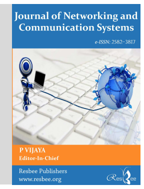
Resbee Publishers

Journal of Networking and Communication Systems

Received 5 May, Revised 25 June, Accepted 3 July



Cluster Based Dense using Hybrid Genetic and Grasshopper Optimization algorithm in WSN

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Abstract: Nowadays, Wireless Sensor Networks (WSNs) play an important role in the communication due to their performance in diverse physical and environmental parameters by using minimum cost sensor devices. Owing to the scientific enhancement, the development of networks is practicable to model the cross-layer protocol on the basis of the energy effectual network. This clearly distresses the extending the lifespan of the network. Hence, this paper tries to develop a new Cross-Layer Design Routing technique in the clustering approach. The developed technique is based upon the cross-layer model through different layers such as physical and network layers. Here, a cluster-based routing model is developed, therefore, an optimal cluster head can be performed by exploiting a novel optimization algorithm named Hybrid Genetic Algorithm (GA) and Grasshopper Optimization Algorithm (GOA). Hence, the extension of the network lifetime can be attained by defining the shortest path. Additionally, based on numerous constraints such as energy utilization, distance, and delay, the optimal cluster head selection is performed. At last, the adopted model performance is confirmed with the existing techniques regarding the lifetime of the network and alive node.

Keywords: Delay, Distance**,** Energy, Lifetime, Network, WSN.

Nomenclature

Abbreviations	Descriptions
ADC	Analog to digital converter
GOA	Grasshopper Optimization Algorithm
BS	Base Station
PSO	Particle Swarm Optimization
WSNs	Wireless Sensor Networks
BOA	Butterfly Optimization Algorithm
ACO	Ant Colony Optimization
VRPDRT	Vehicle Routing Problem with a Demand Responsive Transport
GA	Genetic Algorithm
SUs	Secondary Users
SOA	Sailfish Optimizer Algorithm
ESUCR	Energy and Spectrum Aware Unequal Cluster-Based Routing
Pus	Primary Users
QoS	Quality of Service
TS	Tournament selection

1. Introduction

WSN comprises numerous sensor nodes that are used to sense and distributed in the environment, estimate, and obtain the data. For processing, sensing, and transmitting, these sensor nodes are used which are reasonably priced, and have superior capabilities. In numerous applications, the WSN is exploited such as weather forecasting, medical field, defense, domain, and several industrial and commercial applications. The WSN sensors are dense and exploited a restricted battery as their power source. By exploiting an ADC the sensor gathers and the data processing is performed in order to transmit to the main position which is called BS. For several applications, in order to make a decision, the received data are analyzed at BS. In WSN, the sensor nodes act as a repeater to transfer the information to other sensors and the base station. In addition, the power source of the WSNs must be exploited sufficiently as it cannot be transferred or recharged because of the sensor positioning inthe insensitive and no-man environment [10] [11]. By exploiting several parameters, the WSN model is affected such as scalability, energy efficiency, and fault tolerance. In WSN, the sensor releases its energy in two manners such as environmental parameters sensing and using the nodes for the data transmission to BS. From the environment, the data transmission uses maximum energy than the data sensing and processing in WSN [1].

In order to attain the optimal parameters of QoS, the cross-layer model is deployed. This, sequentially, joins the various communication protocol layers, in order to exchange the information in a non-hierarchal way [2].

Regarding the flat and hierarchical types, the characterization of the routing protocols is performed based on the structure of the network. Each sensor node is required to perform the same role which minimizes the network overhead in proportion to the flat routing protocols. Therefore, it obtains energy efficiencies, scalability, and stability. A cluster-based routing technique obtains its highest impacts on the energy efficiencies of devices while using the hierarchal-based routing protocol [4]

In multi-hoping communication, few methods have developed to minimize the distance covered. In order to set up the multi-hop routing protocols are modelled which act on diverse schemes such as geographic position-based clustering and hierarchy, data-centric. Using the relay nodes, the data-centric protocols start the transmission of the data amid the BS and nodes. Hence, the data redundancy is minimized and also the number of packet transmissions is reduced on the basis of these kinds of protocols. Meanwhile, the network scalability is minimized by exploiting these protocols. On the basis of the sensor nodes' position, the geographic protocols transfer the data packets to the BS. Moreover, one of the main confronts is to determine the geographical position of the nodes. For the transmission of the data, hierarchical protocols pursue the multi-tier architecture. The complete network posses a tree-like structure: normal sensor nodes, CH, and a Base Station. Here, the normal node gathers the data and CH collective and transfers it to the BS. Because of its energy effectuality, researchers have concentrated on modelling the diversity of cluster-based routing protocols to maximize the lifetime of the network, scalability, and load balancing. In the network, using the hierarchical protocols, N number of clusters is produced in terms of the CH by offering the multi-hop routing. Single hop minimized the energy consumption for short distances, however; the transmission of data on larger distances uses high energy which causes the degradation in performances. Therefore, to manage the single and multi-hop routing, few control and management services were developed in order to handle the task distribution [5].

The main contribution of this work is to propose a new Cross-layer design routing technique in the clustering model. The proposed model is based upon the cross-layer model through different layers such as physical and network layers. Here, a cluster-based routing model is developed in that the CHS is performed optimally using a hybrid algorithm named Hybrid GA-GOA. Here, the proposed method assures the extension of the network lifetime by defining the shortest path. Moreover, the CHS is performed optimally regarding several metrics such as energy utilization, distance, and delay. At last, the adopted method is verified and analyzed with the enhanced lifetime of the network against the existing models.

2. Literature Review

In 2021, Biswa Mohan Sahoo et al [1], developed a hybrid optimization approach named GA- PSO algorithm for the CHS and BS mobility-based data transmission for each task. Here, the main aim of the GA method was to aid the optimal CHS and PSO aids to find the optimal for BS mobility. Finally, it was seen via the experimentation analysis and outcomes the developed method performance was better than the conventional methods for several performance measures.

In 2020, Prachi Maheshwari Dr et al [2], developed the BOA for the optimal CHS by the remaining node energy, node degree, distance to the BS, distance to the neighbors, and node degree as well as node centrality. The ACO was developed to recognize the route among the CH and BS; it was exploited to choose the optimal route on the basis of the remaining energy, distance, and node degree.

In 2020, Deepak Mehta et al [3], worked on WSN applications. Here, the nodes possess restricted-energy; during the data transmission, the processing power was high over the large distance, which utilizes more energy. Therefore, this works presents a clarification for this issue with an energy effectual multi-objective criterion clustering and optimization on the basis of the routing model. Subsequent, to the CHS, SOA was exploited to the optimal selection of the path for the transmission of data to the BS. Hence, the energy effectuality was enhanced in WSN, thus, the extension of the lifetime of the networks was attained.

In 2020, Thompson Stephan et al [4], developed an ESUCR protocol it was used to solve the problems in routing and clustering. The formation of the cluster was mostly based upon the remaining energy of the SUs and relative spectrum awareness so that the general data channels for clusters were chosen on the basis of the exterior probability of Pus. Moreover, the proposed method carries out the energy effectual data routing to the base station, at the time of event detection.

In 2020, Renan S. Mendes et al [5], addressed an online dimensionality minimization technique to cope with a numerous-objective formula of a VRPDRT. Here, the main aim was to minimize the costs of operating/riding when meeting passenger requirements and offering high-quality service. An evolutionary method based on the dimensionality minimization model was used because of the conflicting and complexity issue characteristics, to resolve the VRPDRT in that eight diverse objective models were exploited.

3. Proposed model for energy effectual routing

Fig 1 exhibits the architecture model of a cross-layer mechanism through diverse layers. This model assures to be actually effective for the WSN development for optimized energy utilization. Actually, the cross-layer approach is most importantly exploited to attain superior QoS. In order to exchange the information, it relies on diverse communication protocol layers in a non-hierarchical model. Thus, the optimal CHS is performed by considering a cluster-based routing protocol with several metrics such as energy, delay, and distance. In the designed cross-layer aforesaid parametric metrics are performed, in the physical layer, the estimation of energy utilization and distance of the nodes is performed, and in the network layer, the estimation of delay is performed.

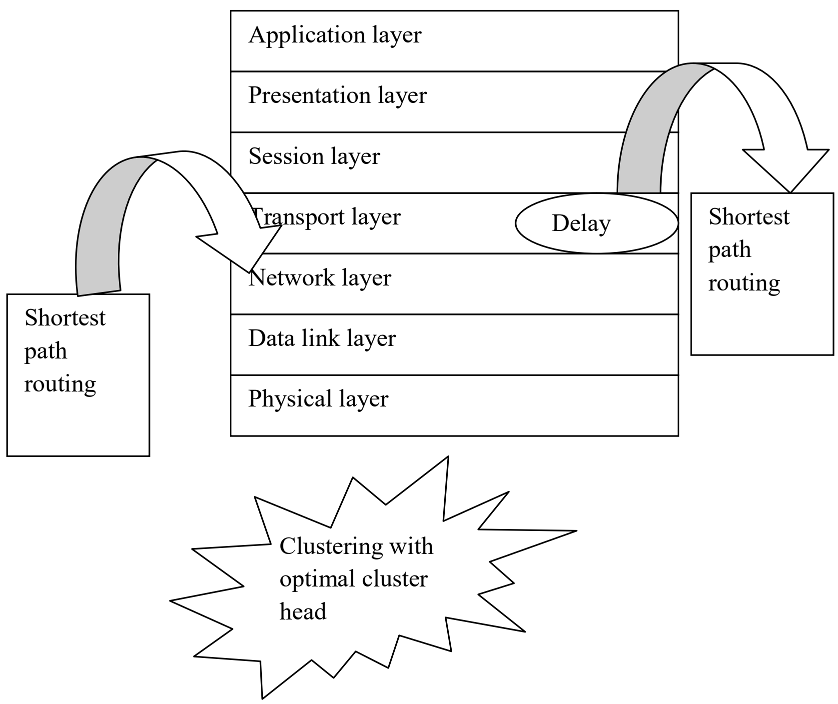


Fig. 1. *Proposed Model for Cluster-Based dense WSN*

3.1 Network Model

In WSN, let N_S represents the sensor nodes that are stationary with appropriate competencies. Moreover, the sensor nodes can be characterized into the advanced node, normal node, and super-advanced node with initial energies E_0, $E_0(1+a)$ and $E_0(1+s)$, respectively.

A node can operate as both the active sensor and CH during the transmission of the data. Moreover, the WSN is related to the topology features, data sensing, sensors allocation, radio communication, and energy utilization. Either in manual or normal mode, the sensors are deployed in the application area. Therefore, the integration of diverse sensor nodes creates the clustering procedure. From these procedures, the sensor nodes are created as clusters in the selection of the CH is performed and the number is stated as N_{CH}. Nevertheless, the CHS is frequently based upon the enhancement of the network. Therefore, the distance between the CH and node must be minimum, due to the direct communication that exists between the CH and node. From the corresponding node to the Base Station, CH only receives the data.

Generally, one of the important issues in WSN is the transmission of the data from one node to the node. Hence, the shortest path should be identified; so as to the transmission of the data can be enhanced. Besides, another aspect is the energy consumption of the node. Therefore, the issues in data transmission comprise the shortest path and the minimized energy. In general, a node needs a lot of energy in order to transmit more information. The minimization of energy attains the optimal positioning of CH, so as to enable the particular CH to transfer a large number of data. In this manner, the CH selection has been done by a node with minimized energy consumption, delay, and distance.

3.2 Distance model

Initially, the chosen CH transmits the message to every node which is acts as the CH. In this case, the distance from the CH is computed by the nodes.

Hence, by a specified cluster, a node is owned, if it possesses minimum distance from CH, then it conveys the message to the suitable CH. Conversely, from the sensor node, the messages are directly transmitted to the BS if the distance between the nodes and CH is higher than the distance between the BS and node. For cluster formation, the node lies at the neighboring distance. Therefore, $Dis(g*h)$ represents the distance matrix, which is used for the network nodes may obtain clustered with the chosen CH as stated in eq. (1), whereas, $e_{N_{CH}}$ represents the Euclidian distance among CH N_{CH} and position normal node information, and $z_1, z_2, ...z_n$ states the sensor nodes.

$$Dis(g*h) = \begin{bmatrix} e_{N_{CH1},z_1} e_{N_{CH1},z_2} ....e_{N_{CH1},z_n} \\ e_{N_{CH2},z_1} e_{N_{CH2},z_2} ....e_{N_{CH2},z_n} \\ : \\ : \\ e_{N_{CHm},z_1} e_{N_{CHm},z_2} ....e_{N_{CHm},z_n} \end{bmatrix} \tag{1}$$

Let two sensor nodes c and d, and their locations as x and y, respectively. In order to evaluate the Euclidian distance between two nodes are stated in eq. (2). The distance matrix of complete elements is indicated as the distance falls among CH of d^{th} node and c^{th} node and it is shown in Eq. (1). An element e_{N_{CH2},z_1} is theoretical to engage the first column matrix with nominal distance. Therefore, the CH $N_{\backslash CH2}$ and node z_1 are related to one another.

$$e_{c,d} = \sqrt{(c_x - d_x)^2 + (c_y - d_y)^2} \tag{2}$$

Additionally, N_{CH} represents the time slot is allotted to each sensor node at the time of the data transmission. Therefore, the most important task of the total N_{CH} was to gather the data from all sensor nodes included in the clusters. Subsequent to the data gathering from the complete sensor nodes in a particular cluster N_{CH} transmits the individual data to the Base Station. When N_{CH} is in active mode, the sensor node continues to stay in sleep mode.

3.3 Energy model

In WSN, one of the other issues is the utilization of energy. In fact, if there is no power supply, it cannot be re-energized suppose the battery is down. Basically, there is a requirement of the augment energy to forward the data to BS from the complete sensor nodes. For the supplementary functions, augmented energy is needed such as reception, sensing, aggregation, transmission. Therefore, the complete energy design requirement when transmitting the message is stated in eq. (3), where, E_{ete} indicates the electronic energy lies on different parameters jointly with spreading, digital coding, filtering, so forth and $E_{TX}(N:e)$ signifies the total used energy necessary to forward N bytes of packets at distance e. The electronic energy model is represented in eq. (4), whereas E_{agg} states the utilization of energy at the time of the data aggregation. Eq. (5) states the total energy needed for N bytes of packets at distance di and the energy needed for amplification stated in eq. (6). The power amplifier energy is indicated as E_{pr} and the required energy when deploying the free space approach is indicated as E_{fr}.

$$E_{TX}(N:e) = \begin{cases} E_{ete} * N + E_{fr} * N * e^2, \text{if } e < e_0 \\ E_{ete} * N + E_{pr} * N * e^2, \text{if } e \geq e_0 \end{cases} \tag{3}$$

$$E_{ete} = E_{TX} + E_{agg} \tag{4}$$

$$E_{RX}(N:e) = E_{ete}N \quad (5)$$

$$E_{agg} = E_{fr}e^2 \quad (6)$$

$$e_0 = \sqrt{\frac{E_{fr}}{E_{pr}}} \quad (7)$$

In general, the eq. (8) states the complete network energy, whereas the energy required in the idle state is represented as E_l and the cost of energy at the sensing time is represented as E_{ST}. It is essential to reduce the total energy stated in Eq. (8).

$$E_{total} = E_{TX} + E_{RX} + E_l + E_{ST} \quad (8)$$

3.4 Objective Model

The primary objective of the proposed model on CHS is to minimize the distance between the selected CH and the node and it also tries to minimize the delay in order to forward the data among one another. Conversely, the network energy needs to attain as the maximum that is merely the least number of energy requires to be exploited during the transmission of the data. Eq. (9) states the main objective model of the proposed CH approach, where the value of η have to depends on $0 < \eta < 1$. As shown in Eq. (10) and Eq. (11), o_m and o_n devises the operations respectively. The modules on energy, delay, and distance are stated γ_1, γ_2 and γ_3. The circumstances of these modules are indicated as $\gamma_1 + \gamma_2 + \gamma_3 = 1$. In Eq. (11), $Z^z - B_s$ states the distance amid the normal and Base station.

$$K_n = \eta o_n + (1-\eta)o_m \quad (9)$$

$$o_m = \gamma_1 * o_i^{dis} + \gamma_2 * o_i^{ene} + \gamma_3 * o_i^{del} \quad (10)$$

$$o_n = \frac{1}{b}\sum_{z=1}^{b}\left\| Z^z - B_s \right\| \quad (11)$$

Eq. (12) states the distance's fitness function, whereas $o_{(m)}^{dis}$ is related to the packet forwarding to Cluster Head from the normal node and then to Base Station from CH. o_i^{dis} requires to residue between [0, 1]. The o_i^{dis} value is attained superior, while the distance between the CH and the normal node is higher.

$$o_i^{dis} = \frac{o_{(m)}^{dis}}{o_{(n)}^{dis}} \quad (12)$$

The analysis of $o_{(m)}^{dis}$ and $o_{(n)}^{dis}$ correspondingly is expressed in Eq. (13), and (14),where Z_z indicates the normal node in z^{th} cluster, CH_z states the CH of z^{th} cluster, the distance amid the BS and CH is indicated as $CH_z - B_s$, $CH_z - Z_z$ states the distance amid the normal node and CH and $Z_z - Z_x$ states the distance amid2 normal nodes, N_z and N_x states the node numberingwhich has not touse the z^{th} and x^{th} cluster onto deliberation.

$$o_{(m)}^{dis} = \sum_{z=1}^{N_z}\left[\left\| CH_z - B_s \right\| + \sum_{\backslash x=1}^{N_x}\left\| CH_z - Z_z \right\|\right] \quad (13)$$

$$o_{(n)}^{dis} = \sum_{z=1}^{N_z}\sum_{x=1}^{N_x}\left\| Z_z - Z_x \right\| \quad (14)$$

The energy's fitness function is stated in Eq. (15). The o_i^{ene} value residues to be higher than 1 and the complete CH cumulative $o_{(m)}^{ene}$ and $o_{(n)}^{ene}$ receives the maximum energy value and the higher number of CH.

$$o_i^{ene} = \frac{o_{(m)}^{ene}}{o_{(n)}^{ene}} \quad (15)$$

Eq. (16) indicates the delay's fitness function that is proportional to all the nodes which subsist in the cluster. Hence, a delay is reduced while the CHs own the minimum number of nodes. The denominator

N_S indicates the complete quantity of nodes in WSN and the numerator indicates the higher number of CH. Moreover, the value o_i^{del} lies amid [0, 1].

$$o_i^{del} = \frac{\max\left(\left\|CH_z - Z_z\right\|\right)_{z=1}^{N_{CH}}}{N_S} \tag{16}$$

4. Proposed model Hybrid GA-GOA algorithm

The proposed Hybrid GA-GOA algorithm uses the advantages of both the GA [9] and GOA algorithms [8]. Here, the GA exploitation ability as well as the GOA exploration ability, whereas GA operators such as crossover and mutation stop the adopted model from falling into the local optimal when the procedures of GOA accelerate the search procedures and convergence to attain the global solution.

A conventional GA method is a meta-heuristic algorithm which is inspired by the process of natural selection that belongs to the larger class of evolutionary algorithms (EA). Generally, GA are exploited to generate high-quality solutions to optimization and search problems by relying on biologically inspired operators like mutation, crossover as well as selection.

In nature, GOA is a new swarm intelligence approach inspired by the foraging and swarming behavior of grasshoppers. The GOA approach has been effectively used to resolve several optimization issues in numerous domains.In the developed model, solution populations are arbitrarily initialized. These solutions attained by GOA are exploring in the optimization issue domain to attain an optimal solution. During this process, the evolution of these solutions is performed by the GA algorithm.

The explanation regarding the proposed Hybrid GA-GOA algorithm is stated as follows:

Algorithm 1: Description of the proposed model

Step 1: Initialization

Initialize the population of search agents in d-dimensions with arbitrary locations in the search space and set the parameters of both the GA and GOA. In d-variables, the preferred fitness function for each agent is estimated. The target location "T" is ascertained as the location of the optimal initial agent.

Step 2: The GOA is exploited to travel in the search space

Using eq. (17), the position of each agent is updated,

$$s\left(|x_j^d - x_i^d|\right) = fe^{\frac{|x_j^d - x_i^d|}{l}} - e^{-|x_j^d - x_i^d|}, \tag{17}$$

$$d_{ij} = |x_j - x|$$

In d-variables, the preferred fitness function for each agent is estimated. The target location "T" is updated as the optimal agent location found till now.

Step 3: Evolution is performed by the GA algorithm:

-Selection [6]: TS will be exploited in the proposed method whereas a count of a tour of agents is selected arbitrarily from the population and the optimal agent from this folk is chosen as a parent. This procedure is continued as frequently as an agent should be selected.

Crossover [6]: Using tournament selection, two agents, $A = [a_1, b_1]$ and $B = [a_2, b_2]$, are chosen as parents. If a is the crossover point for a specific A and B, and the a -values in the offspring's are ascertained using below formulations:

$$a_{new1} = (1-\gamma)a_1 + \gamma a_2 \tag{18}$$

$$a_{new2} = (1-\gamma)a_2 + \gamma a_2 \tag{19}$$

In eq. (18), γ indicates an arbitrary number among 0 and 1. The residual parameter (b in this scenario) is inserted directly from each parent, hence the novel offspring's are

$$offspring_1 = [a_{new1}, b_1] \tag{20}$$

$$offspring_2 = [a_{new2}, b_2] \tag{21}$$

Mutation [7]: Each agent in a string $x_i \in [a_i, b_i]$ is mutated with mutation probability P_m by adding little arbitrary values based on the formulation as stated as follows:

$$X_i = \begin{cases} X_i + \Delta(t, b_i - X_i) & \text{if } \delta = 0 \\ X_i + \Delta(tX_i, -b_i) & \text{if } \delta = 1 \end{cases} \tag{22}$$

$$\Delta(ty) = y\left[1 - r^{(1-t/T)^{\beta}}\right] \tag{23}$$

r indicates a random number r 2 [0; 1] and δ indicates a positive constant selected randomly.

Elitist method: The list of optimal agents directly entered into novel agents set is elitism.

Evaluation: In d variables, the desired fitness function is estimated for each agent. Then the target position "T" is updated as the optimal agent location found till now.

Step 4 (Termination Condition):

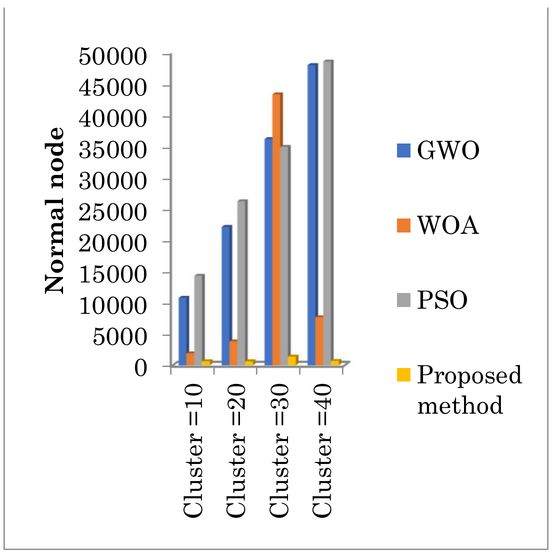
If the utmost count of generations is attained or the agents converge, the developed method will be terminated. At last, the target location T is set as the best solution.

5.Result and Discussion

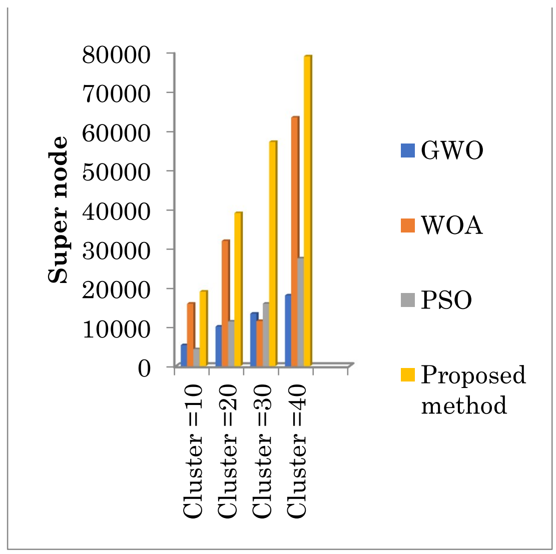
The simulation technique based upon the cross-layer routing protocol was described in this section. Here, one different analysis was performed based on the number of clusters with Cluster Head numbers as 10, 20, 30, and 40, correspondingly. Moreover, the developedtechniquehas experimentedregarding the alive node for 3 node kindsas normal, advanced, and supernodes. Moreover, the analysis was donewith respect to thealive nodes and the lifetime of the network. The proposed method is compared with the conventional models such as Grey Wolf Optimization (GWO), Whale Optimization Algorithm (WOA), and Particle Swarm Optimization (PSO) algorithms.

Fig 2 exhibits the diagrammatic representation of the proposed and conventional models with respect to the several nodes such as normal, advanced, and supernode. Here, most of the advanced and supernodes are selected as a Cluster head. Moreover, the experiment is carried out for the cluster 10, 20, 30 and 40. The complete analysis exhibits that the proposed method is better than the conventional models.

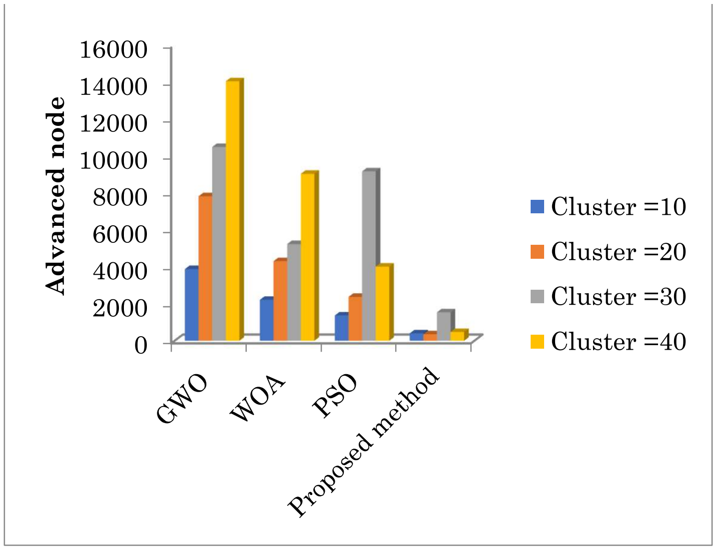
Fig 3 demonstrates the performance analysis of the developed and existing techniques regarding the alive nodes and normalized energy. Here, the overall analysis states that the proposed method is better than the conventional models.



(a)

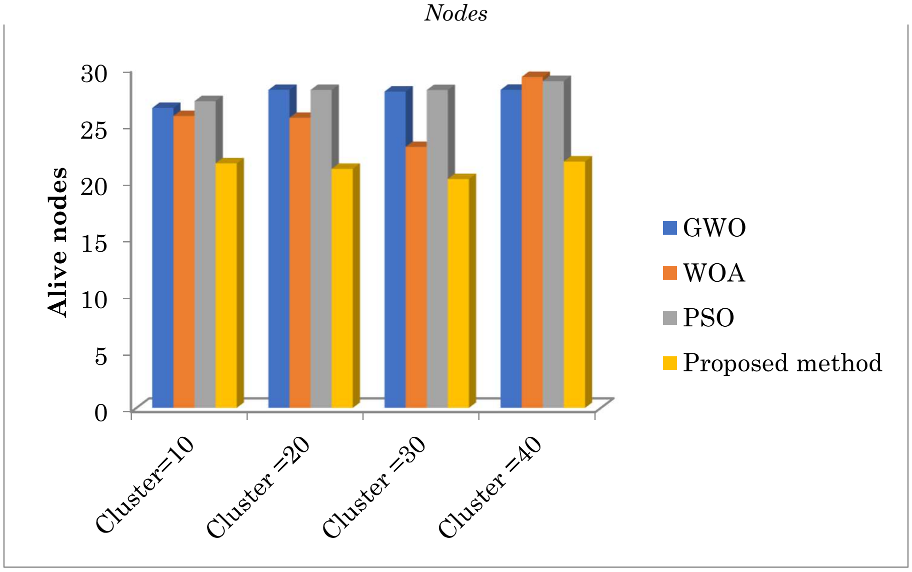


(b)

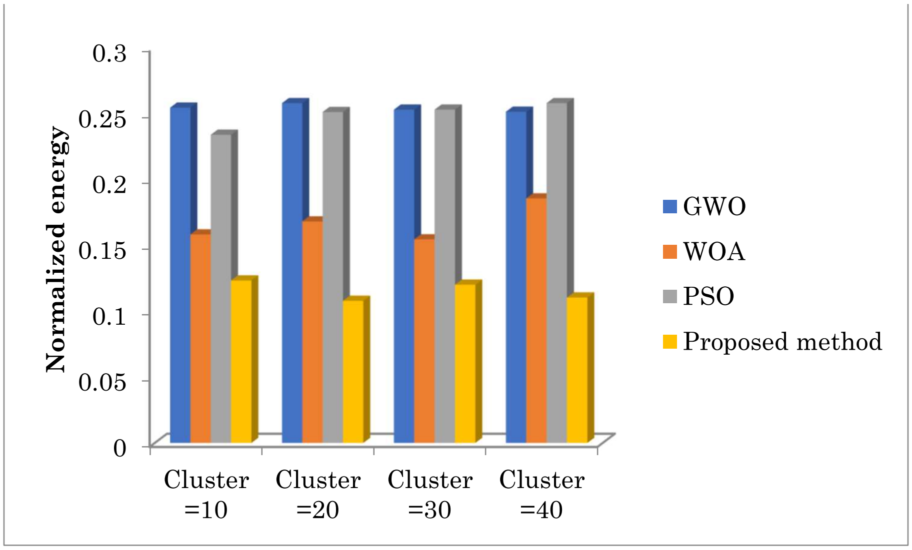


(c)

Fig. 2. *Performance analysis of developed and existingtechniques (a) Normal nodes (b) Supernodes (c) Advanced Nodes*



(a)



(b)

Fig. 3. *Performance analysis of developed and existing techniques (a) alive nodes (b) normalized energy*

6. Conclusion

In this paper, a novel Cross-layer design routing technique was presented on the basis of the clustering model. Moreover, the proposed model was on basis of the cross-layer model via different layers such as physical and network layers. For the optimal CHS, this paper developed a cluster-based routing model. Hence, a new optimization method was developed called Hybrid GA-GOA. The optimal CHS was performed based upon various metrics such as energy utilization, distance, and delay. Finally, the adopted technique was performed and validated with an enhanced lifetime of the network over the conventional techniques. The overall analysis exhibits that the proposed model performs better than the conventional model.

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