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Research Article

Performance Improvement of WSN by using Zone Clustering Routing Protocol with Multi-gateway

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Abstract

Wireless Sensor Network depends on nodes have limited energy, memory, computational power, range and it is important to increase energy efficiency by saving the battery power so as to extend the life time of the given WSN deployment. In WSN, data is measured by nodes and same is send to Base Station at regular interval. Different protocols are used for energy consumption, in wireless sensor network. In this paper we are trying to improve the life time performance of WSN by using zone-divided and energy-balanced clustering routing protocol with multi-gateway. Zone clustering approach divides the area into several zones according to the distance and uses the clustering method among these zones. The key idea of these protocols is that within a cluster there is a cluster-head‖ which receives the data from remaining nodes and such data is sent to gateways. We also investigate the impact of deploying multiple gateways on the following established energy aware load balancing routing techniques: Zone clustering with random and energy efficient cluster head.

Keywords: *Wireless sensor network, Leach, Zone clustering, energy life time, load balancing*

1. Introduction

A wireless network is a rising new technology that will permit users to access services and information by electronic means, irrespective of their geographic location. Wireless networks can be divided in two kinds: infrastructure network and Infrastructure less (ad hoc) networks. Infrastructure wireless network is a network with fixed and wired gateways. A mobile host interrelates with base station within its communication radius. The mobile device move frequently when it is communicating with other mobile devices. A wireless sensor network (WSN) is a group of sensor nodes that are geographically distributed to provide data gathering and monitoring of tasks and events. Wireless sensor networks are increasing in popularity throughout society.Advances in sensor technology, low-power electronics, and low-power radio frequency (RF) design have enabled the development of small, relatively inexpensive and low-power sensors, called micro sensors (Heinzelman *et al*.2002) The emerging of low power, light weight, small size and wireless enabled sensors has encouraged tremendous growth of wireless sensors for different application in diverse and inaccessible areas, such as military, petroleum and weather monitoring. These inexpensive sensors are equipped with limited battery power and therefore constrained in energy. One of the fundamental problems in wireless sensor network is to maximize network lifetime and time delay in data transmission. Network lifetime is defined as the time when the first node is unable to send its data to base station (Akyildiz *et al*.2002). Data aggregation reduces data traffic and saves energy by combining multiple incoming packets to single packet when sensed data are highly correlated. In a typical data gathering application, each node sends its data to the base station, which can be connected via a wireless network. These constraints require innovative design techniques to use the available bandwidth and energy efficiently. Energy usage is an important issue in the design of WSNs which typically depends on portable energy sources like batteries for power .WSNs is large scale networks of small embedded devices, each with sensing, computation and communication capabilities. They have been widely discussed in recent years Coverage is one of the most important challenges in the area of sensor networks. Since the energy of sensors are limited, it is vital to cover the area with fewer sensors. Generally, coverage in sensor networks is divided into area coverage, point coverage, and boundary coverage subareas. Coverage does not ensure connectivity of nodes. In WSNs the sensor nodes are often grouped into individual disjoint sets called a cluster, clustering is used in WSNs, as it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving

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attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A large number of clusters will congest the area with small size clusters and a very small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members.

The focus of this thesis is the deployment of tactical WSNs. Tactical WSNs are remotely deployed in potentially hostile areas with gateway nodes located on the outskirts of these areas. A key challenge in the deployment of tactical WSNs is the limited battery power of each sensor node. This has a significant impact on the service life of the network. In order to improve the lifespan of the network, load balancing techniques using efficient routing mechanisms to achieve energy efficiency must be employed such that traffic is distributed between sensor nodes and gateway(s). In order to solve the load balancing problem, it is important to first understand the layout of a networking system. Modern day networks abstract all the processes that take place between any two nodes and represent them in the form of layers. The general network layering construct is shown in Figure 1.1 and contains the following five layers labelled one through five, respectively: physical, medium access control (MAC), network, transport, and application layers. Generally, layers of one node only rely on information from the layer immediately above or below it, and the information from Layer i of Node X is only accessed from the same layer i of node Y (logical links). In this thesis, we exploit the opportunity to explore a cross-layer solution for the load balancing problem. A cross-layering method does not restrict a layer from utilizing information only from the layer directly above or below it.Specifically, for load balancing and energy efficiency (Singh *et al.*2012).

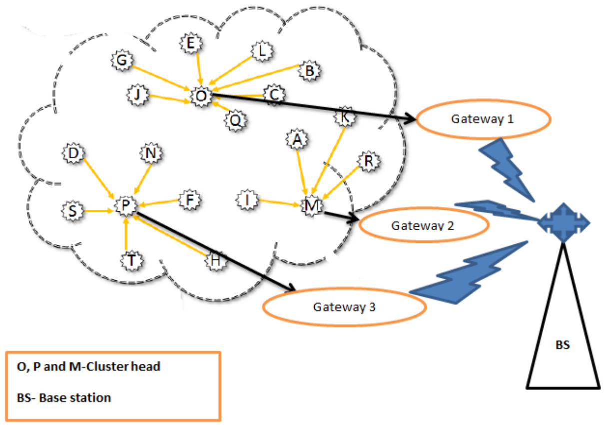


Fig.1 WSN scenario with multi-gateway

This level of balance control allows us to create a network layer protocol with two additional aspects of network layer energy efficiency: 1) creating routing paths that conserve transmission power, and 2) favouring those nodes with higher residual energy to perform high energy consumption tasks. In a second cross-layering implementation, we allow the networking layer to access the application layer to perform data aggregation. Performing data aggregation reduces the size of network data packets, which reduces the energy required to transmit each packet through the network.

The protocols in place at each layer have a dramatic impact on the service life of the network and the coverage area. As node battery levels are depleted, they begin to die out. Thus, various design techniques are needed at each layer to achieve load balancing energy efficiency node across the network.

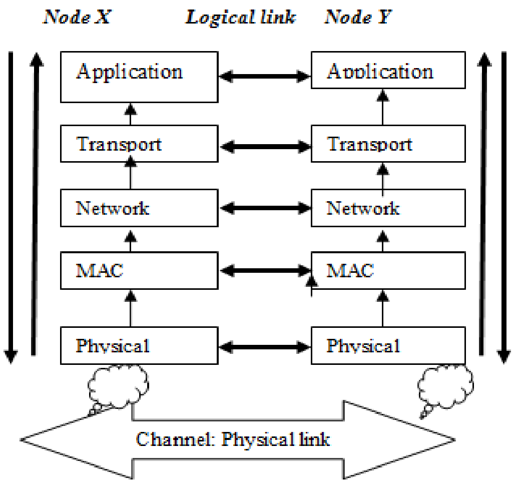


Fig.1.1 WSN Layer reference model

2. Cross-layer approach for load balancing

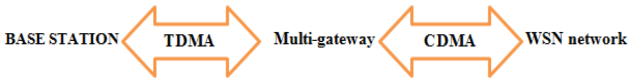
Cross-layer is becoming an important studying area for wireless communications. In addition, the traditional layered approach presents three main problems:

Traditional layered approach cannot share different information among different layers , which leads to each layer not having complete information. The traditional layered approach cannot guarantee the optimization of the entire network. Cross-layer can be used to make the optimal modulation to improve the transmission performance, such as data rate, energy efficiency, QOS (Quality of Service), etc. Sensor nodes can be imagined as small computers which are extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors or MEMS (including specific conditioning circuitry), a communication device (usually radio transceivers or alternatively optical), and a power source usually in the form of a battery.

The base stations are one or more components of the WSN with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables (Mouftah *et al.*2012)

Physical layer: Physical link layer are responsible to providing physical connection between sensor nodes to other side world. For provide physical connection between sensor node and base station we are using multi-gateway.

MAC layer: In data link layer we are using two multiple access technique first is TDMA and second is CDMA. Here TDMA technique is used for information exchange between outside world (base station) to gateway while for securing and avoiding of interference, CDMA access technique used for communication between WSN node and gateway (Heidemann *et al.*2012).



Application layer: In application layer we designed two strategies, 1) use of a traffic generator, and 2) use of a data aggregation technique. The traffic generator of each node generates a 2000 bit data message during each round for transmission to the gateway. Data aggregation is used only for the clustering algorithms and the CH is the only node that can perform data aggregation. The CH receives all the messages from nodes in the cluster. It then includes its own sensor's message, compresses all the messages into one 2000-bit message, and transmits the compressed message to the gateway at the end of each round. data aggregation constant EDA is used to account for the energy to compress messages into one final L=2000 bit message. The data aggregation constant used in our scenarios is consistent with the literature (EDA = 5 nJ/bit) and results in an aggregation cost of EDA × L.

2.1 Routing protocols in WSN

In recent years, many clustering routing protocols are used in wireless sensor network. In our study the main focus is on E-Zone with random and energy efficient CH routing protocols.

LEACH (Low-Energy Adaptive Clustering Hierarchy)

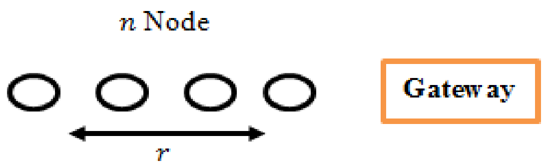
It is hierarchical routing algorithm based on clustering. In each round every node has the probability to get selected as cluster head. It proposes the concept of round for the implementation of periodicity. It involves two phases in every round: cluster set-up phase and steady data transmission phase. In sensor network algorithm is used to divide into clusters. So the communication loads are shared and the energy consumption of every part of the network is balanced but there are some problems in leach protocol like.

1. No guarantee about the placement or number of cluster heads.
2. No secure to delivery of packet'
3. Extra transmission.
4. TDMA access technique.

3. Proposed Method

In our scenario we are trying to improve performance of energy life time of WSN by securing data transmission, avoiding extra transmission and interference data continuity of large information and losses of packet by using Zone clustering routing protocol with multi-gateway.

This concept provides two options at the each layer first of all each node sends their information to the gateway directly, or each node sends their information with MTE by utilizing the nearest neighbour in the optimum path toward the gateway. If we assume the propagation is solely direct-path propagation in which the energy is proportional to d2, there exists an energy balance such that in some cases either direct transmission or MTE routing to the gateway is preferred. Simple network is shown in below Figure , in which n nodes are separated a distance r apart from each other. If direct routing is performed, each node transmits its packet a distance nr to the gateway. If employing MTE routing, each node (except the source node) receives a packet and retransmits the packet to the next node a distance **r** away.



$$E_{DIRECT}= E_{tx}(n,d=nr)=E_{ele}L + \text{€}_{\beta}L(nr)=L(E_{ele}+ \text{€}_{\beta}\, n^2r^2$$

and

$$E_{(MTE)=}nE_{tx}(L,d=r)+(n-1)E_{rx}L=n(E_{ele}L+\text{€}_{\beta}Lr^2)+(n-1)\ E_{ele}L$$

The preferred networking mode is the one that requires less energy. Direct communication with the gateway requires less energy than MTE routing provided.

$$Edirect < EMTE .$$

3.1 Zone clustering with random Cluster head selection

Zone clustering appears less frequently in the literature as compared to LEACH. However, for a tactical network, it may be a preferred networking algorithm because the user can specify how zones are characterized for the network. This yields another aspect of network layer control as compared to LEACH. The general methods that we use for our zone routing algorithm are based on techniques .sensor filed comprised of homogenous zones. A sensor in each zone has a probability p of becoming a CH during each round. The probability p is determined relative to the number of nodes in the zone: p = 1/(number of nodes in zone). Their methodology is useful for a tactical network in that the objective of zoning in a WSN is to ensure that CHs are uniformly selected through the network. Zone clustering algorithm divides the sensor field into z equal zones. Equal zones were chosen because the distribution of nodes is uniform in the field. Equal zones span along the Cartesian x-axis to create z vertical rectangular zones. As shown in Figure 3.1**,** our simulation uses z = five zones. Five zones were chosen to provide a comparison with the LEACH algorithm. Recall that in our LEACH algorithm, the probability of any node being chosen a CH is p=0.05. Thus, in a 100 node network, we would on average to have five CHs. To ensure there are five CHs for our zone clustering algorithm, we must have five zones and each zone is only allowed to have only one CH. The setup phase utilizes the user's inputs for the WSN (or creates the WSN) and partitions the network into the required number of zones. Partitioning the network in zones essentially creates several smaller WSNs that all utilize the same gateway. The zone assigned to any node is described by the node's x-coordinate in the field,

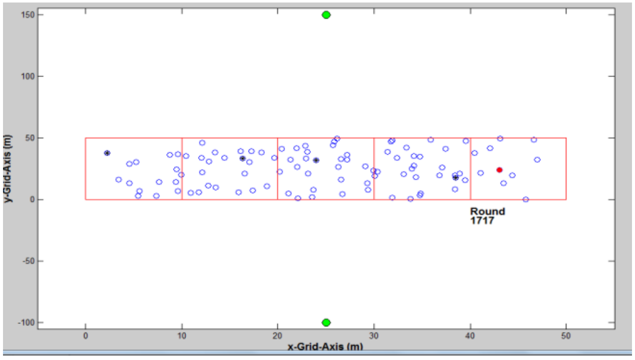


Fig. 3.1 Typical scenario structure with five zone

Once all nodes are assigned to a zone, we begin the simulation at round one and complete the simulation at the maximum desired round. In each round, the set of live nodes for each zone is identified, and the CH is chosen based on a random assignment from this set. Each node in the zone then transmits its L-bit packet to the zone's CH and its energy is decremented according to our radio energy model. The CH for the zone then aggregates all the messages from the nodes in the zone and transmits the aggregated message to the gateway. The process is repeated for each zone at each round in zone CH chooses the optimal gateway to which the aggregated data is sent. In our simulations, the optimal gateway corresponds to the closest gateway to the CH, which minimizes the energy required for the transmission. For ease of simulation, our MAC based approach uses rounds where each node sends a packet to the gateway sometime within each round. All the packets must be received by the CH in each round, at which point the CH aggregates all L-bit packets into one collective L-bit packet and transmits the aggregated packet to the gateway at a later point in the round. We assume the MAC process is similar to that described for LEACH, in which CHs are assigned a TDMA timeslot for transmission to the gateway and CHs are assigned code-division multiple access (CDMA) schemes for intra-cluster communications to prevent interference with other zones.

3.2 Zone Clustering with energy efficient Cluster Head selection

The zone clustering case chooses the CH for each zone Randomly if the highest energy node is chosen to be the CH, individual node energy depletion rates are minimized with the battery levels in any zone depleting at a uniform rate.in this scenario we electing the highest energy node to be the CH during each round in each zone requires additional processing by the gateway to perform CH election. Our simulations perform this aspect automatically with the assumption that it is normally performed by the gateway. One possible implementation of this strategy in practice is that the aggregated packet sent to the gateway includes updated node energies for each node in the zone in the packet header. The gateway, being unconstrained by energy, can then estimate the amount of energy consumed by the CH to transmit the aggregated packet. The gateway can then decide which node in each zone should be assigned the CH for the next round and broadcast this information back to the WSN. In our case, since each node is within communication range of the gateway, every node in every zone will know who its CH is for the next round.

4. Simulation model and result discussion

In this paper, MATLAB simulator tool is used to improve the life time performance of WSN by using zone-divided and energy-balanced clustering routing protocol with multi-gateway.

A simulation using this analysis with a n=100 node network in which the network dimension was increased from 10 m × 10 m to 100 m × 100 m, each node had a starting energy of 0.5 J, L = 2000 bits, Eelec was increased from 10 to 100 nJ/bit, ε fs held constant and the gateway was placed at (x=0, y=−100 m) .From these parameters, we demonstrates that the most energy efficient algorithm to use depends on the network topology and the radio parameters of the system. A simulation was performed on one 100 node network arrangement with sensors uniformly distributed in a 50 m × 50 m grid with similar gateway placement (x=0, y = − 100 m) and constant amplifier parameters. Here in WSN simulations we assume that every node is within communication range of the gateway.

Table.1 Simulation parameter

Energy model	Zone clustering with random cluster head election, zone clustering with energy efficient cluster head elections
Radio type	802.11n
Traffic model	CBR and Data aggregators
Energy Data aggregation(EDA)	5n/j
Packet size (bits)	2000bits
Multiple access technique	TDMA AND CDMA
Physical link	Multi-gateway
Initial node energy (Joules, J)	0.5
Energy to Transmit(ET_X) (nJ/bit)	50
Energy to Receive(ER_X) (nJ/bit)	50
Free space propagation (pJ/bit/m2)	10 to 100
Probability of being a CH (LEACH)	.05
No of nodes	100
Number of Zones (Zone clustering)	5

4.1 Zone Clustering random Cluster Head election with multi-gateway

Zone clustering with random CH election splits the field into five zones, randomly elects a CH in each zone to receive all L = 2000 bit packets from supported nodes and then aggregates the packet into a 2000 bit packet for transmission to the gateway. The first node dead, 10 percent, 50 percent, and 80 percent nodes dead subplots are provided in Figure 4, 5, 6 and 7 respectively, for the multi-gateway case.

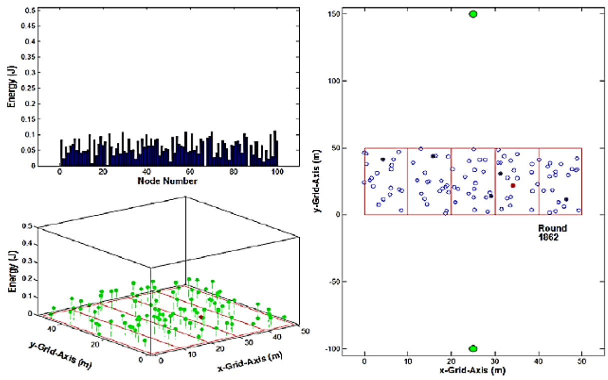


Fig.4. First node dead in Zone clustering random CH election routing with multi-gateway

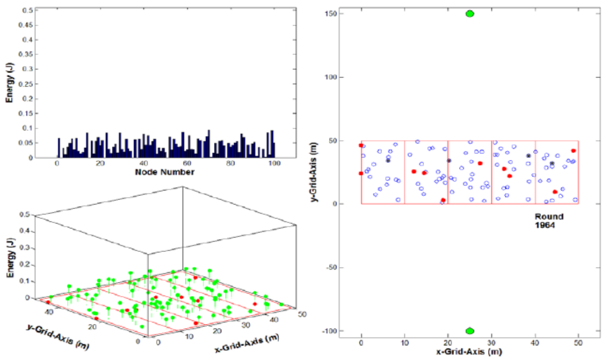


Fig.5 10 % node dead in Zone clustering random CH election routing with multi-gateway

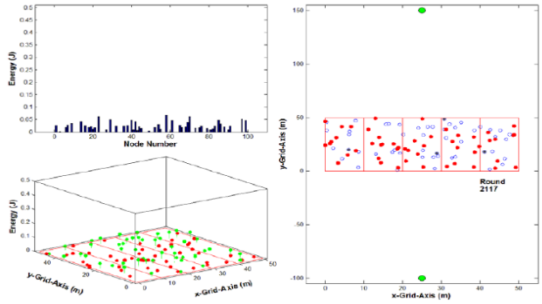


Fig.6 50 % node dead in Zone clustering algorithm with random CH election routing in a multigateway

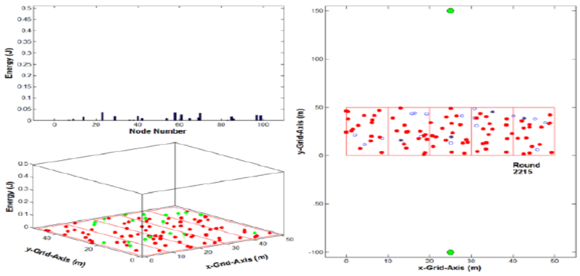


Fig.7 80 % node dead in Zone clustering random CH election routing with multi-gateway

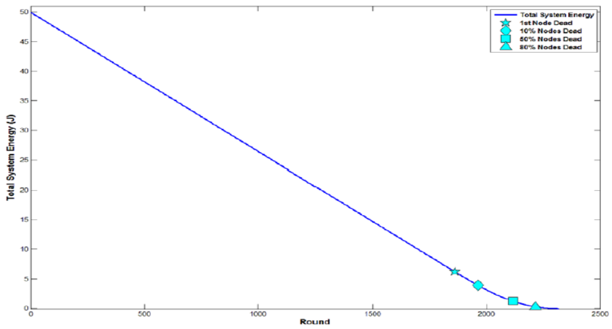


Fig.8 Total WSN energy versus transmission round using Zone clustering random CH with multi-gateway

The total system energy, energy variance, and number of nodes versus transmission round are shown in Figure 8 and 9, respectively. First node dead, 10 percent, 50 percent, and 80 percent nodes dead occur at round 1862, 1964, 2117, and 2215, respectively.

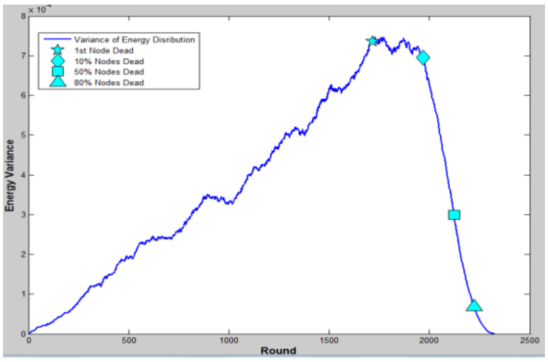


Fig.9 WSN energy variance versus transmission round using Zone clustering random CH election with multi-gateway

4.2 Zone clustering energy efficient cluster head elections with multi-gateway

E-Zone cluster routing algorithm for a multi-gateway scenario splits the field into five zones, elects a CH in each zone to receive all L = 2000 bit packets from supported nodes according to the node that contains the highest energy, and then aggregates the packet into a 2000 bit packet for transmission to the closest gateway.

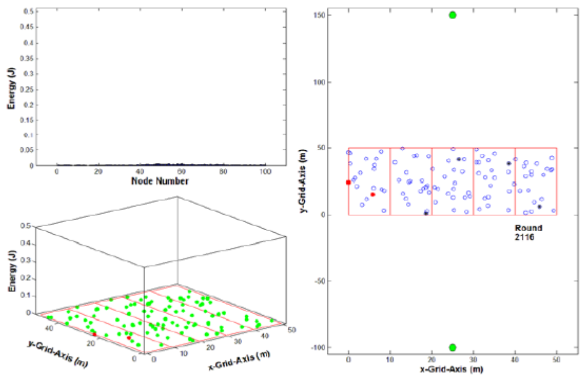


Fig.10 Multi-gateway E-Zone cluster routing algorithm. first node dead die out topology versus transmission round and energy distributions

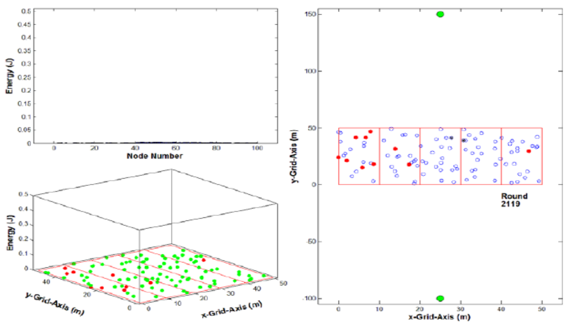


Fig.11 Multi-gateway E-Zone cluster routing algorithm.10 percent node dead die out topology versus transmission round and energy distribution

The first node dead, 10 percent, 50 percent, and 80 percent nodes dead subplots are provided in Figure 10,11,12,and 13 respectively, for the multi-gateway case. The total system energy, energy variance, and number of nodes versus transmission round are shown in Figure 14 and 15 respectively. The first node dead, 10 percent, 50 percent, and 80 percent nodes dead occur at round 2116, 2119, 2126, and 2134, respectively.

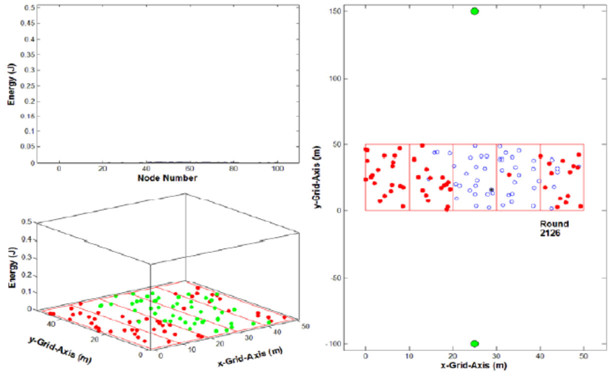


Fig.12 Multi-gateway E-Zone cluster routing algorithm. The 50 percent nodes dead die out topology versus transmission round and energy distributions is illustrated

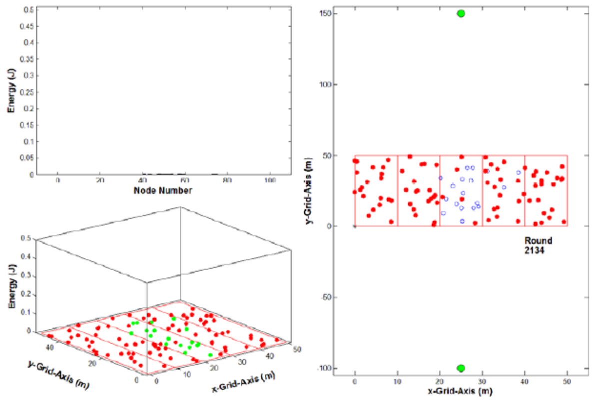


Fig.13 Multi-gateway E-Zone cluster routing algorithm. The 80 percent nodes dead die out topology versus transmission round and energy distributions

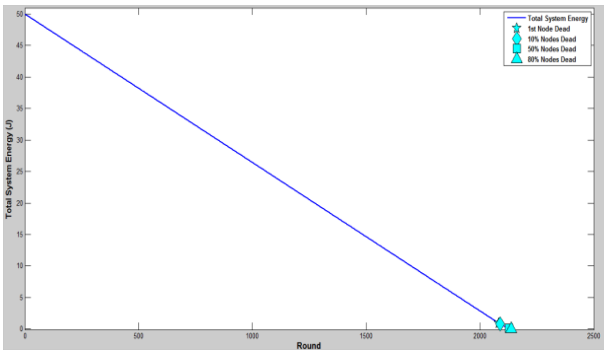


Fig.14 E-Zone cluster routing algorithm in a multi-gateway WSN. Total WSN energy versus transmission round

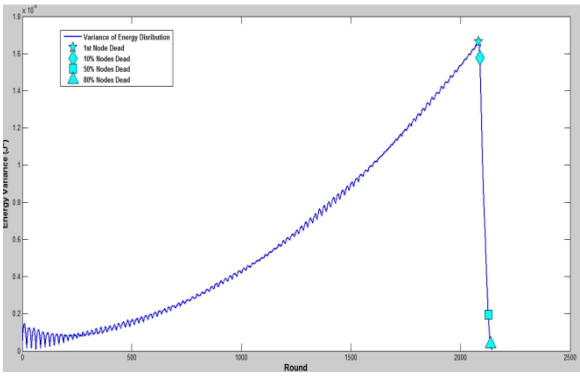


Fig.15 E-Zone cluster routing algorithm in a multi-gateway WSN. The WSN energy variance versus transmission round is illustrated.

Conclusion

- After observing the result it is concluded that zone clustering with energy efficient CH election algorithm (E-Zone) offers the best opportunity to extend WSN service life while maintaining tactical control of the network layer in multi-gateway configurations.
- It produced the least variance in energy distribution at any round and smartly balanced cluster and node loading
- In this paper zones were implemented based on knowledge of physical layer topology and anticipated application layer loading.
- This algorithm also demonstrated the advantages of a cross-layer approach by allowing the network layer to make routing decisions based on node battery levels contained at the physical layer.

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