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Enhanced Energy Efficient Routing Algorithm using Cluster Heads Maximizing Network Lifetime

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ABSTRACT: Wireless Sensor Network consists of enormous range of sensing element Nodes. The most aim is to extend the period of time of the network because the sensors measure deployed principally to perform unattended operations like setting observance. Seismic activity with detection, industrial observance and management etc. of these activities need strong Wireless Communication Protocol with low power consumption. Cluster based mostly Protocol is purposed with most necessary changes, first is minimum distance, most residual energy, minimum distance wont to designated the CH (Cluster Head) rather than likelihood as employed in the LEACH, so it may be used for the sensing element nodes with totally different initial energy among the sensing element nodes so energy is optimally consumed for the cluster members to move with Cluster Heads. The role of the Cluster Head is revolved so the energy consumption may be distributed equally and also the period of time of the Wireless sensing element Network may be extended. Second it selects best path and adopts multi hop communication between cluster head and sink is bestowed here. Experimental results show that the life time of the network is extended as compared to alternative approaches.

KEYWORDS: Wireless Sensor Network, Cluster Heads, LEACH Protocol, MATLAB, OPNET.

I. INTRODUCTION

Wireless Sensor Networks(WSN) have gained world-wide attention in recent years due to the advances made in wireless communication, information technologies and electronics field [1,2,3,4,5].The concept of wireless sensor networks is based on a simple equation: Sensing + CPU + Radio = Thousands of potential applications [6] . It is an in situ ‖ sensing technology where tiny, autonomous and compact devices called sensor nodes or motes deployed in a remote area to detect phenomena, collect and process data and transmit sensed information to users. The development of low-cost, low-power, a multifunctional sensor has received increasing attention from various industries. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel.

WSN term can be broadly sensed as devices range from laptops, PDAs or mobile phones to very tiny and simple sensing devices. At present, most available wireless sensor devices are considerably constrained in terms of computational power, memory, efficiency and communication capabilities due to economic and technology reasons. That's why most of the research on WSNs has concentrated on the design of energy and computationally efficient algorithms and protocols, and the application domain has been confined to simple data- oriented monitoring and reporting applications. WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. If WSNs nodes are more powerful or mains-powered devices in the vicinity, it is beneficial to utilize their computation and communication resources for complex algorithms and as gateways to other networks. New network architectures with heterogeneous devices and expected advances in technology are eliminating current limitations and expanding the spectrum of possible applications for WSNs considerably.

Wireless sensor node architecture: The basic block diagram of a wireless sensor node is presented in Figure 1: It is made up four basic components: a sensing unit, a processing unit, a transceiver unit and a power unit. There can be application dependent additional components such as a location finding system, a power generator and a mobilizer

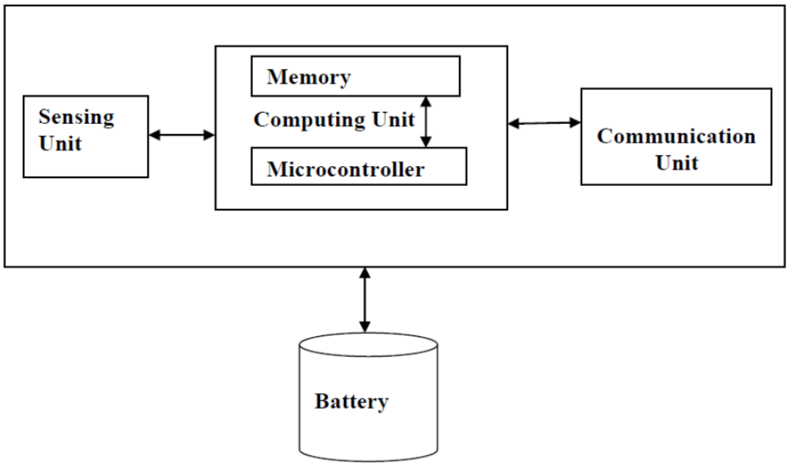

Figure 1 : Architecture of a Wireless Sensor Node

Sensing Unit: Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). Sensor is a device which is used to translate physical phenomena to electrical signals. Sensors can be classified as either analog or digital devices. There exists a variety of sensors that measure environmental parameters such as temperature, light intensity, sound, magnetic fields, image, etc. The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC and then fed into the processing unit.

Processing Unit: The processing unit mainly provides intelligence to the sensor node. The processing unit consists of a microprocessor, which is responsible for control of the sensors, execution of communication protocols and signal processing algorithms on the gathered sensor data. Commonly used microprocessors are Intel's Strong ARM microprocessor, Atmel's AVR microcontroller and Texas Instruments' MP430 microprocessor. For example, the processing unit of a smart dust mote prototype is a 4 MHz Atmel AVR8535 micro- controller with 8 KB instruction flash memory, 512 bytes RAM and 512 bytes EEPROM. TinyOS operating system is used on this processor, which has 3500 bytes OS code space and 4500 bytes available code space. The processing unit of µAMPS wireless sensor node prototype has a 59-206 MHz SA-1110 micro-processor. In general, four main processor states can be identified in a microprocessor: off, sleep, idle and active. In sleep mode, the CPU and most internal peripherals are turned on, and can only be activated by an external event (interrupt). In idle mode, the CPU is still inactive, but other peripherals are active.

Transceiver Unit: The radio enables wireless communication with neighbouring nodes and the outside world. It consists of a short range radio which usually has single channel at low data rate and operates at unlicensed bands of 868-870 MHz (Europe), 902-928 MHz (USA) or near 2.4 GHz (global ISM band). For example, the TR1000 family from RF Monolithics works in the 800-900 MHz range can dynamically change its transmission power up to 1.4 mW and transmit up to 115.2 Kbps. The Chipcon's CC2420 is included in the MICAZ mote that was built to comply with the IEEE 802.15.4 standard [8] for low data rate and low cost wireless personal area networks. There are several factors that affect the power consumption characteristics of a radio, which includes the type of modulation scheme used, data rate, transmit power and the operational duty cycle. At transmitted power levels of -10dBm and below, a majority of the transmit mode power is dissipated in the circuitry and not radiated from the antenna. However, at high transmit levels (over 0dBm) the active current drown by the transmitter is high. The transmit power levels for sensor node applications are roughly in the range of -10 to +3 dBm [9]. Similar to microcontrollers, transceivers can operate in

Transmit, Receive, Idle and Sleep modes. An important observation in the case of most radios is that, operating in Idle mode results in significantly high power consumption, almost equal to the power consumed in the Receive mode. Thus, it is important to completely shut down the radio rather than set it in the idle mode when it is not transmitting or receiving due to the high power consumed. Another influencing factor is that, as the radio's operating mode changes, the transient activity in the radio electronics causes a significant amount of power dissipation. The sleep mode is a very important energy saving feature in WSNs.

Battery: The battery supplies power to the complete sensor node. It plays a vital role in determining sensor node lifetime. The amount of power drawn from a battery should be carefully monitored. Sensor nodes are generally small, light and cheap, the size of the battery is limited. AA batteries normally store 2.2 to 2.5 Ah at 1.5 V. However, these numbers vary depending on the technology utilized. For example, Zinc-air-based batteries have higher capacity in Joules/cm3 than lithium batteries. Alkaline batteries have the smallest capacity, normally around 1200 J/cm3. Furthermore, sensors must have a lifetime of months to years, since battery replacement is not an option for networks with thousands of physically embedded nodes. This causes energy consumption to be the most important factor in determining sensor node lifetime.

II. RELATED WORK

Wireless sensor networks are quite different from general wireless networks due to various constraints and highly application specific nature of WSNs. Consequently, WSNs pose different research challenges. In wireless communication system, the models for signal strength drop over a distance are well developed. Effects of signal reflection, scattering and fading are well understood. In an actual WSN, cost and other application specific issues affect the communication properties of the system. For example, radio communication in WSN is of low power and short range compared to any other wireless communication network. The system performance characteristics vary considerably in WSN even though the same basic principles of wireless communication network are used in WSN. The size, power, cost and their tradeoffs are fundamental constraints in WSNs. Considering the basic differences with the wireless communication systems, many issues have been identified and investigated. Major issues affecting the design and performance of a wireless sensor network are the following:

1) Deployment strategy
2) Localization
3) Clustering for hierarchal routing
4) Coverage efficacy
5) Efficient medium access control
6) Efficient database centric design
7) Quality of service implementation
8) Acceptable security

We have restrained ourselves to the study of first three issues. This thesis concentrates mainly on deployment strategy, localization and clustering for hierarchal routing.

Deployment Strategy : The deployment strategy depends mainly on the type of sensors and the application. The following deployments strategies are generally used in WSNs.

Random deployment: Random deployment is the most practical way of placing the sensor nodes. For a dynamic sensor network, where there is no a-priori knowledge of optimal placement, random deployment is a natural option.

Incremental deployment: The incremental placement strategy is a centralized, one- at-a-time approach to place the sensors. The implementation makes use of information gathered through the previously deployed nodes to determine the ideal deployment location of the next sensor node. This can be calculated at base station.

Computational geometry approach: The computational geometry approach is the simplest method for sensor deployment. In this approach, the target sensing region is constructed by a set of grids or polygons thus deciding the node placement.

Movement-assisted deployment: In certain scenarios, deployment scheme is prone to deviate from the plan, because the actual landing positions cannot be controlled due to the existence of wind and obstacles. For industrial use, where the detection of some part of a machine is required, or in a wildlife sanctuary, one may use mobile sensor nodes, which can move to the desired places to provide the required coverage. In movement-assisted deployment, initially random deployment is performed. Thereafter re-deployment of the mobile sensor nodes is performed with incremental optimization.

The WSN consists of sensor nodes and a base station. So researchers can solve two different problems of deployment. In this thesis, the literature survey for deployment is divided in two parts. In the first part, sensor nodes' deployment is discussed. Thereafter the literature survey on base station deployment has been done. Sensor node deployment problems have been studied in terms of energy conservation by Howard et al. [26] in 2002 and Hoe et al. [27] in 2003. Dhillon et al. [28] optimized the number of sensors in 2004. Also in the same year, Zoo et al. [29] proposed virtual force algorithm (VFA) as a sensor deployment strategy to enhance the coverage after an initial random placement of sensors. One of the successful applications of the computational geometry in WSNs deployment problem is the Voronoi diagram approach investigated by Wang et al. [30] in 2004. In 2005, Lin et al. [31] proposed near-optimal sensor placement algorithm to achieve complete coverage. Liu et al. [32] proposed power aware sensor node deployment in 2006. Poe et al. [33] studied deployment of sensor nodes while considering area coverage, energy consumption, and worst-case delay of the WSNs in 2009. Park et al. [34] achieved optimum sensor nodes deployment using Fuzzy C-means algorithm in 2011. The researches in last decade for sensor node deployment have indicated it to be a application specific problem. Most of the research approaches are geometrical and also optimize the number of sensor nodes in general.

Some of the famous research projects are as follows: Redwoods project [35], which sought to observe the microclimate variations surrounding Redwood trees in a coastal forest. Volcano monitoring using acoustic sensors to detect the seismic activity and record high-frequency measurements [36], and Zebra Net project to gather position data of zebras in their natural environment in Kenya [37].

Presently main issues in sensor node deployment are-

1) Sensor nodes deployment to maximize the coverage in the network. Detection of coverage holes, repositioning of sensor nodes to repair coverage holes,
2) Deployment to achieve minimal energy consumption configuration,
3) Deployment of sensor nodes for a large scale WSN to minimize the event sensing delays.

As in this thesis, investigation in the base station deployment problem has been presented so the literature survey on base station deployment is important. There are several proposed algorithms available in the literature for optimal location of base station in a WSN. Though the Fermat point is very old problem for optimal facility location but when the optimal location depends on several parameters other than only distance, new methods have been evolved. Pan et al. (2003, 2005) [3, 4] provided algorithms for locating a single base station using an upper bound and a lower bound initially. Bogdanov et al. (2004) [38] optimized the positions of base stations in a data collecting sensor network to minimize the power consumed by the sensors. Efrat et al. (2004) [39] used approximation schemes for optimally locating a base station. Wong et al. (2006) [40] proposed novel binary integer programming formulation of the base station placement problem. Akkaya et al. (2007) [5] showed that dynamic positioning of the BS is an efective means for boosting the network dependability. Basheer et al. [41] proposed delaunay refinement based sub optimal receiver placement technique which reduces the dilution of localization accuracy. This method solve two problems of wireless sensor network simultaneously, one is base station positioning and other, minimization of localization error. Recently Paul et al. (2010) [6] also proposed a new optimal location of base station using geometrical approach for maximum lifetime of the sensor network. Most of the algorithms use power minimization between nodes and base station. In this thesis also, power consumption minimization has been considered along with the geometry as well as the path loss exponent of the medium. The issues for investigation in base station deployment are the following.

1) Deployment of base station to maximize network lifetime,
2) Dynamic and multiple base station positioning,
3) Base station deployment for minimal energy consumption.

TECHNIQUES	ALGORITHM	DEPLOYMENT METHOD
Sensor node Deployment	Howard *et al.* [26]	Deployment of a mobile nodes in an unknown environment.
	Heo *et al.* [27]	Deployment of mobile sensor nodes in the region of interest.
	Dhillon *et al.* [28]	Probabilistic optimization of number of sensors.
	Zou *et al.* [29]	Virtual force algorithm as a sen- sor deployment strategy.
	Wang *et al.* [30]	Deployment problem using the Voronoi diagram approach .
	Lin *et al.* [31]	Near-optimal deployment to achieve complete coverage.
	Liu *et al.* [32]	Power-aware sensor node deploy- ment.
	Poe *et al.* [33]	Considering coverage, energy con- sumption, and delay.
	Park *et al.* [34]	Nodes deployment using Fuzzy C- means algorithm.
Base Station Deployment	Pan *et al.* [3, 4]	Minimum Enclosing Circle with lower and upper bound.
	Bogdanov et al. [38]	Minimizing power consumption of sensor nodes.
	Efrat et al. [39]	Approximation schemes for locating a base station.
	Wong *et al.* [40]	Binary integer programming for base station placement.
	Akkaya *et al.* [5]	Dynamic positioning of base station to increase network lifetime.
	Basheer *et al.* [41]	Receiver placement using delau nay refinement by reducing localization error.
	Paul *et al.* [6]	Using geometrical approach for maximum lifetime.

Table 1: Literature survey summary for various deployment techniques represented via various schemes.

III. PROPOSED ALGORITHM

We propose a cluster algorithm for wireless sensor networks based on Residual Energy and Position, while forming the cluster according to residual energy of sensors and fringe position within clustering. It is a key to obtain the optimal electing coefficient which decides the electing time of new cluster head. The cluster head is elected within the cluster when its residual energy is less than a value which is the multiplication the electing coefficient and cluster head's initialization energy this round. To make energy load distribute evenly among all nodes, it is necessary to seek for the maximum residual energy among the nodes within the cluster, and specify it as the cluster head. The node which is near the edges or in the outer zone of the cluster area and whose residual energy is less than a threshold should not be elected to be cluster head to avoid the accumulated transmission energy of more nodes caused by increased distance[2]. A new electing coefficient can be set dynamically after cluster head selection according to number of nodes within cluster and energy dissipative value between cluster head node and member nodes.
The algorithm in this paper is described as follow:

Step1: Initialize network.
Step2: The cluster head calculates its residual energy, $e_{h,resi\text{-}energy}$
Step3:If $e_{h,resi\text{-}energy}$ is less than the energy difference, $\triangle_{energy}$, a new election is started. $\triangle_{energy}$ is defined as

$$\triangle_{energy} = \varepsilon \times \text{MaxEenergy} \qquad (1)$$

where MaxEenergy is the initial residual energy when this node was elected as the cluster head last time, ε the electing coefficient in percentage. The optimal ε value is obtained in our algorithm just as shown in [4]. The election procedure is briefly stated as follows:
step4:seek for the maximum residual energy, MaxResiEergy, among the nodes within the cluster.

$$\text{MaxResiEenrgy} = \max (e_{i,resi\text{-}enery}) \qquad (2)$$

Where $e_{i,resi\text{-}enery}$ is the residual energy of node i in the cluster, i the serial number of the node, covering all nodes in the cluster, the node of MaxResiEenrgy's ID is set to k.
Step5: whether node k is at the fringe position of the cluster. If yes, go to step4, seek for the maximum residual energy, but not include node k;
Step6: If node k is not at the fringe position of the cluster , check its residual energy, E_{resi}. If E_{resi} less than threshold value, go to Step4; If not specify the node of MaxResiEenrgy as the new cluster head and substitute the MaxEnergy with MaxResiEenrgy.
Repeat Step 2 to 6 until exceeds the assigned value.
We define here a variable-Fringe Coefficient(θ) we use in this paper to determinate fringe position. It is defined as follow:

$$\theta = d / R \qquad (3)$$

Where d be distance of member node from the cluster head, R be the radius of cluster head
Considering that There are a great of nodes in the region, so the distance of member node from the cluster head d is relatively short, the propagation loss c an be modelled as inversely proportional to d^2 . So it can be calculated from equation (4) as follows:

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \qquad (4)$$

where
Pr(d) is the receive power given a transmitter receiver separation of d
P_t is the transmit power, G_t is the gain of the transmitting antenna
G_r is the gain of the receiving antenna; λ is the wavelength of the carrier signal
d is the distance between the transmitter and the receiver and
$L \geq 1$ is the system loss factor not related to propagation
Assume there are N nodes distributed uniformly in an M×M region, there are K clusters. Under perfect condition, the region should be covered by K clusters. Assume this region are K circle with radius R[3]. Assume the area is same. Therefore, the radius of cluster head is:

$$R = \sqrt{\frac{c}{K\pi}} M \qquad (5)$$

where c be a constant, $c \geq 1$, is set to ensure the cluster head can cover the region completely.The fringe Coefficient value we proposed in this paper will be concluded by experiment.

IV. PROPOSED METHOD

In the scheme the below approach to support Residual Energy and Positionand energy efficiency of WSN is proposed. A flowchart of the proposed approach is shown in Figure 2. To make energy load distribute evenly among all nodes, it is necessary to seek for the maximum residual energy among the nodes within the cluster, and specify it as the clustered efficient data transmission.

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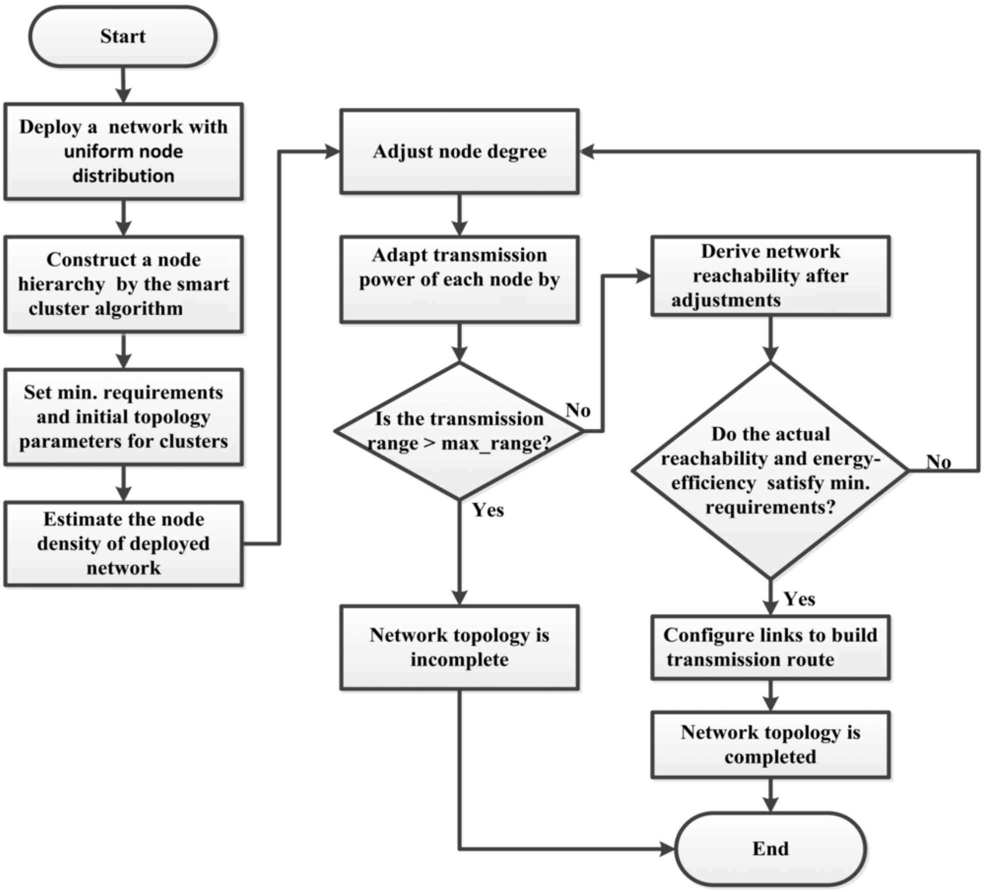

Figure 2: Context or Data Flow Diagram for Proposed Scheme using WSN

Proposed Algorithm

```
%counter for bit transmitted to Bases Station and to Cluster Heads
packets_TO_BS=0; packets_TO_CH=0;
%counter for bit transmitted to Bases Station and to Cluster Heads %per round
PACKETS_TO_CH(r+1)=0; PACKETS_TO_BS(r+1)=0; figure(1);
for i=1:1:n%Checking if the energy is less or reduced by half if (S(i).E<=(Eo/2)) && (S(i).E>0)
plot(S(i).xd,S(i).yd,'yellow .'); Hdead=Hdead+1;
  if(S(i).ENERGY==1)
    Hdead_a=Hdead_a+1;  end     if(S(i).ENERGY==0.5)     Hdead_in=Hdead_in+1;
       end       if(S(i).ENERGY==0)       Hdead_n=Hdead_n+1;      end
       hold on; end%checking the rate of energy dissipation in normal and advance nodes
if (S(i).E<=Eo)||(S(i).E>Eo)       if(S(i).ENERGY==0)            RnEnergy(r+1)=S(i).E;
  end   if (S(i).ENERGY==0.5) RINEnergy(r+1)=S(i).E;
  end   if (S(i).ENERGY==1) RAEnergy(r+1)=S(i).E;
  endend%checking if there is a dead node
if (S(i).E<=0) plot(S(i).xd,S(i).yd,'red .'); dead=dead+1; if(S(i).ENERGY==1) dead_a=dead_a+1;
  end   if(S(i).ENERGY==0) dead_n=dead_n+1; end
hold on;end if S(i).E>0 S(i).type='N'; if (S(i).ENERGY==0) plot(S(i).xd,S(i).yd,'o'); end
```

```
if (S(i).ENERGY==0.5) plot(S(i).xd,S(i).yd,'*'); end
if (S(i).ENERGY==1)plot(S(i).xd,S(i).yd,'D'); end hold on; end % endplot(S(n+1).xd,S(n+1).yd,'x');
HSTATISTICS(r+1).DEAD=Hdead; HDEAD(r+1)=Hdead; HDEAD_N(r+1)=Hdead_n;
HDEAD_IN(r+1)=Hdead_in; HDEAD_A(r+1)=Hdead_a; %When the first node is half dead if (Hdead==1)
if(flag_first_Hdead==0) first_Hdead=r; flag_first_Hdead=1; end % end
```

V. SIMULATION RESULTS

We use: 1. DCP (data communication procedure) to represent lifetime. DCP means the period of a round of data transfer, including data detection, data transmission and data receipt of a sensor nodes in this cluster ; 2. r. r means the times of reversion of cluster head.DCP_first and DCP_last mean that DCP when the first node die and the last node die ,△DCP means the difference of DCP_last to DCP_first ; r_first and r_last express that round of the first node die and the last node die. We have simulated the performance of LEACH in the same situation with initial energy of 0.2J. The variations of △DCP,DCP_first, DCP_last, r_first and r_last are shown in below figure, when the number of nodesincrease.

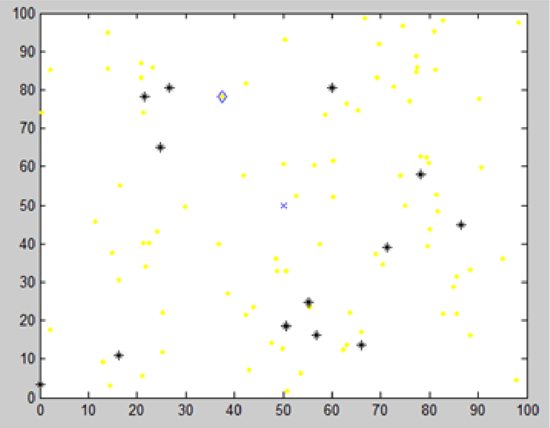

Figure 3 : Shortest Path finding using DCP via Cluster Heads to Conserve Energy and to Shorten Time Span over LEACH

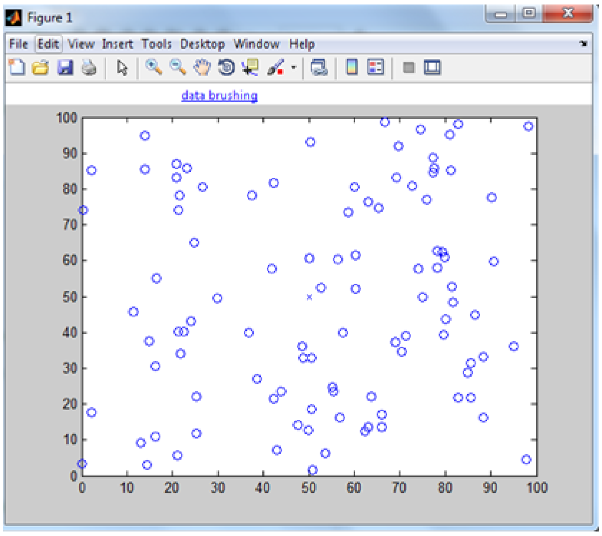

Figure 4 : Nodes Formation using DCP for Data Transmission Served by Cluster Heads.

VI. CONCLUSION AND FUTURE WORK

The presented work is focused on the formation of a reliable and effective clustered network in sensor network. A clustered network is the basic clustering architecture used by any sensor network in which the whole network is divided in small sub networks called clusters. The core operation of a cluster head is to gather the data from nodes and convey the collected data to BS for further processing and analysis. In this work, the clustering architecture is been defined under the limits of network. In such networks, the nodes are having the random mobility over the network as well as the absence of the GPS increases the complexity of the work.

In this thesis, we have defined an improved clustering architecture with cluster heads definition. The work is here performed in the cluster head selection procedure. In this work, some restrictions are defined in cluster head selection such as the maximum number of cluster head in the network cannot exceed to the 10%. The minimum number of nodes are required to connect in the sensing range of a cluster head represents its eligibility. The cluster head selection is also defined parametric; the parameters considered here are the maximum connectivity, maximum energy and the probability vector. The obtained results show that the presented work has improved the network life and the overall communication over the network.

VII.FUTURE SCOPE

Certainly we did not accomplish all we planned to do. The work done here is merely a small work of a major project. In the future this work can be further extended. Here we have taken MATLAB for simulation. With a better simulator like OPNET, which is designed for sensor network, we could have achieved more.

A good exploitation of the system parameters i.e. transmission range and node density to find the best possible optimal setting could also be researched further. Another interesting observable fact that can be studied further is the relationship between the number of hops and the spatial uniformity of energy distribution in a sensor network. Knowing this relationship can help to choose the right parameter in a sensor network for different kind of topology. The next work can also be done to improve the aggregation process in same simple network or in clustered architecture.

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