSN environment. The methods used for the comparison include GWO, WOA and ABC algorithm which are used to compare with the proposed algorithm.

The measures used for investigation are the number of network energy, alive nodes, delay, and throughput, and the developed technique was evaluated with the conventional techniques on the basis of the performance measures. In the WSN environment, the number of alive nodes indicates a number of active nodes. The network energy indicates energy residual in nodes after the conclusion of the transmission, and it must be the utmost value to expand the network lifetime. The network throughput is total data rates transferred over the network within an exacting time, and delay indicates time occupied for data transmission.

5.2 Performance Analysis

Table 1 and 2 shows the analysis of the developed and conventional methods for 50 and 100 nodes. Here, the alive nodes, average throughput, and energy are maximum for the proposed method than the conventional techniques. Additionally, the delay is minimum for the proposed method than the conventional techniques. From tables 1 and 2, it is obvious that the developed technique obtained superior outcomes regarding the performance measures while comparing with the conventional techniques.

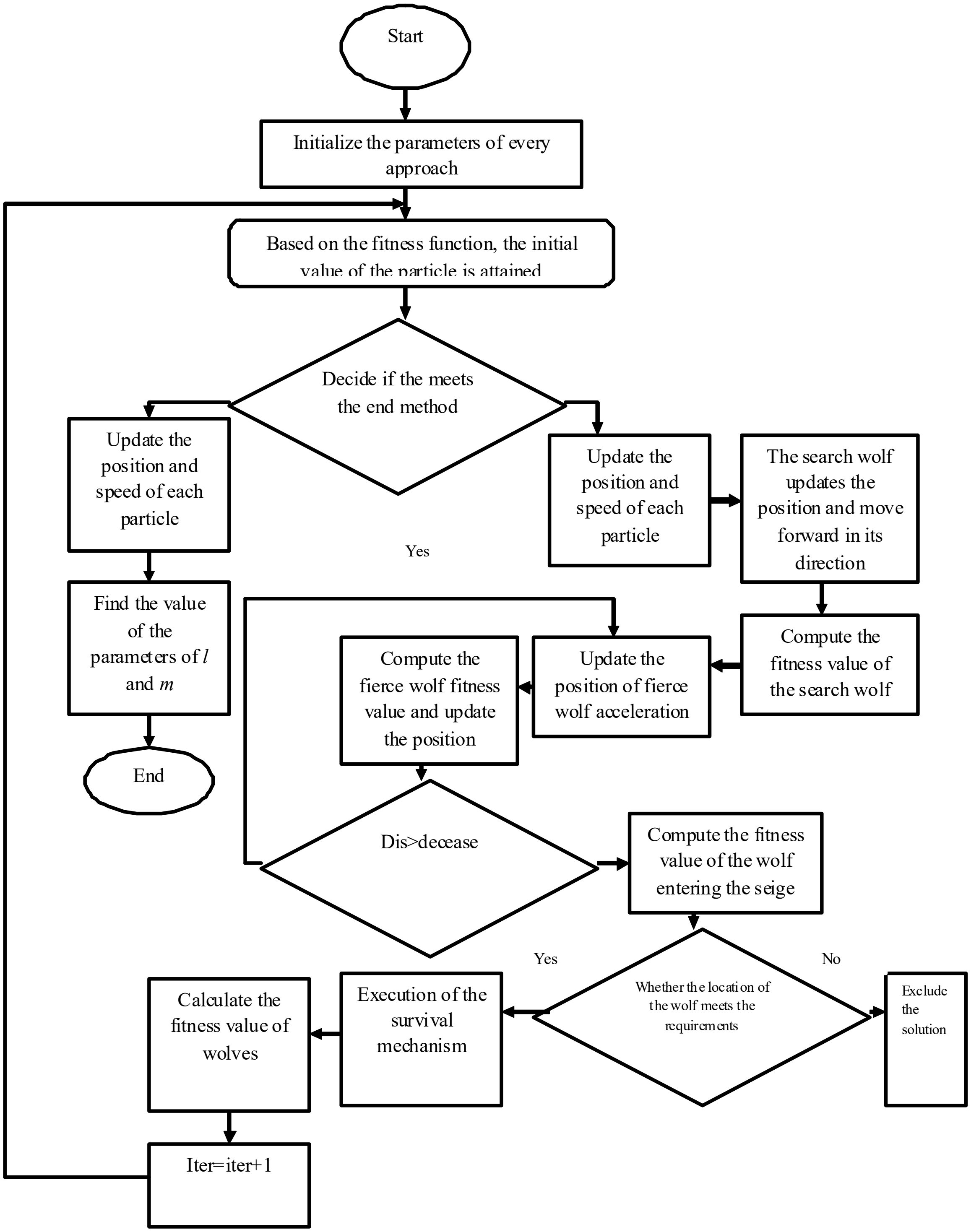

Fig. 2. *Flow chart of the developed technique*

Table 1. *Performance analysis of proposed and conventional algorithms for 50 nodes*

Algorithms	**50 nodes**			
	Alive nodes	Delay	Energy	Average throughput
GWO	21	0.4241	0.0444	0.8221
WOA	16	0.4011	0.0444	0.8227
ABC	4	0.4812	0.0084	0.8247
Proposed	24	0.2164	0.054	0.862

Table 2. *Performance analysis of proposed and conventional algorithms for 100 nodes*

Algorithms	100 nodes			
	Alive nodes	Delay	Energy	Average throughput
GWO	0	0.6227	0	0.7205
WOA	12	0.252	0.0026	0.7204
ABC	25	0.6712	0.0654	0.7205
Proposed	27	0.2022	0.1172	0.7274

6. Conclusion

The MH routing protocol for energy-efficient determines delay and energy confrontation related using communication among hops. This work confirmed an effectual routing protocol exploiting WP and the PSO approach. Initially, the CHs were calculated exploiting the LEACH approach which does not need the a prior information of the network. The CHS attract themselves to forward data packets to the base station, and in Multi-Hop routing, data were forwarded via multiple hops. Nevertheless, optimal hop selection to develop routing in wireless sensor networks was on the basis of the hybrid optimization, called WP-PSO optimization that was the combination of WP and PSO. The developed approach worked on constraints, like intercluster distance, energy, link lifetime delay, intracluster distance, and distance. Moreover, the experimentation outcomes regarding the performance measures show that the developed technique obtained a minimal delay, maximum energy, the maximum number of alive nodes, and average throughput.

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