AN ENERGY EFFICIENT ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS USING K-MEANS CLUSTERING ALGORITHM

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Abstract: Building and using sensor networks has drawn a lot of interest. A wireless sensor network is made up of a lot of little nodes that also serve as routers. Because these nodes only have a little amount of non-replaceable, non-rechargeable power, energy consumption is a major concern. The issue of energy conservation is crucial for extending the network's lifespan. Due to the sensor nodes operate similarly to routers, the choice of routing method is crucial in regulating energy consumption. The architecture for wireless sensor networks is described in this paper, along with the analysis and investigation of several research projects on Energy Efficient Routing in Wireless Sensor Networks.

Keywords: - Energy Efficient Routing, Wireless Sensor Network, industrial wireless sensor networks, NP-complete, mobile sensor networks (MSN), industrial wireless sensor networks (IWSNs), K-means clustering.

INTRODUCTION

The recent advancement in low power electronics, and ubiquitous smart sensors have made wireless sensor network (WSN) as one of the most significant technologies over the past decade. In most cases, a WSN integrates automated sensing, processing, and wireless transmission units into small electronics devices known as sensor nodes [1]. These nodes scatter randomly and densely over the geographical areas to sense various environmental parameters viz. temperature, pressure, humidity, sound, moisture, and seismic events. The sensed information is routed hop-by-hop towards the more potent node, referred as sink to further processed and analyzed [2].

Sensor based applications have started to involve in various platforms and areas, including military surveillance, industrial and home automation, healthcare monitoring, underwater navigation, and environmental monitoring. Recently, researchers have received have realized some specific denominations for various WSN application domains [3] as shown in Figure 1.1. For instance, sensor networks used for transmitting video, audio, and images particularly for surveillance and monitoring purposes may be called as wireless multimedia sensor networks (WMSNs). Sensor networks deployed inside factories or industries for machine condition monitoring and process automation termed as industrial wireless sensor networks (IWSNs). When used for medical and healthcare, the network can be labelled as wireless body area networks (WBANs). In addition, when sensor nodes deployed underwater to facilitate underwater navigation, surveillance, pollution monitoring, and disaster prevention, are termed as underwater wireless sensor networks (UWSNs). Finally, when sensor nodes are mobile, they may be called as mobile sensor networks (MSN). These application domains have different constraints in their nature and requirements which require QoS assurance in terms of delay, reliability, energy-efficiency, bandwidth utilization, adaptivity, scalability and throughput [4–9]. Hence, providing QoS assurance in resource limited environment is one of the critical challenges that are addressed either by modifying the existing routing protocols in WSNs or by proposing new QoS provisioning techniques, for example, multi-constrained routing, clustering, multipath routing, multiple sinks, and mobile sink.

A Wireless sensor network (WSN) is a hard and fast of wireless mobile nodes forming a brief/brief-lived network with none constant infrastructure where all nodes are free to move about arbitrarily and in which all the nodes configure themselves [5]-[9]. In WSN, each node behaves equally as a router as well as a host, despite the fact that the topology of network can also change quickly. Figure 1 shows application area for WSN.

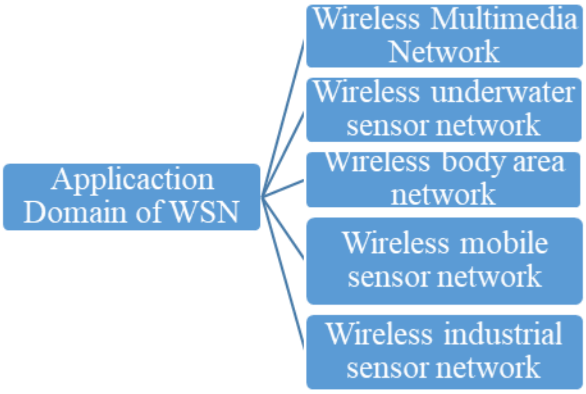

Figure 1: Application Areas of WSN

ISSUES AFFECTING QOS IN WSN

Since WSNs are accepted for a variety of applications for surveillance and monitoring, they have several features of hardware and communications devices that cause some QoS distribution issues. The following are the most critical issues that impact QoS in WSN.

- **Multiple routing metrics**

One of the indispensable strategies to support WSN real time services is multi-constrained QoS routing. Metric routing is used to choose the best optimal relay node and network route for the sink node[15]. Several routing metrics were utilized for optimizing routing selection to meet the application-specific QoS constraints on network levels such as delays, reliability, Hop counting, traffic load and residual energies. However, NP-complete was demonstrated as optimizing one metric leads to more deprivation and the increase in the amount of traffic metrics increases the difficulty of road calculations by finding suitable traffic metrics and retaining an efficient mathematical cost function. Although evolving network dynamics make it difficult to keep updated data in resource-constrained WSN for protocol routing.

- **Dynamic Network**

The topology of the network can differ often as nodes, mobility nodes and node failure are added and removed from the network. Another obstacle for WSN quality supply can also be generated by dynamic network topology.

- **Service differentiation**

Service differentiation is the most common technique for the QoS supply of resource-linked WSN. By making traffic a priority on the basis of one or more criteria, it effectively spreads the limited network resources between different loads, such as remaining hops, time to deadline, residual energy, traffic load and travel distance, and shapes multiple traffic classes. This enables the network layer to consider each of these traffic groups separately, providing an ideal route for any kind of traffic and to meet the QoS requirement of the importance of its transported data. Since traffic community priorities are poorly used, QoS guarantees are difficult to guarantee in a resource-restricted environment. Dynamic priority assignment and dynamic network requirements should also be taken into account in an efficient service differentiation process.

- **Clustering**

Nodes clustering in WSNs is a crucial mechanism that ensures that energy efficiency and reliability are guaranteed by QoS. The cluster divides the network into small clusters with a cluster head (CH) and member nodes in each cluster. If the network has been set up, intra-cluster and inter-cluster communication is defined by communication between the nodes. Members nodes forward their information to the corresponding CHs and the CHs then transmit aggregate data to the BS through multi-hop routing or directly. However, CHs close to the BS are rapidly depleting their energy due to the high intercluster relay load in the multiple shop approach which is responsible for the hot spot problem. In this respect it should be investigated to further resolve the hotspot problem in WSN algorithms with unequal clustering support. In addition, failure of the CH node in the hierarchical WSN interrupts the network connection not only to their member nodes but also to neighboring CH nodes. Therefore clustering algorithms have to be seen as a failure tolerant problem, in order to maintain network connectivity and optimise the life of the network.

- **Multiple sink**

When a single sink is situated in a region that may be far from the source nodes, the network output is likely to degrade very quickly in large WSNs. This is because, compared with far-off sensor nodes, the residual energy of sensor knots near the sink is drained much faster and thus contributes to early sink isolation. In addition, E2E transmission delays can be costly to transfer data across many intermediate nodes. Thus the data transmission speeds are faster when several discs are deployed around the field and the energy of nodes is maintained as the data packets are not required to spread over several hops to reach the discharge. Therefore it is important that many sink deployments locate the optimum count and position of several sink nodes, with the goal of reducing transmission time while maintaining minimum energy consumption.

- **Mobility**

When a static sink is used in the WSN architecture, nodes near the sink quickly exhaust their battery relative to other nodes, causing premature network failure. In recent years, sufficient consideration has been given to the method of integrating mobile sinks into the WSN framework to optimise network life. The use of a mobile sink on the network continuously shifts the hotspots around the sink by its movement, thereby raising the likelihood that each node becomes the nearby node of the sink. This results in the distribution of data traffic on the mobile discharge.

For WSN execution, however, the movement pattern of the sink node is extremely important. In sparse and partitioned architectures, the connection, coverage and reliability of data reporting is increased by controlled sink movement. With uncontrolling sink motion, the network paths that lead to the sink node are continuously changed, causing considerable power and delayed overhead communication. Furthermore, due to the poor communication range, this may also lead to a road breakdown between source and sink. Thus, an effective routing recovery mechanism is to be considered in the mobile sink WSNs which determines the optimal trajectory for the mobile sink.

- **Multipath routing**

Multi-path routing in WSNs is based on the QoS specifications for heterogeneous traffic load, by extending traffic loads along many routes. The traffic allocation equalises energy consumed by adjusting the source and sink transmission node, and reduces the probability of network congestion. In the event of primary route failure, multipath routing may also maintain network stability by a redirection of network traffic to another active node.

- **Energy balance**

The important factor in the design of an energy-constrained WSN is energy-efficiency. During the transmission of the data packet, Distribution of the unbalanced traffic load over sensor nodes can cause the loaded sensor node to decline early energy. Therefore the energy consumption between the sensor nodes can be adjusted reliably by the QoS mechanism along the way to the sink. The Key Challenges Faced by WSN to achieve QoS is shown in figure 2.

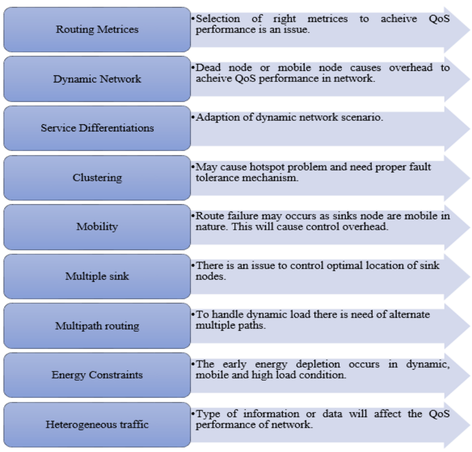

Figure 2: Key Challenges Faced by WSN to achieve QoS

LITERATURE REVIEW

According to the clustering protocol, cluster head is elected in each iteration or round which requires the formation of new clusters regularly. This may lead to excessive utilization of energy due to routing overhead, which may not be acceptable for any mobile devices, especially in IoT devices. So, there is requirement of an energy-efficient CH replacement method that can be employed in order to avoid utilization of extra energy in cluster formation and transmission of advertisement message to cluster members. The unequal clustering routing algorithm is needed to be focused and improved for IoT applications with dynamic number of nodes as well as mobile nodes. This will lead to reduction of network energy consumption and extends the network life cycle with higher stability. Some contribution of researchers are discussed below:

Ullah et al. [1] proposed a data aggregation scheme based on clustering of the nodes and extreme learning machine (ELM) which efficiently reduces redundant and erroneous data. Mahalanobis distance-based radial basis function is applied to the projection stage of the ELM to reduce the instability of the training process. Kalman filter is also used to filter the data at each sensor node before transmitted to the cluster head.

Radhika et al. [2] presented a modified clustering methodology that diminishes the overhead in clustering and message exchanges thereby effectively scheduling the clustering task. The network is clustered subject to the remaining energy of sensor nodes. Energy based parameters decide cluster head nodes and ancillary nodes and the member nodes are linked with them. The roles of the head nodes of the cluster are interchanged depending on the nodes' states. Reclustering of nodes is accomplished to achieve minimum energy consumption by calculating the update cycle using a fuzzy inference system.

Manzoor et al. [3] focused on improving the Two-Level Hierarchy for Low Energy Adaptive Clustering Hierarchy (TL-LEACH) protocol to provide energy efficiency; in terms of communication overhead and making the communication among the end-nodes, cluster-heads and base station as robust as possible. Two major drawbacks of the TL-LEACH protocol have been focused in this research that are mainly related to using the protocol for large-scale WSN and making the communication among the nodes robust. A novel cluster-head selection mechanism has been introduced to improve the energy-efficiency of the TL-LEACH and the new version has been named as Extended TL-LEACH (ETL-LEACH).

Madhumathy et al. [4] proposed an agent cluster-based routing protocol which will subdivide the cluster into independent subgroups according to the satisfaction list. The independent sub groups are associated with an agent node that can communicate to the cluster head. The proposed agent cluster-based routing algorithm is created keeping into consideration to reduce the energy consumption while transmitting data from node to cluster head. The agent node is chosen based on the satisfaction list which reduces the chances of agent node die out problem thus enhancing the network reliability and lifetime.

Behera et al. [5] modified the existing low-energy adaptive clustering hierarchy (LEACH) clustering protocol is modified by introducing a threshold limit for cluster head selection with simultaneously switching the power level between the nodes. The proposed modified LEACH protocol outperforms as compared to the existing LEACH protocol with 67% rise in throughput and extending the number of alive nodes to 1750 rounds which can be used to enhance the WSN lifetime. When compared with other energy efficient protocols, it is found that the proposed algorithm performs better in terms of stability period and network lifetime in different scenarios of area, energy and node density.

Razzaq et al. [6] proposed K-means clustering-based routing protocol and considers an optimal fixed packet size according to the radio parameters and channel conditions of the transceiver. This approach can minimize the energy consumption of individual node and increase the network lifetime as a whole.

Wibisono et al [7] integrated cluster-based and position-based routing protocols for multi-hop scenarios. The self-organized clusters are formed periodically where decision to become cluster head (CH) is performed individually by each node. Direct long communication between selected CH to sink node is avoided to preserve energy and minimize impact of overhearing transmission. Accordingly, a multi-hop communication scheme which adopts position-based routing is applied. The proposed approach has been developed and tested using wireless simulation framework.

Abidoye et al. [8] discussed that according to the LEACH protocol, a new CH is elected in each iteration or round which requires the formation of new clusters regularly. This may lead to excessive utilization of energy due to routing overhead, which may not be acceptable for any IoT devices. In case, a CH has not utilized a good amount of energy in the previous round and there is a fair probability that a node with a low energy may become CH in the next selection process. Hence an efficient CH replacement method has been employed in order to avoid utilization of extra energy in cluster formation and transmission of advertisement message to cluster members.

Xiong et al. [9] proposed Improved-LEACH based on threshold by modifying the primitive threshold formula. A coverage-preserving CH selection algorithm (CPCHSA) for the LEACH protocol is proposed to maximize the network sensing coverage. One of the limitations of these protocols is that the number of CHs chosen is not certain in each round.

Peng et al. [10] proposed an optimized protocol LEACH-B on the basis of LEACH. In this paper, clustering and cluster head election method is improved. Firstly, the great convergence and global optimization capability of BIRCH algorithm can reasonably divide the entire network area into a plurality of sub-regions. Then, electing the cluster head taking the residual energy factor into account, in the sub-region.

Kandpal and Singh [11] have proposed IL-LEACH, where the correlated data is transmitted through a group of nodes into the virtual correlated cluster and allowing only one node to send data. The LEACH protocol has also been modified in recent years aiming to reduce power consumption at different levels.

Siavoshi [12] introduced a new clustering technique to balance the load in the network by dividing it into virtual circles. The cluster size depends on the distance from the BS and is different from each other. When compared with LEACH protocol, they found that network lifetime can be increased to almost 73%.

In order to address this problem, Sasikala et al. [13] have proposed V-LEACH that has three types of nodes in the network named as member node, CH, and vice-CH. The vice-CH acts perform the function of CH when the original CH dies.

Mahapatra et al. [14] discussed a detailed survey of LEACH and its successors considering four important parameters such as clustering method, data aggregation, mobility type and scalability. The LEACH protocol randomly selects CHs and no information about the residual energy of the network is known to the BS.

M.Wu et al. [15] proposed an evolutionary clustering routing algorithm for heterogeneous wireless sensor networks (WSN). The method combines genetic algorithms (GA), ant colony optimization algorithms (ACO) and clustering method. It explores the tradeoff between the algorithm complexity and transmitted energy. Experiment results show that proposed algorithm is superior to other protocols in the stable time (until the first node dies) and the operational time (until 60% nodes die).

Lakshaman et al. [16] proposed a new hybrid approach in routing protocol by combining Particle Swarm Optimization (PSO) routing protocol with clustering algorithm. Here the approach focuses fully on Ant Colony Optimization & Bee Colony Optimization (ACO & BCO) on PSO routing protocol and K-Means clustering algorithm for illustrating the clusters of node or grouping the nodes. The proposed approach is tested for its proficiency, performance, energy consumption level and reliability using OMNETPP. The experimental results are shown in the form of graph.

Sahoo et al. [17] proposed an optimization routing model in which the ‘CH selection’ and ‘sink mobility-based data transmission’,

both are optimized through a hybrid approach that consider the genetic algorithm (GA) and particle swarm optimization (PSO) algorithm respectively for each task. The robust behavior of GA helps in the optimized the CH selection, whereas, PSO helps in finding the optimized route for sink mobility. It is observed through the simulation analysis and results statistics that the proposed GAPSO-H (GA and PSO based hybrid) method outperform the state-of-art algorithms at various levels of performance metrics.

Mehta et al. [18] presented a Multi-Objective Based Clustering and Sailfish Optimizer (SFO) guided routing method to sustain energy efficiency in WSNs. In it the Cluster Head (CH) is selected, based on effective fitness function which is formulated from multiple objectives. It helps to minimize energy consumption and reduces number of dead sensor nodes. After CH selection, SFO is used to select an optimal path to sink node for data transmission. The simulation results show that proposed method has performed 21.9% and 24.4% better in terms of energy consumption and number of alive sensor nodes respectively when compared to GWO. Further, it shows significantly better results than other optimization-based approaches.

Behera et al. [19] shows improvement of the existing stable election protocol (SEP) that implements a threshold-based cluster head (CH) selection for a heterogeneous network. The threshold maintains uniform energy distribution between member and CH nodes. The sensor nodes are also categorized into three different types called normal, intermediate, and advanced depending on the initial energy supply to distribute the network load evenly. The simulation result shows that the proposed scheme outperforms SEP and DEEC protocols with an improvement of 300% in network lifetime and 56% in throughput.

Zhao et al. [20] proposed an improved clustering protocol with data transmission status switchable, which can be used in heterogeneous sensor networks. Cluster heads filter the perceived information and start data transmission link, and then send data to the sink when the information intensity perceived exceeds the preset threshold. Otherwise, cluster heads record the received data and continue receiving data sent by the next round of cluster nodes. We fortunately found in the simulation results that the network lifetime is prolonged several times than the protocol of LEACH.

Table 1: Comparative Study of Various Methods for Cluster-Based Routing Protocols WSN

	Description	Results	Drawbacks
Ullah et al. [1]	Kalman filter is also used to filter the data at each sensor node before transmitted to the cluster head.	Testing accuracy is approx. 70-80%. Energy consumption is increasing steeply with increased round.	Data aggregation at the CH can be efficient only when similar data are grouped and processed together. Designed for fixed dataset. Designed for fixed and homogeneous clusters.
Radhika et al. [2]	Update cluster cycle using a fuzzy inference system.	The number of alive nodes to ~1500 rounds.	Energy consumption is more in mobile condition.
Manzoor et al. [3]	Enhanced two level LEACH protocol is proposed.	Processing space required is about 600 bytes and nodes alive for approx. 1200 seconds.	Not flexible for mobility
Madhumathy et al. [4]	Agent Cluster Based Routing Protocol for Enhancing Lifetime of Wireless Sensor Network	Robustness is increased.	Satisfaction list updation regularly. Which node to decide agent node. Computational complexity is high.
Behera et al. [5]	Proposed an Energy-efficient modified LEACH protocol for IoT application	Outperforms as compared to the existing LEACH protocol with 67% rise in throughput and extending the number of alive nodes to 1750 rounds.	Energy Consumption is high.
Wibisono et al. [7]	Position-Based Scheme for Multi-Hop Routing Protocol in Cluster-Based Wireless Sensor Networks	Packet delivery ratio is about 90%	Not suitable for dynamic and heavy network.
Wenliang et al. [9]	Proposed improved LEACH clustering algorithm, considering the residual energy of the nodes and the factors of the long distance node.	Network is alive more than 1500 rounds. 80% survival rate.	Homogeneous scenario is considered and fixed nodes are taken.

Peng Li et al. [10]	LEACH-B algorithm is proposed. Effectively balance the network load and improve the utilization of energy, so as to extend the network life cycle.	The remaining energy of LEACH-B is always higher than LEACH protocol	Data fusion issue on cluster head node. Only focuses on residual energy of cluster head.

PROBLEM STATEMENT

The major challenges in WSN, that comes out through literature survey are the limited energy of SNs and high energy consumption during transmission of data to the sink node. Clustering though provides efficient method of sensor networking, but suffers an issue of CH selection and data relay in energy efficient way. Many hierarchical routing protocols come in to the picture to cope up the limitations. Some of the hierarchical routing techniques such as LEACH solve the problems up to certain extents and that is limited to energy and minimum distance. The other quality of service assisted parameters is not taken into consideration. The hybrid optimization-based CH selection process primarily relied on key parameters of distance, energy and delay that are significant concerns for electing the optimal cluster head but coverage, connectivity parameters are given less importance. The selection of optimal path in the rule-based energy efficient routing faces the concerns in selecting a route that provides for high throughput and lesser delay. Optimal path selection problem arises due to the extra number of hops considered when packets are directed to sink. Various challenges are given in figure 3. Further, some of cluster-based routing approaches have been identified but are not suitable for dynamic environments as they can't balance several cluster heads or are less-energy efficient.

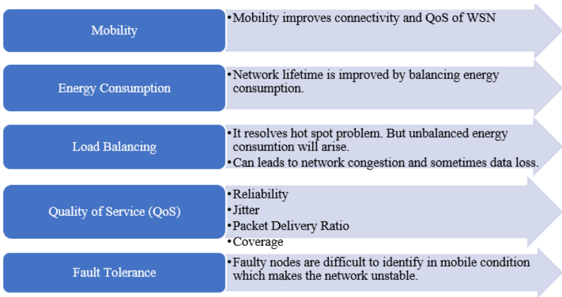

Figure 3: Challenges and Objectives for future Research Scope

PROPOSED METHODOLOGY

Cluster routing techniques work in cycles, with each cycle consisting of three stages: cluster formation, cluster head selection and data transmission. The number of optimal clusters is first estimated in the clustering stage, the early clustering centers needed by the K-Means clustering algorithm are picked by using area division method, and grouping is done by utilizing the objective function. To overcome the many-to-one transmitting version's unequal distribution of node load, this study uses dividing and combining operational activities to change the scale of the area with high-energy usage, balancing the energy usage of devices in the system. This flowchart of proposed methodology is presented in figure 4.

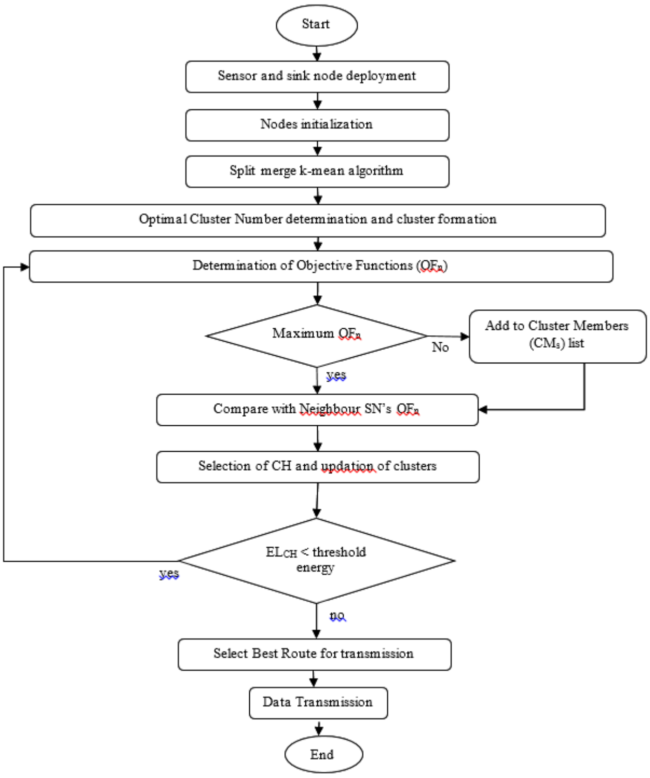

Figure 4: Proposed Framework

Cluster Formation

In Wireless Sensor Networks, the reasonable estimation of the cluster number is generally associated with energy efficiency considerations. If there are enough clusters, there will be too much clustering expense; if there are too few clusters, there will be enough nodes inside every cluster, and a quantity of cluster heads will expire too quickly. Therefore, a sufficient quantity of clusters can not only enhance the system link's effectiveness, but also balance node wasted energy and lengthen the network's lifespan.

The overall energy required by multi-hop transmissions can be calculated by adding the energy usage costs of the clusters and the energy usage costs of the nodes in each cluster that can be written as:

$$E_{overall} = E_{multihop} + m \cdot E_{incluster} \quad (1)$$

Assuming, m circular cluster areas completely cover the system region.

$$M^2 = \pi \cdot r^2 \cdot m \quad (2)$$

The distance between clusters can be calculated as

$$s = 2r = \frac{2M}{\sqrt{\pi m}} \quad (3)$$

When employing the K-means technique to cluster data, the initial cluster centre selected has a direct effect on the clustering result and may have a significant effect on clustering efficiency. The K-means algorithm is a clustering algorithm that uses local search. The algorithm's outcome is determined by the framework's initial state, i.e., the choosing of the initial cluster centre point, and the technique can only ensure convergence to a fixed point, not the objective function's minimal point. The procedure may occasionally converge to the objective function's saddle point. As a result, choosing the initial clustering centre is a critical step in clustering application when using the K-means algorithm to obtain an optimum clustering structure. Check the amount of nodes across each area and make the first cluster centre h_1 the centroid of the area with the most nodes. Compute the difference here between centroid of the other region W_B and the first cluster centre h_1 one at a time, and choose the point with the greatest distance from the first cluster centre as the second cluster centre, i.e. h_2. Continue to calculate the distances between the centroids of the other areas and the cluster centres. The steps for specific clustering are as follows:

Step 1: select k-cluster centres.

Step 2: Find the distances between the n nodes and the k cluster centre points. Every node chooses the cluster with the least distance to connect.

Step 3: As a new cluster centre point, compute the geometric mean of the nodes in each cluster.

Step 4: Evaluate whether the error conditions have been met using the error square sum criterion. If not, go back to Step 2 and continue from there. Instead, the clustering process is completed, and the outcome is k categories.

Algorithm

Algorithm 1
Multi-population Ensemble PSO
Initialize values of MEPSO, consisting LP, N, λ_H
Here, $H \in 1,2,3$
Initialize the sub-population for LDWPSO, UPSO, and CLPSO
Set the function evaluations, N_H, N_r
Initialize positions x
Initialize velocities
Calculate function values FE_S
While (termination condition is not satisfied) do
    i= i+1
Randomly allocate the values of N_H, N_r
If mod (gen, LP)==0
Set the values of K, F_H as described in above equations
$POP_K = POP_K \cup POP_r$
Modify the values of $POP_{1,2,3}$ by LDWPSO, UPSO & CLPSO
  For i= 1:N; if $x_{min} < x < x_{max}$
Again calculate function evaluations
If $F x_i < F(pbest_i)$
    Evaluate ΔF_H from eqn 4.9
If,
$F(pbsest_i) = F(x_i)$
Similarly if $F(gbest_i) = F(x_i)$
        end if
      end if
    end if
end for
end while

To dynamic optimization algorithm, a good balance between exploration and exploitation is necessary. Too much stress on exploration would result in pure random search, whereas too much stress on exploitation would result in pure local search. Besides, the robustness of the algorithm's parameter setting to various problems should also be considered seriously. In this paper, a novel multi-strategy ensemble PSO algorithm (MEPSO) is proposed. MEPSO tries to achieve good balance between exploration and exploitation by setting one part of its population (part I) be in charge of exploitation and the other part (part II) be in charge of exploration. Two new strategies, Gaussian local search and differential mutation, are introduced into the two parts, respectively. The mechanisms used in part I have good effect on the convergence ability of the algorithm, while mechanisms used in part II have the effect of extending the coverage of particle population to avoid being trapped into the local optimum, and to enhance the ability of catching up with the changing optimum in dynamic multimodal environments. Furthermore, the ensemble of these strategies combines both exploration and exploitation together to perform efficient search in dynamic environments. Experimental analyses show that MEPSO is efficient and robust for dynamic optimization problems with various number of peaks and severities.

RESULT AND DISCUSSION

Implementation Details

This chapter shows the simulation results. The simulation scenario is created and simulated for performance evaluation of proposed security algorithm. In order to evaluate the performance of proposed algorithm scheme, the proposed algorithm is simulated in following configuration:

- Pentium Core I5-2430M CPU @ 2.40 GHz
- 4GB RAM
- 64-bit Operating System
- MATLAB Platform

Performance Parameters

Residual Energy

The sum of the remaining energy of all sensor nodes in a network is termed residual energy. This is evaluated in each round or after data transmission. The efficiency of any routing algorithm is determined when it maximizes the residual energy.

Throughput

Another important parameter is the throughput that is calculated on the successful delivery of data packets to the sink node at a particular time. The routing protocols of WBAN are dedicated to maximizing the throughput.

Network Longevity

In WBAN routing algorithms, the most important parameter is network longevity as sensor nodes are battery-operated. This is evaluated by counting the alive and dead nodes after every round or after a particular period.

Result Analysis

WSN areas are simulated for IoT WSN in a particular area. The configuration of the simulation is presented in table 2. Random location of sink node is selected with unlimited energy whereas sensor nodes are deployed with limited energy with different energy levels. The proposed scheme is implemented for variable rounds of iterations for fixed packet sizes.

Table 2. Simulation scenario

Simulation Scenario	Values
Area	100m*100m
Sensor nodes	100-500
Initial energy of network	50 J
Energy Dissipation while transmitting bits	16.7 nJ/bits
Energy Dissipation while receiving bits	36.1 nJ/bits
Energy Dissipation during amplification of power	1.98 nJ/bits
Packet size	4000

Figure 5 represents the simulation result of number of packets transmitted to base station and similarly, figure 6 represents the simulation result for energy utilization by all nodes in the network. Table 3 represents the comparative result analysis of the proposed methodology with existing works.

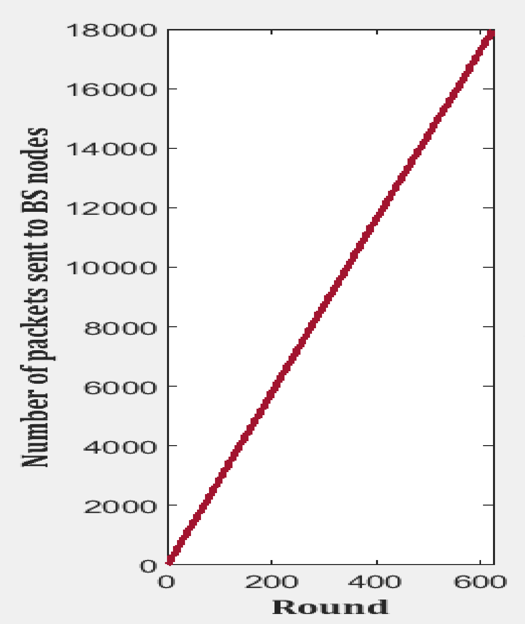

Figure 5: Number of Packets transmitted to Base Station

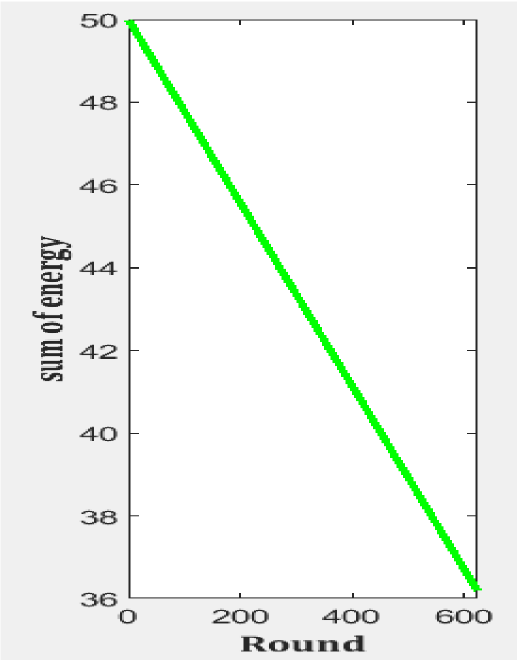

Figure 6: Energy Utilization of Network

Figure 7 shows Residual Energy with 100 Nodes under Homogeneous Network with varied Number of rounds. The residual energy decreases from 50 to almost 49.65 J from 0-100 Rounds. It is maximum for 0 rounds and minimum as the number of rounds increases.

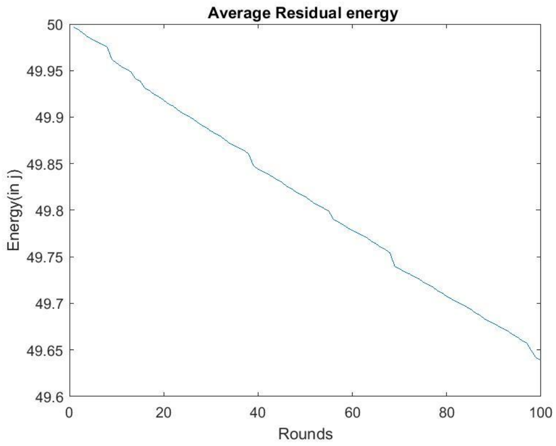

Figure 7: Number of rounds vs Residual Energy with 100 Nodes

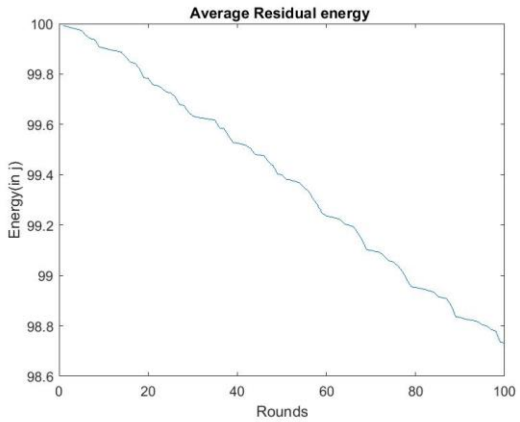

Figure 8: Number of rounds vs Residual Energy with 200 Nodes

Figure 8 shows Residual Energy with 200 Nodes under Homogeneous Network with varied Number of rounds. The residual energy decreases from 100 to almost 98.8 J from 0-100 Rounds. It is maximum for 0 rounds and minimum as the number of rounds increases.

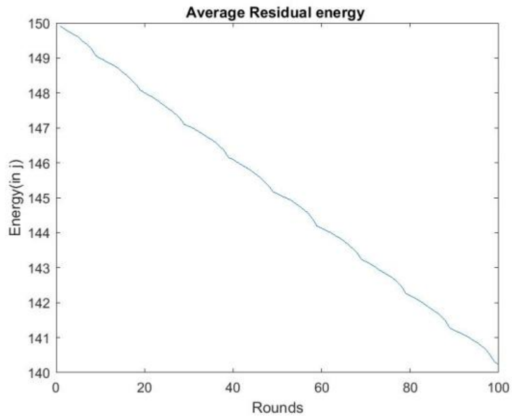

Figure 9: Number of rounds vs Residual Energy with 300 Nodes under Homogeneous Network

Figure 9 shows Residual Energy with 300 Nodes under Homogeneous Network with varied Number of rounds. The residual energy decreases from 150 to almost 141 J from 0-100 Rounds. It is maximum for 0 rounds and minimum as the number of rounds increases.

Figure 10 shows Residual Energy with 400 Nodes under Homogeneous Network with varied Number of rounds. The residual energy decreases from 200 to almost 190 J from 0-100 Rounds. It is maximum for 0 rounds and minimum as the number of rounds increases.

Figure 11 shows Residual Energy with 500 Nodes under Homogeneous Network with varied Number of rounds. The residual energy decreases from 250 to almost 225 J from 0-100 Rounds. It is maximum for 0 rounds and minimum as the number of rounds increases.

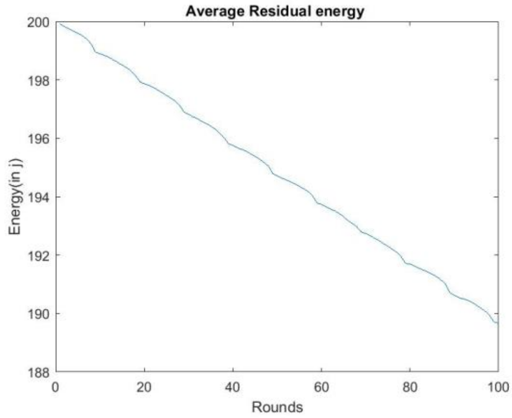

Figure 10: Number of rounds vs Residual Energy with 400 Nodes under Homogeneous Network

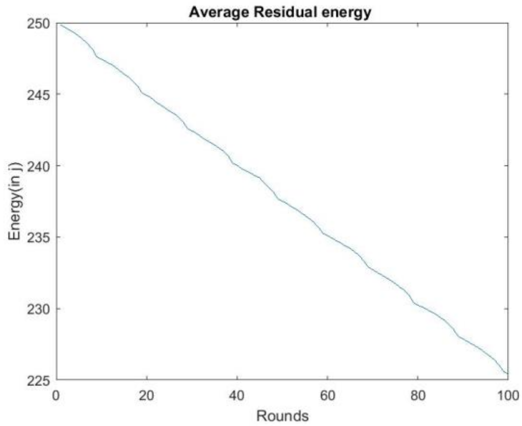

Figure 11: Number of rounds vs Residual Energy with 500 Nodes under Homogeneous Network

Table 3. Comparative Performance Evaluation

Parameters	**Rounds**	**MLEACH [5]**	**PSO [11]**	**Proposed**
First Dead Node	-	1200	2100	3234
Network Longevity	-	7550 rounds	7600 rounds	>8000 rounds
Residual Energy	2000 round	2.24J	1.91J	10J

CONCLUSION

Now-a-days with growing technology such as wireless sensor networks (WSN) are developed with advancement of Internet-of-Things (IoT). While deploying these applications practically, there may arise associated issues. Among all available issues, the major concern is energy utilization while data communication among these resource limited sensors. In this paper we have gien a detail review of various techniques for network imbalancing for IoT with benefits of machine learning to predict the energy wastage. Our future work will consider the trade-offs between coverage, delay and reliability of WSN. In the future, a modified version of the evolutionary algorithm can be used to form balanced clusters in high-speed networks such as vehicular ad hoc networks and flying ad hoc networks, i.e., unmanned aerial vehicles.

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