ENERGY EFFICIENT CLUSTERING & STRADDLING TREE BASED DATA AGGREGATION IN WIRELESS SENSOR NETWORK

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Abstract- ***Wireless sensor networks (WSNs) are mainly used for systematic gathering of useful information and for the transmission of the gathered data to the Clustering for further processing. Despite the innumerable applications of WSNs, the sensor nodes of these networks have limited energy, limited computing power and limited bandwidth, in which energy is major constraint. Clustering has been widely used in WSNs to reduce energy consumption, which decrease the Communication load, and thereby prolong the network lifetime by minimizing the redundant information using the data aggregation model on the cluster heads. Proposed scheme yields better and balanced energy savings while maintaining an equivalent sensing coverage and connectivity. ewe propose E-Span, which is an energy-aware spanning tree algorithm. E-Span is a distributed protocol and facilitates the sources within an event region to perform data aggregation. In E-span, the source node which has the highest residual energy is chosen as the root. Exploiting spatial correlation of nodes to form clusters of nodes sensing similar values, and only cluster head sensor reading is transmit to sink, such can efficiently alleviates the funneling effects. A energy efficient clustering algorithm is proposed which can greatly reduce the number of cluster heads. The Cluster head receives data from the node at its assigned time slot, aggregates and/or sends it to the base station. Simulation is conducted in using NS-2, by varying the number of malicious nodes and results are analyzed for energy consumption, number of data packets sent and percentage of malicious node detection.***

Key Words: Spanning Tree Algorithm, clustering, Communication load, Data Aggregations.

I. INTRODUCTION

In the recent years, the rapid technological advances in micro electro-mechanical systems, low power and highly integrated digital electronics, small scale energy supplies, tiny microprocessors, and low power radio technologies have created low power, low cost and multifunctional wireless sensor devices, which can observe and react to changes in physical phenomena of their surrounding environments. These sensor devices are equipped with a small battery, a tiny microprocessor, a radio transceiver, and a set of transducers that used to acquire information that reflect the changes in the surrounding environment of the sensor node. The emergence of these low cost and small size wireless sensor devices has motivated intensive research in the last decade addressing the potential of collaboration among sensors in data gathering and processing, which led to the invention of wireless sensor networks(WSNs)[1,2].

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, and report the collected data through wireless interface to a center node (sink node). The areas of applications of WSNs vary from civil, healthcare, and environmental to military. Examples of applications include target tracking in battlefields [3], habitat monitoring [4], civil structure monitoring [5], and forest fire detection [6]. Although WSNs resemble conventional ad hoc networks [7] in many aspects, they have their own specific features as follows.

- Sensors are deployed with a large density in a wider area compared with nodes in traditional adhoc networks.
- Naturally data communication in wireless sensor networks is mainly a multi-point to point paradigm.
- Data samples sensed by sensors are spatiotemporally correlated. This correlation has been approved to have great impacts on protocol design in WSNs.
- Most applications in WSNs usually require information about a specific region. Clearly,

addressing each individual sensor for the available data leads a large amount of overhead which is not desired in sensor networks.

LEACH-C protocol, all sensor nodes communicate their position information and energy level to the base station and provide the necessary information to calculate the average node energy. Sensor nodes with remaining energy less than the calculated average node energy are restricted from becoming the cluster head during the current round. Base station finds the predefined number of cluster heads and divides the network into clusters, so as to minimize the energy required for non-cluster head member to transmit their data to the respective cluster heads. LEACH-C assumes that every node knows its location in priori. Hence, cost is imposed due to nodes as they use a GPS receiver to find their location information. The functioning of the protocol in each round consists of the following four phases:

(i) Advertisement phase: Every node of the network sends its information regarding the current energy level and location to base station. The base station analyzes the details and selects the most suitable cluster heads for that round. After selecting cluster heads, the base station broadcasts this information to every node in the network in the form of a list containing node id of cluster head.
(ii) Cluster setup phase: Each node receives the cluster head list broadcasts by the base station. If the nodes own id is present in the list, then that node becomes cluster head for that particular round.
(iii) Schedule Creation: Every non cluster node identifies its TDMA schedule and its cluster head from the Information broadcast by the base station.
(iv) Data Transmission: The Cluster head receives data from the node at its assigned time slot, aggregates and/or sends it to the base station. After a certain predefined time, the next round begins with the advertisement phase.

In addition sensors in such environments are energy constrained and their batteries cannot be recharged. Therefore, with the specific consideration of the unique properties of sensor networks such limited power, stringent bandwidth, dynamic topology (due to node failures, adding/removing nodes, or even physical mobility), high network density and large scale deployments have posed many challenges in the design and management of sensor networks. These challenges have demanded energy awareness and robust protocol designs at all layers of the networking protocol stack. Since sensor nodes are energy-constrained, the networks Lifetime is a major concern; especially for applications of WSNs in harsh environments. There has been a significant interest in designing algorithms, applications, and network protocols to reduce energy usage of sensors [11]. Generally, energy conservation is dealt with on five different levels

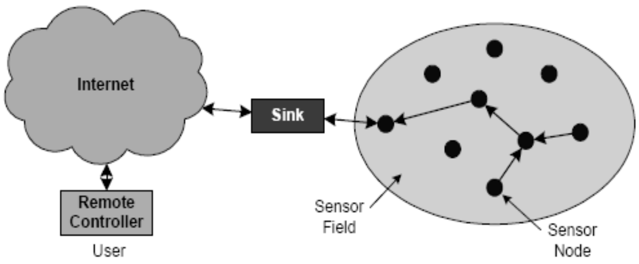


Fig 1.1: Sensor network architecture.

- efficient scheduling of sensor states to alternate between sleep and active modes;
- efficient control of transmission power to ensure an optimal tradeoff between energy consumption and connectivity; data compression (source coding) to reduce the amount of uselessly transmitted data;
- efficient channel access and packet retransmission
- protocols on the Data Link Layer;
- Energy-efficient routing, clustering and data aggregation.

II. Related work

In this section, we provide a brief overview of some related research work,

Grouping sensor nodes into clusters has been widely pursued by the research community in order to achieve the network scalability objective. In addition to supporting network scalability, clustering has numerous advantages. It can localize the route set up within the cluster and thus reduce the size of the routing table stored at the individual node. clustering can also conserve communication bandwidth since it limits the scope of inter-cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes.
Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead. Furthermore, Energy-efficient clustering algorithms for wireless sensor networks have been widely addressed in literature. The main goal of clustering is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink.

Every cluster would have a leader, often referred to as the cluster-head (CH). A CH may be elected by the sensors in a cluster or pre-assigned by the network designer. A CH may also be just one of the sensors or a node that is richer in resources. Cluster formation is typically based on the energy reserve of sensors and sensor's proximity to the CH. For instance, Low-Energy Adaptive Clustering Hierarchy (LEACH), one of the first clustering algorithms proposed for sensor networks, is a distributed, proactive, dynamic algorithm that forms clusters of sensors based on the received signal strength and uses local CHs as routers to the sink. Each node makes its own decision whether to become CH based on how often and the last time it has been CH but also on the optimal percentage of CHs in the network (pre-determined value). Transmissions are operated only by CHs which saves energy. LEACH provides a balance of energy consumption through a random rotation of CHs. However, CHs transmit data directly to the sink, which can be energy-consuming in large-scale sensor networks.

The data sensed by the sensing nodes in a cluster are broadcasted straightly to their cluster head that afterwards aggregates and/or pass the data to another cluster head which will direct it to the base station. Different from the sensor nodes, the base station is not with the restricted resources. Thus the communication from the base station to the sensor nodes can be performed straight forwardly.

III. PREVIOUS IMPLEMENTATIONS

Clustering Process

Low Energy Adaptive Clustering Hierarchy (LEACH) cluster heads are stochastically chosen. For selecting cluster-heads every node n finds a random number between 0 and 1. If the number is below a threshold T(n), the node is decided as a cluster-head for the present round. The threshold is determined as follows

$$T(n) = \frac{P}{1 - P \times \left(r mod \frac{1}{p}\right)} \forall n \in G$$

$$T(N)=0 \quad \forall \quad N€G$$

Where P is the cluster-head probability, r is the number of the present round and G is the set of nodes that is not the cluster heads in the final 1/P rounds. This algorithm guarantees that each node turn out to be a cluster-head accurately once inside 1/P rounds.

Considering the single round of LEACH, it is clear that a stochastic cluster-head choosing will not automatically direct to lesser energy consumption during data transmit for provided nodes. Every cluster-heads can be situated close to the edges of the network or nearby nodes can turn into cluster heads. In this situation several nodes have to link long distances to attain a cluster-head. On the other hand, considering the two or more rounds it could be implicit that choosing appropriate cluster-heads outcome in an adverse cluster-head selection in upcoming rounds because LEACH attempts to dispense energy consumption between every nodes.

The initial technique enhancing the life span of a LEACH network is the addition to the remaining energy level existing in every node. It can be accomplished by decreasing the threshold T (n), comparative to the node's left out energy. Thus, T (n) is multiplied with an aspect representing the remaining energy level of a node:

$$T(n)_{new} = \frac{P}{1 - P\left(r mod \frac{1}{p}\right)} \frac{E_{n\_current}}{E_{n\_max}}$$

Where $E_{n\_current}$ indicates the current energy and E_{n_max} indicates the initial energy of the node.

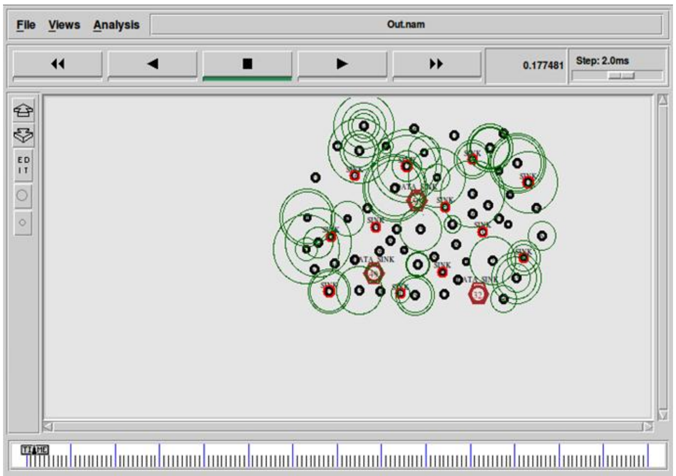
However, an alteration of the threshold equation by the left out energy has an important demerit i.e., after some number of rounds the network is jammed, even though there are some nodes existing with sufficient energy to broadcasting formation to the base station. This is because the cluster-head threshold is very low, since the lasting nodes have a lesser energy level.

$$T(n)_{new} = \frac{P}{1 - P\left(r mod \frac{1}{p}\right)} \left[\frac{E_{n\_current}}{E_{n\_max}}\right.$$

Where *rs* represents the number of successive rounds in that a node has not been cluster-head. When rs attains the value 1/P the threshold T(n) new is changed to the value it had previous to the addition of the left out energy into the threshold equation. Therefore, the possibility of node n to turn into cluster-head boosted since it has a higher threshold. A probable barrier of the network is resolved. In addition, *rs* is reset to 0 after a node turns into cluster head. Therefore, it is guaranteed that data is broadcasted to the base station until the nodes are alive.

For permitting the concurrent transmissions in adjacent clusters and, therefore, decrease inter-cluster interference, every cluster is allocated with a specific spreading code supposed to be orthogonal. When a link is demanded, the base station sets up a QoS-based route Q between the cluster head where the connection is created by its own. The route Q is indicated as a series of pairs of CH nodes: Q = {(0, 1), (1, 2). . . (*i,j*)} Where every pair determines the connection that corresponds to route Q and is the hop length between cluster head 0 and the base station. Every directed connection *(i , j),* where node ( ) is the originating end of the connection, (∈ {0, 1, 2, . . .,}, ∈ {1, 2, . . ., }) is allocated a metric described in terms of its bandwidth, delay and transmission energy.

The transmission energy related with link *(i ,j), (d $_j$),* is the power amplifier energy of node , that is a function of , the distance between cluster head nodes and , and the implicit propagation method. The delay corresponding with connection *(i,j)* is indicated by , the average delay obtained by packets traversing channel head node , and the existing bandwidth corresponding to the link *(i, j),* $_{dj}$, is the least of the existing bandwidths at nodes and . When routing is carried on, a cost metric that contains the linear combination of link *(i, j)*'s transmission energy and delay is created, for all the links *(i,j)* in the network:



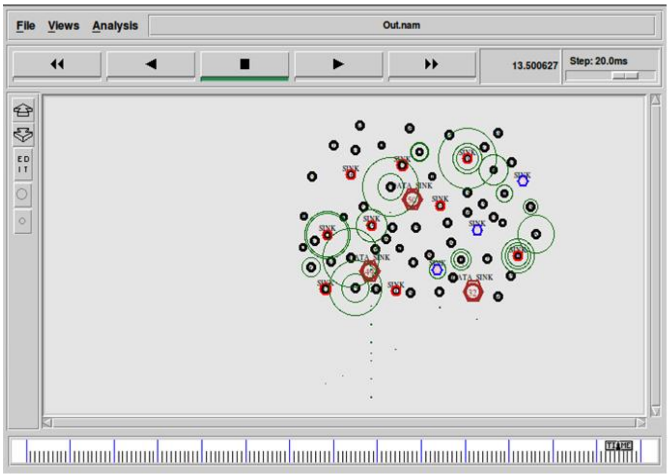
Red- Clustering ; Red & black- Sink; black – No of Node

Fig1.2: Create Node Topology

A Sensor Network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. A Wireless Sensor Network (WSN) is a collection of nodes organized into a cooperative network. Each node consists of processing capability which acts as transceiver. Packet dropping is a compromised node which drops all or some of the packets that is supposed to forward. Packet modification is a compromised node which modifies all or some of the packets that is supposed to forward. Packet dropping and modification are common attacks that can be launched by an adversary to disrupt communication in Wireless Sensor Network

Leach Algorithm

- All senor nodes are identical and charged with the same amount of initial energy. All nodes consume energy at the same rate and are able to know their residual energy and control transmission power and distance. Every node has the capability to support different MAC protocol and data processing. All communication channels are identical. The energy consumption of transferring data from node A to node B is the same as that of transferring the same amount of date from node B to node A.
- Every node can directly communicate with every other node, including the sink node.
- The Sink node is fixed and far away from the wireless network. Thus we can ignore the energy consumed by the sink node. We assume that it always has sufficient energy to operate.
- Every node has data to transfer in every time frame. The data transferred by sobering nodes are related and can be fused.



Red- Clustering; Blue & black- Sink; black – No of Node

Fig1.3 : Sink Communication

IV. SYSTEM IMPLEMETNATION

It proposed the data gathering & aggregation model in sensor network. We also presented an efficient Energy efficient clustering algorithm and Spanning Tree Algorithm to solve the maximum lifetime data aggregation problem. In wireless sensor networks, data aggregation is used to collect local data from neighboring nodes (sources) and generate a data report. it proposed a least spanning tree of cluster heads for sending the aggregated data from cluster heads to sink. Numbers of aggregation levels have increased due to clustering and least spanning tree. Hence the network lifetime has been increased. There are number of important issues related to maximum lifetime data gathering problem that need to be investigated in the future. I proposed a novel energy saving scheme that enhances the basic schemes used in hierarchical sensor networks.

I compared our scheme with two well known sleep scheduling schemes coverage based and linear distance based sleep scheduling schemes. Analytical and simulation results show that our method outperforms other two methods in terms of network residual energy, energy efficiency, network lifetime while maintaining the same degree of network coverage. Experimental results show that the proposed heuristic provides near-optimal network lifetime values within low computation times, which is, in practice, suitable for large-sized sensor networks.

In this paper, we propose E-Span, which is an energyaware spanning tree algorithm. E-Span is a distributed protocol and facilitates the sources within an event region to perform data aggregation. In E-span, the source node which has the highest residual energy is chosen as the root. Other source nodes choose their corresponding parent node among their neighbors based on the information of the residual energy and distance tothe root. By selecting the Directed Diffusion [1] as the underlying routing platform, simulation results show that the lifetime of sources can be extended significantly when E-Span is used A spanning tree is a graph that spans all the nodes as vertices and contains no cycles. The tree is structured in the way that the node with the smallest identifier is chosen as the root. All other nodes are connecting to this selected root via

Each sensor in the network becomes a clusterhead (CH) with probability p and advertises itself as a clusterhead to the sensors within its radio range. We call these clusterheads the volunteer clusterheads. This advertisement is forwarded to all the sensors that are no more than k hops away from the clusterhead.

According a homogeneous spatial Poisson process and hence, the number of sensors in a square area of side $2a$ is a Poisson random variable, N with mean λA , where $A = 4a2$. Let us assume that for a particular realization of the process there are n sensors in this area. Also assume that the Processing center is at the center of the square. The probability of becoming a clusterhead is p ; hence, on average, np sensors will become clusterheads. Let Di be a random variable that denotes the length of the segment from a sensor located at (xi , yi), i = 1,2,..., n to the processing center. Without loss of generality, we assume that the processing center is located at the center of the square area. Then,

***N_i*:** the number of members in a level-i cluster,
L_i *:* the sum of distances between the members of a level-I cluster and their level-i CH,
H_i : the number of hops from a member to its CH in a typical level-i cluster,
CH_i : the total number of level-i CHs,
The Energy and Clustering based on the Location and based on distance information.

$$E[D_i \mid N = n] = \int_A \sqrt{x_i^{\,2} + y_i^{\,2}} \left(\frac{1}{4a^2} \right) dA = 0.765a\,.$$

Since there are on an average np CHs and the location of any CH is independent of the locations of other CHs, the total length of the segments from all these CHs to the processing center is 0.765*npa.*

$$E[C_1 \mid N = n] = \frac{E[L_v \mid N = n]}{r}\,.$$

Define $C2$ to be the total energy spent by all the sensors communicating 1 unit of data to their respective cluster heads. Because, there are np cells, the expected value of $C2$ conditioned on N, is given by

$$E[C2 \mid N = n] = npE[C1 \mid N = n]\,.$$

The sum of distance of level-(i-1) CHs from a level-i CH, i = 2,3,..., h in a typical level-i cluster or the sum of distance of sensors from a level-1 CH is given by

$$E[L_i \mid N = n] = \frac{(1-p_i)\lambda \prod_{j=1}^{i-1} p_j}{2\left(\lambda \prod_{j=1}^{i} p_j\right)^{3/2}}\,.$$

E[C] is minimized by a value of p that is a solution of

$$Cp^{3/2} - p - 1 = 0$$

The above equation has three roots, two of which are imaginary. The second derivative of the above unction ispositive for the only real root of (9) and hence it minimizes th eenergy spent.

Define:

r_n to be the ID of the root selected by node n
d_n to be the shortest-path distance from r_n to node n
$g_n = (_n, r_n, d_n)$ to be the message sent by node n
pn to be the ID of the parent selected by node n
trecv,n to be the time node n received the message from its parent

Initialize: *g_n to (n, n, 0) $\forall$ n $\in$ N*
p_n to n $\forall$ n $\in$ N
$t_{recv,n}$ to 0 $\forall$ n $\in$ N

Get Span (node ID n, time t, timeframe T)

1. *if n is not an event source,*
2. *return*
3. *else {single-hop broadcast gn and start a timer P that expires every T $_{sec}$*
4. *while true,*
5. *if timer P expires and (rn = n or t > $t_{recv,n+T}$),*
6. *set g_n to (n, n, 0)*
7. *set p_n to n*
8. *set $_{trecv,n}$ to t*
9. *single-hop broadcast gn*
10. *if receiving a message gi from node i,*
11. *if r_i < rn, or (ri = rn and di+1 < d_n), or (r_i = $r_{n,\ di+1}$ = d_n, and i _ p_n),*
12. *set gn to (n, r^i, di+1)*
13. *set p_n to i*
14. *set $t_{recv,n}$ to $_t$*
15. *single-hop broadcast gn and restart timer P}*

II. Energy efficient Algorithm for Clustering Head

N_C: The number of cluster heads in one round

N: The total number of nodes in sensor field

1. k=0

2. id=N_{id} mod N_C

3. If (id=k) then

i. N $_{id}$ is a cluster head

ii. Broadcast an advertisement message to all neighboring nodes

iii. Wait for some time to receive reply messages from neighboring nodes

iv. Perform cluster formation

else

a. wait a period of time to receive the advertisement messages from cluster head

b. if (Rec Message =1) then Choose it as a cluster head.

c. Else If (RecMessage>=2) then

Calculate the shortest distance, choose shortest distance node as a cluster head

d. Else

N_{id} is a forced Cluster head

End If

End If

4. after a time interval when a round is completed

k=k+1;

5. If (k=N_C+1) then

k=0

6. Go to step 2.

EndIf

End

Energy Efficient Parameter for the Algorithm

Number of Sensors (n)	Density (d)	Probability (p_{opt})	Maximum Number of Hops (k)
500	5	0.1012	5
1000	10	0.0792	4
1500	15	0.0688	3
2000	20	0.0622	3
2500	25	0.0576	3
3000	30	0.0541	3

Table 1.1: Energy Efficient Parameter

EVALUATION RESULT

In this section, three experiments were designed to evaluate the performance of the improved clustering algorithm. The simulating program was developed by our team using NS2. In the following experiments, Most of studies only consider that wireless sensor networks are equipped with only Omni-directional antennas, which can cause high collisions. It is shown that the per node throughput in such networks is decreased with the increased number of nodes. Thus, the transmission with multiple short - range hops is preferred to reduce the interference. However, other studies show that the transmission delay increases with the increased number of hops. Found that using directional antennas not only can increase the throughput capacity but also can decrease the delay by reducing the number of hops.

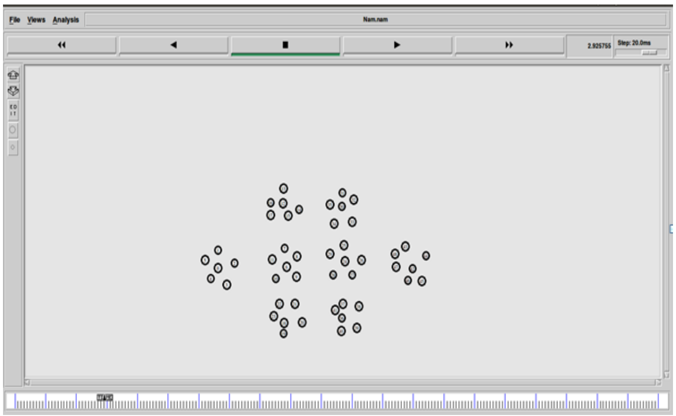
Cygwin is free software that provides a Unix-like environment and software tool set to users of any modern x86 32-bit and 64-bit versions of MS-Windows (XP with SP3/Server 20xx/Vista/7/8) and (using older versions of Cygwin) some obsolete versions (NT/2000/XP without SP3) as well. Cygwin consists of a Unix system call emulation library, cygwin1.dll. With Cygwin installed, users have access to many standard UNIX utilities. They can be used from one of the provided shells such as bash or from the Windows Command Prompt.

Contains both merits and limitations when people use it to simulate WSNs. To the merits, firstly as a non-specific network simulator, NS-2 can support a considerable range of protocols in all layers. For example, the ad-hoc and WSN specific protocols are provided by NS-2. Secondly, the open source model saves the cost of simulation, and online documents allow the users easily to modify and improve the codes. However, this simulator has some limitations. Firstly, people who want to use this simulator need to familiar with writing scripting language and modeling technique; the Tool Command Language is somewhat difficult to understand and write. Secondly, sometimes using NS-2 is more complex and time-consuming than other simulators to model a desired job. Thirdly, NS-2 provides a poor graphical support, no Graphical User Interface (GUI) the users have to directly face to text commands of the electronic devices. Fourthly, due to the continuing changing the code base, the result may not be consistent, or contains bugs.

Parameter used in the Simulation

Parameter	Value
Simulation time	300
Number of nodes	46
Traffic model	CBR
Node Placement	Uniform
Performance parameter	Energy consumption, End to End delay
Routing protocol	AODV
No Coding	TCL
Node ID	1
Signal Strength	70%
Mobility Connection	Clustering Head

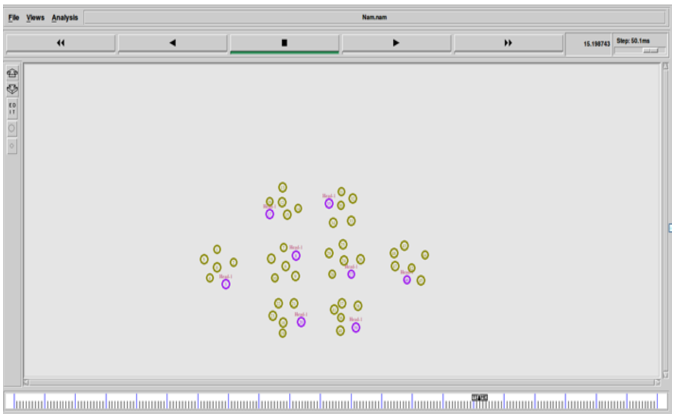
Table 1.2: Simulation Parameters



Red- Clustering; black- cluster Head; black – No of Node; green- Energy

Fig 1.4: Proposed Node

For the experimental results presented in this section, a network of sensors randomly distributed in a 1000m * 1000m field is considered. The number of sensors in the network, i.e. the network size, is kept at 100, 200, 300 and so on. Each sensor has an initial energy of 1.Joule and the base station is located at (250, 330). Each sensor generates packets of size 1000 bits. The energy model for the sensors is based on the first order radio model.



Red- Clustering; Blue - cluster Head; black – No of Node; Green- Energy

Fig 1.5: Clustering Head

The manner in which tree leaders are selected in each level of the hierarchy is examined. Obviously an aggregation tree, for every round of data gathering is defined. For comparison, the MST tree to perform data gathering, with and without aggregation is implemented. In the case of no aggregation, sensors use the similar chain-based hierarchy to transmit their packets to the base station.

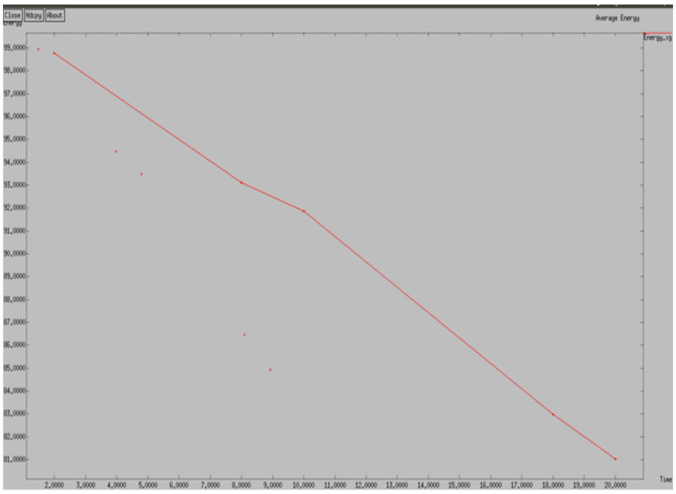


Fig 1.6: Average Energy

To evaluate the performance of the proposed EECH in terms of the delay for accessing the nodes, the network is simulated for various range of mobility. When the mobility of the nodes in the network increases in m/s, the data redundancy has also been removed and the time taken to process the data is decreased.

Conclusion

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. In this paper, A novelty clustering algorithm is proposed which can greatly reduce the number of cluster heads, by exploiting spatial correlation of nodes to form clusters of nodes sensing similar values, and only cluster head sensor reading is transmit to sink, such can efficiently alleviates the funneling effects. Experimental results validate the effectiveness of this approach. In the next research, we will develop a prototype system to further verify the validity of our approach and will give the exact energy consumption.

Future Work:

Wireless Sensor Networks (WSNs) in which each sensor node randomly and alternatively stays in an active mode or a sleep mode. The active mode consists of two phases, called the full-active phase and the semi-active phase. When a referenced sensor node is in the full-active phase of the active mode, it may sense data packets, transmit the sensed packets, receive packets, and relay the received packets. Finally, a packet loss approach will be evaluated.

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