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Design and Simulation of AI Based Dynamic Deployment Algorithm for WSN using NS3

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Abstract: ***Currently the Wireless Sensor Network (WSN) is considered as one among the interesting and emerging research domains. The software and hardware capabilities of sensor nodes in WSN have improved the technology and supported to recognise WSN as one of the motivating and stimulating domains. The implementation and adoption of best dynamic deployment techniques in the application of WSNs have been specified as efficient and well-organised solutions in order to enhance the performance of WSN. The existing dynamic deployment algorithms are reviewed and ensured that there is more scope for the enhancement and improvement in terms of solving the constraints related with the rate of energy consumption and performance of WSN. In this research work, a new dynamic deployment algorithm based on Machine Learning (ML) concepts named as Cluster Head Energy Optimizer (CHEO) is designed and implemented in an urge of enhancing the performance of WSN. The results and conclusion of this research validates the performance of WSN by considering the parameters such as, energy efficiency, area of coverage, rate of data transmission and number of deployed nodes in the selected area of application. The result is compared with the existing dynamic deployment algorithms and concludes that, new algorithm yields the better result than those of existing deployment algorithms.***

Keywords: ***Wireless Sensor Network, Dynamic deployment, Machine Learning, energy efficiency, Area of coverage, Data transmission.***

I. INTRODUCTION

Over the period of two decades, WSN is evolving as one of the wildest growing technologies with its boundless applications in the field of agriculture, monitoring military, environment, healthcare, habitat monitoring etc., It is collection of distributed sensor nodes also called as 'motes' [1-4][10]. These motes are responsible for sensing, transportation and computation of data. These motes are deployed to form the self-defined network.

The main characteristics of these motes are, lesser computational capacity, limited memory and lesser power supply. As the motes are provided with lesser energy, the rate of energy consumption is one of the main constraints in WSN [5]. The Figure 1 explains the architecture of WSN. Depending on the application of WSN, the nodes are widely deployed in a selected area. The deployment of nodes in WSN is categorized as Energy aware node, static and dynamic node deployment. In static node deployment, the nodes are not moving whereas in dynamic deployment scheme, the nodes are movable and hence it is easy to gather the information or data. The sensor nodes are grouped as clusters and to each cluster, a cluster head is formed by themselves based on various parameters. The cluster and cluster formation in WSN are as shown in the Figure 2.

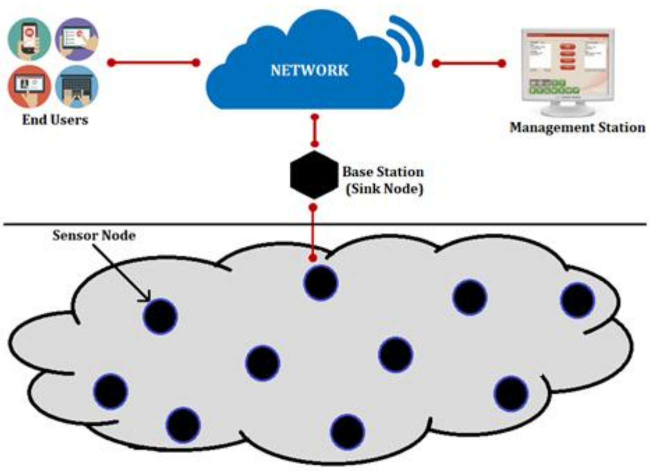

Fig. 1. Architecture of WSN

In dynamic node deployment as the nodes have to keep on moving, the nodes make use of energy continuously either to collect the data or to compute the collected data. After computation of data, they transmit it to the base station which is also called as sink node. From sink node the information is transferred to the end users as in Figure 1[2]. To overcome with this problem of increase in rate of energy consumption, this research work is carried out to enhance the rate of energy consumption and also the performance of WSN.

The rest of the paper is organised as; Section 2 briefs about the Background of this research work, Section 3 analyses ABC and PSO-dynamic deployment algorithms, Section 4 describes, Proposed CHEO Algorithm, Section 5 explicates implementation, Section 6 concludes the research work by discussing about the future scope of the research.

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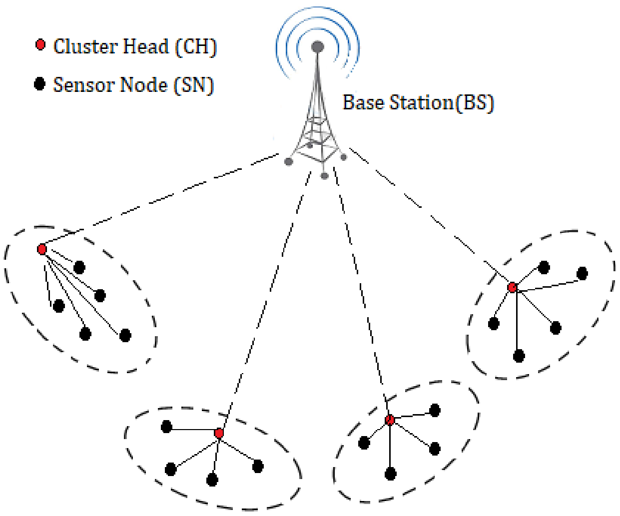

Fig. 2. Clustering in WSN

II. BACKGROUND

The existing research contribution of dynamic deployment approach towards achieving better performance of WSN by reducing the rate of energy consumption, is discussed in this section. According to the study of dynamic deployment algorithms there are two main algorithms Artificial Bee Colony (ABC) and Particle Swarm Optimization (PSO), which result in the better performance of WSN for data transmission [10-11].

i. Emad Alnawafa et al. [3] emphasized the research to present a new method by dividing the complete network into various levels. By following this, every node in the network acts according to its respective position or location and status.

ii. C. Vimalarani, et. al. [5] designed an Enhanced Particle Swarm optimization (E-PSO) algorithm that maximizes the lifetime of WSN by adopting the energy conservation measures to improve the performance of WSN. The results are compared with the existing clustering algorithms and concluded that E-PSO algorithm improves the performance of WSN.

iii. Li-Yu Hu, et. al. [6] investigated that, the distance function effects the K-NN performance in WSN. K-NN algorithm is K-Nearest Neighbour algorithm and is famous algorithm in ML for finding the shortest path between the nodes of network.

iv. Dervis Karaboga et al. [15] designed an ABC algorithm on the basis of Foraging behaviour of honey bee and concluded that this algorithm is more effective for energy optimization of nodes. This algorithm is designed for both dynamic and static deployment but the test is conducted only on dynamic deployment by applying binary detection model.

v. Anastasi G et al. [16] explained the problem in increased rate of energy consumption due to the partition of energy consumption by the different nodes, and also explained the objectives behind the energy conservation in nodes.

vi. Klues K et al. [19] proposed an architecture of node-level and the network in which it is demonstrated that, node comprises of four main components as,

a. Radio subsystem
b. Processing subsystem
c. Sensing subsystem and
d. Power supply subsystem.

A. The Inferences of Literature Survey

The first and foremost inference drawn from the above literature survey is, lack of usage of emerging technology like Artificial Intelligence concepts and algorithms to enhance the performance of the network. This is the main motivation and scope for our research work. According to the survey, during the data transmission, all the nodes of network sense the data even though they are not involved in data transmission process. This leads to the high rate of energy consumption which in turn minimises the performance of network. This difficulty has been overcome in this research work. The nodes which are not involved in data transmission, enter into the sleep mode, by saving the energy of node. This enhances the life time of network.

III. ABC AND PSO DYNAMIC DEPLOYEMNT ALGORITHMS

This research work is continuation of our previous work in the field of designing a dynamic deployment algorithm for best performance of WSN. In the previous survey and research, it is concluded that the ABC and PSO algorithms yield better performance results in WSN by considering the parameters such as, energy consumption, area of deployment, latency of data transmission and throughput of the network. These algorithms are designed and developed by the application of Artificial Intelligence (AI) and Machine Learning (ML) concepts and algorithms. The ABC algorithm is developed by applying the Bellman-Ford shortest path algorithm, according to which the data computation takes place between the nodes and BS by following the shortest path. As a result of this, the energy of nodes which do not take part in computation is saved. Hence the performance of network is enhanced. These algorithms are implemented using MATLAB R2017a version [1-2]. The Figure 3 (a) gives a node deployment and data transmission in WSN. The nodes are dynamically deployed and randomly the data sensing and transmission happens as soon as the node senses the data. Before the data transmission takes place, the node clustering occurs creating the cluster head (CH), which is shown in the Figure 3 (b). The CH is formed based on the KNN algorithm and Euclidian distance between the pair of nodes. The implementation of this ABC and PSO algorithms is discussed in our previous research work [1-2]. This research is an extension of those implementations' ABC and PSO which are dynamic deployment algorithms in WSN.

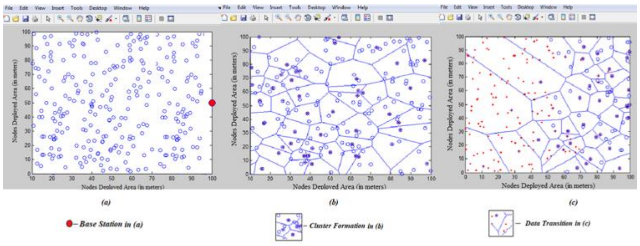

Fig. 3. Deployment of nodes and Data transmission.

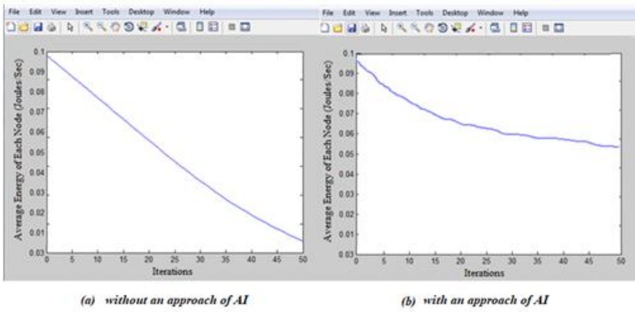

Fig. 4. Average energy of each node during data transmission (without and with an AI approach respectively)

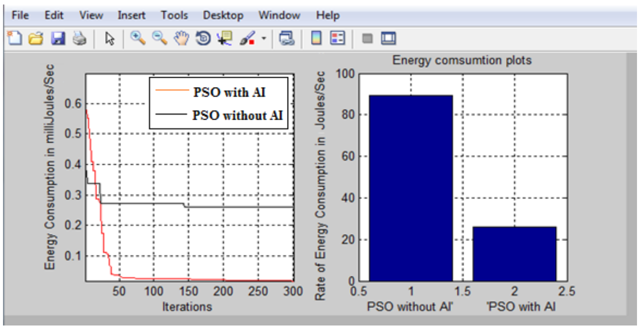

Fig. 5. Rate of Energy Consumption Using PSO Algorithm with and Without an Approach of AI.

The proposed dynamic deployment algorithm CHEO is implemented using simulation tool, ns-3 and ML concepts. The algorithm is developed based on Point-to-Point, Carrier Sense Multiple Access (CSMA) and wireless connections channels. There exists a point-to-point channel between BS and Server, CSMA channel between the cluster and BS and wireless transmission channel between the nodes of network. The architecture of proposed network is as in Figure 6.

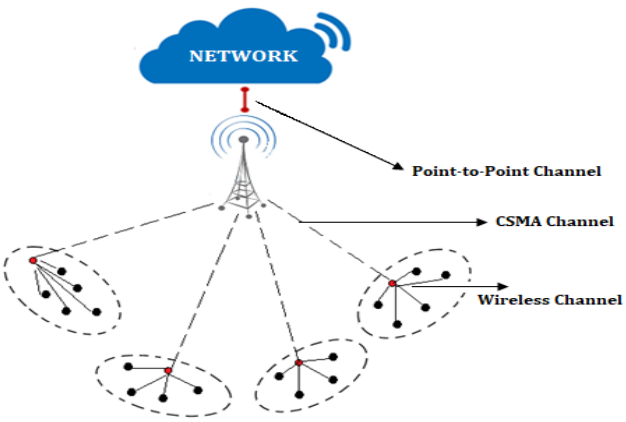

Fig. 6. Architecture of proposed dynamic deployment algorithm.

A. KNN Algorithm and Euclidean Distance Algorithm

K-Nearest Neighbour (KNN) algorithm is a famous clustering algorithm in ML and it functions based on the Euclidean Distance algorithm.

1. This algorithm plays a vital role in forming the clusters in networks based on the parameter. The pseudocode for KNN algorithm is explained as;

i. Initialise a value k, to indicate the number of clusters to be formed.
ii. Randomly select value k of nodes from the set of nodes as the first cluster
iii. From each cluster, compute the shortest distance between each node and clusters that are formed.
iv. Transfer the data from current CH to newly selected CH.
v. Repeat the steps iii and iv until the data gets computed and transferred to BS.

KNN algorithm is basically applied for regression and classification problems. It works on three basic features like:

a. Prediction Power
b. Calculation Time
c. Easy for Understanding

The advantages of KNN algorithms are;

a. This algorithm is easy for implementation.
b. KNN algorithm is a versatile.
c. This does not support for assumptions or adjust the parameters for building the model.

This algorithm is applied for all the search problems. The Figure 7 explains the KNN algorithm through flow diagram.

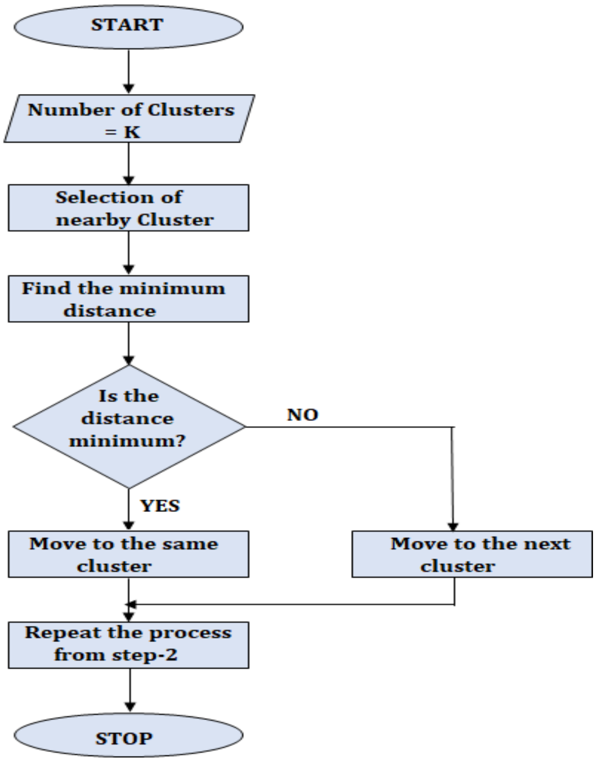

Fig. 7. Flow diagram of KNN-algorithm.

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2. The shortest distance between the pair of nodes and CHs is calculated by applying Euclidean distance algorithm. It is the geometric distance between two points. In the Figure 8, there are two points with coordinates (x1, y1) and (x2, y2). The Euclidian distance (d) between these two points is given by an equation,

$$\mathbf{d = \sqrt{(x^2\text{-}x^1)^2 + (y^2\text{-}y^1)^2}} \quad (1)$$

From the current node, the shortest distance to next node is calculated using this algorithm. Among the set of shortest distances calculated the pair with least distance gets involved in the data transmission. This repeats for all the nodes. The nodes that are not involved in the transmission will go to the sleep mode and hence saves the energy of nodes.

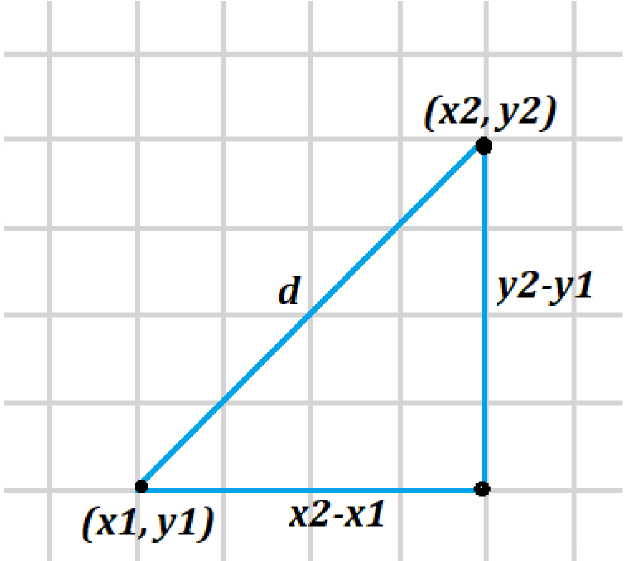

Fig. 8. Euclidian distance between two points.

IV. PROPOSED CHEO ALGORITHM

In this research work a new dynamic deployment algorithm Cluster Head Energy Optimizer (CHEO) is designed and implemented using the simulator NS3. According to this algorithm, the clusters and cluster heads are formed by KNN algorithm of ML concept. The nearest and neighbouring nodes club together to form clusters and cluster heads thus reducing the involvement of all the nodes of network during data transmission.

K-Nearest Neighbour (KNN) algorithm is one of the famous, simplest and easy-to-implement clustering algorithms in ML. The KNN for clustering is an unsupervised learning algorithm and for classification it is supervised learning algorithm. In this research on two important factors, KNN is considered as an unsupervised learning algorithm. First, the destination node is not defined at the beginning of data transmission. Second, the clustering is one of the major ideas in designing this CHEO algorithm. In KNN, K-means number of nearest neighbours which are located at the shortest distance.

The CHEO algorithm based on KNN, functions by following the steps like:

1. Determine the value of K.
2. Find the shortest distance between the new node and all the remaining nodes from current node. The metrics applied for calculating the shortest distance between pair of nodes is Euclidian algorithm.
3. Sort out the distance and find the K-nearest neighbour based on shortest distance value.
4. Analyse the distance and categorise the cluster heads from the listed nodes to form a cluster.
5. Repeat the step 2 until it generates a shortest distance new cluster head.

V. IMPLEMENTATION

This research work is simulated using the simulator ns-3 version 3.27. The implementation is basically targeted on reducing the rate of energy consumption and is mainly implemented to enhance the rate of data transmission and maximize the lifetime of network. The simulation of network is carried out in an area of 100X100 m2 data transmission grid where 50 nodes are deployed. The parameters considered for this research work are, rate of energy consumption, area of coverage, shortest distance between pair of nodes and the initial energy of nodes in the network. In ns-3 simulation, every node is to be assigned with the node-id which is processed through Basic Service Set Identifier (BSSID) of MAC address.

As this research work is concentrated on dynamic deployment of WSN where the nodes are moving continuously, the shortest distance between any pair of nodes is not constant. Based on the grid size, every time before the data transmission occurs, the distance between neighboring nodes is calculated and is redirected to the nearest node with shortest path.

A. About NS3

The ns-3 is one of the simulation tools, that is started in the year 2006. It is an open-source platform for network related education and research. It offers models on how the data packets are computed and transmitted and it also provides an engine for simulation environment. It is designed as a group of libraries that are combined together with external libraries related to software.

B. The deployment of nodes and transmission of data in WSN is clearly described as in the Figure 9. The figure 9(a) shows the dynamic deployment of nodes and the static base station. Figure 9(b) shows the data gathering by nodes and transmission of it and Figure 9(c) explains the formation of clusters and cluster heads. The clusters and cluster heads are formed based on the KNN and Euclidian distance algorithms. The Figure 10 explains the graphs of packet delivery, rate of data transmission and energy of nodes in WSN. As there exists a Point-to-Point, Carrier Sense Multiple Access (CSMA) connection between the nodes and BS, there is no data loss.

The graphs also describe that the rate of data transmission reduces as the energy of node decreases. The Table-I briefs about the data delivery from nodes to base station without the loss of any data. This satisfies the complete reliability of data during the transmission from nodes to BS.

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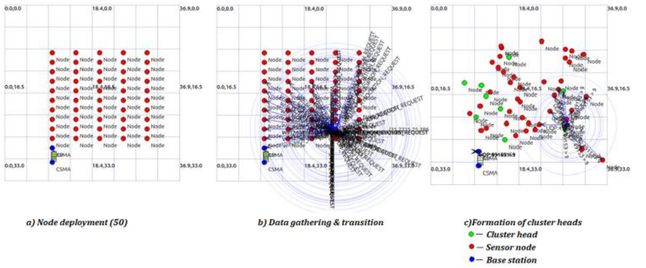

Fig. 9. Deployment of nodes, data transmission and cluster head formation.

Table-I explains the data transmission happening between the nodes (that is from node ID and to node ID). It also gives the time taken (in m.sec) for the data transmission. Along with the data, the information about node and connection between the nodes is reflected in the table. In the Table-I under the metadata (metadata is a group of all data which explains and gives an information about the other data) section the Beacon frame is defined which is acting as one of the main management frames in 802.11 wireless networks This Beacon frame contains the complete information about the network. It has an ability to store all the required information about the network. These frames are sent periodically and they serve to announce that the presence or absence of network. They are transmitted by an Access Point (AP).

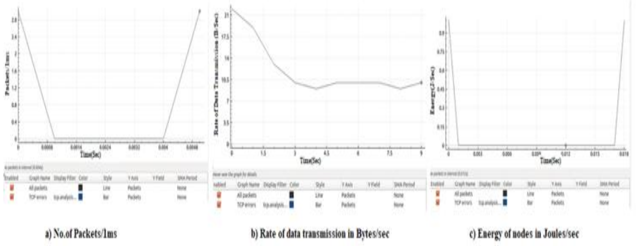

Fig. 10. Graphs to explain packet delivery, rate of data transmission and energy of nodes in WSN.

In WSN, the devices are connected all-together to form a network. The basic infrastructure mode of network is identified by the BSSID. Instead of creating the new IDs for BSSIDs, they are wrapped along with the MAC addresses.

Table- I: Simulation environment and data transmission parameters

To Id	From Id	Data Transmission Time (ms)	Meta Data
50	45	0.048	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:34 BSSId: 00:00:00:00:00:34
50	35	0.035	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:12 BSSId: 00:00:00:00:00:12
50	17	0.051	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:26 BSSId: 00:00:00:00:00:26
50	5	0.032	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:36 BSSId: 00:00:00:00:00:36
50	28	0.021	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:47 BSSId: 00:00:00:00:00:47
50	6	0.025	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:11 BSSId: 00:00:00:00:00:11
50	12	0.023	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:09 BSSId: 00:00:00:00:00:09
50	23	0.012	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:21 BSSId: 00:00:00:00:00:21
50	1	0.048	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:27 BSSId: 00:00:00:00:00:27
50	2	0.043	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:43 BSSId: 00:00:00:00:00:43
50	24	0.034	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:24 BSSId: 00:00:00:00:00:24
50	9	0.018	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:35 BSSId: 00:00:00:00:00:35
50	4	0.012	Wifi MGT_BEACON DA: ff:ff:ff:ff:ff:ff SA: 00:00:00:00:00:46 BSSId: 00:00:00:00:00:46

The Figure 11 gives the comparison graph for rate of energy consumption in dynamic deployment algorithms in WSN. Based on the graph it is analysed that the dynamic deployment algorithm cluster head energy optimizer (CHEO) consumes the lesser energy for data transmission. Hence CHEO algorithm acts as one of the best energy efficient dynamic deployment algorithms in WSN. The Table II compares the rate of energy consumption by considering the three dynamic deployment algorithms ABC, PSO and CHEO and it is measured in terms of J/sec. In the table, No. of Iterations is an independent variable.

Table- II: Rate of energy consumption in dynamic deployment algorithms

No. of Iterations	ABC	PSO	CHEO
1	4.7453	4.7453	4.7453
100	4.12	4.01	4.21
200	3.124	2.97	3.98
300	2.87	2.48	3.75
400	1.897	1.76	3.21
500	0.432	0.12	1.97

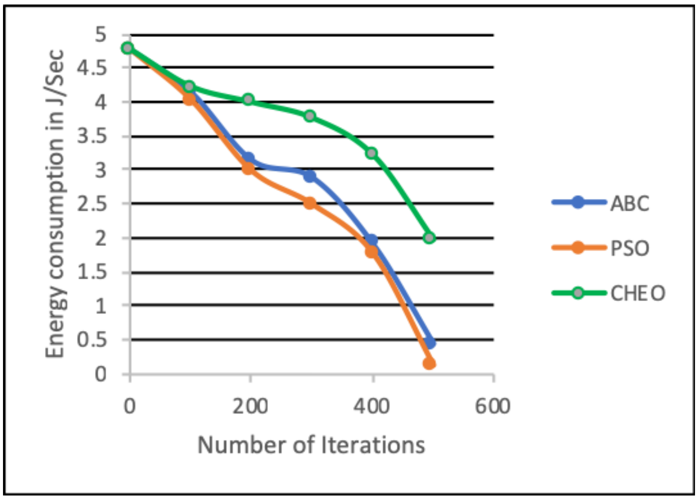

Fig. 11. Comparison graph for rate of energy consumption in ABC, PSO and CHEO dynamic deployment algorithms in WSN

VI. CONCLUSION AND FUTURE SCOPE

The network performance is enhanced by considering the parameters such as, rate of energy consumption, area of coverage, rate of data transmission and number of nodes deployed in the selected area of application. This research work is carried out with an application of ML algorithm for dynamic deployment strategy. The KNN algorithm of ML, along with Euclidian distance algorithm is applied to find the shortest path between the pair of nodes before the data transmission. By following this methodology, the nodes that are not taking part in transmission save their energy and hence the lifetime of WSN increases by consuming 30% less energy compared to ABC and PSO algorithms. The simulation environment and results conclude that, the WSN application satisfy the requirements for better performance and reduced computation time compared to other dynamic deployment algorithms.

In this research work, an implementation is carried out by considering the static base station and in the future scope of this research, implementation will be carried out by treating base station as a dynamic node and analyzing the performance of WSN with the consideration of the same parameters of this research.

REFERENCES

1. Renuka C. Herakal, et.al, "Simulation of AI Based PSO Algorithm in WSN", International Journal of Engineering & Technology, Volume 7(4) 2018, pp. No. 5132-5136. DoI:10.14419/ijet. v7i4.27407.
2. Renuka C. Herakal, et.al, "Simulation of AI Based ABC Algorithm for Energy Efficiency In WSN", International Journal of Pure and Applied Mathematics, Volume 120 No. 6 2018, 11579-11591, ISSN: 1314-3395 (on-line version).
3. Emad Alnawafa, et. al, "New Energy Efficient Multi-Hop Routing Techniques for Wireless Sensor Networks: Static and Dynamic Techniques", Sensors 2018, 18, 1863;
4. Renuka Rajesh Patil, et. al, "Power Efficiency of WSN-A Survey on Usage of AI Algorithms", Indian Journal of Science and Technology", Volume 10(6) , DOI: 10.17485/ijst/2017/v10i6/109419, February 2017, ISSN(Print): 0974-6846, ISSN (Online) : 0974-5645.
5. C. Vimalarani, et. al, "An Enhanced PSO-Based Clustering Energy Optimization Algorithm for Wireless Sensor Network", Hindawi Publishing Corporation, The Scientific World Journal, Volume 2016, Article ID 8658760, 11 pages.
6. Li-Yu Hu, et. al, "The distance function effect on k-nearest neighbour classification for medical datasets", Springer plus. 2016; 5(1): 1304, Published online 2016 Aug 9.
7. Dan Li et. al, "An Improved PSO Algorithm for Distributed Localization in Wireless Sensor Networks", Hindawi Publishing Corporation International Journal of Distributed Sensor Networks, Volume 2015, Article ID 970272, 8 pages.
8. Yacouba Ouattara, et. al, "Three Thresholds for the Efficiency in Energy Management in WSN", Journal of Advances in Computer Networks, Vol. 3, No. 1, March 2015.
9. Hosam Rahhala, et.al, "A Novel Multi-Threshold Energy (MTE) Technique for Wireless Sensor Networks", Proceedings of International Conference on Communication, Management and Information Technology (ICCMIT 2015), Science Direct, Procedia Computer Science 65 (2015).
10. Renuka R. Patil et. al, "Deployment Algorithms in WSN-A Study", IEEE International Advance Computing Conference (IACC)-2015, 978-1-4799-8047-5/15.
11. Renuka R. Patil et. al, "Analogy of Static and Dynamic Node Deployment Algorithms in WSN", proceedings of 2nd International Conference on-Emerging Research in Computing, Information, Communication and Applications-ERCICA-2014, ISBN-978935102621.
12. D. Karaboga, C. Ozturk and B. Gorkemli, "Artificial Bee Colony algorithm for dynamic deployment of wireless sensor networks", Turk J Elec Eng & Comp Sci, Vol. 20, No. 2, 2012©TUBITAK, doi:10.3906/elk-1101-1030.
13. Yubin Xu et. al, "A Clustering Algorithm of Wireless Sensor Net-works Based on PSO", H. Deng et al. (Eds.): AICI 2011, Part I, LNAI 7002, pp. 187–194, 2011. © Springer-Verlag Berlin Heidel-berg.
14. Raghavendra V. Kulkarni et. al, "Particle Swarm Optimization in Wireless-Sensor Networks: A Brief Survey", Article in IEEE Transactions on Systems Man and Cybernetics Part C (Applications and Reviews)-April 2011,
15. Celal Ozturk, Dervis Karaboga and Beyza Gorkemli, "Probabilistic Dynamic Deployment of Wireless Sensor Networrks by Artificial Bee Colony Algorithm", Sensors 2011, 11, 6056-6065; doi: 10.3390/s1100606056.
16. Anastasi G, Di Francesco M. "Energy conservation in wireless sensor networks: A surve". Ad Hoc Networks. 2009 May; 7(3):537–68.
17. Jun-Zhao Sun, et. al, "Multi-Threshold Based Data Gathering Algorithms for Wireless Sensor Networks", Journal of Networks, Vol. 4, No. 1, February 2009.
18. Sang Jin Lee et. al, "A Threshold Determining Method for the Dynamic Filter", IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.4, April 2008.
19. Klues K. "Power Management in Wireless Networks", research-gate publication, paper-id-265348518, September 2006.

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