International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Energy Efficient Hierarchical Clustering using HACOPSO in Wireless Sensor Networks

Pavithra G.S., Babu N.V.

Abstract: ***The Wireless Sensor Network (WSN) is a collection of a various number of sensor node involved in a tremendous region for communicating data packets from one place to another in a productive way. The most significant techniques in the WSN are clustering, power consumption, lifetime and productive transmission of information in a secured manner with interconnected mobile nodes in networks. The clustering is the process of grouping the nodes for sharing the data packets to one cluster member to another cluster member through cluster heads present in the networks, which saves energy. Hence, K-Means clustering algorithm is used along with the Hybrid Ant Colony and Particle Swarm Optimization (HACOPSO) to produce a hierarchy of each CHs and observe that the energy savings increase with the number of levels present in the hierarchy. Ad hoc On-Demand Distance Vector Routing (AODV) uses two different operations to find and maintain routes: the route discovery process operation and route maintenance. Therefore, "K-Means-HACOPSO" methodology precisely transmit data from source to destination by evaluating better through-put, packet delivery ratio, packet loss, end-to-end delay and energy consumption in a secured environment.***

Index Terms: ***Ad hoc On-Demand Distance Vector Routing, Hybrid Ant Colony and Particle Swarm Optimization, Wireless Sensor Network, Power Consumption, Route discovery, Route Maintenance.***

I. INTRODUCTION

In WSN, energy consumption is a major factor that alters the metric of network lifetime. Reducing energy consumption during communication between nodes is a major issue to consider while designing a wireless sensor network. A vast majority part of Routing Protocol (RP) is concentrating on energy efficiency. Grouping remains the most effective RPs utilized in WSN [1]. Limiting energy dissemination and amplifying network lifetime in WSN are significant difficulties in the design of RP for ad-hoc networks. The LEACH, SEP and DEEC protocols are proposed based on the uncertainty, stability period, the network lifetime, the number of CHs per round and number of alive nodes in the WSN [2]. The typical clustering RP such as v-leach protocol is proposed to progress network lifetime in the networks [3].

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Pavithra G S*, Department of Computer Science & Engineering, S J B Institute of Technology, Bengaluru, India.
Dr. Babu N V, Department of Electrical & Electronics Engineering, S J B Institute of Technology, Bengaluru, India.

WSNs contains of low-cost, low power and energy-constrained sensors accountable for checking a physical phenomenon and reporting to sink node where the end-user can access the data. The SCRC-WSN is the strongest characteristics for defining the optimal no. of clusters in the sensor networks [4]. WSNs requires robust and energy efficient communication protocols to diminish the energy consumption and by increasing security. Improved V-Leach enables multi-hop transmission amongst the clusters by including the selection of transmitting nodes [5].

The new technologies are combined rapidly into the comprehensive architecture to meet the necessities of the present time. WSNs are used in monitoring temperature, pressure parameters and flow level in enormous levels. Command, communications, intelligence, surveillance, reconnaissance and aiming systems in a wireless network is highly defined [6]. The sensor nodes communicate over small distance through a wireless medium. The wireless networks constraints following characteristics such as dense sensor node deployment, battery-powered sensor nodes, self-configurable, severe energy, storage constraints, computation, unreliable sensor nodes, data redundancy, traffic pattern and frequency topology change etc. [7]. The RPs in WSNs are divided into two categories, clustering routing, and flat routing. All nodes have equal functionalities and performance in transmitting data by multiple hops. In clustering, nodes have different responsibilities and separated into groups called clusters. The cluster head (CH) communicates with BS and other nodes. The selection scheme for cluster head should be energy efficient and also should be capable of maintaining the stability of the network. The main theme of WSN is used to extend the lifetime without considering the local information [8]. The pressures of the topology-exposure problem offer a Topology-Hiding multi path Protocol (TOHIP) in WSN. The protocol creates multiple node disjoint routes in a route discovery attempt and excludes unreliable routes before conveying packets [9]. In stochastic multipath routing, the source node transfers from single path to the various path on the basis of a transition probability [10] To overcome this problem, K-Means along with the HACOPSO methodology and AODV is used for hierarchical clustering in mobile sensor by transmitting data in the search of multi-cast between CH, BS and sink node. In that, HACOPSO is used for identifying minimum distance among CHs to a node by which identification of clusters for a node is being optimized.

.

The performance of the proposed methodology will be appraised in terms of end to end delay, Through-put, Packet delivery ratio, and packet loss, and energy consumption.

II. RELATED WORK

Sabet Maryam et al. [11] has presented a decentralized energy efficient clustering on hierarchical routing algorithm for WSN. Due to transmission of messages such as data and control packets, the energy consumption in the networks occurs. The cluster head election occurs based on the degree and calculation of distance to reach the base station. The delay data increases along with the less selection of CH distance to the BS in large scale networks.

Gurbinder Singh Brar et al. [12] has introduced direction of energy efficient based PEGASIS-DSR Optimized Routing Protocol (PDORP) for WSN. The Power Efficient Gathering Sensor Information system (PEGASIS) is used for cache and directional transmission concept of both proactive and reactive routing protocols. The selection of optimal path in the dynamic environment should be further extended.

Jin Wang et al. [13] has presented dynamic routes adjustment approach on energy efficient cluster for WSNs with mobile sinks. The nodes need to reconstruct their routes towards the latest location of mobile sink to achieve efficient data dissemination. The selection of cluster heads doesn't communicate with sink node due to a larger network model.

Natasha Ramluckun et al. [14] has addresses Ant Colony Optimization (ACO) and chain cluster based routing techniques for energy efficient. The integration of the clustering method to PEGASIS with ACO to reduce redundancy of data, neighbor nodes distance and transmission delay with long links. The node failure transmission is stopped with the packet lost more. Hence, appropriate method for relaying information during a fault should be addressed further.

Amit Sarkar et al. [15] has introduced cluster head selection for energy efficient and delay-less routing in WSN for having effective transmission of data with less energy. The firefly with cyclic randomization is selected for best cluster head. The total number of transmissions involved in route discovery and data delivery is addressed more, which is the drawback of this network.

Santosh V. Purkar et al. [16] has presented clustering for efficient energy for heterogeneous WSN. The selection of CH with various parameters with the sensor nodes at the particular run time with initial energy, residual energy and hop count. The weight based distance based on different parameters for finding best possible node is not addressed with proper explanation.

Samayveer Singh et al. [17] has introduced DEEC protocol for improving lifetime in WSNs. The above parameters helps to choose cluster with the different respective cluster members using threshold and weighted election probability in the networks. The protocols do not assume proper distribution of node location in large scale network.

Jin Wang et al. [18] has performed PSO based on the clustering algorithm with mobile sink for WSNs. The clustering is performed based on selection of cluster head by considering residual energy and position of the nodes. The main drawbacks is that, the selection of energy and position of neighbor nodes should be achieved further with the usage of routing protocols.

Joon-Woo et al. [19] has processed based on scheduling algorithm for energy efficient coverage in ant colony of WSN. The above mentioned algorithm is used for the mainly for the probability sensor detection model to a heterogeneous sensor set. The saving energy and prolonging the coverage of an interest area should be improved.

Behrang Barekatain et al. [20] has introduced an energy aware routing for WSN on the combination of Kmeans and Genetic Algorithm (GA). The cluster based routing is used to find the optimum number of CH using improved GA. A Kmeans is use to balance energy distribution with longer network lifetime in WSN. The hierarchical clustering using Kmeans and GA should be implemented in large number of nodes with the base station locations in further.

PROBLEM DEFINITION

This sub-section explains about the problem statement of energy-efficient approaches in WSN and also detailed about how the proposed methodology gives solution to the described problems. The concerns of energy efficient wireless sensor approaches are detailed below.

- Energy-efficient Heterogeneous clustering (EHC) and route identification technique in clustered WSN among obstacles are used. Clustering is one of the key ideas for energy consumption and to build the lifetime of a sensor node in a system. The time interim is less in sensor arrange until the demise of the principal dynamic hub is analyzed [18].
- Based on the location of sensor nodes, the sink node divided the field of the network into various different logical regions in the heterogeneous LEACH environment. The quality of the mobile sensor can develop higher energy efficiency in the network [19].

Solution: The Nodes only interrelates with a small set of network topology within the transmission range of the wireless networks. The identification of CH should be changed from time to time dynamically for increasing the network lifetime. Hence, the formation of dynamic cluster will reduce energy consumption. To address this concern, a K-Means clustering methodology along with AODV RP is used in this paper.

III. ENERGY-EFFICIENT HIERARCHICAL CLUSTERING USING "K-MEANS-HACOPSO" IN WSNS

Energy constraints are the most critical-problems in sensor applications and that needs to be optimized to prolong the life of resource constraints sensor network. K-Means-HACOPSO works in three steps: Initiation, cluster Formation and Data transmission. The system consists of major steps 1) the network is initialized and deployment of nodes takes place. 2)

The nodes will be grouped into different clusters. 3) cluster-head selection is based on the remaining energy and the distribution of neighbor nodes 4) route estimation using AODV-RP. 5)
The Hybrid optimization of ACO and PSO techniques takes place. The pheromone value of ACO is used as a velocity updation of PSO techniques. 6) And, CHs collects data from active nodes and forward them to the sink. The Overall block diagram of K-Means-HACOPSO for WSNs methodology is shown Figure.1. In proposed method, the consideration of learning factor c is getting influenced by the other particles (derived from the pheromone value of Ants obtained from Ant Colony Optimization). Hence, the particles can be provided with the mechanism to share the information among others of the group. By thus the particles get closer and closer towards the optimal solution.

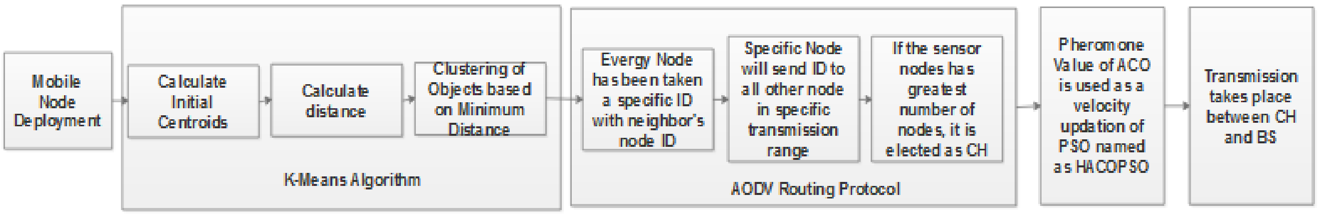

Fig. 1. Overall Block Diagram for Proposed Methodology

A. Hierarchical clustering in WSN

Clustering are used to simply the node management, to lessen energy consumption, to accomplish adaptability, and to recover load balancing and robustness and information aggregation. Nodes are gathered to form cluster. The Base station continuously needs to produce an aggregated value to the end clients and the data aggregation to be sent are helpful in reducing the transmission overhead and the energy consumption. The clustering can be distinct in the groups as the separation of the nodes present. The other nodes which are responsible for sensing and forwarding the collected data to the CH are called the member nodes.

B. Clustering K-Means Algorithm

K-Means is one of the effective and promising clustering algorithms in which it involves re-grouping nodes into several various clusters in the network. The foundation of clusters is based on two parameters such as: the number of clusters and second parameters is the Euclidean distance used to discover the neighboring cluster for each node. Here, 20, 40, 60, 80 and 100 nodes are divided into 3, 4, 7, 7 and 8 clusters respectively. The proposed selection process is explained based on the following.
The selection of CHs for the K-Means clustering algorithm is based on two statements such as, first, the CHs position should be the cluster center, and second, the remaining energy of the node. The centroid selection method is based on the iterative optimization of the distance between the nodes to categorize. The algorithm generates K-clusters from a set of "N" nodes. The objective function of K-Means algorithm is explained below in Eq. (1).

$$F = \sum_{r=1}^{K} \sum_{x1 \in Cr} (x_i - ch_r)^2 \qquad (1)$$

Where c_r is the set of nodes that belongs to cluster r, The Euclidean distance is used for the clustering by K-Means, which is expressed in Eq. (2).

$$d(x_i, CH_r) = \sqrt{(x_i - ch_r)^2} \qquad (2)$$

Therefore it only seeks to find the global minimum of ch_r., where x_i is a node of a cluster, ch_r the CH. The advancement of the K-Means bunching calculation is done in four stages, the initial step is picking the ideal number of groups to create in WSNs, then for each cluster chose the CH randomly, after the attribute the nearest bunch to every node utilizing the Euclidean separation. The {x1, x2, x3…………..xn} represented the wireless sensors organized in the field and {ch1, ch2……….chk} is the CH chosen initially randomly. The Eq. (3) and (4) explains Euclidean distance and cluster updation below.

1. Initialize the intermediate of the clusters arbitrarily ch_r where r = 1,……,k and K < n
2. Attribute the closest cluster to each data point using Euclidean distance

$$C_j = j : d(x_j, ch_r) \le d(x_j, ch_l), l \ne r, j = 1....n \qquad (3)$$

3. For all clusters k, the cluster middles ch_{lr} are updated using:

$$ch_r = (\frac{1}{C}) \sum_{j=1}^{c_i} x_i \qquad (4)$$

1) Energy Model

A wireless sensor node uses its energy to carry-out three main task: acquisition, data processing and communication. However, the energy consumed in the data processing operation is less important than communication (energy obligatory to send or receive data to another node). The distance between transmitter and receiver data to another node. The distance among transmitter and receiver impacts the amount of the consumed energy to send information into distance. The energy consume by the network can be determined by the given conditions to communicate a k-bit for a distance d, which is given in Eq. (5) and (6).

$$E_{Tx}(K,d)=E_{Tx}-etec+E_{Txamp}(k,d) \quad (5)$$

The energy exhausted in the transmit electronics for free space propagation ETx-fs is described by:

$$E_{Tx-mp}(K,d)=K*(E_{elec}+\Im_{fs}*d^2)ifd<d_0 \quad (6)$$

The energy used and finished in the transmit electronics for free-space propagation. The equation of ETx-fs is described in Eq. (7) and (8).

$$E_{Tx-mp}(K,d)=K*(E_{elec}+\Im_{fs}*d^4)ifd\geq d_0 \quad (7)$$

$$E_{Tx-mp}(K,d)=K*(E_{elec}+\Im_{amp}*d^4)ifd\geq d_0 \quad (8)$$

The energy consumed by the receiver to receive a message of k bits is given in Eq. (9).

$$E_{Rx}(K)=E_{Tx-elec}(k)=k*E_{elec} \quad (9)$$

Where: E_{TX} is the electrical energy for transmitting a K-bit message over a distance d, E_{elec} corresponds to the energy per bit required for transmitting the data packets. E_{fs} and $\Im_{amp}$ are constants to the vitality per-bit, which is necessary in the transmission intensifier to transmit a L-bit message over a separation d^2 and d^4 for free space and multipath propagation modes. In Eq. (7) and (8). The equation for control distance is $d=d_0$ is given below in Eq. (10).

$$d_0=\sqrt{\Im_{fs}/\Im_{amp}} \quad (10)$$

The distance between the trans-receiver is larger than the crossover distance d_0. Otherwise, the free space model is adopted to measure the energy dissipation.

C. AODV RP

The AODV is a reactive routing protocol. It is a source driven RP in which correspondence begins just when wanted by source node as unicast and multicast. Nodes maintain routing information in the routing table which is presented in the path and updation is done in the particular node, which is affected by topological changes in the network. Figure.2 demonstrates the message connections of the AODV-protocol. At the point when a basis has information to transmit message to an un-known destination, it communicates a Route Request (RREQ) for that destination. Each intermediate node makes a route to the destination, as the Route-Reply (RREP) engenders. The route with the shortest path is chosen if different RREPs are received by the source.

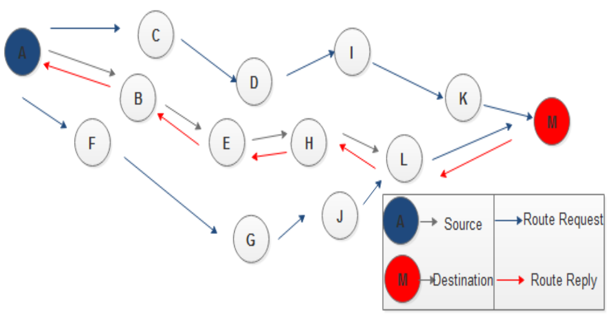

Fig. 2. RREQ and RREP in RP

Every node along the route informs the timers related to the routes to the source and destination by maintaining the routes in the routing table. A node can't make certain whether the route is still-valid by consequently removing the route from its routing table. A Route Error (RERR) is sent to the source of the information in a hop-by-hop fashion if the information is receiving and a connection break is recognized. Each intermediate node in-validates route to an unreachable destination as the RERR propagates towards the source.

D. Hybrid Ant Colony and Particle Swarm Optimization (HACOPSO)

An ACO simulates the normal behavior of ants, including their components of participation and adaption. The ACO algorithm depends on the three following ideas: First, every path followed by an ant is related to an applicant answer for a given issue. Second, the measure of pheromone deposited on the way is relative to the quality of the nature of the consistent candidate solutions for the objective issue, when an ant tails a way. Third, the paths with a larger measure of pheromone are progressively appealing to the ant. Eventually the ants will unite to the path, which is relied upon to be ideal or close ideal for the target after some iteration. The probability for ant l at node k moving to node l at generation u is defined as in Eq. (11).

$$Q_{j,l}^{K}(u)=\frac{t_{j,k}(u)d_{j,k}^{-\beta}}{\sum_{u\in\Gamma^{kt}} t_{j,v}d_{j,v}^{-\beta}},k\in\Gamma_j^k \quad (11)$$

Where is the intensity of the pheromone on edge is known as i and k, which is the considered as distance. The arrangement of nodes that suffer to be visited by ant k position at node I to make the solution feasible. Based on the global-pheromone updating rule, the pheromone value is updated on all edges. The ant built their tours is expressed in the following Eq. (12), (13) and (14).

$$t_{j,k}(t+1)=(1-\rho)_{j,k}(t)+\Delta t_{j,k}(t) \quad (12)$$

Where $\Delta t_{j,k}(t)=\sum_{K=1}^{NP}\Delta t_{j,k}(t)=\sum_{K=1}^{NP}\Delta t_{j,k}^{k}(t)$ (13)

$$\Delta t_{j,k}(t) = \begin{cases} \frac{Q}{Lk} & if\ (j,k) \in tourdonebyantk \\ 0 & Otherwise \end{cases} \quad (14)$$

The Eq. (14) is the pheromone decay, where it signifies the trail dissipation when the ant chose a city and resolve to move. Lk - is the distance of the visit achieved by ant k and m is the no.of ants. The bio-inspired schemes have been applied effectively in a spectrum over-lay perspective. The PSO algorithm to solve non-linear continuous optimization issues. A population based PSO algorithm develops an advantageous arrangement (or set of arrangements) for an issue.

The principle point is to find the global optimum of a distance function (fitness function) defined in a given space. The route is measured as a particle in this research work. The PSO contains a swarm of a predefined size of the particles. In this research, the best route is selected by using the PSO algorithm.

Hybridization of ACO and PSO in which "n" is a discriminating patterns of candidate, which is generated randomly. All patterns are occupied into the dimension of k*l, where each pattern resembles to one grid based on the order of their generation. The particle "n" agents are produced and consistently dispersed to the search-space in which each particle agent inhabits to evaluate the fitness value. Due to the fixed topology, the minimum no. of neighbors is selected based on network topology size. Hence, the pheromone value of ACO is used as a velocity updation for PSO. Hence, the process is repeated for a fixed number of repetitions and the pattern with the maximum fitness is returned as the solution that satisfies all the constraints.

IV. RESULT AND DISCUSSION

The "K-Means-HACOPSO" method is implemented in the Network simulator-NS2. The simulations parameters are shown in Table 1. The simulation starting time and ending time is expressed and taken as 0.1-50 Secs by considering the different nodes as 20, 40, 60, 80 and 100. The model of the network is considered as Omni Antenna with the MAC type 802_11. The implemented algorithm provides better performances by associating with the existing methods. The performance metrics are shown below..

A. Packet Delivery Ratio (PDR)

PDR is based on the total amount of data packets forwarded to the destination by the source node with excluding the lost packets in the network, which is given in Eq. (15)

$$Delratio = \frac{(no.of\ \ packets\ sent - packets\ lost)}{no.of\ \ packets\ sent} \times 100 \quad (15)$$

B. Energy consumption

The large amount of node's energy value is equal to the large amount of received energy consumption rate in the network. A specific rate of energy is dropped for every transmission of packets in the node. Hence, the energy rate is calculated based on the total simulation time in the network which is given in Eq. (16)

$$Energy = \frac{amount\ of\ energy\ \ for\ every\ packets}{total\ simulation\ time} \quad (16)$$

C. E2E Delay

The E2E delay is calculated based on the data packets sending time to the source and receiving time from the destination node in the network by considering the hop count is known as delay, which is given in Eq. (17).

$$Delay = Time\ spend\ on\ Hop1 + time\ spend\ on\ Hop2 + ... + time\ spend\ on\ Hop\ n \quad (17)$$

D. Routing Overhead

It is considered as the routing of data packets delivered to the source node in the network divided by the total number of data packets reached at the destination, explained in Eq. (18).

$$Routing\ Overhead = \frac{Total\ no.of\ routing\ packets}{Total\ no.of\ delivered\ data\ packets} \quad (18)$$

The Evaluation of Nodes vs. delay between Kmeans-HACOPSO and existing method is plotted in Fig. 3 the delay value is decreased in Kmeans-HACOPSO method, when associated with the EECPEP [16], hetDEEC [17] and Kmeans-AODV method with different 20, 40, 60, 80 and 100 Nodes. In the simulation system, the end-to-end delay with various number of nodes in the destination is measured. The number of nodes with the sink node is measured and managed in the network. The packets should reach to the sink node by measuring the time in the network. The number of nodes in the network increases with the delay.

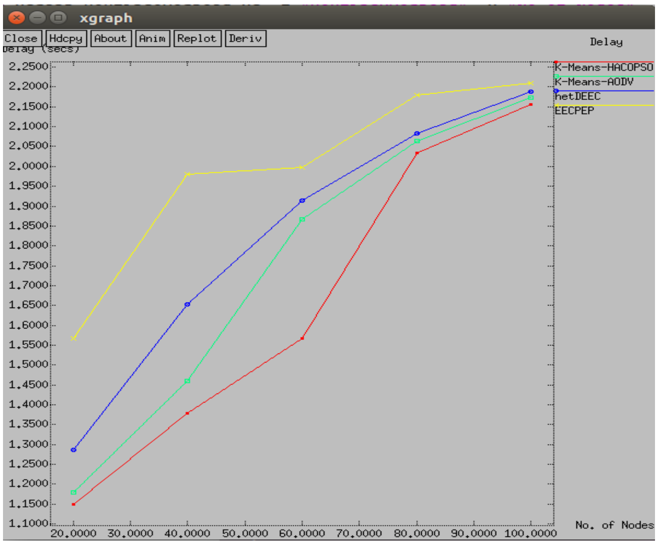

Fig. 3. Number of nodes vs. Delay

The Evaluation of Nodes vs. Throughput between Kmeans-HACOPSO and existing method is plotted in Fig. 4 the Throughput value is improved in Kmeans-HACOPSO method, when associated with the EECPEP [16], hetDEEC [17] and Kmeans-AODV method with different 20, 40, 60, 80 and 100 Nodes.

The throughput of the network is high because of the fact that the network management partitions the WSN into gatherings. Each of these groups has well defined area. The throughput is expected to increase gradually if the number of nodes is increased.

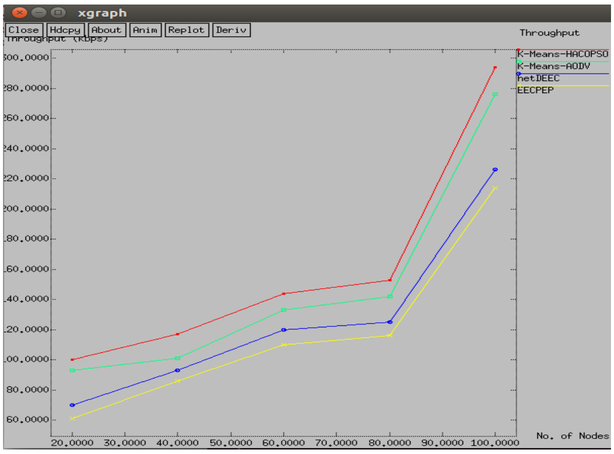

Fig. 4. Number of nodes vs. Throughput

The Evaluation of Nodes vs. energy among Kmeans-HACOPSO and existing method is plotted in Fig. 6 the Energy value is decreased in Kmeans-HACOPSO method, when associated with the EECPEP [16], hetDEEC [17] and Kmeans-AODV with different 20, 40, 60, 80 and 100 Nodes. In this simulation, the energy degree for each sensor node with the general sink nodes are introduced. Figure.5 shows that the energy consumption in case of sensor nodes is less. The energy consumption of administrator sink node is high yet not as much as that of the sensor node. This is because of the colossal number of sensors, which should to send their data to the supervisor sink node. The sink nodes consume low energy because of their functions are viewed as combined data taking care of. The general sink node with least consumption of energy because of the long inter-processing time which is required to deal with an exceptional occasion. Overall results of energy consumption prove that Kmeans-HACOPSO system has best performance that the other existing one.

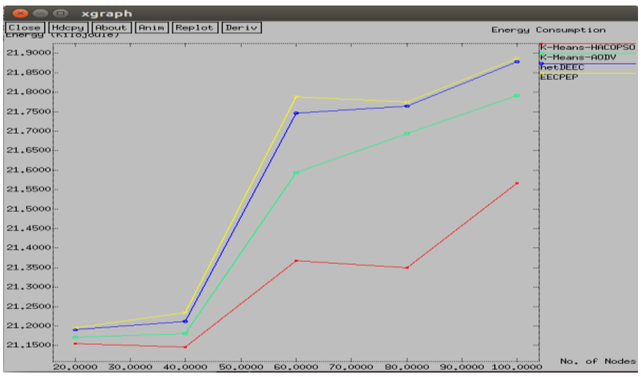

Fig. 5. Number of nodes vs. Energy

The Evaluation of Nodes vs. Routing Overhead between Kmeans-HACOPSO and existing method is plotted in Fig. 6 the Routing Overhead value is decreased in Kmeans-HACOPSO method, when compared with the EECPEP [16], hetDEEC [17] and Kmeans-AODV method with different 20, 40, 60, 80 and 100 Nodes. AODV has less routing overhead irrespective traffic load. The DSDV increase routing load in the network with the intermittent broadcasts of control packets. AODV send periodic updates of the regular intervals in the nodes even if the RREQ packets is not received to any other nodes in the networks. AODV adapts hop-by-hop routing whenever it is needed and performs high traffic. The existing methods performs less at moderate sized load and low due to the source routing and the size of packet header not to be larger at low and moderate sized traffic.

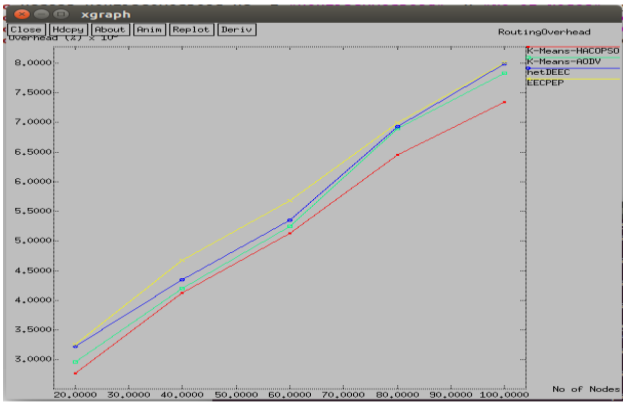

Fig. 6. Number of nodes vs. Routing Overhead

The simulations parameters are shown in Table 1. The starting time and ending time of the simulation is calculated based on Secs (START-TIME is 0.1 Sec) and (END-TIME is 50 Sec) by changing static nodes (20. 40, 60, 80 and 100) with Omni Antenna model and MAC-TYPE as 802_11.

Table I. Simulation Parameter

Clustering algorithm	K-Means
Cluster Optimization	HACOPSO
Routing Protocol	AODV
Simulator used	NS2
Start time of Simulation	0.000000000
End time of Simulation	50.00000000
Mobile nodes Count	20, 40, 60, 80 and 100
Type of Antenna Model	Omni Antenna
Speed Used	28ms
Type of Network Interface	Wireless
MAC Address	MAC/802_11
Power of Initial Transmit	0.66W
Power of Initial Receive	0.39W

V. CONCLUSION

The "K-Means-HACOPSO-WSN" Methodology is to improve the network energy consumption by efficient clustering for effective selection of CHs with route establishment using RP. A CH selection is effectively applied to heterogeneous energy wireless sensor networks as a solution to the CH selection problem.

A wide system energy consumption model is established with the optimal number of cluster to determine the minimum energy consumption using K-Means. The CH node sends the data to the base station after the data of each member node are fused in the network. The AODV routing protocol is used to transfer data packets from one node to another by optimizing HACOPSO techniques. From obtained simulation results, the proposed methodology gives best-routing along with delay, throughput.

Energy consumption and routing overhead among existing methods such as EECPEP, hetDEEC Protocol and Kmeans-AODV methodology. The network nodes are battery operated and have a limited amount of power so the main objective of this work was to develop an energy-efficient clustering protocol in order to improve network lifetime without degrading the network performance. Hence the efficiency of the network also can be enhanced further with better cluster formation by adding some heterogeneity in the network.

REFERENCES

1. A. Mahboub, M. Arioua, and I. Ez-Zazi. (2016). Multiple zonal approach for clustered wireless sensor networks. *International Conference on Electrical and Information Technologies (ICEIT)*, pp. 219-224.
2. A. Mahboub, M. Arioua, E. M. En-Naimi, and I. Ez-zazi, (2016). Performance Evalution of Energy-Efficient Clustering Algorithms In Wireless Sensor Networks. *Journal of Theoretical & Applied Information Technology, 83(2).*
3. A. Ahlawat, and V. Malik, (2013), An extended vice-cluster selection approach to improve v leach protocol in WSN. *Third International Conference on Advanced Computing and Communication Technologies (ACCT), pp. 236-240.*
4. B. Elbhiri, S. El Fkihi, R. Saadane, N. Lasaad, A. Jorio, and D. Aboutajdine, (2013). A new spectral classification for robust clustering in wireless sensor networks. *In 6th Joint IFIP Wireless and Mobile Networking Conference (WMNC), pp. 1-10.*
5. H. Shah, and S.R. Bhoyar, (2014). Improved V-LEACH Protocol in Wireless Sensor Networks with Data Security. *IOSR Journal of Electronics and communication Engineering (IOSR-JECE) 9(5), pp. 49-54.*
6. D. Gupta, Wireless Sensor Networks 'Future trends and Latest Research Challenges, *10(2), pp. 41-46.*
7. D. Goyal, and M. R. Tripathy, (2012), RPs in wireless sensor networks: a survey. *IEEE Second International Conference on Advanced Computing & Communication Technologies (ACCT).*
8. S. S. Meelu, M. Katiyar, Efficient CH Selection Scheme for Wireless Sensor Network Using Deterministic Protocol, *16(3), pp. 62-67.*
9. Y. Zhang, T. Yan, J. Tian, H. Qi, G. Wang, Z. Li, (2014). A topology-hiding Multipath RP in mobile ad hoc networks, *Elsevier.*
10. S. Sarkara, R. Datta, (2015). A secure and energy-efficient stochastic multipath routing for self-organized mobile ad hoc networks, *Elsevier.*
11. M. Sabet, and H.R. Naji, (2015). A decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks. *AEU-International Journal of Electronics and Communications*, 69(5), pp.790-799.
12. G.S. Brar, S., Rani, V. Chopra, R. Malhotra, H. Song, and S.H. Ahmed, (2016). Energy efficient direction-based PDORP routing protocol for WSN. *IEEE access*, 4, pp.3182-3194.
13. J. Wang, J. Cao, S. Ji, and J.H. Park, (2017). Energy-efficient cluster-based dynamic routes adjustment approach for wireless sensor networks with mobile sinks. *The Journal of Supercomputing*, 73(7), pp.3277-3290.
14. N. Ramluckun, and V. Bassoo, (2018). Energy-efficient chain-cluster based intelligent routing technique for Wireless Sensor Networks. *Applied Computing and Informatics*.
15. A. Sarkar, and T.S. Murugan, (2019). Cluster head selection for energy efficient and delay-less routing in wireless sensor network. *Wireless Networks*, 25(1), pp.303-320.
16. S. V. Purkar, and R. S. Deshpande, (2018). Energy Efficient Clustering Protocol to Enhance Performance of Heterogeneous Wireless Sensor Network: EECPEP-HWSN. *Journal of Computer Networks and Communications*, 2018.
17. S. Singh, A. Malik, and R. Kumar, (2017). Energy efficient heterogeneous DEEC protocol for enhancing lifetime in WSNs. *Engineering Science and Technology, an International Journal*, 20(1), pp. 345-353.
18. J. Wang, Y. Cao, B. Li, H.J. Kim, and S. Lee, (2017). Particle swarm optimization based clustering algorithm with mobile sink for WSNs. *Future Generation Computer Systems*, 76, pp.452-457.
19. J.W. Lee, and J.J. Lee, (20120. Ant-colony-based scheduling algorithm for energy-efficient coverage of WSN. *IEEE sensors journal*, 12(10), pp.3036-3046.
20. B. Barekatain, S. Dehghani, and M. Pourzaferani, (2015). An energy-aware routing protocol for wireless sensor networks based on new combination of genetic algorithm & k-means. *Procedia Computer Science*, 72, pp.552-560.
21. K.J. Elma, and S. Meenakshi, (2018). Energy Efficient Clustering for Lifetime Maximization and Routing in WSN. *International Journal of Applied Engineering Research*, 13(1), pp.337-343.
22. R. Shukla, and A. Kumar, (2018). An Energy Efficient Scheme for Precision Agriculture Using WSN in Heterogeneous Environment. *International Journal of Engineering Science Invention (IJESI)*, 7(1), pp.82-88.

AUTHORS PROFILE

Pavithra G S Completed her B.E. and M.Tech degrees in computer science and Engineering from Visvesvaraya Technological University, Belgaum, India in 2003 and 2009 respectively. Currently she is working as Associate Professor in the Department of Computer Science and Engineering at S J B Institute of Technology, Bengaluru, India. Her areas of interest include clustering techniques and routing protocols for wireless sensor networks.

Dr. Babu N V completed his B.E. in Electronics & Communication Engineering from Visvesvaraya Technological University, M.Tech in Applied Electronics from Dr. MGR Education & Research Institute and Ph. D from Kuvempu University. Currently he is working as Professor in the Department of Electrical & Electronics Engineering at S J B Institute of Technology, Bengaluru, India. His areas of interest include Wireless Sensor Networks, VLSI & Embedded systems, Image processing.