DAO- LEACH: an Approach for Energy Efficient Routing based on Data Aggregation and Optimal Clustering in WSN

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Abstract: Wireless Sensor Network (WSN) consists of spatially distributed and dedicated sovereign sensor nodes with confined resources to politely monitor physical and environmental conditions. In recent years, there has been a rising interest in WSN. One of the major confrontations in WSN is developing an energy-efficient routing protocol to enhance the network longevity. With that concern, this work contributes in providing a novel approach called DAO-LEACH (Data Aggregation based Optimal- LEACH) by which the energy efficient routing in WSN is attained based on effective data ensemble and optimal clustering. Aggregating the data sent by cluster members comprehend in draining network load and amending the bandwidth. In order to minimize the energy dissipation of sensor nodes and optimize the resource utilization, cluster head is elected for each cluster. Moreover, the energy efficient route in WSN is obtained by combining the nodes having maximum residual energy. Experimental results have shown that the proposed approach furnishes efficient route for data transmission among the sensor nodes in an adept manner, thereby prolonging the network lifetime.
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1. Introduction

Wireless Sensor Network (WSN) is a distributed system consists of a base station and a number of petite wireless sensing devices that incorporate micro sensing, computing and wireless communication capabilities. Data sensed by the sensor nodes in the WSN are eventually transmitted to the base station where the information can be accessed. As a new technology for data collecting and processing, there are an ample range of applications of WSNs in military, commercial, health applications, nuclear power plants and so on.

Furthermore, each sensor node of WSN is composed of four substantial blocks namely, sensing unit, processing unit, communication unit and power unit. The sensing unit measures a certain physical condition like temperature and pressure in the deployed environment. The processing unit involves in collecting and processing signals obtained from sensors. The wireless communication unit is responsible for transferring signals from the sensor to the user via the base station (BS). The power unit supports all previous units to provide the required energy in order to carry out the mentioned tasks [6]. The distinctiveness of a sensor node lies in its light weight and tiny size. However, there are a lot of constraints such as confines on resources in terms of memory, energy, computational speed, bandwidth and so on.

While analyzing, Energy efficiency has been notorious as the most important issue in research of WSN. Hence, there is of great significance to design an energy efficient routing protocol for WSN. In terms of routing protocol, there avail two different solutions from existing works, given as flat routing and hierarchical routing. In flat routing, each sensor node involves in the same role and sends their data to sink node directly which always results in faster energy consumption and excessive data redundancy. In hierarchical routing, the complete network is divided into several clusters, in accordance with the distance between the nodes and the hop count. For aggregating the data from various sensor nodes, there is a requirement of aggregation point called cluster heads. Hence, each cluster consists of some sensor nodes and a cluster head [5].

Clustering-based routing algorithms are more efficient and appropriate than flat routing algorithms in WSN. On the other side, data aggregation process reduces the number of message exchange between the nodes and the base station and saves some energy. Henceforth, this paper focuses on defining a schema efficient routing based on data aggregation and optimal clustering for an adequate attainment of WSN.

Additionally, the proposed mechanism has been developed with the consideration of efficiencies and deficiencies of LEACH (Low Energy Adaptive Clustering Hierarchy), which is one of the popular and efficient protocols that induces the nodes to minimize the energy consumptions in the networks is LEACH. This protocol arranges the nodes into groups, so that each cluster has a cluster-head for a specific period for its own cluster. LEACH randomly elects the cluster-head in each round by which the energy will be evenly distributed. In this approach the base station is fixed and other nodes are energy constrained in nature.

The remainder of this paper is organized as follows. Section 2 gives a brief description of LEACH and its deficiencies. Section 3 provides a deliberation on the related work. Section 4 presents the proposed DAO- LEACH pertaining to increasing energy efficiency and network life time. Section 5 presents the experimental results and Section 6 concludes the paper with pointers to future work.

2. LEACH and its deficiencies

Low-Energy Adaptive Clustering Hierarchy (LEACH) is an adaptive and self-organized clustering protocol proposed by Heinzelman [22] [23] [24]. When data transfers to the sink node, the operation of LEACH is separated into rounds, where each round actualizes with a setup phase for cluster formation and followed by a steady-state phase. Figure 1 depicts LEACH's Hierarchical Routing Architecture. Though LEACH performs random election of cluster heads to accomplish load balancing among the sensor nodes, the model still has some deficiencies which are described as follows:

- In LEACH, a sensor node is chosen as the cluster head using distributed probabilistic approach whereas the non-cluster nodes determine which cluster to join depending on the signal strength. This approach indemnifies lower message overhead, but cannot assure that cluster heads are uniformly distributed over the entire network and the whole network is dispensed into clusters of comparable size and load imbalance among the cluster heads may involve in reducing network lifetime.
- In LEACH, it is assumed that all nodes are isomorphic and all nodes have similar amount of energy capacity in each election round. Such a supposition is impractical in most application circumstances. Hence, LEACH should be enhanced to report for node heterogeneity.
- Moreover, LEACH entails source nodes to send data to cluster heads directly. However, if the cluster head is extremely away from the source nodes, they might disburse excessive energy in data transmission. Further, LEACH requires cluster heads to transfer their aggregated data to the sink node over a single-hop link. Nevertheless, single-hop transmission may be quite costly when the sink appears far away from the cluster heads.

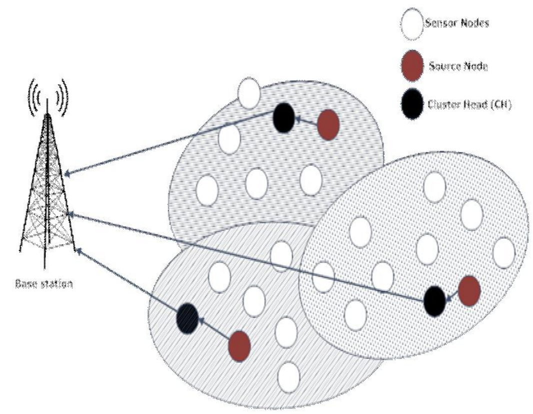

Figure1: LEACH's Hierarchical Routing Architecture

- LEACH also holds an assumption that all sensor nodes have sufficient power to reach the sink node if needed which might be impervious for energy constrained sensor nodes.

In order to address the deficiencies described above, a data aggregation based optimal clustering-LEACH (DAO-LEACH) is proposed in this paper. In DAO- LEACH, the residual energy of sensor nodes is considered in cluster formation and cluster-head election. Accordingly, the non-cluster node decides its cluster head based on the residual energy of the available cluster heads and the size of the cluster. For desirable sensing coverage, the mobility of the nodes are effectively monitored and managed by Gaussian distribution.

3. Related Works

Since energy efficiency is more substantial for WSN, myriad research works have been done for effective routing in WSN. Distributive Energy Efficient Clustering (DEEC) protocol was developed in [8] based on residual energy of a sensor node and the hotness of the region that is used by the node. The authors contributed the paper for providing prolonged network lifetime and low energy consumption. Following that, another approach called MELEACH had been developed by the motivation of LEACH protocol [7]. The approach was designed in terms to be applicable to large-scale WSNs. The paper concentrated on channel allotment among neighbor clusters and the co-ordination between the cluster heads while data collection. The channel assignment was effectively managed by controlling the size of the cluster and cleaving cluster heads from backbone nodes. There was no discussion about the network longevity.

While in application point-of-view, WSN involves in designing an adaptive energy-aware watermarking scheme that tolerate the transmission distortion and obtain high authentication scheme [16]. Further in [21], an algorithm was proposed using Gaussian distribution for coverage optimization in WSN. There given that the deployment of sensor nodes was to place sensors in a governable manner, thereby maximal network lifetime was achieved. The analytical model captured the inherent properties of the lifetime and coverage by using distinctive attributes.

Lifetime of WSN is considerably increased by hierarchical clustering algorithms [13]. The paper targeted on heterogeneity of nodes regarding their energy. They assumed that the sensor nodes were equipped with small amount of energy and the nodes were not mobile. It was also given that the heterogeneous networks comprised two types of nodes namely, type-1 node and type-0 node, where type-1 node was having more battery power than type-0 node. They adapted clustering and cluster head selection scheme based on weighted election probabilities of each node.

CETAR (Consumed- Energy- Type- Aware Routing) incorporates the amount of energy consumption per operation for making adept routing decision that impose on extend the lifespan of WSN [17]. The routing decision had been made based on energy consumption for operations such as data processing, sensing, data transmission among sensor nodes and routing operations. Two types of CETAR were investigated in this paper.

1. Biased Consumed Energy (BCE) CETAR
2. Aggressively and Adaptively (AA) BCE CETAR

The work could be further enhanced by combining CETAR with other energy aware routing algorithm for attaining better results.

It is also vital to afford QoS [Quality of Services] in WSN, while data transmitted through a routing schema. On that note, the paper [19] discussed about some QoS parameters and progression of QoS routing protocol for wireless multimedia sensor networks (WMSN). Some of the parameters are adaptability, multi-constrains QoS, data influenced routing, cross-layer problem, etc.

A review on energy efficient protocols for WSN was given in [1]. There presented that all routing protocols will fall under three major categories as given in the figure presented below:

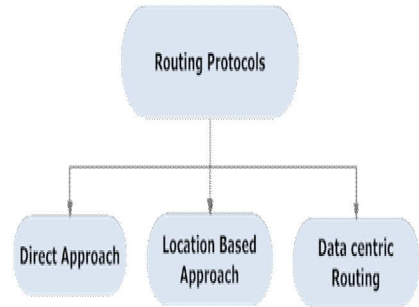

Figure 2: Classification of Routing Strategies

The paper also brought out discussion about energy efficient routing in WSN that categorized under two broad classifications.

- Clustering Based Approach
  - LEACH (Low-Energy Adaptive Clustering Hierarchy)
  - HEED (Hybrid Energy Efficient Distributed clustering)
  - DECA (Distributed Efficient Clustering Approach)
- Tree Based Approach
  - PEGASIS (Power Efficient Gathering in Sensing Information System)

Comparing the above routing protocols regarding its related parameters such as latency, mobility and cluster stability, the paper [4] suggested that the clustering based routing is more efficient and advanced in managing mobile sensor modes. Along with those results, the paper [4] developed MLEACH (Modified LEACH) to decrease the network system throughput and delay, and amend energy saving. The work more concentrated on network stability and the working procedure comprised of two rounds such as full transmission round and half transmission one.

An energy aware routing protocol was proposed in [18] to perform admission control, determination of bandwidth requirements and the evaluation of sensor's residual energy. By adopting selective forwarding approach in accordance with sensor location forwarding approach in accordance with sensor location, the delay of carried flows were optimized. The major limitation regarding this work is that the work accomplished with static sensor nodes without the consideration of node's mobility. Cross-layer based routing design was given in [20] for supporting QoS in wireless multimedia sensor networks (WMSN). This model provided large data transmission without affecting the quality of sources in WMSN. Regarding this architecture, routing layer, data link layer and application layer interacts with one another to attain the objective adaptively.

Following, an efficient algorithm for data collection was proposed in [9] with minimal number of full transmission based clustering technique. The cluster head selection was divided into three levels, wherein the cluster head elected at final level aggregates the entire data and transmits that to the base station. In such a way that the number of full transmissions got reduced and energy efficiency had been achieved, but there was no concern about the lifespan of WSN.

In WSN, generally, there arises problem related to node collision. On that note, the authors of [12] developed a multilayer-MAC protocol with two main features: reduced number of collisions and reduced duty cycle and the comparison was made with the existing MAC protocol. However, the paper highly attended on reducing energy consumption rather than data ensemble. In order to improve the data collection procedure in WSN, an effective algorithm was proposed in [14]. A mobile robot was considered for the research, where its navigation scheduled on the basis of time and location. The authors mainly focused on effective data collection made in partitioned WSNs and avoiding the collision of data aggregation, data routing and topology control. Two control approaches were defined in the paper: Local Based Approach (LBA) and Global Based Approach (GBL). With the algorithm, each root of the partitioned WSN was considered as a local link for every sub- WSN, once their parent node became dead. Those sinks would accommodate the sensed data forwarded from their sub-WSN locally. Further, the navigation strategies of a mobile robot were taken into account for scheduling strategies. Another algorithm called distributed intelligent data gathering was developed by the authors in [15]. The process comprised two phases namely, cluster formation and path formation. In cluster formation phase, an energy-aware clustering scheme was proposed in distributed and localized manner, whereas in path formation phase, an optimized algorithm was proposed for routing with dynamic requirements. In this approach, a mobile collector was employed for gathering the sensed data. The reliability over the link and the energy efficiency could be amended in further contributions of related works.

The authors of [2] were motivated by the above works and proposed an Energy Efficient Level Based Clustering Routing Protocol (EELBCRP) in which the WSN was partitioned into several angular rings according to its power level at the base station. With the core of this work, the network lifetime could be further improved by incorporating some more efficient approaches. A distinctive model given in [3] that impose the data mining features for enhancing the energy efficiency in WSN by improved LEACH communication model. The authors considered the two types of sensor networks: single-feature and multi-feature. The single-feature sensor network composed nodes that repot only one feature, whereas the nodes in multi-feature sensor network reports more than one feature. Further, the network was classified under homogeneous and heterogeneous category. The entire work of this proposal was based on the above considerations.

In [10] coverage based energy efficient algorithm was proposed. It was stated in the paper that multi-hop short range communication among the sensor nodes were comparatively energy efficient than single-hop long range communication. Moreover, the work was involved in making uniform distribution of CHs using non-overlapped cluster regions. The main focus was to achieve higher packet reception rate irrespective to network longevity. Another work in [11] developed MG-LEACH (Multi Group Based LEACH) that also focused the aforementioned criteria in a different dimension such that same redundant nodes were located in the same region.

The ideas that are presented in the related works are highly supportive and functional for the proposed DAO-LEACH methodology.

4. Proposed Model

As stated earlier, the main contribution of the work is to reduce the energy consumption and increase the network longevity. Hence, DAO-LEACH is proposed here for data ensemble based optimal clustering and that results in producing energy efficient route for data transmission between the source and the sink node. Clustering is an adept methodology for data ensemble in WSN, in which the cluster head is termed as aggregated node that performs data accumulation from the received cluster member data. Furthermore, Gaussian distribution based nodes deployment has been performed for effective coverage of sensing area and node aggregation is performed based on the conditional probability theorem.

4.1 Network Deployment Model

Let us consider a WSN in a 2D plane with N sensor nodes, which are deployed on the environment by 2D Gaussian distribution (i.e, Normal Distribution). It is given by,

$$f(a,b) = \frac{1}{2\pi\sigma_a\sigma_b} e^{-\left(\frac{(a-a_i)^2}{2\sigma_a^2}+\frac{(b-b_i)^2}{2\sigma_b^2}\right)} \quad (1)$$

Where (a_i, b_i) is the deployment point and σ_a and σ_b are the standard deviation for a and b dimensions, respectively. Then, the deployment point is considered at the central point of the disk i.e. $a_i = b_i = 0$. The Gaussian distribution (GD) is given as,

$$f(a,b) = \frac{1}{2\pi\sigma_a\sigma_b} e^{-\left(\frac{a^2}{2\sigma_a^2} + \frac{b^2}{2\sigma_b^2}\right)} \quad (2)$$

The traffic pattern conceded is that each node senses its data and the BS is responsible for collecting data from sensors, periodically. In this section, the coverage probability has also been derived with respect to the Gaussian distribution (σ_a, σ_b). Along with that, in this section, the coverage probability with respect to Gaussian distribution ($\sigma_a = \sigma_b$) is derived. This stands that in the sensor deployment process, the two dimensions a and b are independent and submitted with the same standardization of GD, ($\sigma_a = \sigma_b = \sigma$). Simultaneously, the deployment points of both dimensions are the center point of the disk A, termed as, O (0,0).

In particular, the probability density functions of a and b will be given as follows:

$$f(a) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{a^2}{2\sigma^2}} \quad (3)$$

$$f(b) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{b^2}{2\sigma^2}} \quad (4)$$

Since the two dimensions a and b are independent, the PDF for point (a, b) that has been deployed a sensor is given as,

$$f(a,b) = f(a) \times f(b) = \frac{1}{2\pi\sigma^2} e^{-\frac{a^2+b^2}{2\sigma^2}} \quad (5)$$

In the above equation $a^2 + b^2$ is the square of distance from the point (a,b) to the center point. By solving, it is obtained that any two points in the disk having the same distance'd' to the center point have the same deployment probability.

4.2 Cluster Formation

Formation of clusters in sensor network depends on the time duration for receiving the neighbor nodes message and the residual energy (R_{Energy}) of the neighbor node. Thus, the clustering protocol is divided into rounds where each round is triggered to find the optimal cluster heads for each sensor nodes in the network. Let us assume the sensor nodes exchange beacon messages with its neighbor that composed the list of neighbors and its residual energy. It is also defined that two nodes do not transmit data in same time slot in order to reduce the interference.

The time duration for cluster formation procedure is taken as T_{CF}, which is triggered every network operation time duration and duration of cluster formation termed as rounds for selecting new cluster heads. Since WSN depends on multi-hop hierarchical network architecture, the hop distance and the hierarchy level plays the vital role in the cluster formation.

The cluster formation procedure comprises four stages.

Stage 1

Stage 1 operation involves information gathering about the neighbor nodes by broadcasting the beacon messages. Then, the respective nodes collect reply messages from the neighboring sensor nodes for the broadcast beacon messages.

Stage 2

In stage 2, a sorting algorithm is executed to obtain the list of neighbor nodes regarding its hop distance. The list of neighbor nodes is enacted in descending order

Stage 3

When its two- hop neighbor node is not enclosed, analyze all the members of stage 2 one-by-one and crown any one two-hop neighbor for being as a candidate for the cluster.

Stage 4

Stage 4 handles in the execution of sorting algorithm based on the residual energy of the neighbor nodes.

Each round of cluster formation procedure operates in all the four stages for effective clustering to provide better communication with the sensor nodes and the data ensemble.

4.3 Optimal Cluster Head Selection

Let us assume that the intra-cluster communication section is long enough, so that all member nodes of a cluster having data can send to their respective CH, so that all CH having data can send to the sink node. The CH performs data aggregation before transmitting the data to the sink node.

Energy consumption of the cluster heads is reasonably expensive, so the residual energy of sensor node is the substantial criteria for the election of cluster head. In addition, data ensemble can save considerable energy while the source nodes forming one cluster are deployed in a relatively small area when the sink node is far away from the source nodes, because sensor nodes require much few energy for transmitting data to the cluster head instead of sending data directly to the sink. Hence, it is logical to infer that the nearer source nodes within a cluster, the lesser energy they consume to send data.

With respect to the above deduction, an election weight is determined by taking account of the concentration degree of sensor nodes and their residual energy for optimal cluster-head election. Let us consider a WSN of N nodes {1,2, …, N}. $D^r(i)$ is termed to be the concentration degree of node i, (i.e) the number of sensors that can sense the environment during r^{th} round.

W(k,r) is given as the election weight of k in r^{th} round,

$$\alpha = \frac{1}{1+\beta}$$

(6)

$$\beta = \frac{R^r_{Energy(K)}}{\overline{R}_{Energy(K)}}$$

(7)

$$w(k,r) = \alpha \frac{R^r_{Energy(K)}}{R^r_{Energy}} + (1-\alpha)\frac{D^r(K)}{\frac{N^{-1}}{C}} \qquad (8)$$

Where C is the number of clusters, $R_{Energy(K)}$ is the initial energy of the node k, $\overline{R}_{Energy(K)}$ is the average residual energy in r^{th} round. α is stated as the adaptive factor to fiddle with the impact of concentration degree and residual energy to the election weight and β represents the R_{Energy} of node k in round r. With the reduction of R_{Energy}, αwill steadily increases to adapt to the declination of the number of effectual sensor nodes in WSN.

Moreover, it is vital to evaluate the optimal probability for a sensor node to become a cluster head. In order to determine that, let us consider the following terms:

d_{MH} is termed as the average distance between the cluster member and cluster head. E_0 is given as the energy required by a sensor for data transmission, M is the deployed area and d_{HS} is represented as the distance between the cluster head and the sink node. With those considerations, the equations presented below are framed.

$$d_{MH} = \int_0^{amax}\int_0^{bmax}\left(\left(a^2+b^2\right)*\rho(a,b)\right)da\,db$$

(9)

When the distance of a significant group of nodes to the sink is greater than d_0 then,

$$S_{op} = \sqrt{\frac{N}{2\pi}}\sqrt{\ }\, d_0 \frac{M}{d_{HS}}$$

(10)

Thus, the optimal probability of a sensor node to become a CH, P_{op}, is computed as follows,

$$P_{op} = \frac{S_{op}}{N}$$

(11)

It is also stated that if the clusters are not formed in an optimal way, the total energy consumption of the sensor network per round is increased considerably either when the number of clusters that are created is larger or particularly when the number of the clusters that are formed is less than the optimal number of clusters. Figure 3 exemplifies the overall flow of the proposed model.

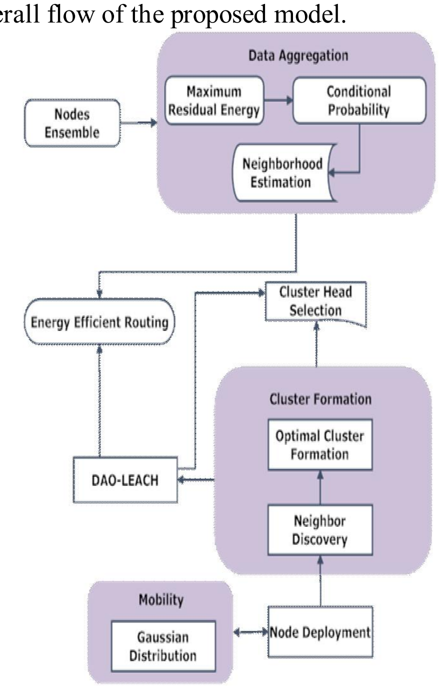

Figure 3: Overall flow of the Proposed Model

4.4 Node Aggregation Via Data Ensemble

In this operation, a cluster of nodes in a WSN is replaced with a single node without altering the underlying joint deployment of the network. While aggregating the nodes, data ensemble also takes place. It is needed to find a macro node which is capable for aggregation. However, the process incorporates two steps: Path definition and Pair of

Combinable nodes. Following, conditional probability has been applied for adept node aggregation process. The conditional probability of the macro node should be equal to the product of all component nodes' conditional probabilities. It is explained here with an example (figure 4).

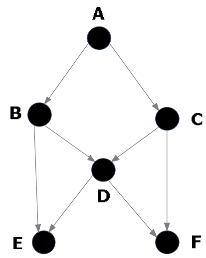

Figure 4: Sample Network

If the nodes B, C and D are combined into a macro node M, then the conditional probability of M |A (A- predecessor) is equal to:

$$P(M|A)=P(B,C,D|A)=P(B|A)P(C|A)P(D\,|\,B,C) \quad (12)$$

It is also stated from the above figure that the conditional probability of a macro node's successor is equivalent to the conditional probability of the successor given all the component sensor nodes in the macro node, except the nodes that are not linked directly to the successor node. Here, E is the successor and the above statement is given as,

$$P(E|M)=P(E\,|\,B,C,D) \quad (13)$$

By aggregating the sensor nodes using conditional probability theorem, the data has also been aggregated and packed for transmission through an efficient path to the sensor node.

4.5 Energy Efficient Routing

With the accomplishment of all process explained above, an energy efficient route has been obtained to transmit the aggregated data from the source to sink.

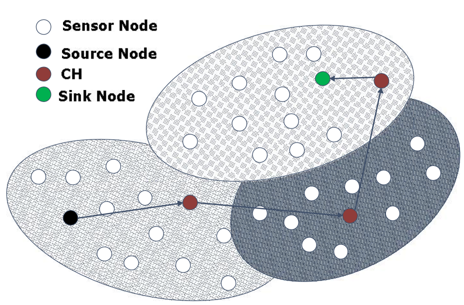

Figure 5: Energy Efficient Routing

The figure presented above shows the energy efficient routing for adequate communication of nodes having high residual energy. Here, the nodes deployment has been achieved by the Gaussian distribution, by which the process cannot be affected with high mobility of sensors. Data aggregation based optimal clustering supports in reducing energy dissipation of nodes, thereby decreases the energy consumption and prolongs the WSN lifespan.

5. Simulation Results

The affirmed work is compared with the results produced by LEACH to evaluate the efficiency of DAO-LEACH using NS2 simulations. In that, our research model performed on 100 nodes which are arbitrarily deployed and dispersed in a 100×100 square meter area. Sensor nodes restrain two kinds of namely, sink nodes and the common sensor nodes with limited energy.

The simulation results are analyzed and compared to LEACH with the parameters such as throughput, variance of energy, energy consumption, average energy utilization, remaining energy, End-End delay and Packet Delivery Ratio (PDR).

Table 1: Simulation Parameters

Parameters	Values
Network Size	(100*100m)
Node Distribution	Random
Initial Energy	2 Joule
BS Position	(110,45)
No. of Sensor nodes	100

Table 1 shows the simulation parameters that we have taken for producing simulation results for proposed DAO-LEACH approach. Here, the sensor nodes are randomly distributed with initial node energy as 2 Joule. The location of the base station (BS) is assumed as (110, 45) and when the energy of the node becomes less than or equal to 0, the node is considered as the dead node. With these parameters we produce our simulation results.

It is obvious from the results that the proposed method is more efficient than the existing. Figure 6 exemplifies the correlation between simulation time (milliseconds) and throughput (Mbps). From the pictorial representation, it is apparent that our proposed DAO- LEACH model produces high throughput than the LEACH clustering model. Our adduced method provides improved rate of effectual message delivery through the communication channel than the compared mechanism.

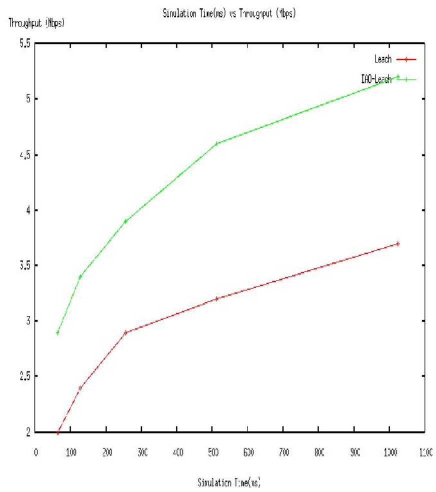

Figure 6: Simulation Time (ms) Vs Throughput (Mbps)

In order to provide evidence of our proposed methodology that it is designed by the consideration of energy efficient mechanisms, the simulation result in figure 7 demonstrates the relationship between simulation time and variance of energy (nJ) for the existing LEACH and DAO- LEACH methods. The graphical representation of figure 8 illustrates that our affirmed methodology consumes less energy than LEACH approach since we use the eminent conceits of clustering models and cluster head selection. The main concern of our proposal is to afford a method for optimal energy consumption in wireless sensor network using energy efficient cluster selection mechanism and provide efficient routing. The process shows that the average energy utilization is considerably reduced in our approach by the trasmission of data is done with cluster heads.

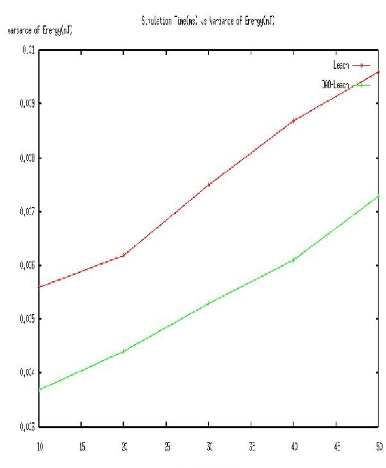

Figure 7: Simulation Time (ms) Vs Variance of Energy (nJ)

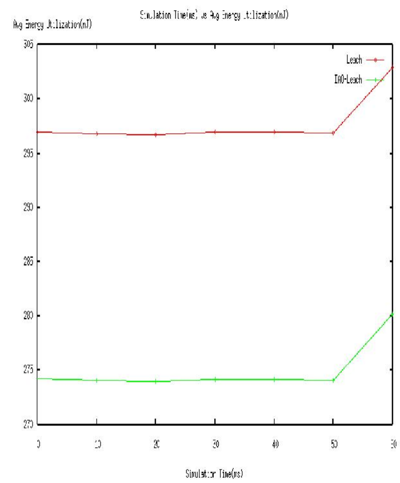

Figure 8: Simulation Time (ms) Vs Avg Energy Utilization (nJ)

In accession to the optimal energy consumption, our approach provides minimized end-end delay. Figure 9 demonstrates the alliance between the simulation time and end-end delay, which provides an evidence for the consistency of the proposed work. The average time delay to trasmit the packets to sink node or to the BS is termed as end-end delay, which is significantly reduced in the adduced work than the existing LEACH.

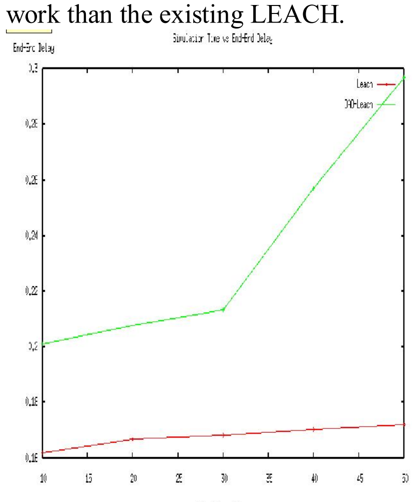

Figure 9: Simulation Time (ms) Vs End-End Delay (ms)

PDR in WSN is described as the ratio between the number of received data packets to the number of generated data packets by sensor nodes. The figure presented below evinces the relation between the simulation time and the packet delivery ratio that determines the accuracy and reliability of the communication between the sensor nodes in wireless sensor network. The simulation result provided beneath exhibits that approximately 30% of DAO-

LEACH is greater than the LEACH results. Thus, our method produces results with higher precision rate. The DAO-LEACH contributes an innovative method for energy efficient clustering and routing with concentration and centrality and data aggregation.

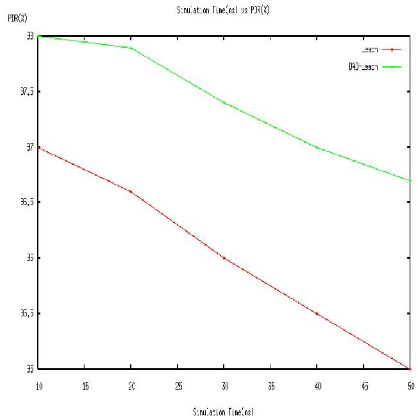

Figure 10: Simulation Time (ms) Vs PDR (%)

6. Conclusion and Future Work

Since a decade, WSN have been envisioned to support numerous monitoring applications. In which, energy efficient routing is much consequential to enhance the lifetime and stability of the system. Focusing that, ADO-LEACH has been proposed in this paper for determining efficient route for communication and data transmission among the nodes. Gaussian distribution is adopted for node deployment that highly adaptive for node mobility in WSN. Moreover, data aggregation has been performed with the conditional probability based node aggregation method, where the data ensemble has been attained effectively, and an optimal clustering and cluster head selection procedures are incorporated by which the energy dissipation of nodes can be reduced considerably. Finally, an energy efficient route is obtained for communicating the source and the sink node that increases the network longevity.

With respect to future enhancements, this work is open for distinctive research areas where valuable contributions can be done. Here, it is also suggested that consideration of idle sensor nodes while routing will provide more efficiency.

References

[1] B.Baranidharan and B.Shanthi, “A Survey on Energy Efficient Protocols for Wireless Sensor Networks,” International Journal of Computer Applications, 2010, Vol. 11, Issue. 10, pp. 35- 40.

[2] Meenakshi Diwakar and Sushil Kumar, “An Energy Efficient Level Based Clustering Routing Protocol For Wireless Sensor Networks,” International Journal Of Advanced Smart Sensor Network Systems, 2012, Vol. 2, Issue. 2.

[3] Shivanna K and Shalini Kumari H A, “Energy Efficient Data Mining in Multi-Feature Sensor Networks Using Improved Leach Communication Protocol,” IOSR Journal of Computer Engineering, 2012, Vol. 3, Issue. 3, pp. 8- 11.

[4] Abuhelaleh and Mohammed, “Modified LEACH – Energy Efficient Wireless Networks Communication,” Journal of Novel Algorithms and Techniques in Telecommunications and Networking, 2010, pp. 123- 127.

[5] Yuzhong Chen, and Yiping Chen, “An Energy Efficient Clustering Algorithm Based on Residual Energy and Concentration Degree in Wireless Sensor Networks,” In the Proceedings of the Second Symposium International Computer Science and Computational Technology, 2009, pp. 306-309.

[6] Neha Jain, “Energy Efficient And Cluster Based Routing Protocol For Wireless Sensor Network:A Review,” International Journal of Advance Technology & Engineering Research, 2011, Vol. 1, Issue. 1.

[7] Jing Chen, Hong Shen, “MELEACH-L: More Energy-efficient LEACH for Large-scale WSNs,” In the Proceedings of 4th International Conference on Wireless Communications, Networking and Mobile Computing, 2008, pp. 1-4.

[8] Udit Sajjanhar and Pabitra Mitra, “Distributive Energy Efficient Adaptive Clustering Protocol for Wireless Sensor Networks,” In the Proceedings of International Conference on Mobile data management, 2007, pp. 326- 330.

[9] K.K Paliwal, 2Rohit Anand, 3Priyanka Garg, “Energy Efficient Data Collection Algorithm in Wireless Sensor Network,” International Journal of Electronics & Communication Technology, 2011, Vol. 2, Issue. 3.

[10] Ankit Thakkar and Dr K Kotecha, “CVLEACH: Coverage based energy efficient LEACH,” International Journal of Computer Science and Network, 2012, Vol. 1, Issue. 3.

[11] Muhammad Haneef, Zhou Wenxun and Zhongliang Deng, “MG-LEACH: Multi Group Based LEACH an Energy Efficient Routing Algorithm for Wireless Sensor Network,” In the Proceedings of 14th

International Conference on Advanced Communication Technology, 2012, pp. 179-183.
[12] Manish Kumar Jha, Atul Kumar Pandey, Dipankar Pal and Anand Mohan, "An energy-efficient multi-layer MAC (ML-MAC) protocol for wireless sensor networks," International Journal of Electronics and Communications, 2011, pp. 209- 216.
[13] Dilip Kumar, Trilok C. Aseri and R.B. Patel, "EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks," Journal of Computer Communications, 2009, Vol. 32, pp. 662-667.
[14] Tzung-Cheng Chen, Tzung-Shi Chen and Ping-Wen Wu, "On Data Collection Using Mobile Robot in Wireless Sensor Networks," IEEE Transactions On Systems, Man, And Cybernetics, 2011, Vol. 41, Issue, 36.
[15] Rongbo Zhu, Yingying Qin, and JiangqingWang, "Energy-Aware Distributed Intelligent Data Gathering AlgorithminWireless Sensor Networks," International Journal of Distributed Sensor Networks, 2011, pp.1-13.
[16] Honggang Wang,Dongming Peng,Wei Wang,Hamid Sharif, "Energy-aware Adaptive Watermarking for Real-Time Image Delivery in Wireless Sensor Networks," In the Proceedings of IEEE International Conference on Communications, 2008, pp. 1479- 1483.
[17] Shinya Ito and Kenji Yoshigoe, "Performance Evaluation Of Consumedenergy- Type-Aware Routing (Cetar) For Wireless Sensor Networks," International Journal of Wireless & Mobile Networks, 2009, Vol. 1, Issue. 2.
[18] M.A. Koulali, A. Kobbane, M. Elkoutbi And M. Azizi, "A QoS-Geographic and Energy Aware Routing Protocol for Wireless Sensor Networks," In the Proceedings of International Symposium on I/V Communications and Mobile Network (ISVC), 2007, pp. 1- 4.
[19] Cao shasha and Ke zongwu, Chen niansheng, "Research of QoS Routing Technology for Wireless Multimedia Sensor Network," International Colloquium on Computing, Communication, Control, and Management, 2009, Vol. 4, pp. 334- 337.
[20] Ghalib A. Shah, Weifa Liang and Xiaojun Shen, "Cross-Layer Design for QoS Support in Wireless Multimedia Sensor Networks," In the Proceedings of Global Telecommunications Conference, 2010, pp.1- 5.
[21] Demin Wang, Bin Xie, and Dharma P. Agrawal, "Coverage and Lifetime Optimization of Wireless Sensor Networks with Gaussian Distribution," 2008, IEEE Transactions On Mobile Computing, Vol. 7, Issue. 12, pp. 1444- 1458.
[22] W. R. Heinzelman, A.Chandrakasan, H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences, 2000.
[23] S.Ozdemir, Y.Xiao, "Secure data aggregation in wireless sensor networks: A comprehensive overview," Computer Networks, vol. 53,pp. 2022-2037, August 2009.
[24] H.S.Lee, K.T.Kim, H.Y.Youn, "A New Cluster Head Selection Scheme for Long Lifetime of Wireless Sensor Networks," ICCSA 2006, vol.3983, 2006.