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Energy Efficient and Node Density Based Dual Base Station Deployment for Large Scale Wireless Sensor Network

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Abstract*:* Wireless sensor network (WSN) one of the top-rated technologies used and integrated in majority of the other technologies. WSNs come with different categories like –Industrial WSNs, Large Scale WSN, Health Sector WSNs and many others. This paper aims to review the impact of the WSNs in the current market and try to address the base station localization issues in the large scale WSNs. The main issues in the base station positioning, is to make the network energy efficient by making the nodes transfer the data to the base station with optimal energy. The proposed algorithm aims to adopt the dual base station techniques with clustering process. Each base station will be deployed based on the density of the nodes to ensure the efficient energy transfer by the sensor nodes. The proposed algorithm has proved to be efficient in terms of network lifetime.

Keywords*: Large Scale WSNs, LEACH, Mobile Base Station, Multiple Base Station Location, SEP, Virtual Base Station Location,*

1 Introduction

Wireless Sensor Network (WSNs) one of the widely used technologies with variety of applications in the recent years. WSNs are the most prominent component for the Internet of Things, Machine Learning, and Artificial Intelligence. Most of the data are collected is from WSNs and the same will be used for Data Analytics using IoT, AI, ML.

As per some of the marketing statistic the WSNs market is expected to reach $148.67 billion by 2026, exhibiting a CAGR of 18.3%. And overall market size was $85.7 billion in 2021 and it is to be reached $108.6 billion by 2028 [1]. Another forecast on WSN predicted the market value of WSN will reach to $215 billion by 2028, which was $56 billion at 2020 [2] as shown in Figure-1.

The major reason for the impact of the WSNs is because of the increase in the various applications of WSNs. Some of the major applications of WSNs are –Surveillance, Military, Industrial IoT (IIoT), Smart Wearable, Health and many others as shows in Figure-2.

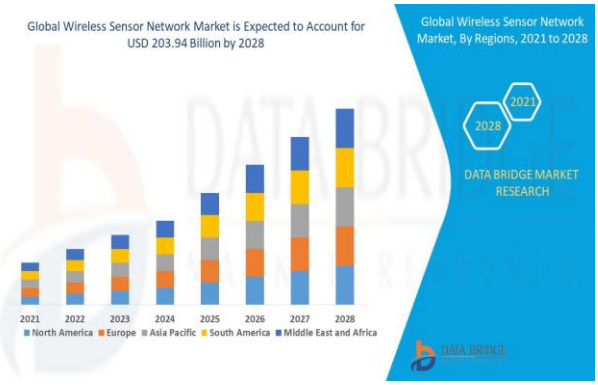

Fig. 1 WSN Market Forecast [2]

Fig. 2: WSNs Application [3]

This is paper is organized as follows-

In this section-1, Introduction of WSNs focusing on need and impact WSNs. WSNs market needs applications and variety of applications. Seciton-2 addresses the various issues and problems in WSNs focusing on large scale WSNs and issues in base station location optimization.

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This paper aims to review and analysis only the recently published papers in order to get the latest and updated information in the identified concepts.

Section-3 is focused on the proposed work to address the identified problem focusing on the increasing the lifetime of the WSNs and effective positioning of the base satiation in collecting the data from sensor nodes. Section-4 presents the working of proposed work and discussion of the proposed algorithm. Section-5 discusses the result and proposed topology and finally, section-6 concludes the outcomes of the proposed work.

2 Problem Formulation

This section focused on the presenting the various issues in positioning base station in large scale WSNs. And also, a detailed analysis is carried out on some of the existing approaches in dealing with various issues in positioning base station in large scale WSNs, enhancing the lifetime of the WSNs with efficient routing, clustering. The review carried is summarized as follows:

- **Mobile and IoT network:** In this existing work [4], the author has addressed the issues of base station positioning using 2 innovative approaches. In first approach mobile node is used as alternate routing process to transfer the data form sensor nodes to base station. In second approach mobile node is used to generate a new alternate path with a disjoint set from sensor nodes to base station. These two approaches have proved to be efficient in addressing the various congestion near the base station. These approaches can also be used for the other network application like IoT.
- **Optimal Base Station Location in WSNs:** In this [5] approach genetic algorithm and K-means algorithm-based location optimization for base station proposed. Genetic algorithm is adopted for finding the optimal location for the base station and K-means algorithm is integrated for the clustering process of the WSNs for efficient data transmission. Once the clustering process is initiated a hierarchical inter cluster routing is used with multi-hop data transfer. This work is simulated by considering various parameters and the results shows in the increase in the lifetime of the network.
- **Energy efficient positioning of base station in clustered WSN [6]:** In this existing method an analysis of base station positioning is carried out. This algorithm used the clustering process for the data transmission from sensor nodes to sink. For the base station positioning a static positioning approach is adopter as shown in figure-3. Base station is positioned a different position in different cases. Case-1 and 2 base station position is set to centre of the network and starting point of the network respectively. Case 3 and Case-4 base station is positioned a bottom middle and out of the network boundary respectively.

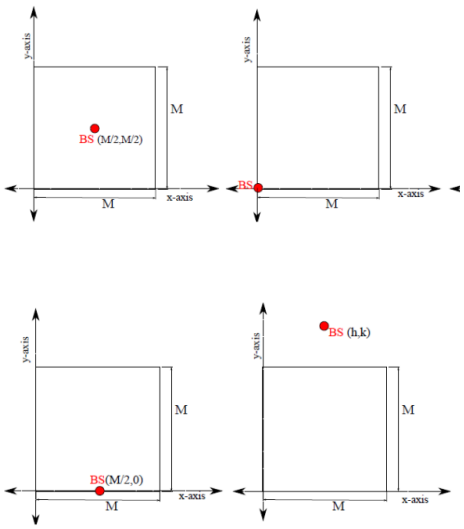

Fig. 3: Base Station Positioning

- **Analysis on Positioning of Base Station and CHs for Improving Energy Efficiency in WSNs:** In this existing work [7] a details analysis has been carried out in making the WSNs energy efficient. Based on the analysis carried a cluster-based energy efficient algorithm is proposed by modifying one of the most prominent algorithms in WSNs- LEACH. Based on the LEACH clustering technique a concept of residual energy used for reducing the energy consumption by the sensor nodes. This approach there by shows the increase in the lifetime of the network.
- **Increasing Energy Efficiency of WSNs Through Optimization of Mobile Base Station Locations [8]:** An optimal positioning of the base station is adopted in this approach to enhance the lifetime of the network. A virtual base station grid location is created in the network. Using the virtual location of base station, distance estimation is carried out from all sensor nodes to virtual base station. Once the distance is calculated the total energy required for data transmission will be calculated. Like this distance and total energy is calculated for multiple virtual bases station position. Finally, the base station will be positioned in the optimal position where the total energy required for data transmission from sensor nodes to bases station is least. For this approach a stable election protocol is uses as a clustering process.
- **Reference Particles-based LTE Base Station Positioning [9]:** In this existing approach LTE based base station positioning is done. Based on the wireless signal received from the nodes to base station, a location reference signal power is calculated. Based on the signal strength the position of the base station is calculated. A signal propagation model is carried out to figure the base station signal strength in each zone or group.

3. Research Requirements

In Section-2 a detailed review on WSNs issues highlights the various approaches of base station and the efficiency of the network. In this section a detailed analysis over the existing approaches is carried out to identify the further enhancements to increase the lifetime of WSNs. Table-1 shows the various approaches used for optimizing the base station location.

Table-1: Various Base Station Optimizations

Method	Clustering	Virtual Base Station	Base Station Position	Algorithm
[4]	No	No	Mobile Base Station	Optimal Route using multi-hop mobile base station
[5]	Yes k-means based clustering	No	Mobile	Genetic Algorithm
[6]	No	No	Static Multiple location	Focused only on positioning BS
[7]	Yes LEACH Based Clustering	No	Static Multiple location	LEACH
[8]	Yes	Yes	Mobile Base Station	Clustering Based
[9]	No	No	Single Base Station positioned based on the signal power	Signal Propagation Techniques

3.1 WSN Application requirements:

Most of the WSNs applications is for data collection and except the data to be fresh and reach the base station without any delay. In large sensor networks collecting data from numerous sensors will be very difficult. By summarizing the analysis of the table-1, following are the various techniques that can be used for optimizing base station positioning in large scale WSNs [10-14]

- Multiple Base Station
- Mobile Base Station
- Virtual Base Station Positioning
- Base Station Signal based Positioning
- Clustering in WSNs

Considering all these factors, this paper aims to propose a clustering based WSNs with multiple Dual Base Station for large scale WSNs.

4. Proposed Base Station Optimization Technique

Based on the survey the proposed algorithm focuses on improving the Lifetime of the WSNs using Dual Base Station for Large scale WSNs. Following are the concepts explored and adopted for the survey for the proposed techniques.

Large Scale Topology Creation: In the proposed network topology 100 sensor nodes are used over the network area of 1000 x 1000 this will give the exposure of WSNs in large scale with numerous nodes and analyze the situation for optimizing the base station.

Dual Base Station: The proposed technique aims to focus on usage of dual base station. The novelty involved here is positioning the Base Stations based on the sensor nodes density or population of the sensor nodes. Since the network lifetime is depended on the sensor nodes, the main focus must be given to optimize the energy of these nodes to communicate to the Base Stations. Figure -4 shows the topology of the proposed technique.

- **Positioning of Base Stations:** The 2-base station is placed in the area where the sensor density or population is very high. This process makes the sensor nodes to spend less amount of energy to transfer to data to base station

- **Changing the Base Station Position:** Another novelty of the proposed techniques changing the position of these dual base stations during the half round of simulation time to balance the load between the dual base stations.

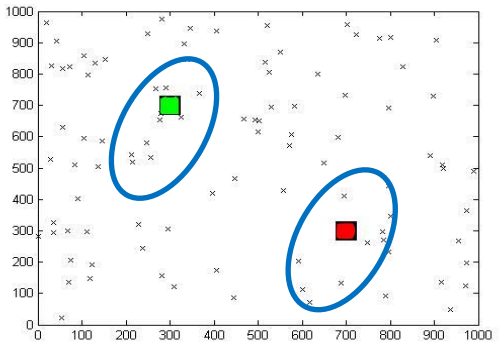

Fig. 4 Proposed Topology

Other Parameters considered for the proposed algorithm:

- Number of Sensors considered by implementation
- Energy of the Sensor nodes
- Cluster Density
- Energy Dissipate Model:**E = (ETX ∗ EDA) ∗ K + EFS ∗K(EBS ∗EBS),** EDA,EFS, EBS are the Node's circuit energy required for Data Aggregation, Antenna Energy Dissipation and Energy Required for Transmission

4.1 Proposed Energy Optimized Dual Base Station Algorithm

Step-1: Initially sensor nodes are deployed on the large scale WSNs

Step-2: For the nodes deployed in the network, node density will be calculated based on the number of nodes available within the short distance.

Step-3: Based on the node density two base station will be deployed where the density is more

Step-4: Initiate Clustering Process using an optimal Cluster head

Step-5: Once the Cluster is formed each cluster head will identify the nearest based station from the dual base station. Based the shortest distance each cluster head will transfer the data to either 1st Base Station or 2nd Base Station.

Step-6: At the half round of simulation the dual base station will be swapped with next high density nodes region and same clustering process will be carried out.

5. Result and Discussion

In this section the result of proposed algorithm is explained. Based on the proposed algorithm as discussed in section-4 a simulation model is designed and developed using MATLAB.Figure-5 and Figure-6 shows the clustering topology of the proposed dual base station algorithm. And each base station is possible deployed in the high-density sensor node's location.

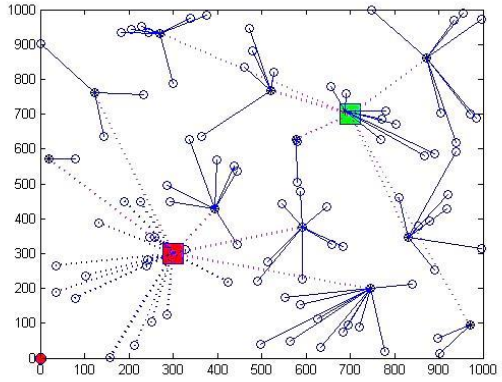

Fig. 5 Topology of Clustering Process

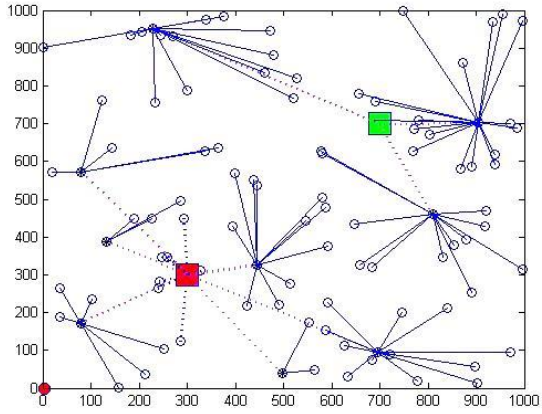

Fig. 6 Topology of another set of Clustering Process

Figure - 7 and Figure-8 shows the topology of clustering process after the half round of simulation process. In figure-7the base stations positions are different compared to figure- 5 and figure-6.

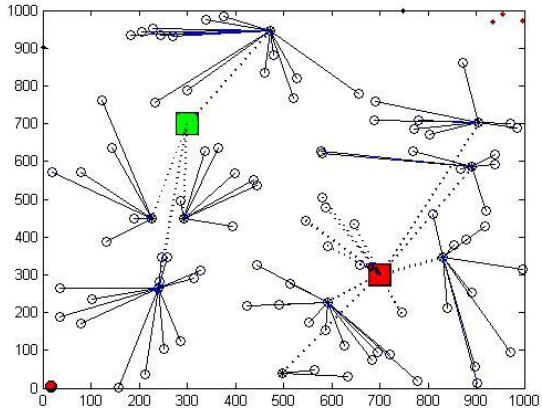

Fig. 7 Topology after Half-round

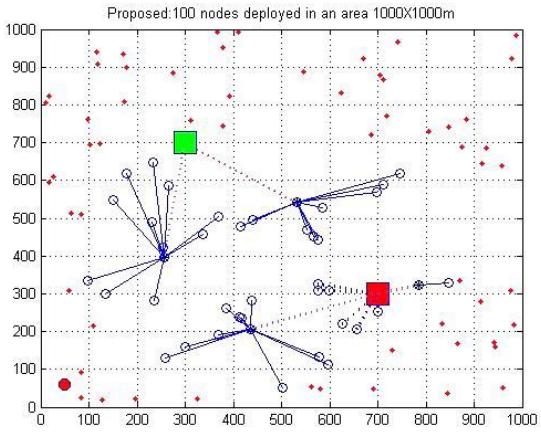

Fig. 8 Topology after Half-round nearing to end of the simulation

Figure-9 shows the density of the nodes during the simulation rounds. The proposed clustering algorithm results in the optimal clustering to increase the lifetime of the WSNs.

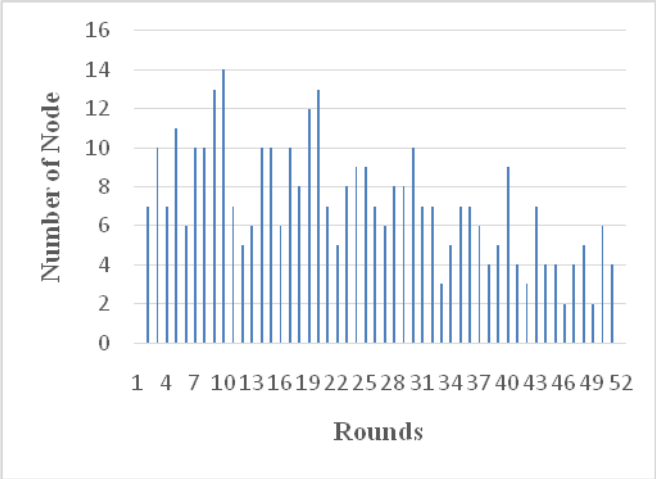

Fig. 9: Density of Node

Figure-10 shows the performance of the proposed algorithm. The number of alive nodes is plotted in the graph and the increase in the number of dead nodes are not gradual. This proof, justify the performance of the network lifetime of the proposed algorithm. At the end of the simulation round is around 40% which is measured for the simulation area of 1000x1000 Sq.mt. Therefore, the proposed algorithm as achieved good performance with the idea of dual base station in large scale WSNs.

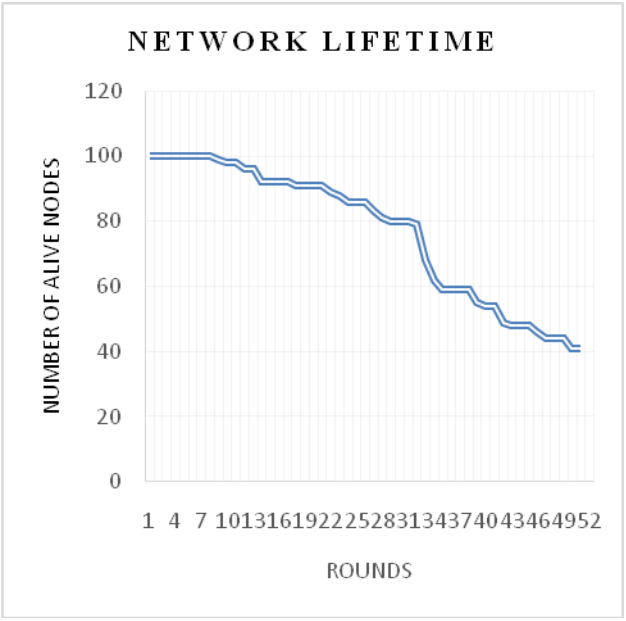

Fig. 10 lifetime of the proposed algorithm

6. Conclusion

WSNs with some much of impact in the current market as discussed in the section-1. WSNs have numerous applications in various sectors. The proposed algorithm is based on the node density, where the dual base station in deployed in the high density region to ensure the optimization of node energy used for data transmission to base station. With the use of dual base station in the network it is benefitted for nodes, clusters and cluster head. Each of the nodes and cluster head will have option to transmit the data to the nearest base station. And base station also can share the load of the sensor by collecting the data from the required area rather than collecting the data from sensor from far distance. The topology and result discussed in this paper shows the performance of the propose algorithm.

Conflicts of interest

There is no conflict of interest and not funded by any agency.

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