

A Hybrid Glowworm Swarm Optimization for Enhancing the Lifespan of Wireless Sensor Networks

Deepak raj D (✉ deepakraj0708@gmail.com)

Annamalai University <https://orcid.org/0000-0003-0740-1969>

RAJA K

Annamalai University

AYYASAMY A

Annamalai University

Research Article

Keywords: GSO, Harmony Search, Tabu Search, Localization, Luciferin, Wireless Sensor Networks, Electric Grids

Posted Date: March 22nd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-274464/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

A Hybrid Glowworm Swarm Optimization for enhancing the lifespan of Wireless Sensor Networks

D. Deepakraj¹, K. Raja², A. Ayyasamy³

¹Dept. of Computer & Information Science, Faculty of Science, Annamalai University, Annamalainager, Chidambaram, Tamilnadu, India.

²Department of Information Technology, Faculty of Engineering and Technology, Annamalai University, Annamalainager, Chidambaram, Tamilnadu, India.

³Department of Computer Science and Engineering, Faculty of Engineering and Technology, Annamalai University, Annamalainager, Chidambaram, Tamilnadu, India.

E-Mail: deepakraj0708@gmail.com, rajak_cdm@yahoo.co.in, samy7771@yahoo.co.in

Abstract:

The special features of smart grid technology includes regular metering communication, renewable power incorporation, allotment computerization and whole scrutinizing and organization of complete power grid. Little micro-electrical automatic schemes that are deployed in collecting and broadcasting data from ambience are Wireless Sensor Networks (WSNs). Providing security and energy consumptions are the most emerging issues in Wireless sensor network communication. To enhance the lifespan of a network, energy efficiency should be increased by decreasing energy consumption of the sensor nodes, thus striking a balance in the power consumption of each node. As the primary source of origin of energy consumption of sensor nodes is long distance transmission of data, good impact on energy consumption can be provided through an efficient routing protocol. So as to enhance the lifespan of a network, a number of protocols have been put forth in the form of optimization algorithms. This study involves Glowworm Swarm Optimization (GSO). In GSO, a probabilistic cost is computed by every glowworm in spite of finding its neighboring glowworm that has the enhanced luciferin intensity than others. Based on this probability cost, a glow worm moves towards the chosen glowworm. To enhance GSO performance, the GSO hybrid optimized with Harmony Search (HS) and Tabu Search (TS) local methods are also proposed. Results prove that proposed method achieves better performance.

Keywords: GSO, Harmony Search, Tabu Search, Localization, Luciferin, Wireless Sensor Networks, Electric Grids

1. INTRODUCTION

WSNs are made up of 100s and 1000s of sensor nodes which are distributed independently in observing physical or ecological considerations including pressure, heat, tremor and movement at various disaster positions such as earthquakes. At least one sensor is present in every node in a SN which is a communication device that resembles a land transient, a small embedded system and a battery for provider of energy ([Gong et al, 2018](#); [Elhoseny, Tharwat, Yuan & Hassanien, 2018](#)). Energy plays an important role as the nodes are battery-operated. There are several fields involved such as armed battlefield, fire discovery and erstwhile excessive surroundings. As a result of depletion of power dead nodes are increased and it is quite hard to replace them with new one in remote conditions. So, it is crucial to exploit the duration of sensors by increasing the battery life. ([Manjusha and Kannammal, 2014](#), [Janani and Kumar, 2013](#)).

According to standard, the term grid implies an electrical system which supports energy production, broadcast. The technology of power grid is going on huge metamorphosis and one of such recent innovative addition is smart grid. Smart grid is nothing but improvised power grid technology. To deploy Smart grid network, infrastructure of both electrical and broadcasting are inevitable. A smart grid is an improvement of the latest power grid. Based on convention, the power grid bears the power from middle producer to consumers. With the use of modern information technologies, a smart grid can deliver power effectively and can respond to large range of consumers ([Fang et al, 2012](#); [Guerrero et al, 2017](#); [Sancho-Asensio et al, 2014](#)).

Two-way communication system is depended upon in WSN with smart grid, where consumers can interact with the network, where both power consumption data and feeding back the energy produced into the grid. As smart grid technology is digital and not electromechanical. In power grid, the daily operation will range from physical apparatus ensures to distant inspecting and prophetic time-oriented preservation by a number of specialized sensors ([Robinson & Rajaram, 2016](#)). AMI is used smart grid technology providing easy communication with the consumers and also monitor and control their power consumption. With the use of advanced sensor technologies, consumers can have more advanced home automation tools implemented ([Sharma and Pandove, 2017](#)).

When the location of certain fixed or mobile devices remain uncertain, localization becomes important. Then an efficient localization algorithm can conclude the position of individual devices by using all available information for the WSNs. The positioning of mobile robot is another application which has its basis on the signal strength that is received from a set of radio beacons that are located at known locations on the factory floor ([Harold](#)

[Robinson and Rajaram, 2015](#)). If an electrical network has to be fully accountable, a number of monitoring devices have to be installed on its nodes and links (to be accurate, the device can be localized anywhere along any link) ([Balaji, Golden Julie & Robinson, 2017](#)). Moreover, the message collected by these devices need to be relayed to centralization servers which stored and/or performed computation on these data. Through power lines or wireless medium communication of data can take place. The main aim is in installing just few devices subject to satisfactory monitoring of the network ([Poirion et al, 2014](#)).

With regards to smart grid applications, the WSNs used have different features when compared to other networks that used for erstwhile nonspecific appliances. Secrecy of data communication is dealt in confidentiality. Authentication is needed to prevent false data from hostile nodes. It assures authenticity of messages. Accessibility implies reliability of military when there is an attack. Integrity refers to messages being received unaffected at the intention. Authorization denotes that only sensor nodes that are authorized can contact and illegal data sharing should be restricted ([Chhaya et al, 2017](#)).

The method of optimization is the constraints of a function sought for standards that can maximize or diminish the task. In this, the entire suitable assessments are called sufficient solution and finest assessment is the best resolution. All the mathematical oriented problems are identified using the optimized algorithms. There are various optimization techniques are used in scheduling and resource allotment. This is again a non-deterministic polynomial hard problem. To an extent, these problems can be solved by swarm intelligence algorithms. These types of algorithms are used to improve the scalability, reliability, quality of service and enhanced packet delivery in networks. Hybrid method is executed that fewer efficient in preliminary iterations while believing noteworthy space of ultimate optimal solution with holds to preliminary solutions.

The main objectives of the proposed work are

1. A hybrid GSO-based dynamic algorithm is proposed to reduce the data traffic and consumption of energy among the sensor nodes.
2. Extremely consistent links are proposed for increasing the lifetime of the WSN.
3. Significantly improved load balancing technique is proposed to maintain the high link quality among the electric grids in WSN.
4. The proposed work is framed to increase the accuracy, reduced computational runtime, increased number of packets and priority packets received; more number of clusters is framed within the WSN environment using electric Grids.

2. RELATED WORKS

In WSN, one of the issues faced in achieving reliable communication is localization. Localization is nothing but estimating a sensor node's position. Extended Kalman Filtering (EKF) is a nonlinear version of Kalman Filtering (KF) which has its own problem of consistency compacts with the case that is the nonlinear stochastic in nature. Efficient localization algorithm was proposed ([Chander Janapati et al, 2015](#)) through which sensor nodes approximate their position with elevated precision. This work's purpose is to develop PSO assisted EKF for localization in WSN. For time critical applications, performance evaluation proved that PSO-EKF was better compared to conventional KF.

An Energy Efficient Ant Based Routing (EEABR) Algorithm ([Camilo, Carreto, Silva & Boavida, 2006](#)) is used for maintaining the energy utilization of WSN. In this algorithm forward ants and backward ants where utilized to discover the path through number of intermediate nodes. These intermediate nodes were selected based on the pheromone trail of the node and residual energy of neighbours from current routing table. However, this algorithm is suitable for early time of delivering packets; this algorithm cannot discover the optimal solution because of variation in the collection of pheromone trail.

Multipath Routing Adaptive energy-efficient and lifetime-aware routing protocol (QELAR) ([Hu, Fei & Qelar, 2010](#)) routing protocol is used the concept Q-learning method for learning the nodes energy and workload. Based on the learning the work will be efficiently shared among the nodes will improve the energy efficiency by dynamically using routing table. Ant colony optimization router chip (ACORC) ([Okdem & Karaboga, 2009](#)) is developed for routing in WSN. It provides the reliable data delivery with presents of fault.

BeeSensor based on the principle of honey-Bees is introduced for swarm intelligent based routing methodology ([Saleem, Di Caro & Farooq, 2011](#)). It contains four stages of protocol scouting, foraging, swarming and pocketing. The working principle of Packer is to establish connection between higher layer node and place appropriate forger. Foragers are similar to workers in Bee. It will collect packet from source node to sink node through already established path by Scouts (Forward and Backward). Swarming encapsulate all the foragers into own group. BeeSensor perform better that Swarm.

Fuzzy Ant Colony Optimization Routing (FACOR) algorithm ([Amiri et al, 2014](#)) is merged the two principles one is from ant algorithms foraging with fuzzy logic. This algorithm gives better result than AODV for finding optimal path and improved packet delivery ratio.

A distributed modification methodology (Yao & Jiang, 2015) is used for WSN to accomplish localization and position modification of nodes; WSLA+WSRA have to run iteratively in real applications. Through the analysis of experimental results of WSLA, some errors are found and WSRA is eventually proposed, which is based on geographical relationships of neighbours. A nested solution method (Keskin, Altinel, & Aras, 2015) was proposed to demonstrate the location of the sensor networks with improve the efficiency using simulated approaches. HS algorithm (Guo & Mu, 2015) in optimizing WSN node position computation, by minimizing the collision of assortment fault and recovering the location truthfulness node; it also diminish the mathematical convolution, increase speed. A HS-based deployment algorithm (Harold Robinson et al, 2016) is used to help in locating the most favourable location of sensor nodes to exploit network coverage and diminish its cost. The suitable amount of sensor nodes is automatically evolved and their optimal locations modified through the capacity of HS. This is possible through the integration of the impression of adjustable duration encoding in every solution vector in representative a changeable quantity of aspirant sensor nodes are complex exposure rate, the quantity of sensor nodes and maximum space within sensor nodes which can confirm the choice of most favourable amount of sensor nodes and their locations.

An Improved Harmony-search Energy Efficient Routing Algorithm (Zeng & Dong, 2016) which has its basis on HS algorithm which is a meta-heuristic. Several prime improvements have been proposed to address the WSN routing issues with HS protocol: Primarily, on the basis of features of routing in WSNs, there is enhancement of the encoding of Harmony Memory (HM); next, there is enhancement in the improvisation of New Harmony. Prematurity in generations is reduced by vibrant adjustment for the constraint HM Consideration Rate and confined exploration capability is strengthened. Simultaneously, there is discarding of alteration procedure of HS method in order to build the proposed routing algorithms have less parameter. Finally, the local search ability is improved through the proposition of a successful confined investigate scheme, where the union swiftness and truthfulness of routing method is improved.

Hybrid-Multi-Objective Evolutionary Algorithm based on Decomposition (MOEA/D) (Xu, Ding, Qu & Li, 2018) is used to complete the multi-objective optimization in WSN are effectively optimized through the methodology. Optimal path selection (Vijayalakshmi & Anandan, 2018) is used to enhance the lifespan of the network and its energy efficiency. With poor local optima problems, a number of meta-heuristic techniques, especially PSO have been used effectively. The basis for the proposed technique is PSO and TS algorithms. The

impact of heterogeneity of nodes, more energy resources are present in a proportion of inhabitants of sensor nodes ([Golden Julie, Tamil Selvi & Harold Robinson, 2016](#)).

The basis for Glowworm Swarm Optimization algorithm is that one glowworm gets attracted to another depending upon the concentration of Luciferin. Basically, glowworms interact with one another by releasing luciferin. While they are soaring, they release luciferin, so that brightness can be given out. Through this fluorescent light, they attract the others flying around them. Depending upon the attentiveness of luciferin, the concentration of luminous increases and the glowworm preserve create a centre of attention of related glowworms. By simulation, the features of glowworm swarm optimization algorithm can be formulated: this algorithm's search strategy is several-point corresponding inclusive arbitrarily find based on inhabitants with no progress of mathematical operations. Based on the glowworm's decisions, the exploration gateway is indomitable and most favourable consequence is reached ([Zhou, Zhou, Wang & Zhao, 2013](#)). Every solution is called "harmony" and is characterized by a D-dimension authentic vector in the basic HS algorithm. There is haphazard production of preliminary population of harmony vectors and is stored in Harmony Memory (HM). Then invention of a latest contender harmony is prepared from all elucidation sin HM with the exploit of memory thoughtfulness rule, and terrain alteration rule. Ultimately, modernizing of HM was completed as evaluated to inventive harmony ([Wu, Qian, Ni & Fan, 2012](#)). Additionally, the search-based algorithms are based on primal shape of tabu search. The supplementary better shapes of tabu search enclose numerous key methodologies that may jointly construct the most excellent results ([Orojloo & Haghighat, 2016](#)).

The drawbacks of the existing works are whenever the Wireless sensor network based smart grid applications, conventional methods are used for gathering the global data and obtaining the position of the sensor nodes. The sensor nodes having the reduced memory and watchful usage of resources in an active network topologies in smart grid based surroundings. Hence, the existing methods are unable to optimize the performance of reliable communication in extended behaviour. Also, the proactive neighbour finding methodology is used for dynamic routing in an alternate path. Hence, the existing methods failed to provide the optimized framework for memory exploitation. This increased the packet delay and network overhead in WSN.

3. HYBRID GLOWWORM SWARM OPTIMIZATION

3.1. Network Formation

GSO algorithm finds its applications in many fields including multimodal function and combination optimization, robotics applications, and WSNs. It is also used widely in certain NP-Hard problems such as Travelling Salesman Problem (TSP) and 0-1 knapsack issues. There are certain disadvantages of GSO algorithm which include reduced precision in later iterations, decreased convergence speed and easy trapping in local optimal solutions (Du, Lei & Wu, 2014). The quality of optimization process can be enhanced by the proposed hybrid HS-GSO-method. As GSO can utilize previous local and global solutions, and HS can acquire preliminary most favourable solutions of the complex problem, hybrid HS-GSO method is executed. GSO is fewer efficient in preliminary iterations while believing noteworthy space of ultimate optimal solution with holds to preliminary solutions. Regarding this, allotment of original iterations to HS methodology acquires position in the proposed hybrid HS-GSO method. This work occupies 20% iteration to HS technique and the enduring to the remaining iterations to hybrid HS-GSO technique to modernize optimal solutions. On the other hand, final iteration in HS is not efficient completely in modernizing optimal solutions. As no sorting is required in GSO method, the optimal solution with elevated speed is achieved in GSO. Consequently, the last iterations are allocated to GSO technique for acquiring the completed optimal solution. In this work, 40% of the iterations are allocated to GSO method (Nazari-Heris, Fakhim-Babaei & Mohammadi-Ivatloo, 2017). Figure 1 demonstrates the wireless sensor network formation with the sensor nodes, sink node is elected using the algorithm and the data can be sending from the source node to the destination node through the active path.

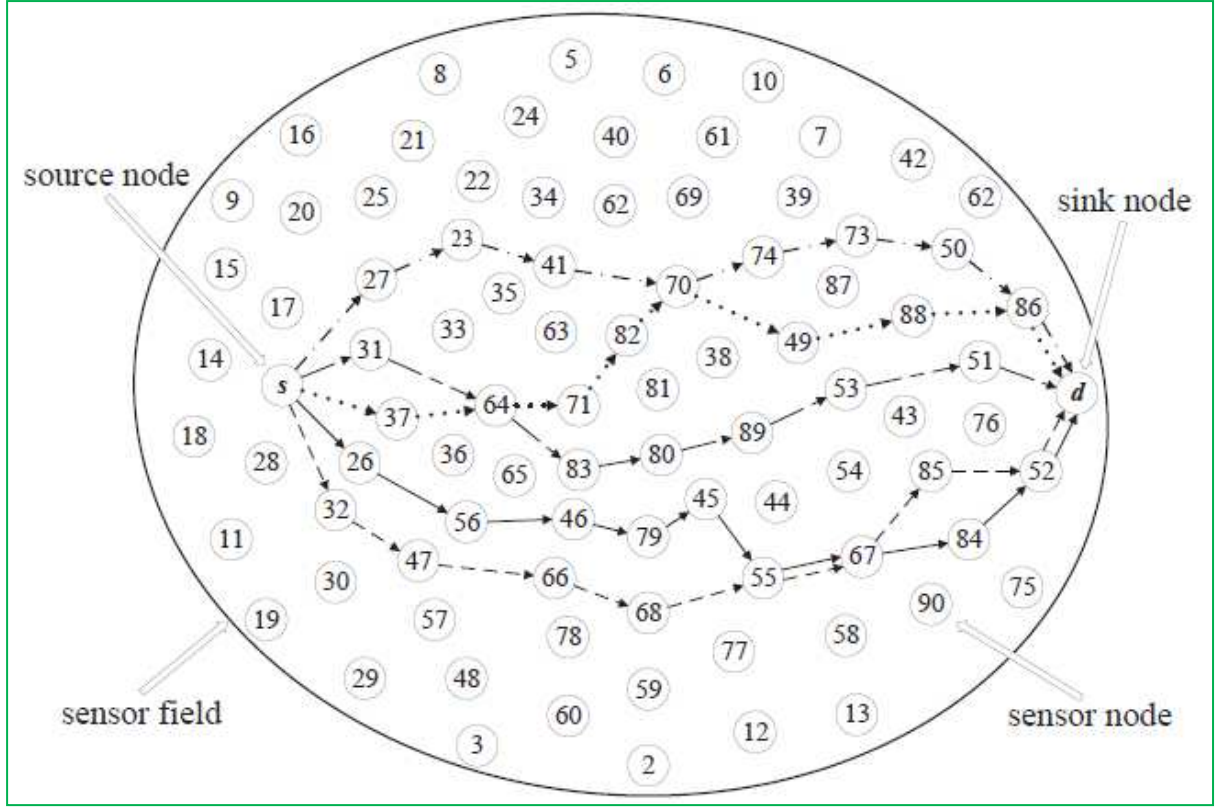


Figure 1. Wireless Sensor Network Formation

The location of the glowworm is computed for updation of luciferin. In this procedure, every glowworm includes the initial luciferin value with the current functional value. Moreover, the small amount of luciferin is deleted from the initial value. The updating value is calculated using the Eq. (1)

$$lu_i(p+1) = (1 - \gamma) lu_i(p) + \omega O(x_i(p+1)) \quad (1)$$

In this work, some modifications are accomplished in implementing HMCR, PAR, and BW. The pitch adjusting rate is computed in Eq. (2).

$$PAR(iteration) = PAR_{initial} + (PAR_{final} - PAR_{initial}) \left(\frac{iteration}{MaxIteration} \right)^{1.25} \quad (2)$$

The harmony memory considering rate is computed in Eq. (3).

$$HMCR(iteration) = HMCR_{initial} + (HMCR_{final} - HMCR_{initial}) \left(\frac{iteration}{MaxIteration} \right)^{1.25} \quad (3)$$

The bandwidth is computed in Eq. (4).

$$BW(iteration) = BW_{initial} + (BW_{final} - BW_{initial}) \left(\frac{iteration}{MaxIteration} \right)^{0.8} \quad (4)$$

The final optimization value is computed in Eq. (5).

$$V_i^{new} = \begin{cases} V_i(k) \in \{V_i(1), V_i(2), \dots, \dots V_i(k)\}, & x_1 > HMCR \\ V_i(k) \in \{V_i^1, V_i^2, \dots, \dots, V_i^1\}, & x_2 \leq HMCR \\ x_i(k) + x_3 * BW, & x_3 \leq PAR \end{cases} \quad (5)$$

Figure 2 demonstrates the steps are followed in the algorithm. Initially, GSO values are updated; the Luciferin value and the GSO movements are updated accordingly. If the updated value of the adjacent node is in the communication range, we obtain the optimum solution otherwise, update the values.

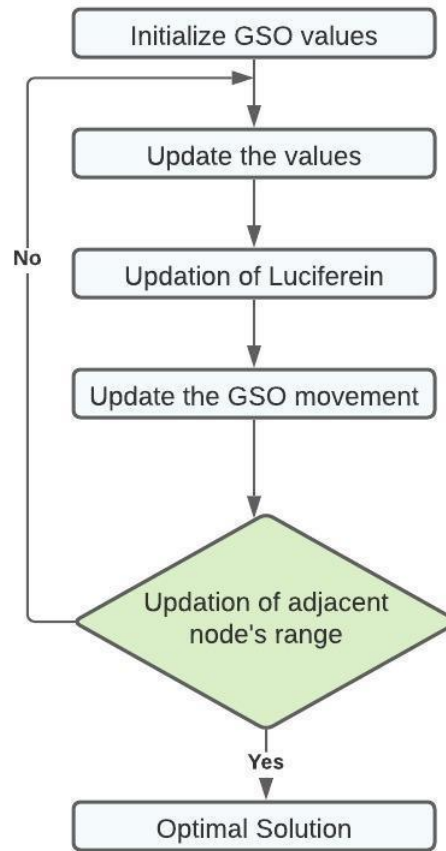


Figure 2. Flow chart for the algorithm

3.2. Algorithm – Proposed Hybrid GSO

Total amount of dimensions = d

Total amount of glowworms = g

Let ss is the size of the step

Let $x_i(p)$ is the position of glowworm it at period p

deploy_randomly;

for i = 1 to n do

```

 $lu_i(0) = lu_0$ 
 $ra_m^i(0) = ra_0$ 
assign MaxIteration as the maximum iteration number
assign  $p = 1$ ;
while ( $p \leq \text{MaxIteration}$ )do
{
    for every glowworm  $i$  do
 $lu_i(p+1) = (1 - \gamma) lu_i(p) + \omega O(x_i(p+1))$ 
    for every glowworm  $i$  do
    {
 $A_i(p) = \{j: m_{ij}(p) < ra_m^i(p); lu_i(p) < lu_j(p)\};$ 
        for every glowworm  $j \in A_i(p)$  do
 $pr_{ij}(p) = \frac{lu_j(p) - lu_i(p)}{\sum_{k \in A_i(p)} lu_k(p) - lu_i(p)}$ 
 $j = \text{choose\_glowworm}(\overrightarrow{pr});$ 
 $x_i(p+1) = x_i(p) + s \left( \frac{x_j(p) - x_i(p)}{\|x_j(p) - x_i(p)\|} \right)$ 
 $ra_m^i(p+1) = \min\{ra_s, \max\{0, ra_m^i(p) + \beta (g_p - |A_i(p)|)\}\}$ 
    }
}
 $p = p + 1$ ;
}

```

Initially, generate the GSO values for evaluating the values of every initial path in GSO. The new path is improvised by evaluating the new path of updating the values. If the newly generated path is working well compared to the previous paths, utilize the new path for data communication. Harmony search algorithm has been used to solve numerous problems with simple way of implementation and fast convergence through the capability of global search. Tabu search is utilized to provide the solution for combination optimization issues and it is used for the local search.

The level of luciferin is computed in Eq. (6).

$$lu_i(p+1) = \max\left\{0, \left((1 - \gamma) lu_i(p) + \omega O(x_i(p+1))\right)\right\} \quad (6)$$

The probability of movement is computed in Eq. (7).

$$pr_j(p) = \frac{lu_j(p)}{\sum_{k \in A_i(p)} lu_k(p)} \quad (7)$$

The updated luciferin value is calculated in Eq. (8).

$$x_i(p+1) = x_i(p) + s \left(\frac{x_j(p) - x_i(p)}{||x_j(p) - x_i(p)||} \right) \quad (8)$$

The random value is computed in Eq. (9).

$$ra_m^i(p+1) = \frac{ra_s}{1 + \beta D_i(p)} \quad (9)$$

Distance for the node i is computed in Eq. (10).

$$D_i(p) = \frac{A_i(p)}{\pi ra_s^2} \quad (10)$$

The updated random value is computed in Eq. (11) and Eq. (12).

$$ra_m^i(p+1) = \alpha + \frac{ra_s - \alpha}{1 + \beta A_i(p)} \quad (11)$$

$$ra_m^i(p+1) = \begin{cases} ra_m^i(p) + \beta_1 |A_i(p)|, & \text{if } |A_i(p)| \leq n_p \\ ra_m^i(p) - \beta_2 |A_i(p)|, & \text{if } |A_i(p)| > n_p \end{cases} \quad (12)$$

β_1 and β_2 are constant parameters

The luciferin limit is computed in Eq. (13).

$$\lim_{p \rightarrow \infty} lu_i(p) \leq \lim_{p \rightarrow \infty} lu^{max}(p) = \left(\frac{\omega}{\gamma} \right) O_{max} \quad (13)$$

The proposed Hybrid GSO algorithm used the concept of the dimensions and Glowworms initially. The position of the glowworm is computed at the period of time. The sensor nodes are deployed randomly to construct the network. For every sensor node, the level of luciferin is computed. For every adjacent node, finding within time period p, probability of movement from i to j within the time period p, distance from i to j within the time period p are computed. Finally, choose the suitable glowworm.

3.3. Optimizing the Transmission Range of the Proposed Method

Combinatorial optimization can be resolved through a local search algorithm, TS are used in order to force penetrating progression in covering new searching area and to prevent early conclusion to confined optimal solution (Fang & Zhang, 2016).

With regards to global search, GSO performs very well but not so proficient with confined exploration; whereas TS achieves fine in confined exploration and not so well in global search. Thus, a combination of both can lead to the formation of a new algorithm which can perform both local and global search in all the iterations, leading to an increase in

the probability of discovering the optimal points (Zhang & Wu, 2012). Figure 3 illustrates the Glowworm formation within the radius.

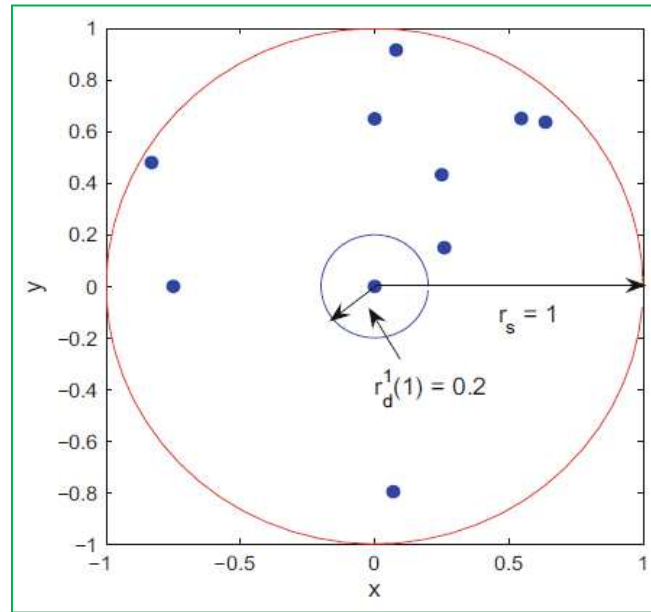


Figure 3. Glowworm formation within the radius.

The updated distinct model of the movement repeatedly acquires to solve the optimization problem. In reality, throughout the movement procedure, every glowworm travels a distance of restricted step size s between neighbours. Therefore, whenever the distance within a glowworm x imminent a neighbour $y < s$, x selects the location of y and befalls an organizer to y . Figure 4 demonstrates the GSO transmission range. Table 1 demonstrates the notations are used in the proposed technique.

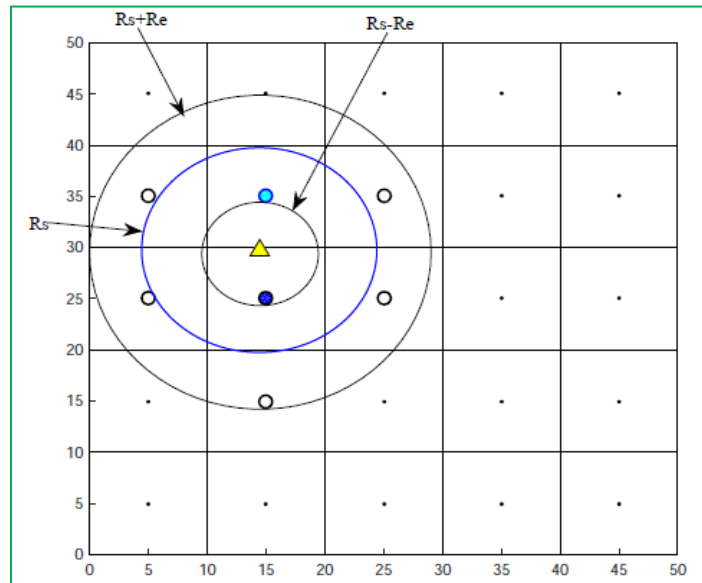


Figure 4. GSO Transmission Range

Table 1. Notations used

Notations	Descriptions
$lu_i(p)$	level of luciferin
p	time period
γ	constant for luciferin decay
ω	constant for luciferin enhancement
$O(x_i(p))$	objective function
i	value of glowworm
j	neighbour for glowworm i
$A_i(p)$	adjacent node finding within time period p
$MaxIteration$	maximum iteration number
$pr_{ij}(p)$	probability of movement from i to j within the time period p
$m_{ij}(p)$	distance from i to j within the time period p
α	lower bound
PAR	pitch adjusting rate
β_1	constant parameter 1
β_2	constant parameter 2
O_{max}	maximum value for the objective function
BW	bandwidth
$ra_m^i(p+1)$	neighbour range
$D_i(p)$	Distance for the node i
$HMCR$	harmony memory considering rate

3.4. Calculating Node Location and Angle of the sink node

For calculating the converse correlation of the Wireless Sensor Networks, the locations must be measures with the use of the exclusive points. This method is implemented using Monitoring in Figure 5. Monitoring is extremely important where two or more sinks nodes are accessible in WSN.

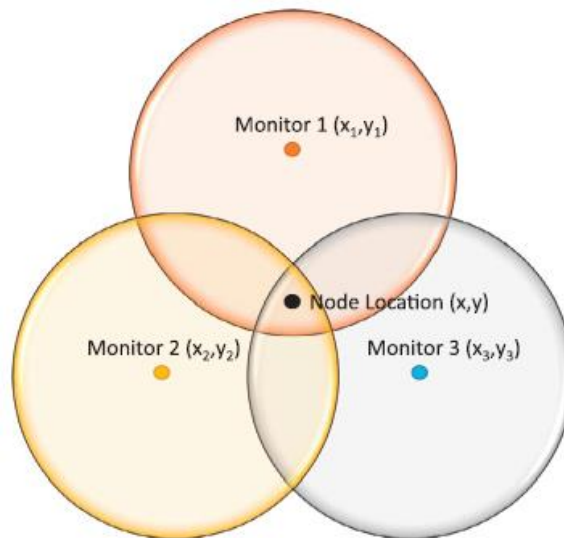


Figure 5. Monitoring of node location

Angle of the sink node is computed where the coordination points can match with the location of the node with particular angle in Figure 6. The particular angle is determined as the Angle of the sink node. It will find the location of the sensor node.

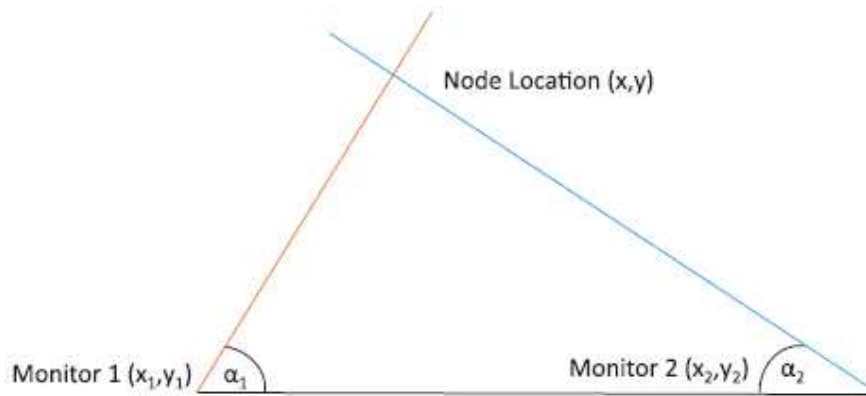


Figure 6. Angle of Sink node

4. RESULTS AND DISCUSSION

The simulation of the Wireless sensor networks are framed using the random deployment of the nodes and it is simulated with Network Simulator 2. The Simulation Results compared the Proposed Work HybridGSO with HSGSO and TSGSO. In the Wireless Sensor Network environment, sensor nodes, fusion centre and standby node are placed in Figure 7. They occupied the specific area of positioning the sensor node. The sensor nodes are positioned at [0.40 m, 0.60 m]. For every anchor node, the fusion centre is used to find the distance of the sensor nodes with constraint. The minimum and the maximum boundary values are initialized to discover the position of the sensor nodes.

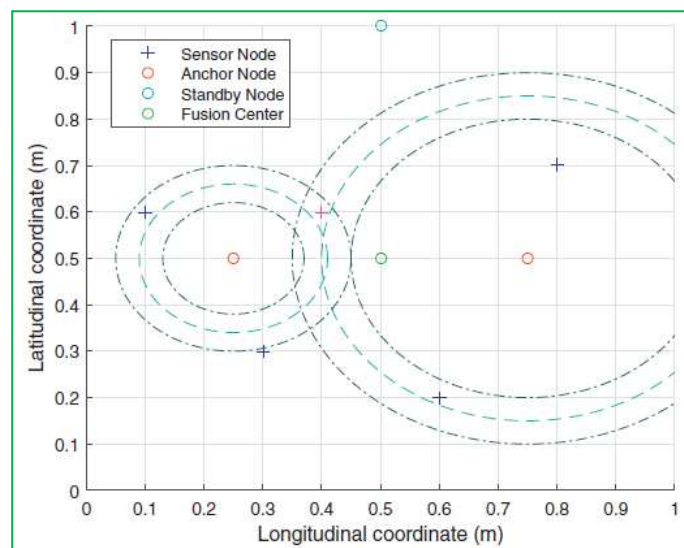


Figure 7. Radius Calculation

The sink nodes are placed in the WSN environment to monitor every node in the network. The data is communicated to the sink node through the fusion centre node to implement the proposed algorithm. The fusion centre is responsible for identify the position of the sensor nodes in the network. The standby node accesses the distance within the sensor node to the sink node. The entire WSN setup is illustrated in Figure 8. Figure 9 illustrates the cluster formation using hybrid GSO.

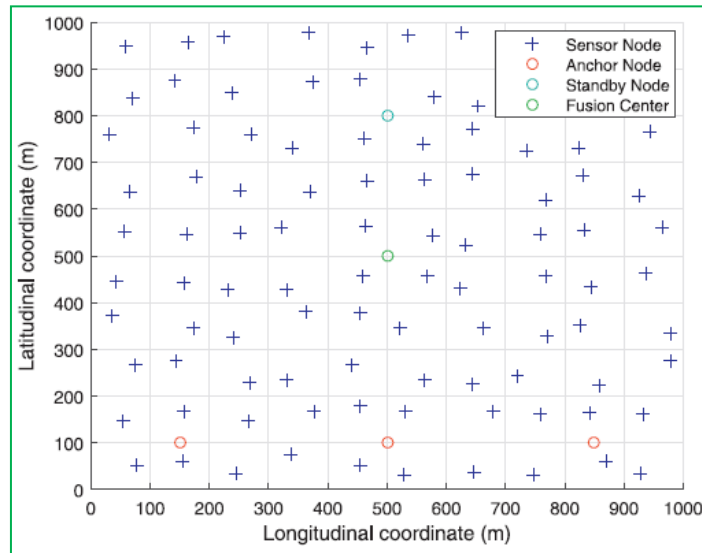


Figure 8. Wireless Sensor Network group formation

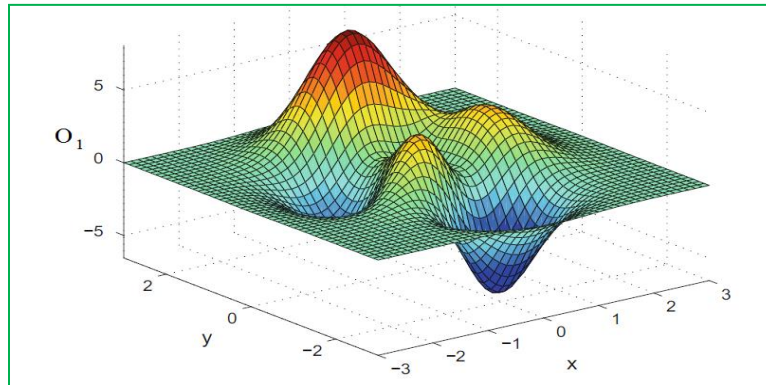


Figure 9. Cluster formation using hybrid GSO

For every simulation stage, we generate the total computational runtime for the whole simulation with the mean calculated time per feature set, per iteration and per node. At last, we separated the whole runtime into the number for node to calculate the runtime of every node. The simulation results are described in Figures (10, 11, 12, 13). The simulation results prove that the 3 sink node monitoring is performed well compared with the 2 sink node monitoring in every stage of the simulation.

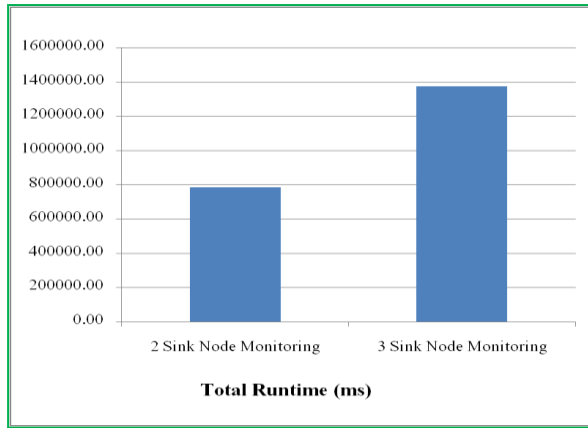


Figure 10. Total Runtime

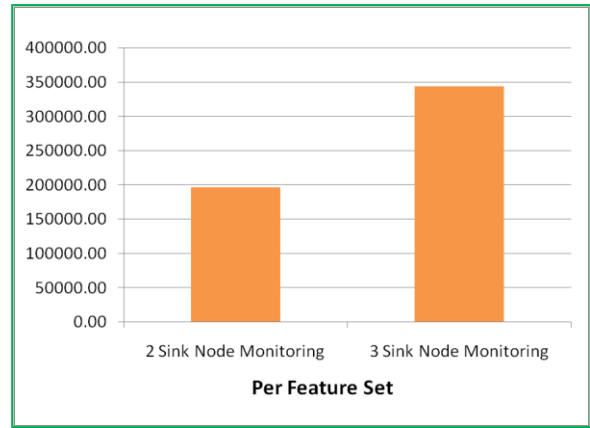


Figure 11. Per Feature Set

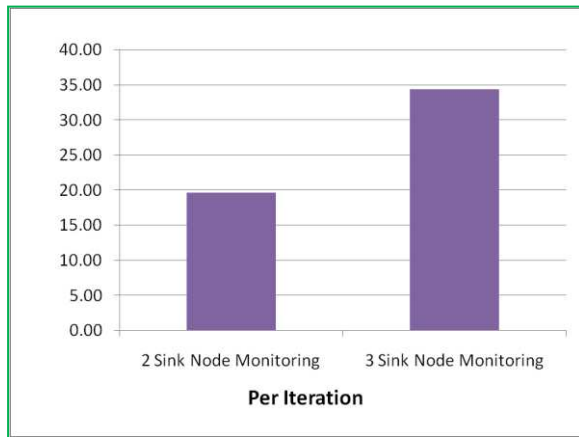


Figure 12. Per Iteration

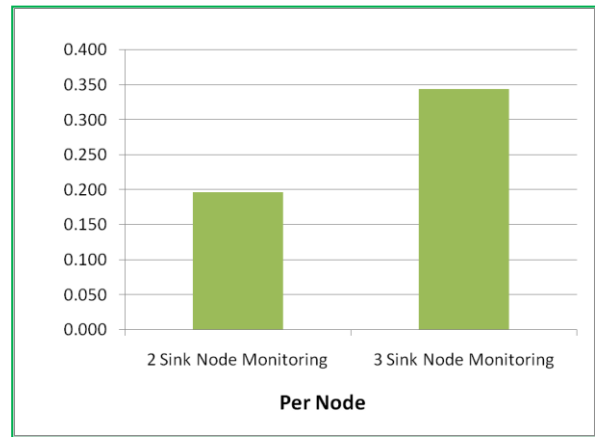


Figure 13. Per Node

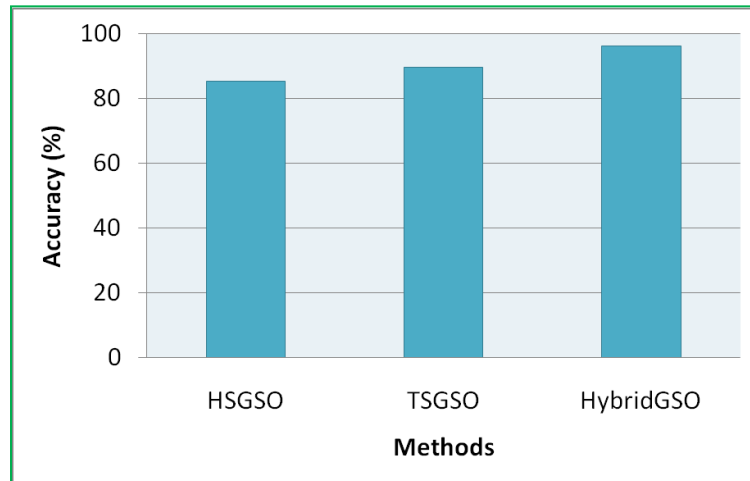


Figure 14. Accuracy (%)

The accuracy is calculated using the how many search parameters are matched with the total amount of search parameters. The position of the sensor node is used for finding the accuracy parameter. The WSN is deployed using the sensor nodes and sink nodes. Figure 14 demonstrates the Accuracy percentage of all the methods used in the simulation. The result

suggests that the proposed method has the better Accuracy percentage compared to the related techniques.

For every experiment, the total runtime for the whole simulation is computed using all the input possibility permutations to discover the mean runtime per stages. The experimental result suggests that the computational runtime for the proposed work is reduced while compared to all the related works. Figure 15 illustrates the computational runtime in ms.

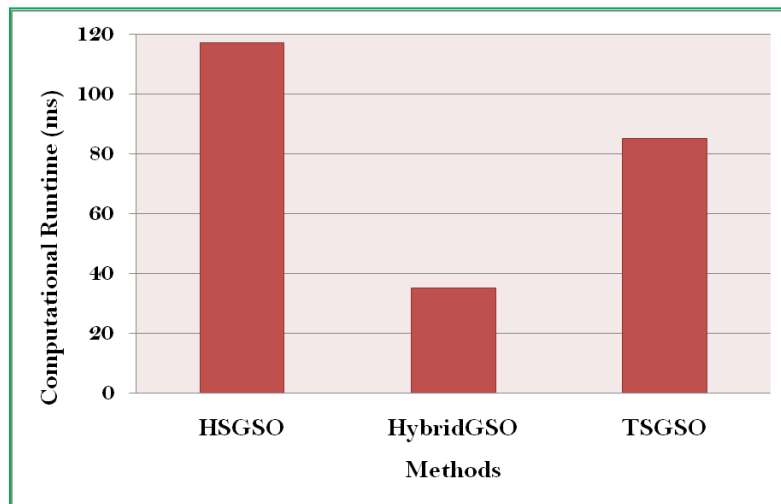


Figure 15. Computation Runtime

The data packets which are received at base station is demonstrated in Table 2.

Table 2 Data Packets delivered to the Base Station for Hybrid GSO

Number of Rounds	HSGSO	TSGSO	HybridGSO
200	58	62	68
400	54	56	60
600	50	55	60
800	49	53	57
1000	46	50	54
1200	42	45	49
1400	41	44	48
1600	31	33	36
1800	28	30	33
2000	22	24	27

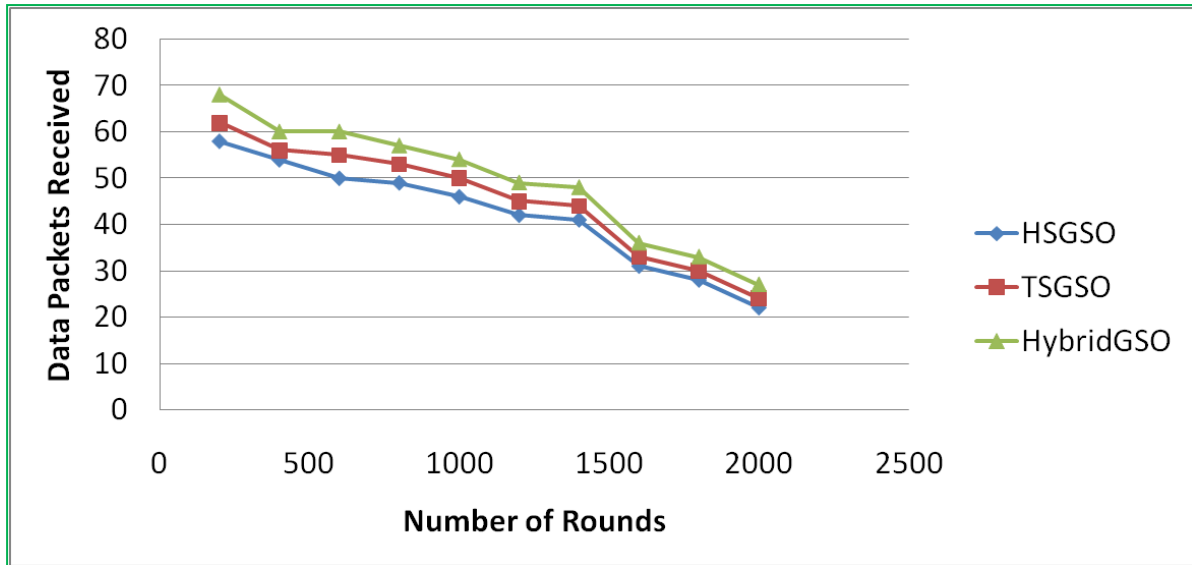


Figure 16 Data Packets delivered at Base Station for Hybrid GSO

From the figure 16, it can be observed that the Hybrid GSO has higher amount of data packets delivered at base station by 15.55% for HSGSO and by 2.46% for TSGSO.

The total amount of priority packets delivered at base station is demonstrated in Table 3.

Table 3 Priority Packets delivered at Base Station for Hybrid GSO

Number of Rounds	HSGSO	TSGSO	HybridGSO
200	10	14	18
400	9	13	17
600	8	11	14
800	8	11	14
1000	7	10	12
1200	6	9	11
1400	6	8	11
1600	6	9	11
1800	5	8	11
2000	5	8	10

From the figure 17, it can be observed that the Hybrid GSO method has higher amount of priority packets delivered at base station by 106.35% for HSGSO and by 63.97% for TSGSO.

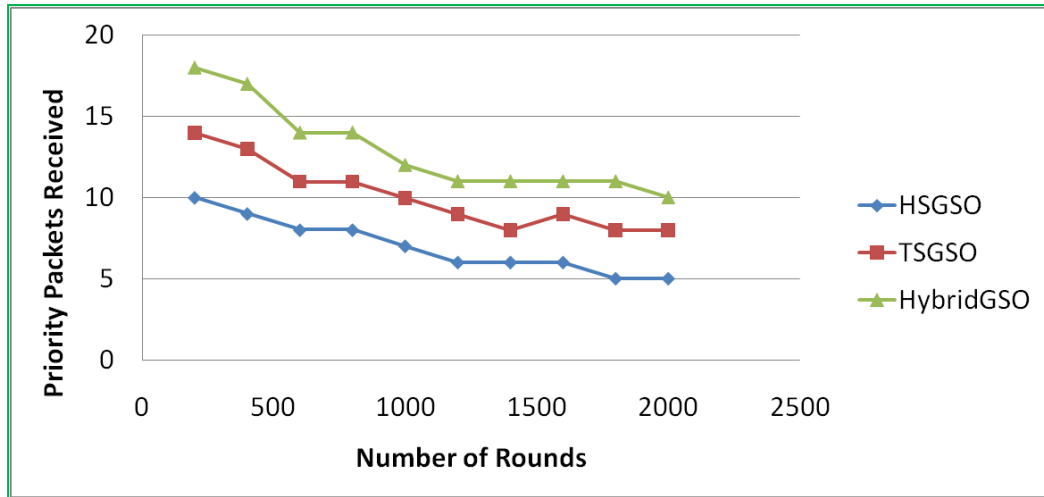


Figure 17 Priority Packets delivered at Base Station for Hybrid GSO

The total amount of clusters formed is demonstrated in Table 4.

Table 4 Clusters Formed for Hybrid GSO

Number of Rounds	HSGSO	TSGSO	HybridGSO
200	8	11	14
400	7	10	13
600	6	9	11
800	6	9	11
1000	5	8	11
1200	5	7	10
1400	4	7	10
1600	5	7	9
1800	4	6	8
2000	4	6	8

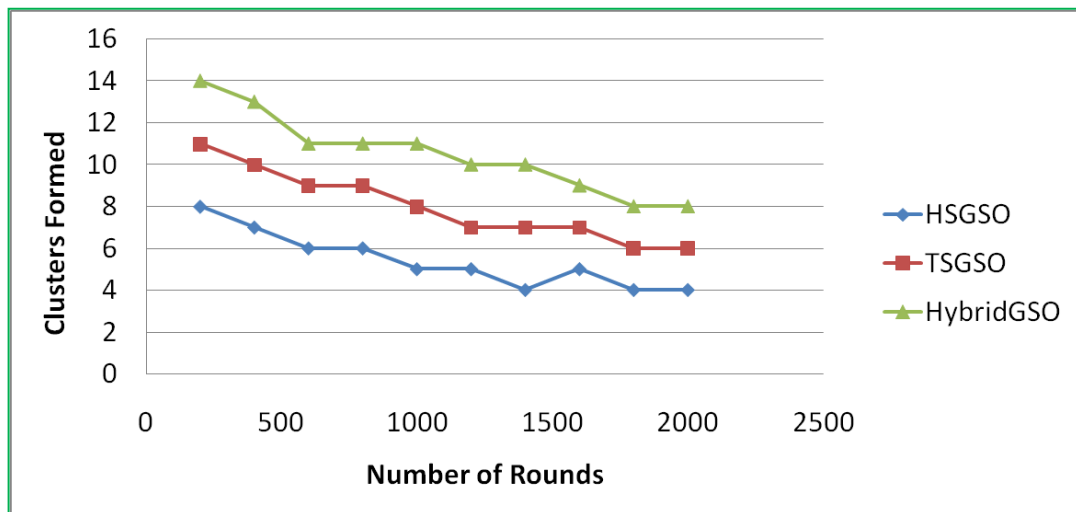


Figure 18 Number of Clusters Formed for Hybrid GSO

From the figure 18, it can be observed that the Hybrid GSO method has higher number of clusters formed averagely by 64.15% for HSGSO and by 13.19% for TSGSO for the different number of rounds.

Time complexity of the proposed technique is analyzed as the computation of individual values that the initial phase is to compute the power consumption and storage capacity of the sensor nodes by the algorithm at every position of the luciferin intensity. Time complexity is measured as $\Theta(\alpha N_s N_v^2)$. The space complexity of the proposed technique is measured as $\Theta(\alpha N_s \beta N_v^2)$. The time complexity and the space complexity is minimum so that it can solve the optimization issues while the number of sensor nodes are increased.

5. CONCLUSION

A complex, hierarchical, heterogeneous network is smart grid. Several applications of smart grid take place through WSN. WSNs play a vital role in energy management in home, business applications and industry. This work involves hybrid GSO (HS-GSO and TS-GSO) algorithm. HS mimics the improvisation process of musicians. Clarification area is searched as a whole in the HS algorithm in finding optimum vector, where the objective function is optimized. The terminology of GSO algorithm is integrated in this hybridization in the HS order, so as to limit the search time for the optimum. TS belong to the category of confined search methodologies. The advantages of mutually GSO and TS are commonly used by this innovative algorithm and this has a quick calculation speed and confined mathematical solution is evaded robustly. Results show that the Hybrid GSO method has superior amount of clusters evaded by 64.15% for HSGSO and by 13.19% for TSGSO for the dissimilar amount of rounds.

DECLARATION STATEMENT:

Conflict of interest:

Declaration of Interest Statement: The authors declare that they do not have any conflict of interest. This research does not involve any human or animal participation. All authors have checked and agreed the submission.

AUTHOR CONTRIBUTIONS: **Author1:** Writing - original draft, Writing - review & editing, Conceptualization, Data curation, Validation. **Author2:** Writing - original draft Conceptualization, Data curation, Validation and Supervision. **Author3:** Conceptualization, Writing - original draft, Formal analysis, **Funding:** This work has not supported by any funding agency/institution.

REFERENCES

- Amiri, E., Keshavarz, H., Alizadeh, M., Zamani, M., & Khodadadi, T. (2014). Energy efficient routing in wireless sensor networks based on fuzzy ant colony optimization. *International Journal of Distributed Sensor Networks*, 10(7), 1–17.
- Balaji, S., Golden Julie, E. & Robinson, Y.H. (2017). Development of Fuzzy based Energy Efficient Cluster Routing Protocol to Increase the Lifetime of Wireless Sensor Networks, *Mobile Netw Appl* (2017), 1-13.
- Camilo, T., Carreto, C., Silva, J., Boavida, F. (2006). An energy-efficient ant-based routing algorithm for wireless sensor networks, in: M. Dorigo, L. Gambardella, M. Birattari, A. Martinoli, R. Poli, T. Sttze (Eds.), *Ant Colony Optimization and Swarm Intelligence. Springer Berlin Heidelberg*, 4150, 49–59.
- Chander Janapati, R., Balaswamy, C., & Soundararajan, K. (2015, January). Enhanced mechanism for localization in wireless sensor networks using pso assisted extended kalman filter algorithm (pso-ekf). In *2015 International Conference on IEEE on Communication, Information & Computing Technology (ICCICT)*, 1-6.
- Chhaya, L., Sharma, P., Bhagwatikar, G., & Kumar, A. (2017). Wireless Sensor Network Based Smart Grid Communications: Cyber Attacks, Intrusion Detection System and Topology Control. *Electronics*, 6(1), 5.
- Du, M., Lei, X., & Wu, Z. (2014, July). A simplified glowworm swarm optimization algorithm. In *IEEE on Evolutionary Computation (CEC), 2014 IEEE Congress*, 2861-2868.
- Elhoseny, M., Tharwat, A., Yuan, X., & Hassanien, A. E. (2018). Optimizing K-coverage of mobile WSNs. *Expert Systems with Applications*, 92, 142-153.
- Fang, S., & Zhang, X. (2016). A Hybrid Algorithm of Particle swarm optimization and tabu search for distribution network reconfiguration. *Mathematical Problems in Engineering*, 2016.
- Fang, X., Misra, S., Xue, G., & Yang, D. (2012). Smart grid — the new and improved power grid: A survey. *IEEE communications surveys & tutorials*, 14(4), 944-980.
- Golden Julie, E., Tamil Selvi, S., & Harold Robinson, Y. (2016). Performance Analysis of Energy Efficient Virtual Back Bone Path Based Cluster Routing Protocol for WSN. *Wireless Personal Communications, Springer*, 1–19, DOI 10.1007/s11277-016-3520-5.

- Gong, X., Plets, D., Tanghe, E., De Pessemier, T., Martens, L., & Joseph, W. (2018). An efficient genetic algorithm for large-scale planning of dense and robust industrial wireless networks. *Expert Systems with Applications*, 96, 311-329.
- Guerrero, J. I., García, A., Personal, E., Luque, J., & León, C. (2017). Heterogeneous data source integration for smart grid ecosystems based on metadata mining. *Expert Systems with Applications*, 79, 254-268.
- Guo, Y., & Mu, B. (2015). Node Localization Technology of Wireless Sensor Network (WSN) Based on Harmony Search (HS) Algorithm. *Information Technology and Mechatronics Engineering Conference (ITOEC 2015)*.
- Harold Robinson, Y., & Rajaram, M. (2015). Energy-aware multipath routing scheme based on particle swarm optimization in mobile ad hoc networks. *The Scientific World Journal*, 1–9. doi:10.1155/2015/284276.
- Harold Robinson, Y., Golden Julie E., Balaji S., Ayyasamy A., (2016), Energy Aware Clustering Scheme in Wireless Sensor Network Using Neuro-Fuzzy Approach. *Wireless Personal Communications, Springer*, 1-19, Doi:10.1007/s11277-016-3793-8.
- Hu, T., Fei, Y., Qelar (2010). A machine-learning-based adaptive routing protocol for energy-efficient and lifetime-extended underwater sensor networks. *IEEE Transactions Mobile Computing*, 9 (6), 796–809.
- Janani, S. V., & Kumar, P. G. (2013). A survey on algorithms for cluster head selection in WSN. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, 1(2), 1909-1913.
- Keskin, M. E., Altinel, I. K., & Aras, N. (2015). Combining simulated annealing with Lagrangian relaxation and weighted Dantzig–Wolfe decomposition for integrated design decisions in wireless sensor networks. *Computers & Operations Research*, 59, 132-143.
- Manjusha, M. S., & Kannammal, K. E. (2014). Efficient Cluster Head Selection Method For Wireless Sensor Network. *International Journal of Computational Engineering Research*, 4(2), 43-49.
- Nazari-Heris, M., Fakhim-Babaei, A., & Mohammadi-Ivatloo, B. (2017, December). A novel hybrid harmony search and particle swarm optimization method for solving combined heat and power economic dispatch. *In Smart Grid Conference (SGC)*, 2017 1-9.
- Okdem, S., & Karaboga, D. (2009). Routing in wireless sensor networks using an ant colony optimization (ACO) router chip. *Sensors*, 9(2), 909-921.

- Orojloo, H., & Haghighat, A. T. (2016). A Tabu search based routing algorithm for wireless sensor networks. *Wireless Networks*, 22(5), 1711-1724.
- Poirion, P. L., Toubaline, S., D'Ambrosio, C., & Liberti, L. (2014, September). Localization on smart grids. In *XII GLOBAL OPTIMIZATION WORKSHOP*, 101-103.
- Robinson, Y. H., & Rajaram, M. (2016). A memory aided broadcast mechanism with fuzzy classification on a device-to-device mobile Ad Hoc network. *Wireless Personal Communications* 90.2 (2016), 769-791.
- Saleem, M., Di Caro, G. A., Farooq, M. (2011). Swarm intelligence based routing protocol for wireless sensor networks: Survey and future directions. *Information Sciences* 181 (20), 4597–4624.
- Sancho-Asensio, A., Navarro, J., Arrieta-Salinas, I., Armendáriz-Iñigo, J. E., Jiménez-Ruano, V., Zaballos, A., & Golobardes, E. (2014). Improving data partition schemes in Smart Grids via clustering data streams. *Expert Systems with Applications*, 41(13), 5832-5842.
- Sharma, P., & Pandove, G. (2017). A Review on Sensor Network in Smart Grid. *International Journal of Advance Research, Ideas and Innovations in Technology*, 3 (3), 268-274.
- Vijayalakshmi, K., & Anandan, P. (2018). A multi objective Tabu particle swarm optimization for effective cluster head selection in WSN. *Cluster Computing*, 1-8.
- Wu, B., Qian, C., Ni, W., & Fan, S. (2012). Hybrid harmony search and artificial bee colony algorithm for global optimization problems. *Computers & Mathematics with Applications*, 64(8), 2621-2634.
- Xu, Y., Ding, O., Qu, R., & Li, K. (2018). Hybrid Multi-objective Evolutionary Algorithms based on Decomposition for Wireless Sensor Network Coverage Optimization. *Applied Soft Computing*.
- Yao, Y., & Jiang, N. (2015). Distributed wireless sensor network localization based on weighted search. *Computer Networks*, 86, 57-75.
- Zeng, B., & Dong, Y. (2016). An improved harmony search based energy-efficient routing algorithm for wireless sensor networks. *Applied Soft Computing*, 41, 135-147.
- Zhang, Y., & Wu, L. (2012). Tabu Search Particle Swarm Optimization used in Cluster Analysis. *Journal of Science*, 1(1), 6-12.
- Zhou, Y., Zhou, G., Wang, Y., & Zhao, G. (2013). A glowworm swarm optimization algorithm based tribes. *Appl. Math*, 7(2L), 537-541.

Figures

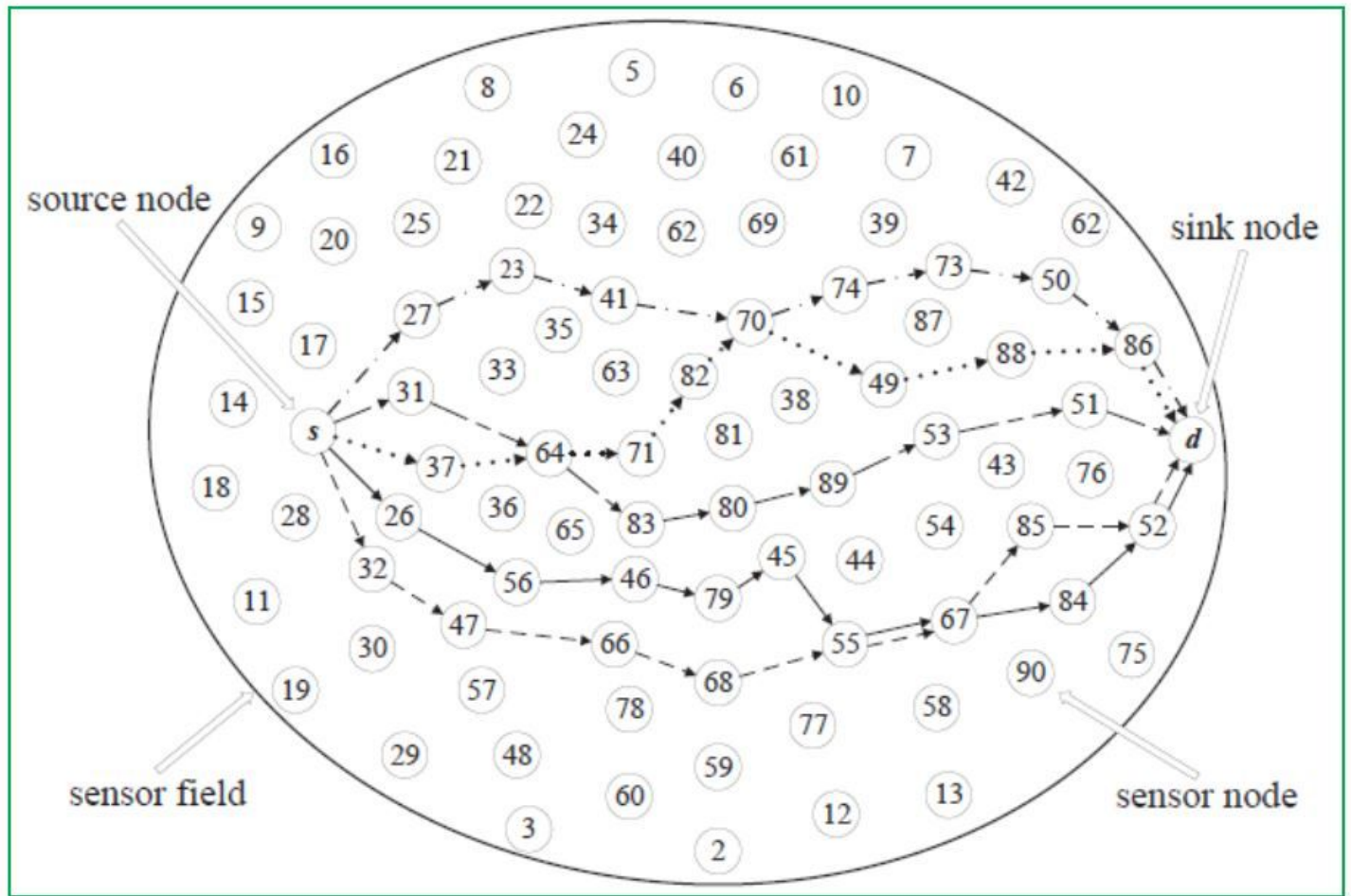


Figure 1

Wireless Sensor Network Formation

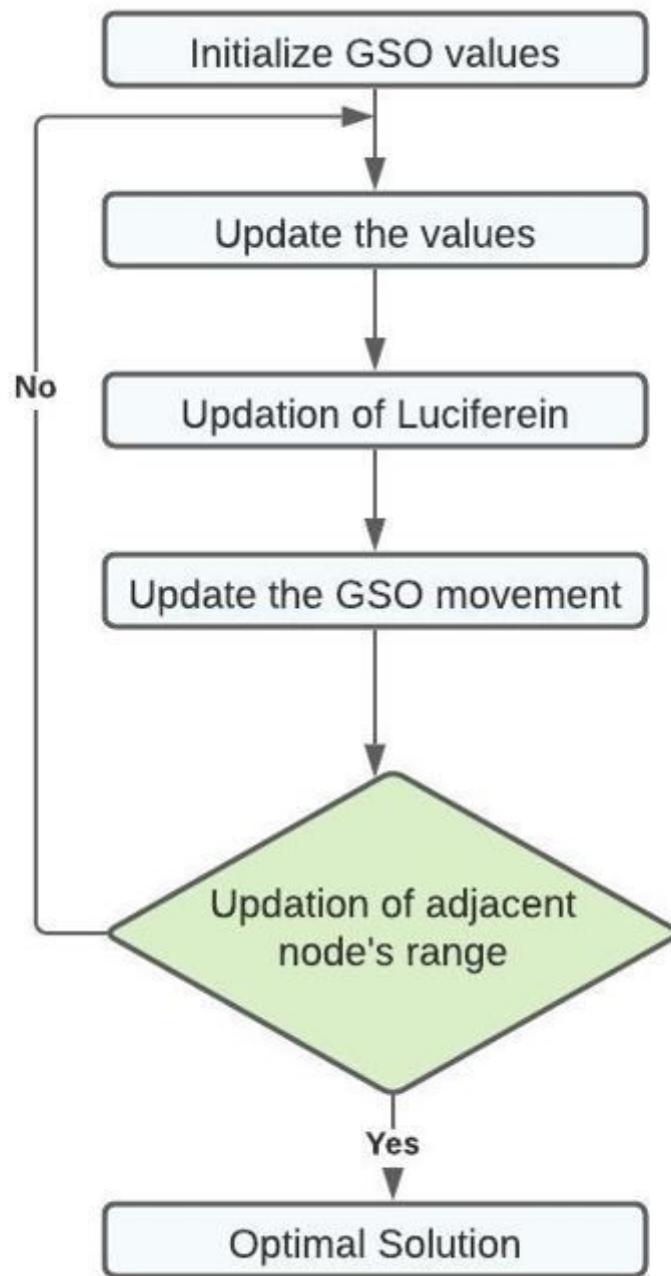


Figure 2

Flow chart for the algorithm

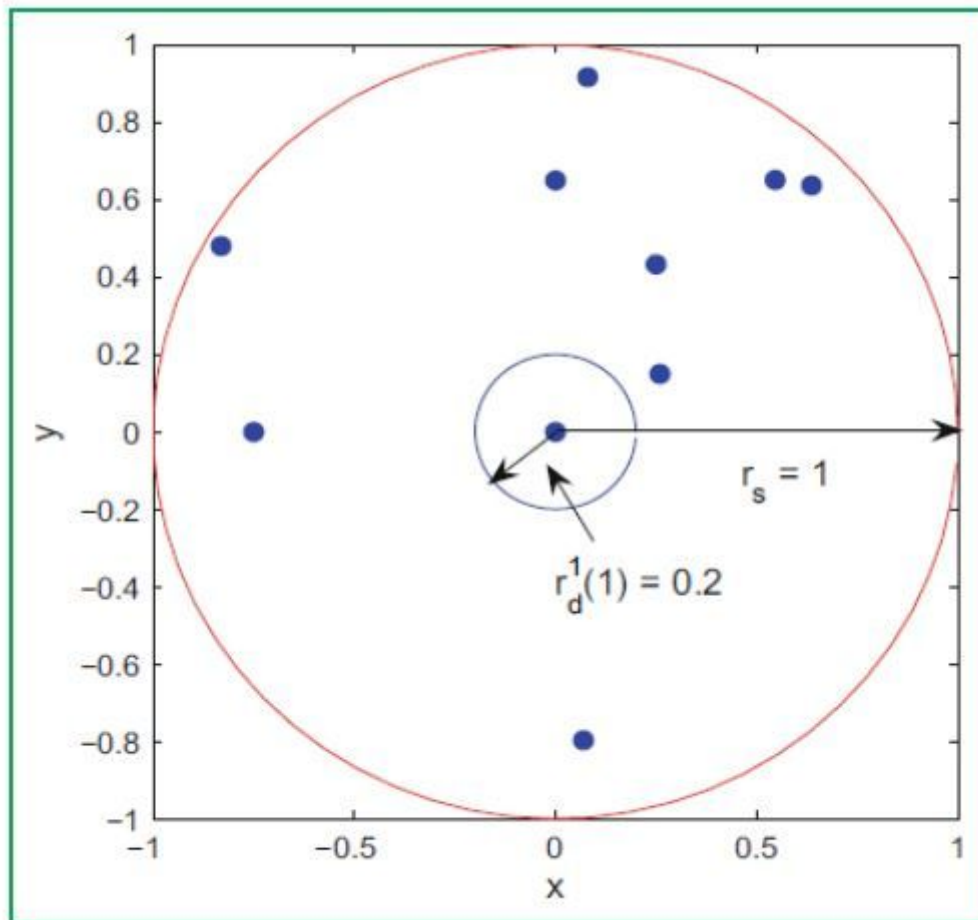


Figure 3

Glowworm formation within the radius.

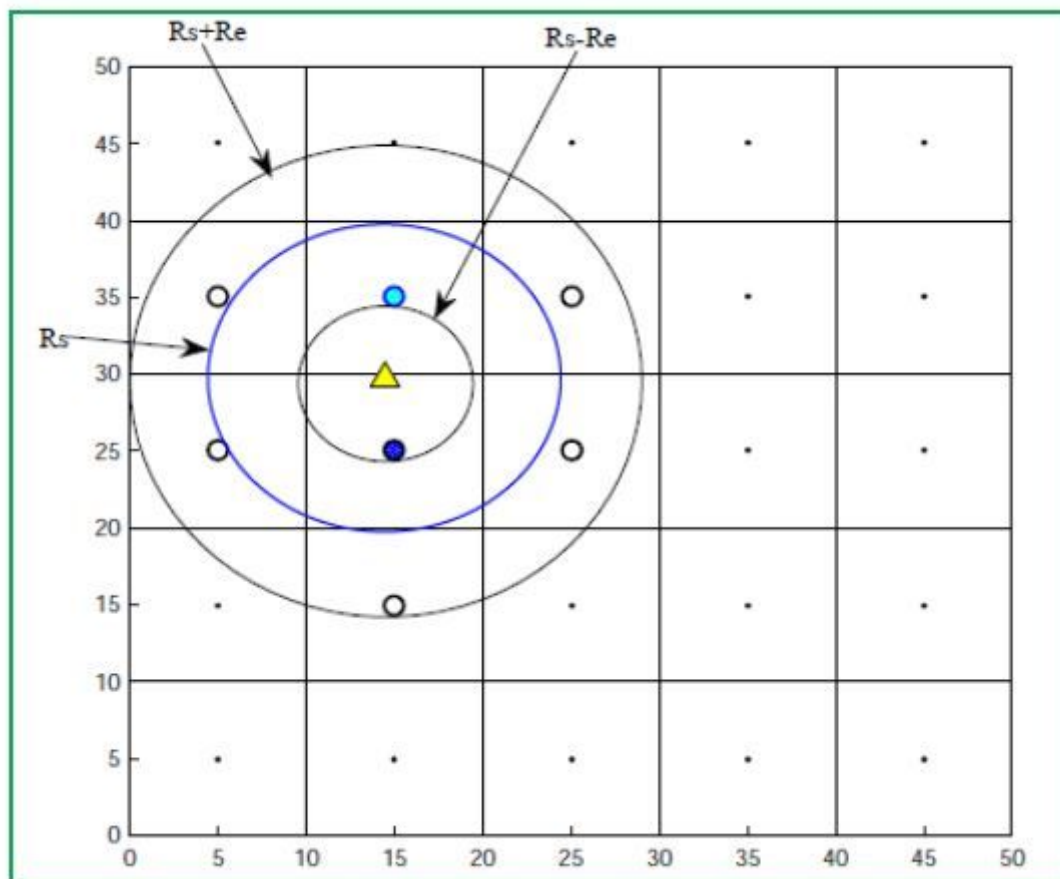


Figure 4

GSO Transmission Range

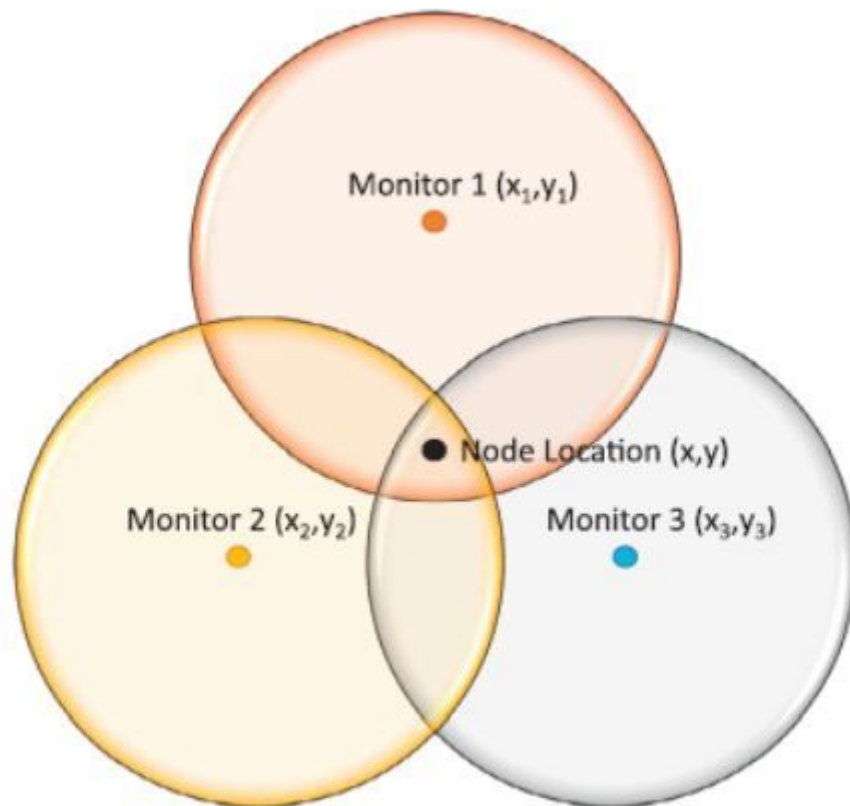


Figure 5

Monitoring of node location

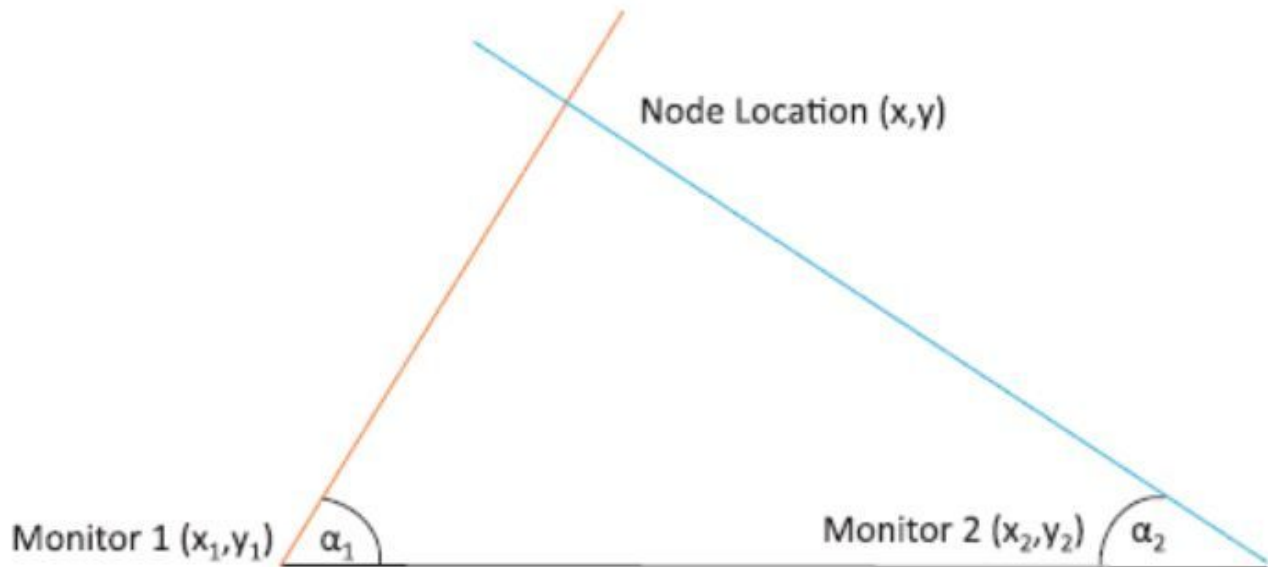


Figure 6

Angle of Sink node

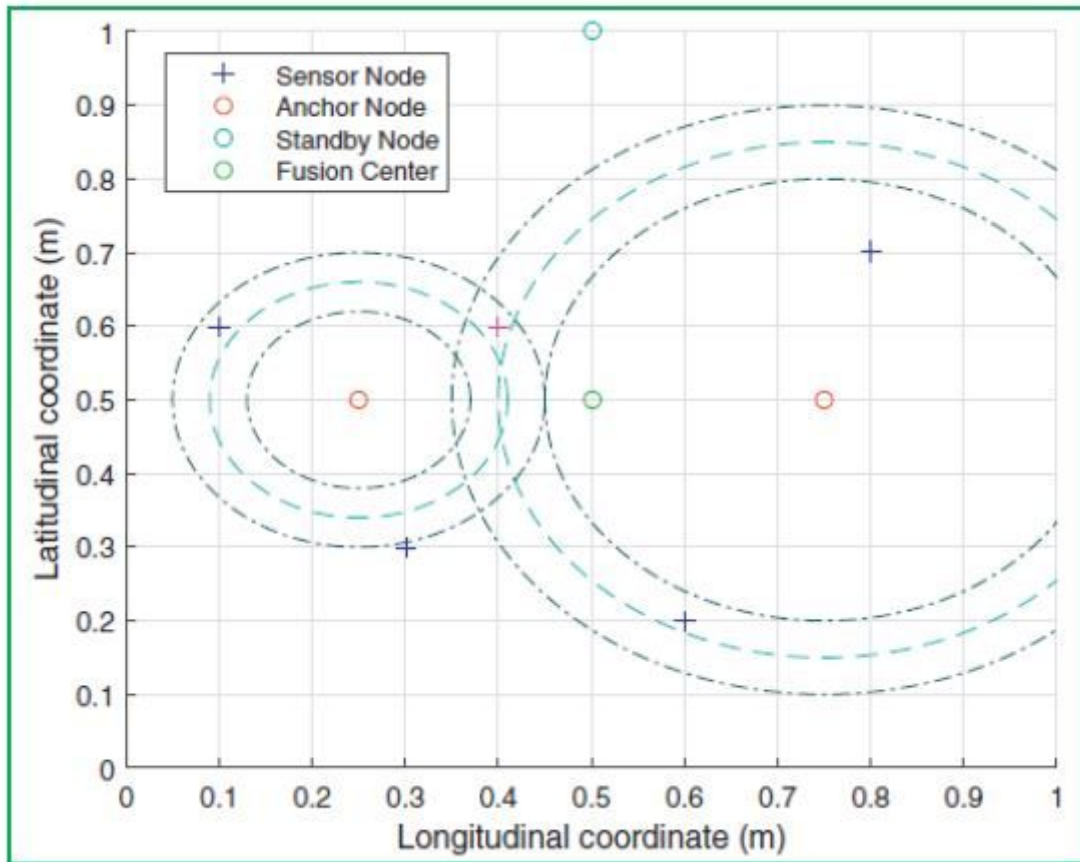


Figure 7

Radius Calculation

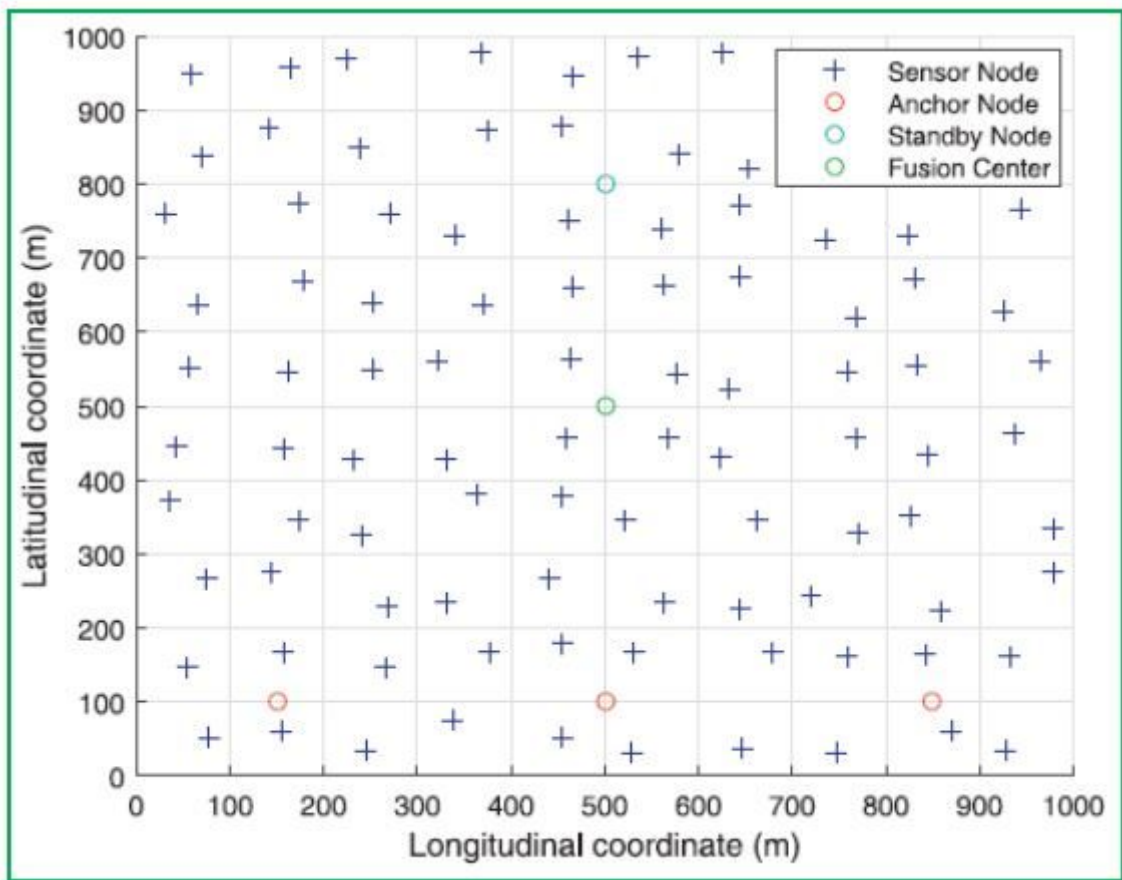


Figure 8

Wireless Sensor Network group formation

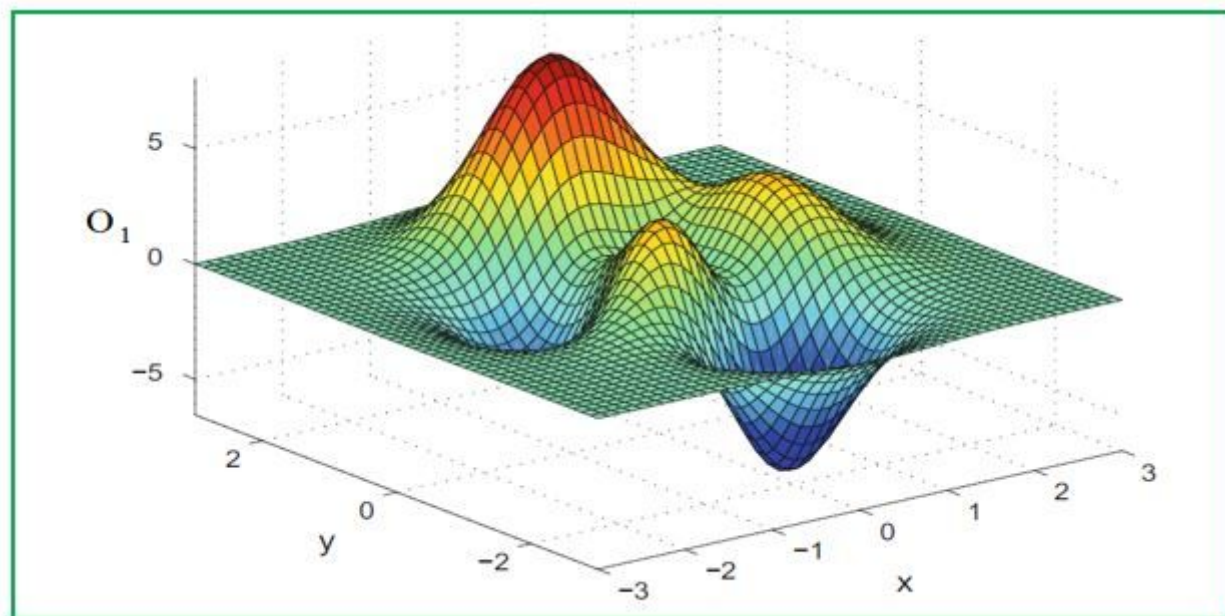


Figure 9

Cluster formation using hybrid GSO

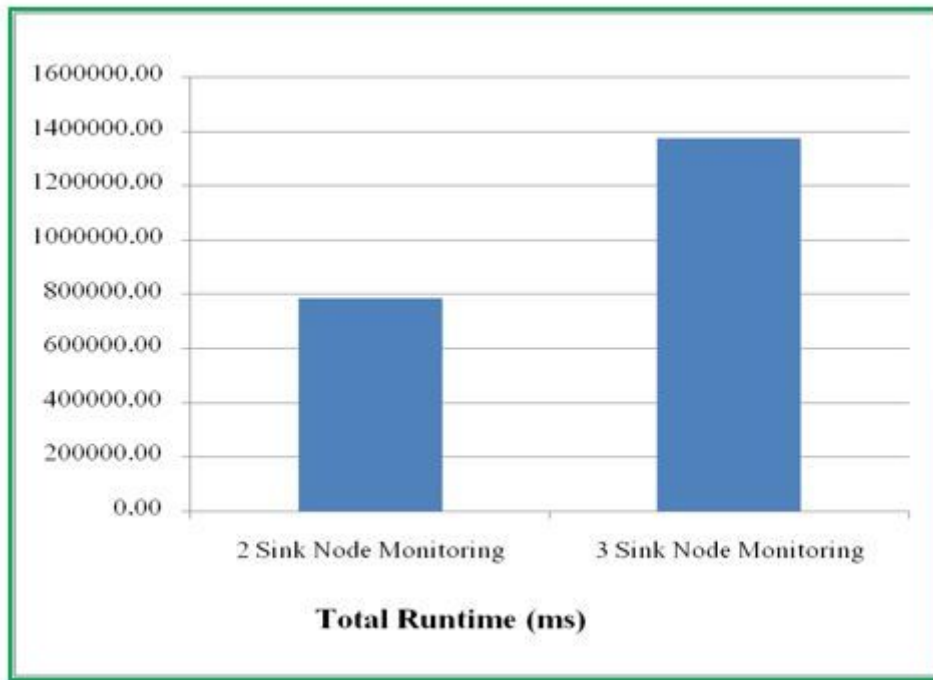


Figure 10

Total Runtime

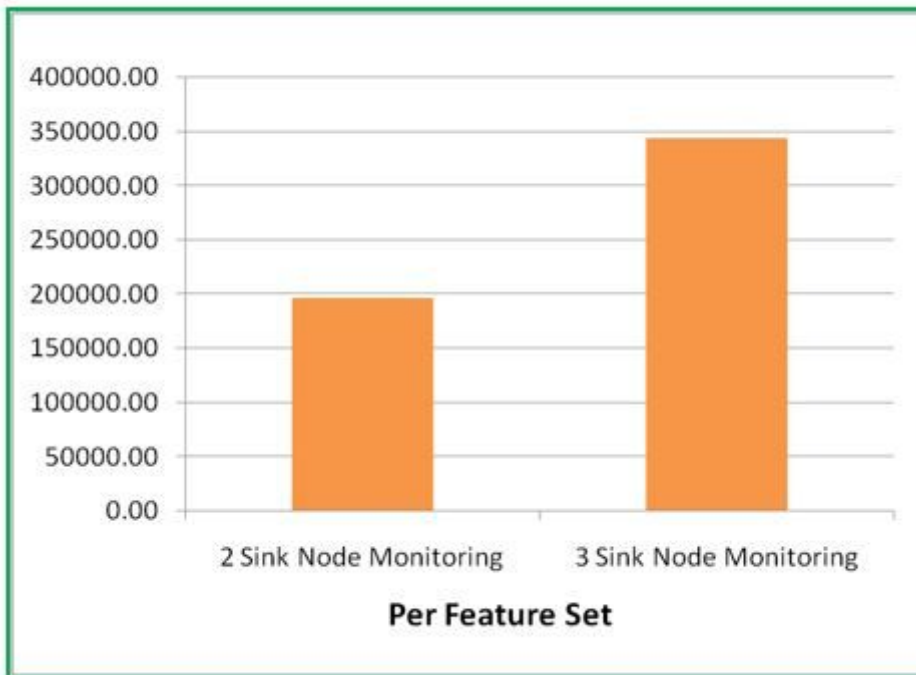


Figure 11

Per Feature Set

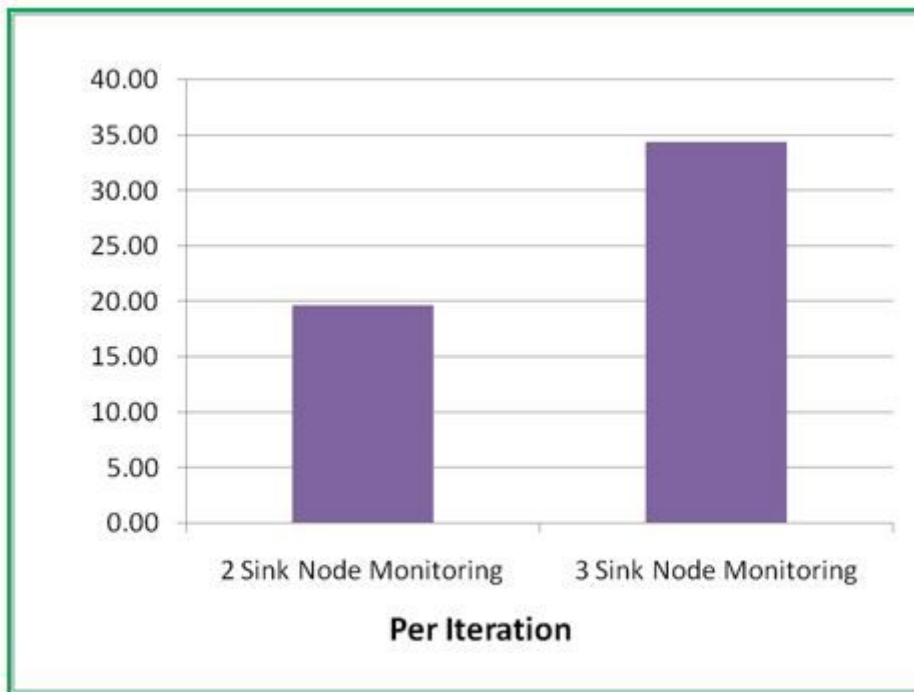


Figure 12

Per Iteration

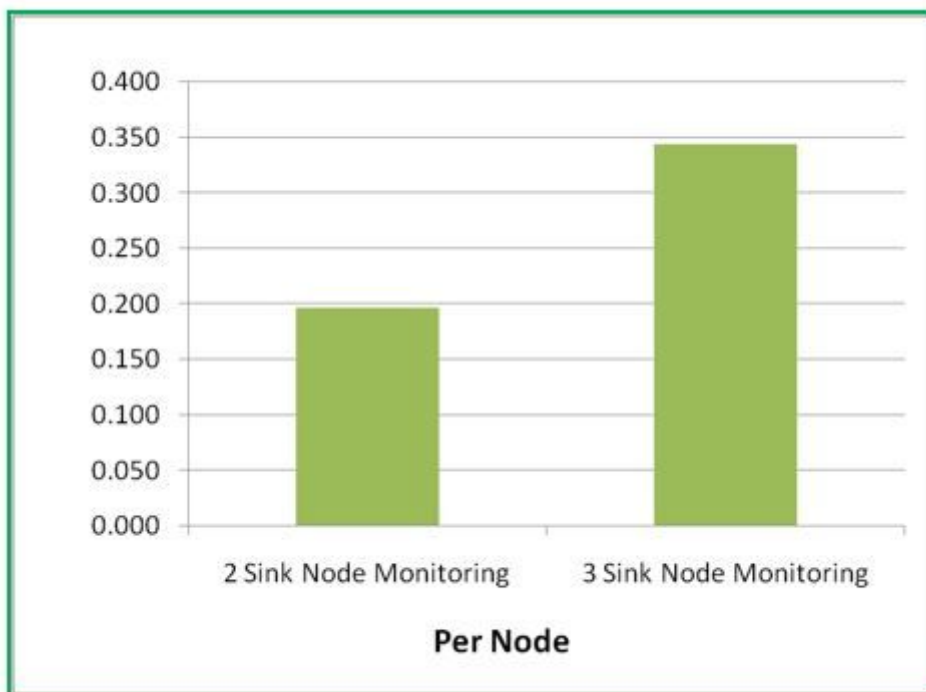


Figure 13

Per Node

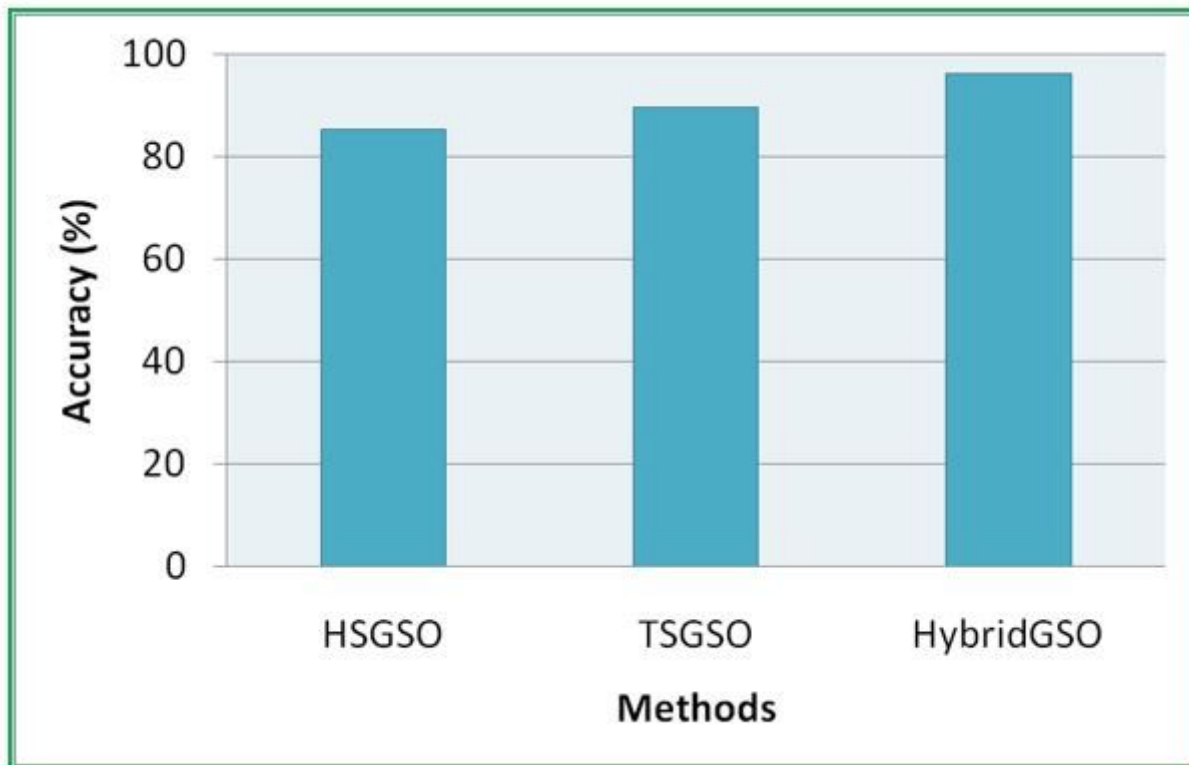


Figure 14

Accuracy (%)

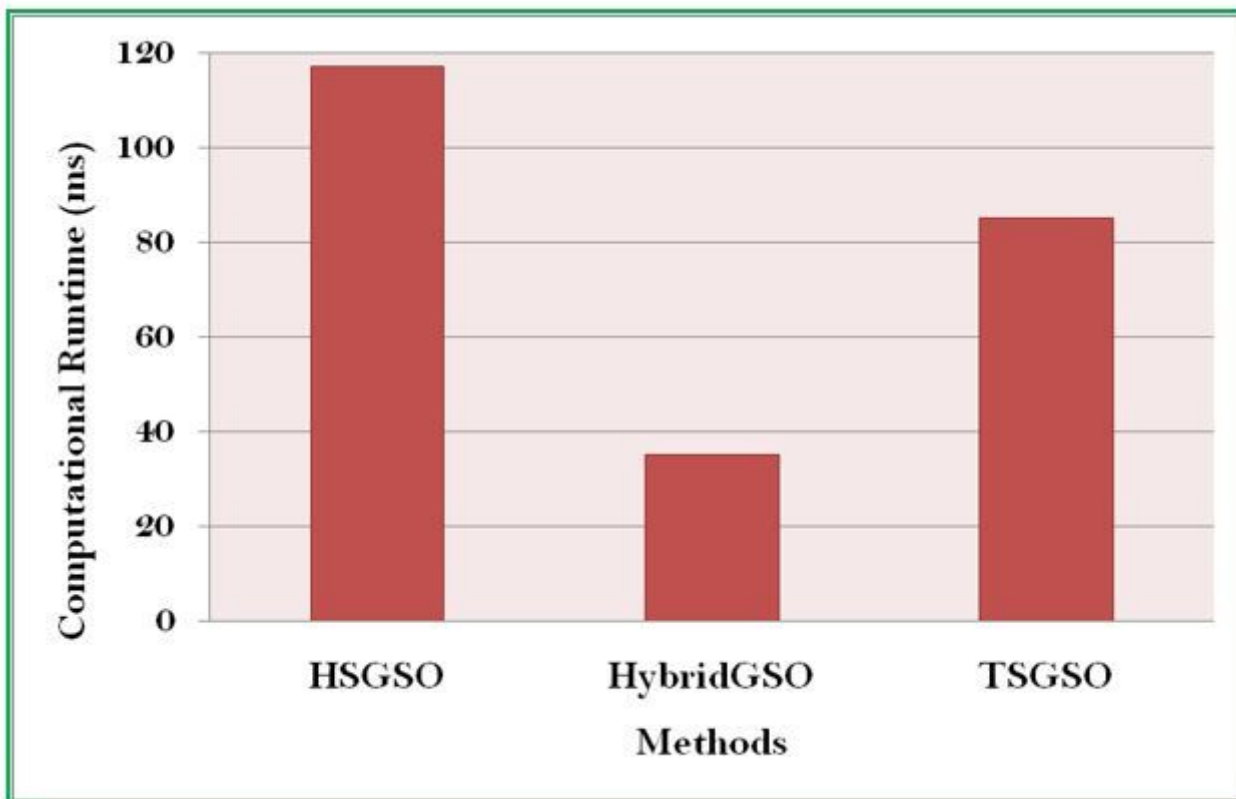


Figure 15

Computation Runtime

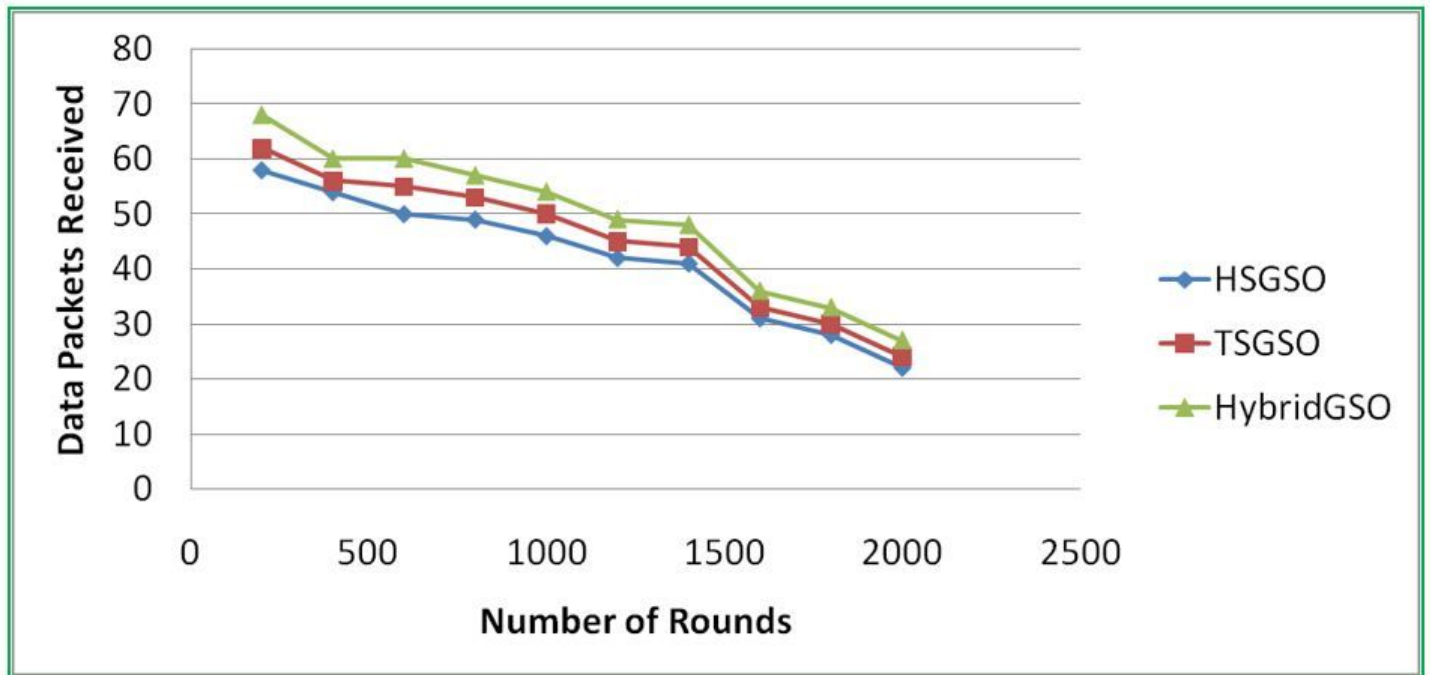


Figure 16

Data Packets delivered at Base Station for Hybrid GSO

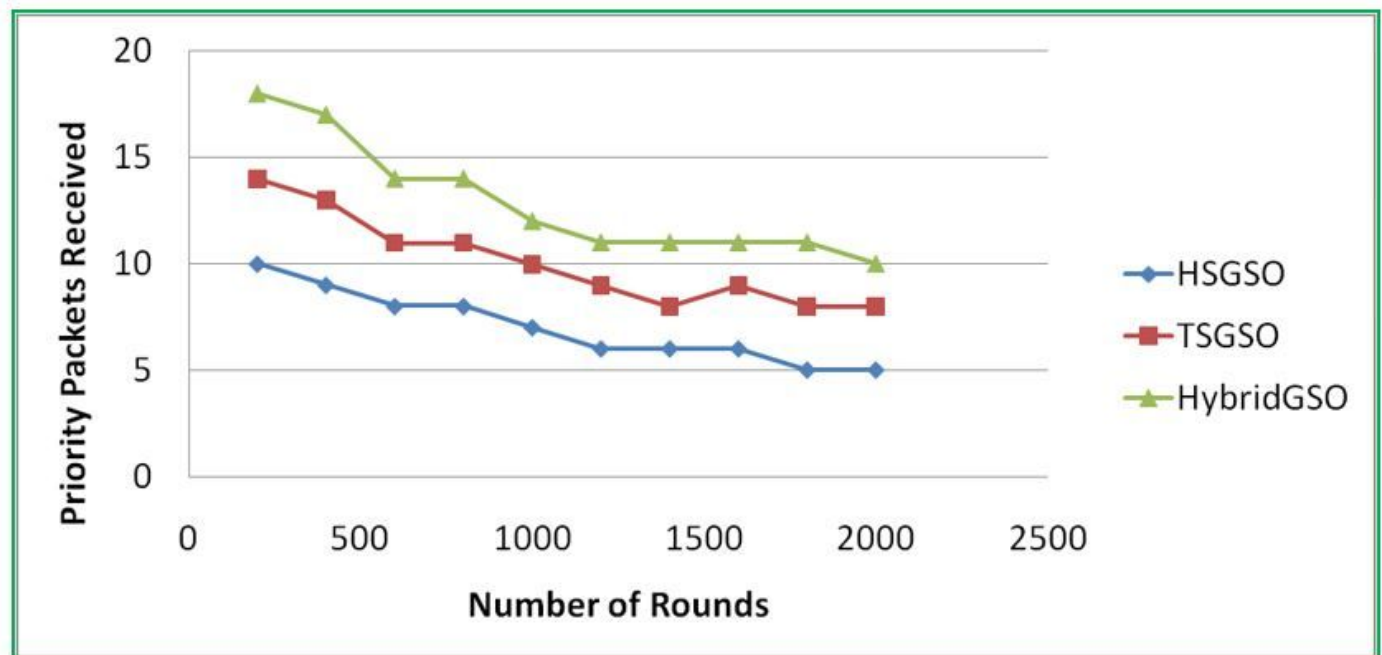


Figure 17

Priority Packets delivered at Base Station for Hybrid GSO

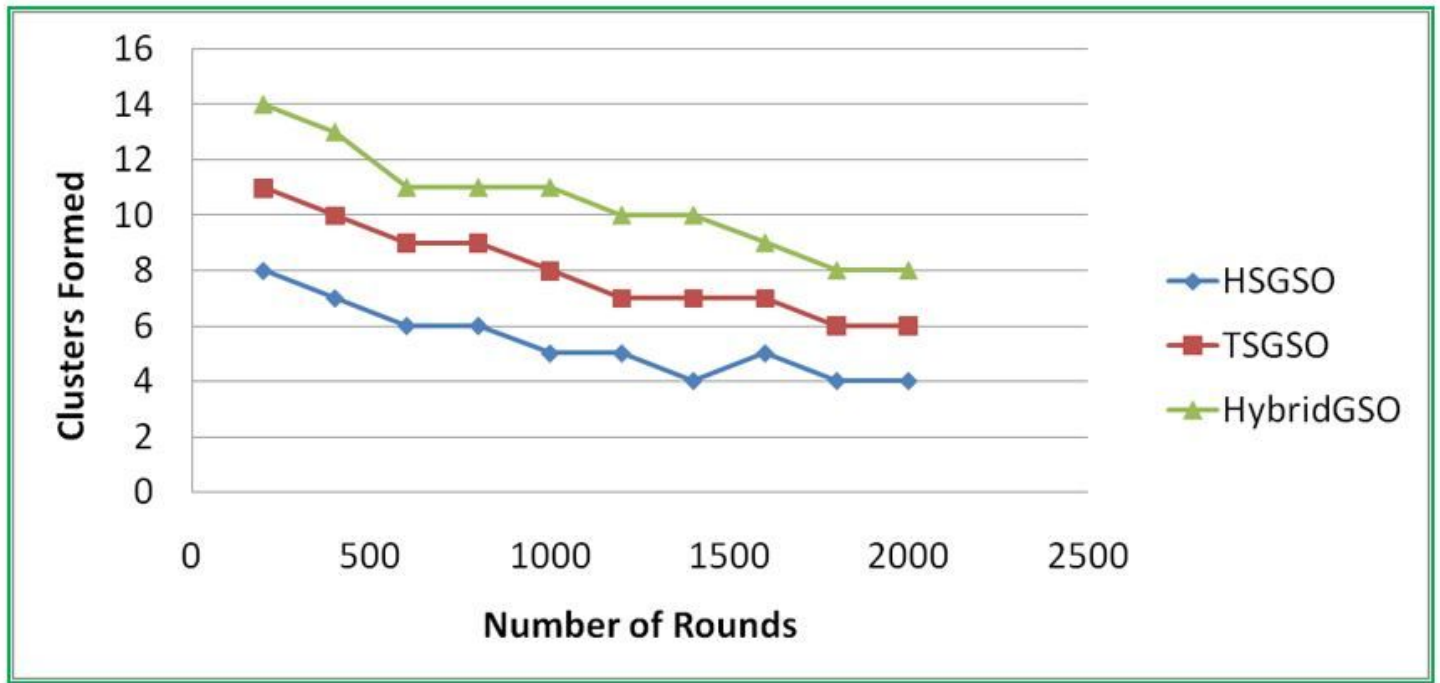


Figure 18

Number of Clusters Formed for Hybrid GSO