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Effective Sensory Communication using GEAR Protocol

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Abstract: ***Large numbers of sensors are being deployed in unattended regions e.g. in forests, seas and also in remote areas. The motivation behind it is to reduce the human assistance and improve life-time of network. Since these sensor nodes are battery constraint and excessive use of any node causes early depletion in residual energy level of that node in the network and node can die early. So in this paper by using GEAR (Geographical & Energy Aware Routing) Protocol, it is emphasis that commination among the nodes should be energy efficient by an intelligent neighbor selection to forward the packet to the sink. GEAR is recursive data dissemination scheme inside the region.Group Based Deployment Model and applying energy aware routing makes GEAR more effective than the previous. The routing design of GEAR is based on two parameters: location and current and residual energy levels of nodes***.

Keywords:WSN, Routing, Geographical Routing, GEAR.

1. Introduction

The key concern in WSN communication is to reduce the power dissipation while communication takes place in the network. Nodes are deployed in those regions where human assistance is difficult or almost not possible like in flood forest-fire and earthquake like situation. So these nodes are deployed to reduce both human efforts and assistance. But issue start with the battery life of the deployed nodes. Since, nodes are constrained with the battery then there is a need to utilize the nodes properly like wake (working time in a day) and sleep (energy conservation time) and also routing so that all nodes can effectively take part in the communication and make it energy efficient.

In general WSN consists of number of nodes. These node consists of different units those are responsible for the different functions. These units are Figure 1,

- Processing Unit
- Power Unit
- Storage Unit

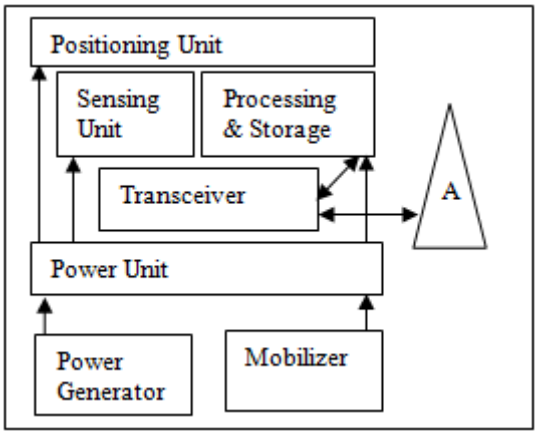


Figure1: Sensing Node

- Sensing Unit
- Positioning Unit
- Transceiver Unit

Standards for Transport Protocols in Wireless Sensor Network

- Physical Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Upper Layer (Communication)

1) **Physical Layer:** It deals with the communication channel, sensing, actuation and signal processing. It provide the physical medium to interact with the environment to compute the defined scenario using the sensing and computing equipment.
2) **Data Link Layer:** It is used to control the contention for sending the data among the nodes. It provides the error and flow control mechanism.
3) **Network Layer:** It provides the topology and routing scheme for nodes to disseminate the packets towards and inside the network.
4) **Transport Layer:** It includes data dissemination and accumulation, caching, and storage.

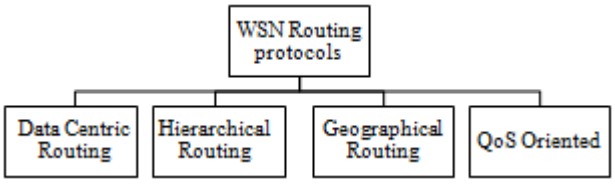


Figure 2: WSN Routing Protocols

Now, we come to the routing scheme in the WSN [1],[2], Figure 2. Here we are mainly focusing on Geographical Routing. There is brief about all three kinds of routing.

i. Data Centric

In this mechanism query is made by the sink node from particular region inside the wireless sensor network. Since data is requested through the quires hence it is required to provide attribute based naming to specify the properties of data. In this, Data are transmitted from every WN with in the region; this gives rise, however, to significant redundancy along with inefficiencies in terms of energy consumption e.g. SPIN, GBR [1].

ii. Hierarchical Routing
In this a chain is formed, including nodes at different tiers transmit the information towards the sink. Like in PEGASIS [3] (Power-efficient gathering in sensor information systems) a chain is formed from source to destination using greedy neighbor selection algorithm and all the nodes are attached in to the chain formation. Other examples are GPSR, LEACH.

iii. Geographical Routing
In this query is made on the basis of geographic information of the nodes in the sensor network and also data is disseminated using the geographical information of the nodes. If we add energy aware feature in this then it has ability to select the neighbor on the basis of residual energy and intelligent neighbor selection scheme e.g. GEAR (geographical and energy aware routing) GAF(geographical adaptive fidelity) [4, 5].

iv. Quality of service (QoS) aware protocols consider end-to-end delay requirements in setting up the paths in the sensor network e.g. sequential assignment routing (SAR) Stateless protocol for end-to-end delay (SPEED) [1].

2. Motivation

Since all the nodes in wireless sensor network are battery constrained, we can say that they have a certain life-time. In any particular scenario if nodes are deployed then they should work till their life-time or near to it but if any node dies quite early due to only energy issue i.e. depletion of energy of the battery can cause a serious issue to the communication system of that particular region. It may occur due to the frequent use of that node in the region. So, motivation is that to make the communication among the nodes effective in terms of nearest neighbor selection and energy conservation for future need.

3. Related Works

Work towards the GEAR started after the shortcomings of Hierarchical Routing, since they are including all the nodes in chain formation from source to destination in PEGASIS or if we see the working of GPSR then it includes the nodes near the perimeter of the region and nearer to destination and use it frequently, in this manner if a node is using quite frequently, its energy level will go down and this node will get down and next time to establish the communication we have select some other node which might be away from the destination. In this way energy to transmit data towards the sink will more than the previous node. In contrast GEAR provides new approach in which all nodes are not involved in spite of this it include only those nodes which is geographically aware and have information about the residual energy.
Here is description about PEGASIS [3] methodology that is been done before we start GEAR.

a. Greedy approach is used to make the chain from source to destination e.g. DFS.
b. Objective of PEGASIS
   i. Uniform energy across the network and by this increase the network life-time.
   ii. Reduce data delay incur on their way to source to sink.
c. It assumes network is homogenous.
d. Nodes have global knowledge about them. In this devices contain CDMA equipped transceivers. Nodes have responsibility to deliver data to the sink. It uses the chain structure, nodes communicate with their closest neighbor to the end node. Greedy means to add the nearest neighbor only on the basis of RSSI.
e. Chain leader is selected on the basis of highest residual energy and it shifts its position after each round.
f. Hierarchical PEGASIS in this there are three steps:

Data aggregation at group level.
I. Data exchanged
II. Data delivered to the sink by the chain leader.

Issues with PEGASIS

a) Since greedy approach is used in chain formation and if nodes are involved in chain formation are of low residual the communication may drain down without completion.
b) It is assumed that in PEGASIS methodology that all nodes can directly communicate with the sink, so in long range communication high amount of energy will be dissipated.
c) Bottleneck issues in order to form chain to the neighbor.

4. Geographic and Energy Aware Routing

Geographical Routing provides the mechanism to deliver the packet in a destination location based on the location information only. There is concept of regions to which data has to be delivered for this purpose whole geographic area is divided to number of sub-regions and the target packet is delivered to that region and then it is delivered to that specific node to which is targeted to. Properties of geographical routing:

a) Scalability
b) Statelessness
c) Low maintenance overhead.

Since as discussed previously all nodes in WSN are constrained with the energy so there is a need to provide an energy aware metrics [6] for the purpose of making communication effective at geographical point of view. It include some key points that must have taken under-consideration to develop a geographic and energy aware routing protocol.

a) Minimize energy consumed per packet
b) Maximize time to network partition
c) Minimize variance to node power level
d) Minimize cost per packet
e) Minimize maximize Node cost

GEAR uses this energy aware metrics to compute the neighbor selection in order to balance the energy consumption among the nodes. Here is brief description about the metrics.

4.1Minimize Energy Consumed Per Packet

Its main concern is to conserve energy. Suppose that j nodes n_1…….n_k where n_1 and n_k are source and destination nodes respectively. Let t(a,b) is the energy consumed in transmission and receiving of one packet over one hop a to b. Then total energy, ej, consumed will be

$$\sum_{i=1}^{i=k-1} t(n_i, n_{k+1})$$

Issue: Due to shortest path selection in this approach will tend to node die issue.

4.2 Maximize Time to Network Partition

Main area of concern in this metric is that as much we will take time to make the geographical partition regions will be more specified and packets will be delivered more effectively in that specified region. After the region definition is tries to provide an assurance of high throughput with less delay. It is also gives the idea to save the node energy e.g. if we have a geographical region and we need to send the data to a particular node in a specified region then it will send the data to only that targeted region and cut other nodes to involve in this.

4.3 Minimize Variance to Node Power Level

When a WSN is created it contains large number of Nodes and each node has equal importance viz. if one Node will be used again-n-again for the communication in order to use the shorter path its battery will be depleted and consequently node will die. Then issue will arise that which node will be taken as middle path for shortest path from source to sink. In order to this the load should be share among all the nodes in order to make the communication effective and improve the network lifetime. It uses a load sharing approach similar to load balancing in distributed network. JSQ is proposed solution for it. In this a node sends data to its closest neighbor with minimum amount of data to be transmitted.

Issue: Selection of best neighbor to transmit the traffic to next hop.

Solution: Augmented path and flow redirection algorithms to balance the energy consumption among the nodes.

4.4 Minimize Cost per Packet

For maximizing the life of all the nodes in the network this network metrics is used. In this path selected by the metrics try to leave those node which have the depleted energy reserves. Let $f_i(x_i)$ is a function that denotes the node cost or weight of node i, and $x_i$is the total energy expanded by node i so far then

$$c_j = \sum_{i=1}^{k-1} f_i(x_i)$$

Here $f_i$represents the node reluctance to forward the packet. So f_i is chosen as a monotone function then no any node will be overused. It will provide better node life and simultaneously it also represents the remaining battery life.

4.5 Minimize Maximize Node Cost

This approach suggests to minimize the maximize node cost after transmitting N packets or after a threshold time period.

5. GEAR Protocol

GEAR(Geographic and Energy Aware Routing) [4], [5], is a location based routing protocol which takes energy conservation as a major area of concern in routing the data from source to sink. It uses an energy aware neighbor selection and forwards the packet in recursive manner. It has better network lifetime time other non-geographical routing. GEAR Protocol have two phases for packet forwarding Packets towards the target region and disseminating packet inside the target region. For forwarding packets towards the target region there are two scenario as follows:

a) When a neighbor close to the sink exists near the source, then it uses next hop packet forwarding to disseminate the packet towards the sink.
b) When neighbor to sink exists far away from the source then it uses cost computation functions and computation of HOLES to deliver the packet to the sink.

Radio Model for GEAR Protocol as shown in Figure 3:

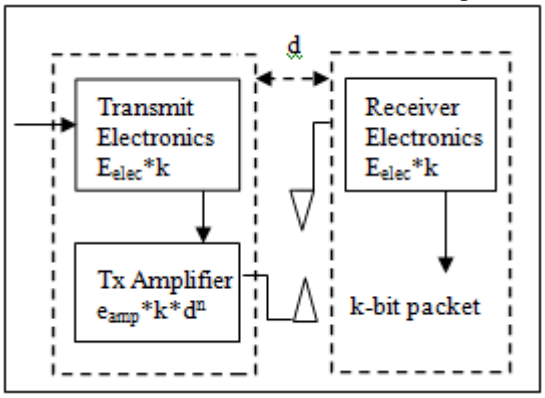


Figure 3: RADIO Model of GEAR

$E_{Tx}(k,d)=E_{Tx-elec}k+E_{tx-amp}(k,d)$
$E_{Tx}(k,d)=E_{elec}*k+E_{amp}*k*d^2$
$E_{Rx}(k)=E_{Rx}$-elec(k)$E_{Rx}(k)=E_{elec}*kE_{Rx}(k)=E_{elec}*k$
Where E_{Tx}= Transmitting power or Transmitting Cost

E_{Rx}= Receiving Cost
k = number of bits that has to be sent
d = distance between the nodes.
$d=d^2$= due to channel loss
e_{amp}= for the transmit amplifier

Assumptions for GEAR protocol before simulation:
a) Nodes are destined to a specified target region.
b) Each know about its own energy level and location information as well as neighbor location information [4],[5],[6] using low cost GPS or some beacon and beacon less services.
c) Link between two nodes are symmetric i.e. communication between each node is bidirectional.

As it is discussed previously that GEAR protocol has two phases. But the packet dissemination is always dependent on the neighbor selection. In GEAR we talk about energy aware neighbor selection. In contrast to other routing methodologies GEAR can support a larger number of nodes. This advantage of GEAR adds complexity in neighbor selection because there could be a number of neighbors then how to select a better one is an issue with energy awareness. In context of this there is some existing work and one proposed work.

5.1 Energy Aware Neighbor Selection

In this case there are two functions that are taken under consideration are as follows:
i. Learned Cost
ii. Estimated Cost.

Learned Cost h(Ni, R) is collected by any node in the network where Ni is number of nodes and R is the target region. Each node infrequently updates its status to its neighbors. Each node collects this information and update the learned cost. In case if the node is in a hole then it calculates the estimated cost to a node which is far away form that node. Described in Figure 4.

Estimated cost is denoted by c(Ni, R) and computed as
$C(Ni, R)=\alpha d(Ni, R)+(1-\alpha)e(Ni)$
Here,
α is tunable weight ranges from 0-1
e(Ni) is energy consumed by node Ni , it is the normalized function among all the nodes.
d is the centroid of the region R.

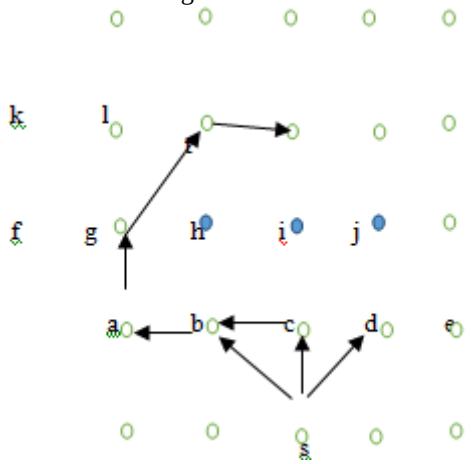


Figure 4: Learning Path around Holes [4]

Here node G, H, I are energy depleted and hence cannot be considered in path selection.

5.2 Recursive Packet forwarding inside the Region

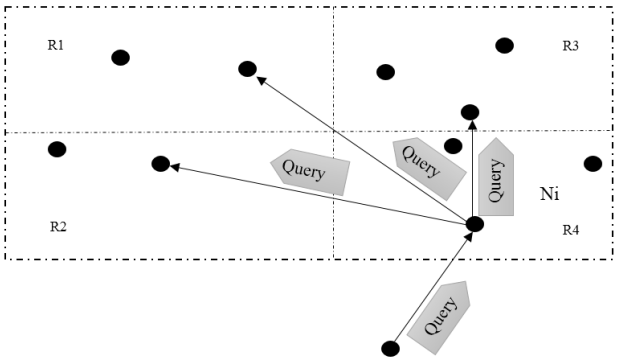


Figure 5: RecursiveForwardinginsidetheregion [4]
Figure 5 shows the packet forwarding scheme in GEAR.

6. Proposed Solution

There are issues for Energy Aware and Location based routing due to which transmission become inefficient and continuously looped causes the node to die earlier. Here two solutions are proposed these are as following:
i. Beaconless & GPS less Location Discovery
ii. Energy Aware Routing

6.1 Beaconless & GPS less Location Discovery

Beacons, sometime calls as Anchor, is a node which has information about its location either by Manual or GPS configuration in this. When a beacon broadcast its information to nearby nodes other nodes arrange themselves according to that information. It is also high energy node which is used for this purpose.

On the same time if we see GPS is also used for this purpose it provide correct location but it has so certain and unavoidable inherent issues. So we can say in using GPS [7] and Beacons there is a strong chance that network lifetime will reduce These are as following issues concern with using it:
a. GPS is a costly device
b. GPS connects with satellite which is an energy consuming process.
c. Large amount of energy dissipated in using beacons.

Solution: Group based Deployment Scheme, Figure 6.
1) First of all here is a concept of deployment point, sensor nodes are grouped into n groups and each group is deployed according to that reference point.
2) It is possible that groups may not fall in a uniform manner so those locations usually follows a probability distribution function called priori, with this it is possible to discover the location of the nodes using observing the group membership of the node.

In this for discovering the location likelihood function is used. For this kind of localization we have two components
a. Reference Point: Whose coordinates are known!
b. Spatial Relationship between sensor nodes and reference point.
When sensor nodes are deployed corresponding to a deployment point then the coordinates of that point is usually known. So using spatial relationship and reference point we can find the location of sensor nodes. At each deployment point a group of nodes are deployed.

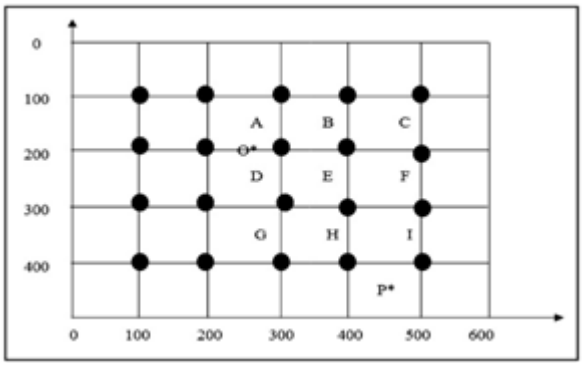


Figure 6: Group Based Deployment [7]

a. Group Based Deployment Model

Assumptions:
i. Suppose we have N nodes those are divided into ‘n’ equal size nodes,

Gi for i=1 to n.
Where Gi is corresponding deployment point with co-ordinates (x_i,y_i).

ii. Since sensor deployment point is predetermined hence we can store it in the memory of the sensor node.
iii. In deployment time, the resident point of any node K from group Gi, works with the pdf, as follows:

$$f_K^i(x, y|K \in Gi) = f(x - x_i, y - y_i)$$

b. Deployment Distribution

The model of deployment distribution is totally dependent on deployment method. Here Gaussian distribution has been used for the model. Deployment Distribution uses 2D approach for any node K from group Gi, is distributed along (x_i,y_i). The mean of Gaussian distribution μ equals (x_i,y_i) and pdf for node K in Gi is as following:

$$f_K^i(x, y|K \in Gi) = \frac{1}{2\pi\sigma^2} e^{-\frac{[(x-x_i)^2+(y-y_i)^2]1}{2\sigma^2}}$$
$$= f(x - x_i, y - y_i)$$

Here σ is standard deviation.
Since nodes distribution is not uniform but we can use proper distance between neighbor deployment point and σ. The probability to find the node in each small region can estimated up to exact distance.

6.2 Energy Aware Routing

For energy aware routing [8] there are two phases

a. Initialize wake and sleep cycle &Keep a threshold limit of power for nodes.
b. Intelligent neighbor Selection.

It is important for the nodes to define a sleep and wake cycle also set a threshold value in reference of power of that node it will save it from excessive use of power. Sleep and wake cycles are used define working hours of a node in a day. So that it could be prevented from overusing of energy and node. Simultaneously threshold value make it realize that up which limit it can take part in then communication. After that a node comes under a vulnerable condition and if used could cause in communication breakdown. Choice of MAC [9] also plays important role in energy conservation, e.g. if initial power is E watts, Figure 7 , is supplied to a node and each transmission needs ε and receiving needs δ. Then total residual energy must be a function of Δ i.e.

$$\Delta = E - n\varepsilon - n\delta$$

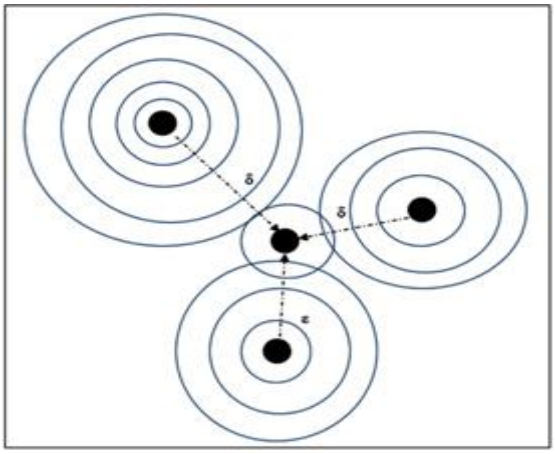


Figure 7: Energy Estimation

For example is each cycle of transmission requires avg. of 2 joules and initial power level is 10000 joules. Then when energy remains near to 50 joules it should consider under the threshold value and that will not take part in communication any more.

6.3 Methodology

In order to develop the GEAR protocol following methodology has been used but before doing this there are few prerequisites those are performed to setup the network like

i. Nodes Selection: It deals with the node for a particular scenario like selection of node for temperature sensing, humidity or for sea-level monitoring is done.
ii. Node Setting: Nodes are selected and their settings are made or changed from default to require.
iii. Node Deployment: Nodes will be deployed as they are discussed above.

The methodology is shown as a flowchart below in Figure 8. It defines step by step processing of for simulation of GEAR protocol like in real-time. Only thing that is left in this is environment but there is a field in the TCL which can be modified and fields can be added as per requirement. For this options and modification fields can be added in trace file and in .nam inside TCL script. Trace file and network animation file is defined in TCL file at the beginning of the scripting viz. in defining options. Trace file is like the log file of the complete transmission and captures each instances while nam represents the animation of the network. Proposed methodology is shown below:

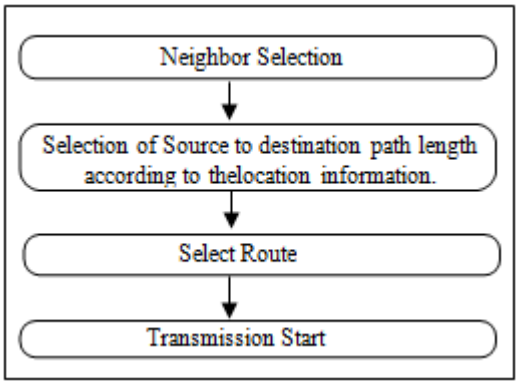


Figure 8: Methodology

7. Simulation and Results

7.1 Sensor Simulator Framework

Here, for my project simulation I am using NS2.35 simulator. It is an open source and discrete event driven simulator used mainly in research areas of Computer Networks. Introduced in 1989, got enormous success in the research field, academics and government sectors. It was founded by DARPA, VINT, SAMAN &, NSF, CONSER. To investigate the network performance we can easily use scripting language to configure the network and get the desired result.It supports both wired andwireless protocol and their functionality e.g. routing algorithms, TCP, UDP etc.

Architecture of NS2 [10]:

Architecture of NS2 is shown in Figure 9 NS2 consists of two languages

1. C++
2. OTcl(Object-Oriented Tool Command Language)

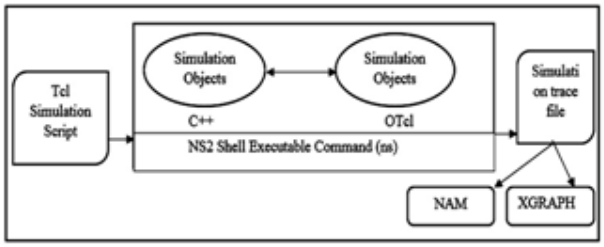


Figure 9: Architecture of NS [10]

C++ works as the backend of the simulation and OTcl works as the frontend. These two languages are linked together by TclCL.

7.2 Network Implementation

In network implementation and simulation there are some steps that has to be performed before the simulation process starts.

Table 1: Simulation Parameters

Parameters	Values
No of nodes	30
No of Source/Sink	1
Network Dimension	800*800
Transition Time	0.005sec
LogTime	150sec
MAC protocols	IEEE 802.11
Idle power dissipation	1.0 joules
Receive Power Dissipation	1.0 joules
Node initial energy	1000joules

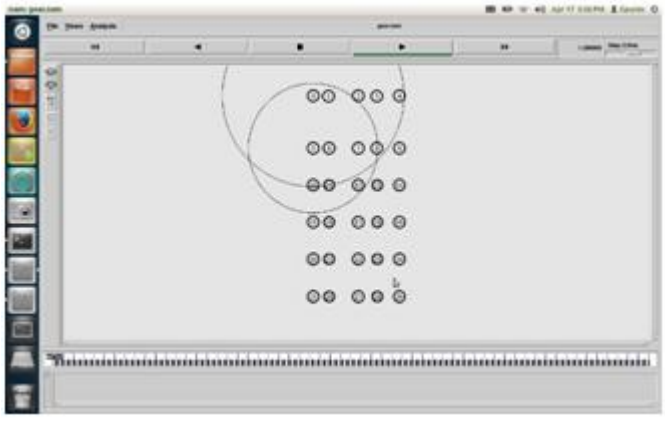


Figure 10: Simulation of GEAR

There are some pre-defined expectations from GEAR to improve the result. Like use of GPS and beacons has not to be done for is, Use of GEAR filters has been done in tis that makes data transmission using directed diffusion and neighbor selection has been done using A* algorithm which has included its directed diffusion file. It is not like those protocols which uses DFS [11] for data dissemination.

Table 2: Simulation comparison of flooding and GEAR

Parameters/Protocol	*Flooding*	*Gear*
Approach	Flat	Location Based
Traffic Type	Uniform	Uniform
Energy Dissipation	Discrete	Linear
Communication	Broadcasting	Recursive forwarding
Network Life-Time	Imbalanced	Balanced

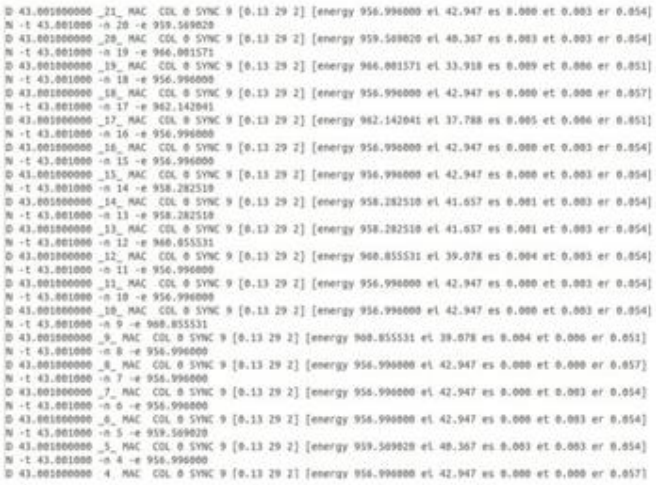
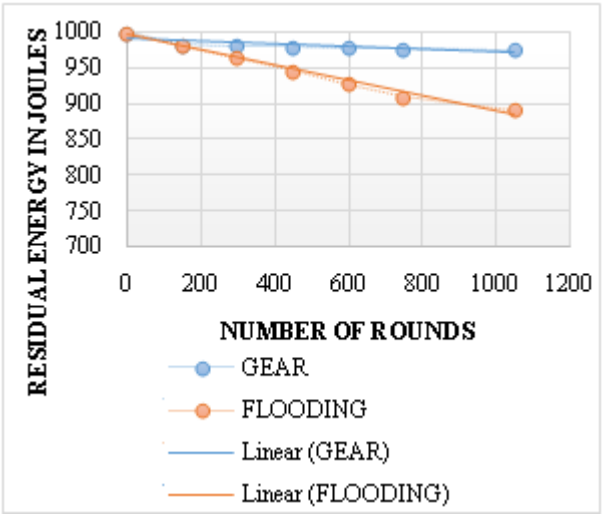


Figure 11: Log File of Energy Dissipation in GEAR



Graph 1: Gear Vs Flooding

Source of flooding data is [12]. Graph 1 shows how GEAR shows stability as transmission starts while Flooding leaks in stability. It dissipates large amount of data as compare to GEAR and also proves that network life-time in this is also quite low. Graph shows the nominal drop in GEAR after each time interval and number of rounds which FLOODING gives a sharp drop in its residual energy level. It proves GEAR's better performancein improving network life time. Hence, basic issues for making communication energy efficient is done in this dissertation. It is done using allproposed methodology and solution. This chapter is for simulation for GEAR protocol which is done in this using ns2.35 and Ubuntu 12.04. Various results are shown in figures above.

8. Conclusion

It can easily visualize from graph 1 that GEAR has better

performance and network life time Table 2 shows a comparison from flooding with parameters like their approach, use of energy and network size. Theoretically, some comparison are made on different performance parameters, it can say that GEAR has better performance in comparison of data centric and hierarchical routing if we see it is not like Flooding of SPIN which unnecessarily broadcast data and consumes node energy, Unlike PEGASIS and LEACH it does not waste power in election of CH's and CL's. It is different by using data centric approach and location based routing to make it accurate and energy efficient.

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