To Improve the Lifetime of the WSN Nodes Lifetime by Forming the Clustering Heads using Heuristic Algorithm

Dr. A. Sundar Raj and M. Sivaranjani

Abstract

WSNs are an emerging technology that consists of large number of low cost, low power sensor nodes; a sensor node, an electronic device that is capable of detecting environmental conditions. Those sensor nodes can be deployed randomly to perform many applications such as monitoring physical events, for example environmental monitoring, battlefield surveillance, disaster relief, target tracking, etc. and they work together to form a wireless network. During last few years many unequal clustering algorithms have been proposed for Wireless Sensor Networks as an efficient way for balancing the energy consumption and prolonging the lifetime of the networks. In Existing proposal we achieved full throughput by using AODV algorithm. We have slight power loss during data transmission. To overcome that power loss here we are using the heuristic algorithm. a heuristic is a technique designed for solving a problem more quickly when classic methods are too slow, or for finding an approximate solution when classic methods fail to find any exact solution. This is achieved by trading optimality, completeness, accuracy, or precision for speed. In a way, it can be considered a shortcut. A heuristic function, also called simply a heuristic, is a function that ranks alternatives in search algorithms at each branching step based on available information to decide which branch to follow. Cluster head selection and rotation were done based on highest residual energy. The important feature of our proposed unequal clustering technique in transmitting data to the base station was analyzed and emphasized. The proposed unequal clustering technique shows better results when the network's lifetime is compared to the equal clustering. Its concept can be effectively used to design energy efficient routing protocol in WSN. In our approach, the clusters are formed unequally into different sizes to analyze how it could affect the network lifetime of WSN by using heuristic algorithm.

I. Introduction

Rapid advances in Wireless Sensor Networks (WSNs) have enabled densely deployment of nodes. WSNs are an emerging technology that consists of large number of low cost, low power sensor nodes; a sensor node, an electronic device that is capable of detecting environmental conditions. Those sensor nodes can be deployed randomly to perform many applications such as monitoring physical events, for example environmental monitoring, battlefield surveillance, disaster relief, target tracking, etc. and they work together to form a wireless network. A typical node of a WSN is equipped with four components: a sensor that performs the sensing of required events in a specific field, a radio transceiver that performs radio transmission and reception, a microcontroller which is used for data processing and a battery that is a power unit providing energy for operation. The limited energy given to each node, supplied from non- rechargeable batteries, with no form of recharging after deployment is one of the most crucial problems in WSN. Many routing protocols have been proposed for WSNs. Most of the hierarchical algorithms proposed for WSNs concentrate mainly on maximizing the lifetime of the network by trying to minimize the energy consumption. Researchers agreed that clustering of nodes in wireless sensor networks is an effective program of energy conservation. Clustering is defined as the grouping of similar objects or the process of finding a natural association among some specific objects or data. In WSN it is used to minimize the number of nodes that take part in long distance data transmission to a BS, what leads to lowering of total energy consumption of the system. Clustering reduces the amount of transmitted data by grouping similar nodes together and electing one node as a cluster head, where aggregation of data is performed to avoid redundancy and communication load caused by multiple adjacent nodes, then sending the aggregated data to the next cluster head or to the BS, where it is processed, stored and retrieved. Routing is very challenging in WSNs due to the characteristics that distinguish these networks from other wireless networks like mobile adhoc networks or cellular networks. Due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high. Furthermore, sensor nodes that are deployed in an adhoc manner need to be self-organizing as the adhoc deployment of these nodes requires the system to form links and cope with the resultant nodal distributions, especially as the operation of sensor networks is unattended.

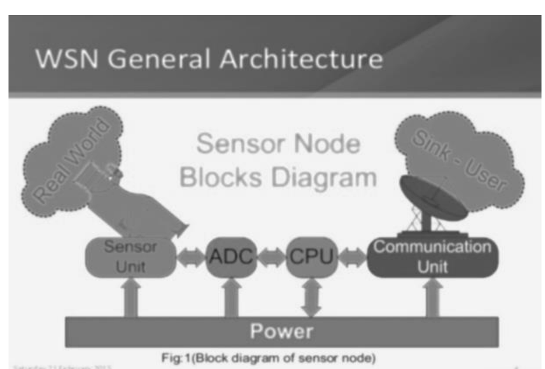

Fig 1: WSN General Architecture

In WSNs, sometimes getting the data is more important than knowing the IDs of which nodes sent the data. In contrast to typical communication networks, almost all applications of sensor networks require the flow of sensed data from multiple sources to a particular BS. This, however, does not prevent the flow of data to be in other forms (e.g., multicast or peer to peer).Sensor nodes are tightly constrained in terms of energy, processing, and storage capacities. Thus, they require careful resource management.

II. Clustering Mechanism:

Clustering is defined as the grouping of similar objects or the process of finding a natural association among some specific objects or data. In WSN it is used to minimize the number of nodes that take part in long distance data transmission to a BS, what leads to lowering of total energy consumption of the system. Clustering reduces the amount of transmitted data by grouping similar nodes together and electing one node as a cluster head, where aggregation of data is performed to avoid redundancy and communication load caused by multiple adjacent nodes, then sending the aggregated data to thenext cluster head or to the BS, where it is processed, stored and retrieved. Routing is very challenging in WSNs due to the characteristics that distinguish these networks from other wireless networks like mobile adhoc networks or cellular networks.

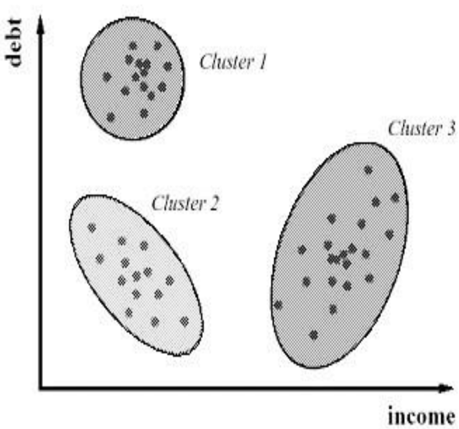

Fig 2: Cluster Heads

In any clustering organization intra- cluster communication as well as inter- cluster communication can be single hop or multi-hop. However, the hot spot and network partitioning arises when using multi-hop routing in inter-cluster communications. Because the cluster heads close to the BS, are burdened with heavy relayed traffic that will make them die faster than other cluster heads, resulting in loss of coverage of sensing. To effectively prolong the life time of network sensors, the network should be designed carefully to be energy efficient. Many of the previous clustering algorithms organize the network into equal size clusters; however, the problems of unbalanced energy consumption exist. We proposed an unequal size clustering algorithm that results in more uniform energy dissipation among cluster heads and prolongs the life time of the whole network.

III. Routing Challenges in WSN

In most application scenarios, nodes in WSNs are generally stationary after deployment except few mobile nodes. Nodes in other traditional wireless networks are free to move, which results in unpredictable and frequent topological changes. However, in some applications, some sensor nodes may be allowed to move and change their location even with very low mobility. Position awareness of sensor nodes is important because data collection is normally based on the location.

1. Deploying Nodes:

Node deployment in WSNs is application-dependent and can be either manual (deterministic) or randomized. In case of deterministic, the sensors are manually placed and data is routed through predetermined paths. However, in random node deployment, the sensor nodes are scattered randomly, creating an adhoc routing infrastructure. If the resultant distribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy-efficient network operation. Inter sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

2. Energy consumption:

In a wireless environment, sensor nodes can use their limited supply of energy performing computations and transmitting information. As such, energy-conserving forms of communication and computation are essential. Lifetime of sensor node shows a strong dependence on battery lifetime. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes, and might require re-routing of packets and re-organization of the network.

3. Link heterogeneity:

The existence of a heterogeneous set of sensors raises many technical issues related to data routing. For example, some applications might require a diverse mixture of sensors for monitoring temperature, pressure, and humidity of the surrounding environment, detecting motion via acoustic signatures, and capturing images or video tracking of moving objects. Either these special sensors can be deployed independently or the different functionalities can be included in the same sensor nodes.

4. Connectivity:

Sensor nodes are expected to be highly connected so as to avoid isolation from each other. This may not prevent the network topology from being variable and the network size from shrinking due to sensor node failures. In addition, connectivity completely depends on the random distribution of nodes.

5. Quality of service:

Data should be delivered within a certain period of time from the moment it is sensed, or it will be useless. Therefore, bounded latency for data delivery is another condition for time- constrained applications. However, in many applications, conservation of energy, which is directly related to network lifetime, is considered relatively more important than the quality of data sent. As energy is depleted, the network may be required to reduce the quality of results in order to reduce energy dissipation in the nodes and hence lengthen the total network lifetime. Hence, energy-aware routing protocols are required to capture this requirement.

IV. Routing Protocols

Different routing protocols are designed to fulfill the shortcomings of the resource constraint nature of the WSNs. The deployed WSN can be differentiated according to the network structure. Therefore, routing protocols for WSN needs to be categorized according to the nature of WSN operation and its network architecture. WSN routing protocols can be subdivided into two broad categories, network architecture based routing protocols and operation based routing.

V. Route Selection Base Classification of Routing Protocols

The routing protocols can be classified on the method used to acquire and maintain the information, and also on the basis of path. This classification is based on how the source node finds a route to the destination node.

1. Proactive Protocols:

Proactive routing protocols are also known as table driven protocols which maintains consistent and accurate routing tables of all network nodes using periodic dissemination of routing information. Most of these routing protocols can be used both in flat and hierarchal structured networks. The advantage of flat proactive routing is its ability to compute optimal path which requires overhead for this computation which is not acceptable in many environments. While to meet the routing demands for larger ad hoc networks, hierarchal proactive routing is the better solution.

2. Reactive Protocols:

Reactive routing protocols do not maintains the global information of all the nodes in a network rather the route establishment between source and destination is based on its dynamic search according to demand. In order to discover route from source to destination, a route discovery query and the reverse path is used for the query replies. Hence, in reactive routing strategies, route selection is on demand using route querying before route establishment. These strategies are different by two ways: by re-establishing and re-computing the path in case of failure occurrence and by reducing communication overhead caused by flooding on networks.

3. Hybrid Protocols:

These protocols are applied to large networks. Hybrid routing contain both proactive and reactive routing strategies. It uses clustering technique which makes the network stable and scalable. The network cloud is divided into many clusters and these clusters are maintained dynamically if a node is getting added or leaving a particular cluster. This strategy uses proactive technique when routing is needed within clusters and reactive technique when routing is needed across the clusters. Hybrid routing exhibit network overhead required maintaining clusters.

VI. Architecture Based Routing Protocols

Protocols are divided according to the structure of network which is very important for the required operation.

1. Flat-Based Routing:

Flat-based routing is needed where every node plays same role, huge amount of sensor nodes are required. Since the number of sensor nodes is very large therefore it is not possible to assign a particular Id to each and every node. This leads to data-centric routing approach in which Base station sends query to a group of particular nodes in a region and waits for response.

- Energy Aware Routing (EAR)
- Directed Diffusion (DD)

- Sequential Assignment Routing (SAR)
- Minimum Cost Forwarding Algorithm (MCFA)
- Sensor Protocols for Information via Negotiation (SPIN)
- Active Query forwarding In sensor network (ACQUIRE)

2. Hierarchy-Based Routing:

When network scalability and efficient communication is needed, hierarchical-based routing is the best match. It is also called cluster based routing. Hierarchical-based routing is energy efficient method in which high energy nodes are randomly selected for processing and sending data while low energy nodes are used for sensing and sending information to the cluster heads(CH). This property of hierarchical-based routing contributes to the network scalability, network lifetime and minimum energy.

- Hierarchical Power-Active Routing (HPAR)
- Threshold sensitive energy efficient sensor network protocol (TEEN)
- Power efficient gathering in sensor information systems
- Minimum energy communication network (MECN)
- Low Energy Adaptive Clustering Hierarchy(LEACH)

3. Location-Based Routing:

In this kind of network, sensor nodes are scattered randomly in an area of interest and mostly geographic position is known where they are deployed. They are located mostly by means of GPS. The distance between nodes is estimated by the signal strength received from those nodes and coordinates are calculated by exchanging information between neighboring nodes.

- Sequential assignment routing (SAR)
- Ad-hoc positioning system (APS)
- Greedy other adaptive face routing (GOAFR)
- Geographic and energy aware routing (GEAR)
- Geographic distance routing (GEDIR)

VII. LEACH Protocol

Low Energy Adaptive Clustering Hierarchy (LEACH) is a TDMA based MAC protocol which is integrated with clustering and a simple routing protocol used in WSNs. The aim of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network. It is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station(sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. It is assumed in LEACH that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for N rounds, where N is the desired percentage of cluster heads. Thereafter, each node has a probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data. All those nodes which are not cluster heads only communicate with the cluster head.

VIII. LEACH Properties

1. Cluster based
2. Random cluster head selection each round with rotation
3. Cluster membership adaptive
4. Data aggregation at cluster head
5. Cluster head communicate directly with sink or user
6. Communication done with cluster head via TDMA
7. CDMA across clusters

In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or cluster head. If the cluster heads were chosen a priori and fixed throughout the system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. Thus LEACH includes randomized rotation of the high energy cluster head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. Sensors elect themselves to be local cluster heads at any given time with a certain probability. These cluster head nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to belong by choosing the cluster head that requires the minimum communication energy. Each cluster head creates a schedule for the nodes in its cluster. The radio components of each non- cluster-head node to be turned off at all times except during its transmit time, thus minimizing the energy dissipated in the individual sensors. Once the cluster head has all the data from the nodes in its cluster, the cluster head node combines the data and then transmits the compressed data to the base station. If the base station is far away in the scenario, there is a high energy transmission. However, since there are only a few cluster heads, this only affects a small number of nodes. The operation of LEACH is broken up into rounds, where each round begins with a setup phase, when the clusters are organized, followed by a steady-state phase, when data transfers to the base station occur. In order to minimize overhead, the steady-state phase is long compared to the set-up phase.

IX. Clustering Attributes

1. Clustering properties:

Often clustering schemes strive to achieve some characteristics for the generated clusters. Such characteristics can be related to the internal structure of the cluster or how it relates to others. The relevant properties are:

- Cluster counts
- Stability
- Inter CH connectivity
- Intra Cluster topology

2. Cluster-head capabilities:

The following attributes of the CH node are differentiating factors among clustering schemes:

- Type of nodes
- Mobility
- Role of CH

3. Clustering process:

The coordination of the entire clustering process and the characteristics of the algorithms vary significantly among published clustering schemes. The deemed relevant attributes are:

- Node grouping
- Cluster head selection
- Methodology
- Algorithm

X. Energy balancing

After the random deployment of nodes, each of M clusters can have (n1 ,n2 ,n3 , …) numbers of nodes. Since the sensor nodes are deployed with a uniform distribution, then the network density

ρ is: m = n/s

where N is the total number of nodes, S is the surface of deployment. According to our proposal, different clusters contain different number of nodes which can be defined as a product of the network density and the cluster surface:

ni = m.si

where ni is number of nodes in i-th cluster of si surface.

XI. Multi-hop data transmission

All cluster nodes send the data gathered from sensing field to the CH. CH receives data from its cluster members, aggregates them then sends them to the CH closer to the BS or directly to the BS. Intra-cluster communication assumes single hop data transmission, while the inter-cluster communication implements multi-hop data transmission to avoid long distance data transmission that causes excessive energy depletion and CH's premature death. According to the radio hardware energy dissipation simple model, the total energy for forwarding k bits of data is the sum of energy spent by each of ( ) cluster members to transmit k bits to the CH and energy spent by CH to receive these data and then to transmit it to the next CH or to the BS. The total energy consumed by the network in one round consists of three components: inner transmission energy used within each cluster, utter transmission energy applied for sending data between clusters and then the receive energy necessary for receiving data. For this clustering mechanism, the problem is formulated as energy minimization using Linear Optimization Programming techniques. Based on the geometric structure of the network; numbers of nodes, average distances between cluster members and CHs di and distances between contiguous CHs Di can all be expressed as functions of clusters' radiuses (R1, R2 ,… Ri and Rmax).

The network has the following general characteristics: 1. All nodes are homogeneous and they have the same capabilities. 2. All nodes have the same initial energy (n). 3. The BS is placed at (0, 0); the origin of the area of deployment. 4. Nodes positions are defined by radius and angle. 5. Nodes are immobile after deployment. 6. A normal node transmits its data directly to its respective cluster head within a particular cluster. 7. Cluster heads use the multi-hop routing scheme to send their data to the next cluster head and then to the BS. 8. Nodes are uniformly randomly distributed.

XII. AODV Algorithm

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad hoc networks. AODV reduces the network wide broadcasts to the extent possible. AODV reduces the network wide broadcasts to the extent possible. Significant reduction in control overhead as compared to DSDV. The Ad hoc On-Demand Distance Vector protocol is both an on- demand and a table-driven protocol. The packet size in AODV is uniform unlike DSR. Unlike DSDV, there is no need for system-wide broadcasts due to local changes. AODV supports multicasting and unicasting within a uniform framework. Each route has a lifetime after which the route expires if it is not used. A route is maintained only when it is used and hence old and expired routes are never used. Unlike DSR, AODV maintains only one route between a source-destination pair. Each AODV router is essentially a state machine that processes incoming requests from the SWANS network entity. When the network entity needs to send a message to another node, it calls upon AODV to determine the next-hop. Whenever an AODV router receives a request to send a message, it checks its routing table to see if a route exists. Each routing table entry consists of the following fields:

- Destination address
- Next hop address
- Destination sequence number
- Hop count

If a route exists, the router simply forwards the message to the next hop. Otherwise, it saves the message in a message queue, and then it initiates a route request to determine a route. The following flow chart illustrates this process:

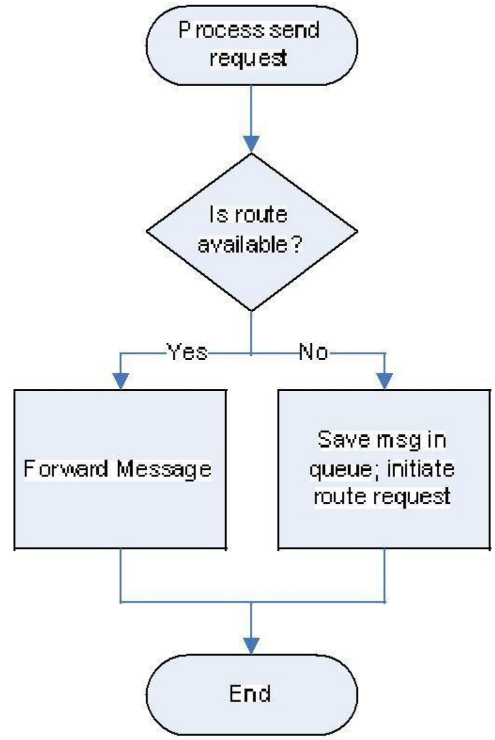

Fig 3: AODV routing

Upon receipt of the routing information, it updates its routing table and sends the queued message (s). AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance.

XIII. Heuristic Algorithm

It is difficult to imagine the variety of existing computational tasks and the number of algorithms developed to solve them. Algorithms that either give nearly the right answer or provide a solution not for all instances of the problem are called heuristic algorithms. This group includes a plentiful spectrum of methods based on traditional techniques as well as specific ones. For the beginning we sum up the main principles of traditional search algorithms. The simplest of search algorithms is exhaustive search that tries all possible solutions from a predetermined set and subsequently picks the best one. Local search is a version of exhaustive search that only focuses on a limited area of the search space. Local search can be organized in different ways.

1. Popular hill-climbing techniques

belong to this class. Such algorithms consistently replace the current solution with the best of its neighbors if it is better than the current. For example, heuristics for the problem of intragroup replication for multimedia distribution service based on Peer-to-Peer network is based on hill-climbing strategy. Divide and conquer algorithms try to split a problem into smaller problems that are easier to solve. Solutions of the small problems must be combinable to a solution for the original one. This technique is effective but its use is limited because there is no a great number of problems that can be easily partitioned and combined in a such way.

2. Branch-and-bound technique is a critical enumeration of the search space. It enumerates, but constantly tries to rule out parts of the search space that cannot contain the best solution.

3. Dynamic programming is an exhaustive search that avoids re- computation by storing the solutions of sub problems. The key point for using this technique is formulating the solution process as a recursion.

A popular method to construct successively space of solutions is greedy technique, that is based on the evident principle of taking the (local) best choice at each stage of the algorithm in order to find the global optimum of some objective function. Usually heuristic algorithms are used for problems that cannot be easily solved. Classes of time complexity are defined to distinguish problems according to their "hardness". Class P consists of all those problems that can be solved on a deterministic Turing machine in polynomial time from the size of the in-put. Turing machines are an abstraction that is used to formalize the notion of algorithm and computational complexity. A comprehensive description of them can be found in. Class NP consists of all those problems whose solution can be found in polynomial time on a non- deterministic Turing machine. Since such a machine does not exist, practically it means that an exponential algorithm can be written for an NP- problem, nothing is asserted whether a polynomial algorithm exists or not. A subclass of NP, class NP-complete includes problems such that a polynomial algorithm for one of them could be transformed to polynomial algorithms for solving all other NP problems. Finally, the class NP-hard can be understood as the class of problems that are NP-complete or harder. NP-hard problems have the same trait as NP- complete problems but they do not necessary belong to class NP, that is class NP-hard includes also problems for which no algorithms at all can be provided. In order to justify application of some heuristic algorithm we prove that the problem belongs to the classes NP-complete or NP-hard. Most likely there are no polynomial algorithms to solve such problems, therefore, for sufficiently great inputs heuristics are developed.,

Branch-and-bound technique and dynamic programming are quite effective but their time-complexity often is too high and unacceptable for NP complete tasks. Hill-climbing algorithm is effective, but it has a significant drawback called pre-mature convergence. Since it is "greedy", it always finds the nearest local optima of low quality. The goal of modern heuristics is to overcome this disadvantage.

Simulated annealing algorithm invented in 1983, uses an approach similar to hill-climbing, but occasionally accepts solutions that are worse than the current. The probability of such acceptance is decreasing with time.

Swarm intelligence was introduced in 1989. It is an artificial intelligence technique, based on the study of collective behavior in decentralized, self-organized, systems. Two of the most successful types of this approach are Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO). In ACO artificial ants build solutions by moving on the problem graph and changing it in such a way that future ants can build better solutions. PSO deals with problems in which a best solution can be represented as a point or surface in an n- dimensional space. The main advantage of swarm intelligence techniques is that they are impressively resistant to the local optima problem.

Evolutionary Algorithms succeed in tackling premature convergence by considering a number of solutions simultaneously. Later we discuss this group of algorithms more elaborately.

Neural Networks are inspired by biological neuron systems. They consist of units, called neurons, and interconnections between them. After special training on some given data set Neural Networks can make predictions for cases that are not in the training set.

In practice Neural Networks do not always work well because they suffer greatly from problems of under fitting and over fitting. These problems correlate with the accuracy of prediction. If a network is not complex enough it may simplify the laws which the data obey. From the other point of view, if a network is too complex it can take into account the noise that usually assists at the training data set while inferring the laws. The quality of prediction after training is deteriorated in both cases. The problem of premature convergence is also critical for Neural Networks.

Support Vector Machines (SVMs) extend the ideas of Neural Networks. They successfully overcome premature convergence since convex objective function is used, therefore, only one optimum exists. Classical divide and conquer technique gives elegant solution for separable problems. In connection with SVMs, that provide effective classification, it becomes an extremely powerful instrument. Later we discuss SVM classification trees, which applications currently present promising object for research.

Conclusion

We analyzed a new efficient clustering approach for multi-hop routing of WSN, in order to balance energy consumption among CH nodes, in which unequal size clusters are formed based on numerical analysis for Linear Optimization. Our proposed unequal clustering mechanism is compared to an equal clustering where cluster approximately consists of the same number of nodes. Through analysis and simulations, we showed that our unequal size clustering achieves a significant improvement of the lifetime of the network. Our approach applies an unequal cluster formation of sensor nodes. Cluster head selection and rotation were done based on highest residual energy. The important feature of our proposed unequal clustering technique in transmitting data to the base station was analyzed and emphasized. The proposed unequal clustering technique shows better results when the network's lifetime is compared to the equal clustering. After the validations of the results, we investigated the network lifetime of the proposed technique by comparing the time in which the first node dies and time in which all nodes die during the 400 rounds of simulation to that of the equal ra0diuses clustering technique for different simulation parameters such as varying number of clusters, node density, maximum angle and maximum radius with the aim of life time maximization. Analysis shows that energy efficiency of WSNs can be further improved by using the unequal clustering method. Its concept can be effectively used to design energy efficient routing protocol in WSN. In our approach, the clusters are formed unequally into different sizes to analyze how it could affect the network lifetime of WSN using Heuristic algorithm. In this approach we achieved 100% throughput without power loss.

Result and Output:

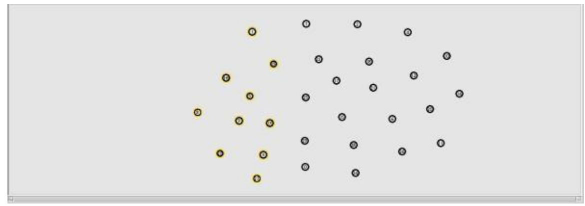

Fig 4: Node definition

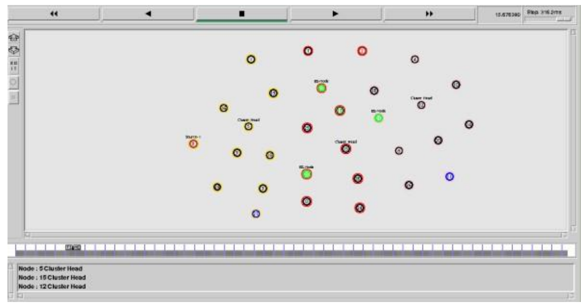

Fig 5 : Node Creation

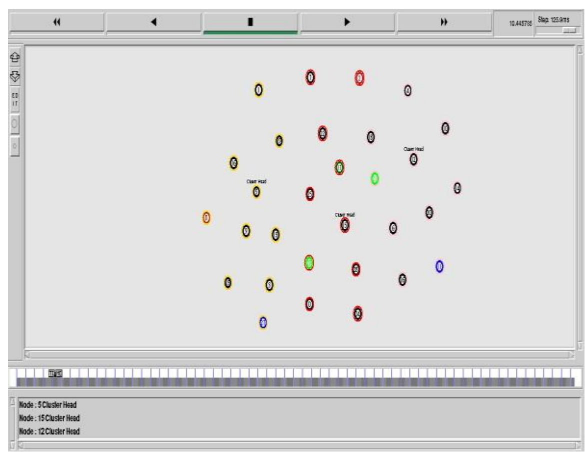

Fig 6: Cluster head formation

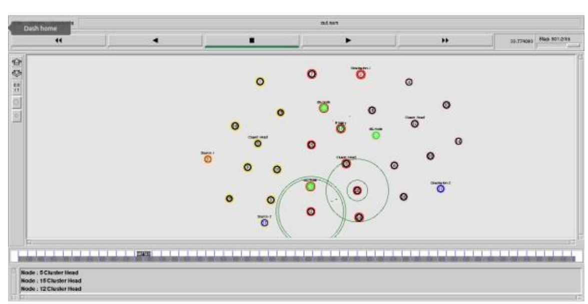

Fig 7: Data transmission

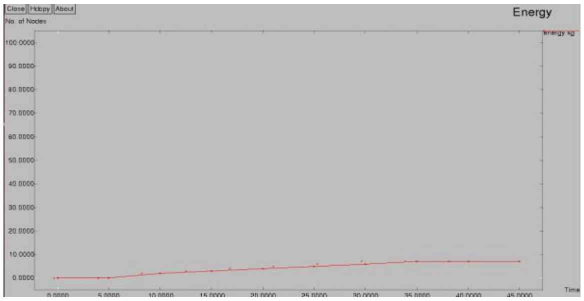

Fig 8: Energy

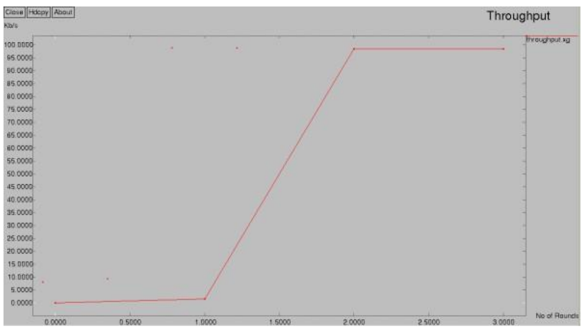

Fig 9 :Throughput

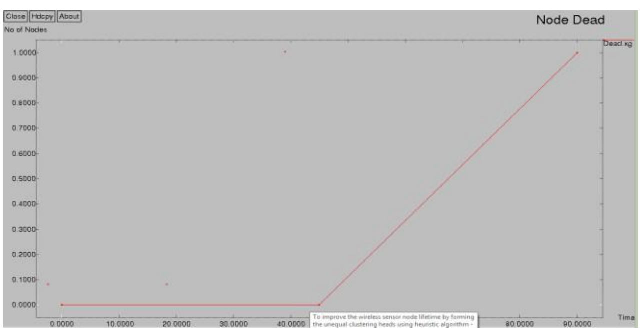

Fig 10: Node Dead

Fig 11:Cluster

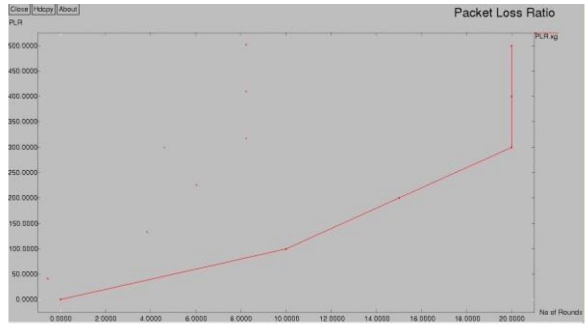

Fig 12: Power Loss Ratio

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