A NOVAL APPROACH FOR REDUCING ENERGY CONSUMPTION IN ROUTING PROTOCOL FOR CLUSTERED WIRELESS SENSOR NETWORKS

A Thesis Submitted
in Partial Fulfillment of the Requirements
for the Degree Of

MASTER OF TECHNOLOGY

In
WIRELESS COMMUNICATION AND SENSOR NETWORKS

by

AMITOSH PANDEY
(Enrollment no: 11704540647)

Under the Supervision of

[Mr.AKHILESH KUMAR M
[ASSOCIATE PROFESSO[illegible]

BBD UNIVERSITY

SCHOOL OF ENGINEERING
BABU BANARASI DAS UNIVERSITY
LUCKNOW
June, 2019

CERTIFICATE

It is certified that the work contained in this thesis entitled **"A Novel Approach for Reducing Energy Consumption in Routing Protocol for Clustered Wireless Sensor Networks"**,by **AMITOSH PANDEY** (1170454001), for the award of **Master of Technology** from Babu Banarasi Das University has been carried out under my supervision and that this work has not been submitted elsewhere for a degree

SUPERVISIOR
Mr.AKHILESH KUMAR MAURYA
(Associate professor)
Department of ECE
BBDU, LUCKNOW

Nitin 19/07/19
HEAD OF DEPARTMENT
Dr. NITIN JAIN
(Professor)
(HEAD OF DEPARTMENT)
Department of ECE
BBDU,LUCKNOW

Date: 19.07.2019

Declaration

I, **Amitosh Pandey** declare that the thesis titled "**A Novel Approach For Reducing Energy Consumption in Routing Protocol For Clustered Wireless Sensor Networks**" has been composed solely by me and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgment, the work presented is entirely by my own.

Amitosh Pandey
Signature

ABSTRACT

Due to the vast potential of the sensor networks to enable applications that connect the physical world to the virtual world, the Efficient design and implementation of wireless sensor networks has become a hot area for researchers in recent years. Energy efficiency is a key issue in WSN as the sensor nodes are equipped with limited resources. Clustering based protocols have been suggested in reducing the energy consumption while packet forwarding to the base station. In this research paper, a novel technique to reduce energy consumption has been proposed. The algorithm has been implemented using MATLAB and compared to existing LEACH protocol. The results obtained in terms of number of dead nodes, number of alive nodes and throughput suggest that the proposed technique achieves better results than the LEACH protocol.

ACKNOWLEDGEMENT

The completion of this synopsis" **A novel Approach for reducing Energy Consumption Routing Protocol for Clustered Wireless Sensor Networks**", gives me right opportunity to convey my gratitude to all those who helped me throught the duration.

I express my heartfelt gratitude towads my coordinator Mr. Ashutosh Rastogi and supervisor Mr. Akhilesh Kumar Maurya for their constant help. I also sincerely thankful to Dr. Nitin Jain, Head of Department, **BABU BANARSI DAS UNIVERSITY LUCKNOW** for guiding me in every aspects of my dissertation. I'am thankful for providing me an excellent insight to the problem and his encouragement and inspiration throughout the work.

Thanks to all of you!

Amitosh Pandey

(AMITOSH PANDEY)

(1170454001)

M.TECH(WCSN)

BBD UNIVERSITY

LUCKNOW

TABLE OF CONTENTS

List of Figure

List of Abbreviation

Abbreviation	Full name
MEMS	Micro Electro-Mechanical Systems
RF	Radio Frequency
WSN	Wireless Sensors Network
QoS	Quality of Service
GAF	Geographical Adaptive Fidelity
SPIN	Sensor Protocol for Information via Negotiation
MCFA	Minimum Cost Forwarding Algorithm
EAR	Energy Aware Routing
TEEN	Threshold-Sensitive Energy-Efficient Sensor Network protocol
GPS	Global Positioning System
GEAR	Geographic and Energy-Aware Routing
TDMA	Time Division Multiple Access
LEACH	Low Energy Adaptive Clustering Hierarchy
MAC	Media Access Control
CH	Cluster Head
J	Joule

CHAPTER 1

INTRODUCTION

The Efficient design and implementation of wireless sensor networks has become a hot area for researchers in the recent years, due to the vast potential of the sensor networks to enable the applications that connect the physical world to the virtual world. Potential applications for such large-scale wireless sensor networks exist in a variety of fields, including military operations medical monitoring, environmental monitoring, surveillance, home security and industrial machine monitoring. By networking large numbers of tiny sensor nodes, it is possible to obtain the data about physical phenomena that was difficult or impossible to obtain in more conventional ways. In the next coming years, as advances in micro-fabrication technology allow the cost of manufacturing sensor nodes to continue to drop, increasing deployments of wireless sensor networks are expected, with the networks eventually growing to large numbers of nodes.

1.1 Wireless Sensor network:

With the recent advancement in Micro Electro-Mechanical Systems (MEMS) technology, low power digital circuitry and RF designs, Wireless Sensor Networks (WSNs) are considered to be one of the potential emerging computing technologies, edging closer towards a widespread feasibility [5]. Several useful and varied applications of WSNs such as weather and climate monitoring, detection of chemical or biological agent threats, and healthcare monitoring require information gathering in harsh and inhospitable environments. Cheap and smart sensors networked through wireless communication with the Internet hold remarkable purposes for controlling and monitoring environment, homes, health care, military, and other strategic applications. These applications demand the use of various equipment including cameras, acoustic, Infrared and seismic tools and sensors measuring different physical parameters [7]. A network of the smart sensors can be deployed in a host of different environments, for example in the military scenarios, to detect various threats. Thus these networks can gather the intelligence in battlefields, track enemy lines, monitor potentially harmful chemical and the nuclear materials using neutron based detectors, and detect viruses, toxins using bio-sensor chips coated with antibodies to attract specific biological agents [10] [14].

In the Figure 1.1, it shows a typical cluster-based WSN architecture. The nodes detects the information and transmit it to the base station through an intermediate node called the cluster-head node. The cluster-head aggregates the data, compresses it and then transmits it to the base station. The base station serves as a gateway to send the data to the another network. The database connected to the base station provides the means to update and retrieve the data on demand.

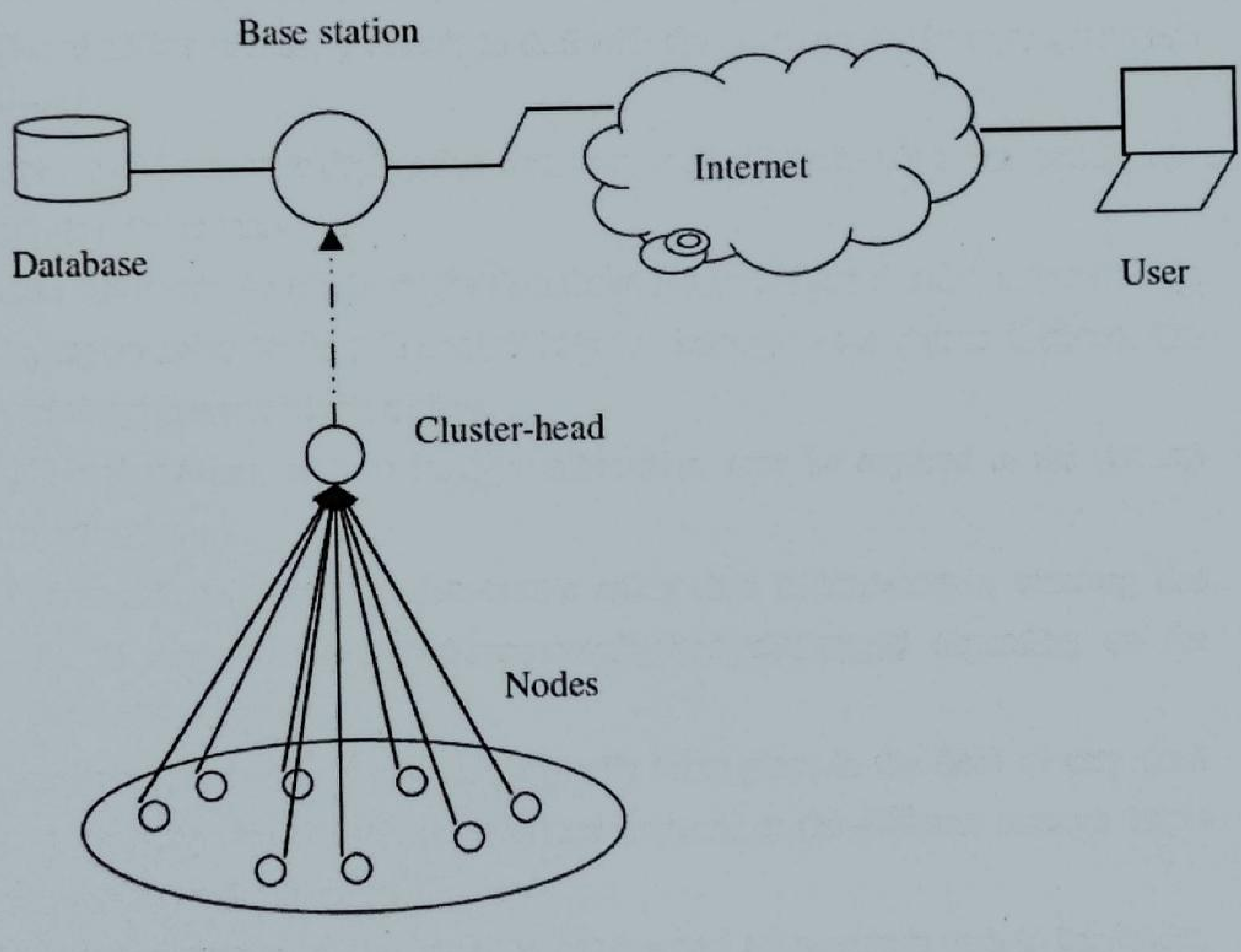

Figure 1.1: WSN architecture

It should be mentioned that the sensor networks do share some commonalities with the general ad hoc networks. Thus,the protocol design for the sensor networks must account for the properties of ad hoc networks, including the following.

• Lifetime constraints imposed by the limited energy supplies of the nodes in the network.

• Unreliable communication due to the wireless medium.

• Need for self-configuration, requiring a little or no human intervention.

However, several unique features exist in theWSNs that do not exist in the general ad hoc networks. These features present the new challenges and require the modification of designs for traditional ad hoc networks.

• While traditional ad hoc networks consist of the network sizes in the order of 10s, sensor networks are expected to scale to sizes of 1000s.

• The Sensor nodes are typically immobile, meaning that the mechanisms used in traditional ad hoc network protocols to deal with the mobility may be unnecessary and overweight.

• Since the nodes may be deployed in harsh environmental conditions, unexpected node failure may be common.

• Sensor nodes may be much smaller than the nodes in traditional adhoc networks (e.g., PDAs, laptop computers), with smaller batteries leading to the shorter lifetimes, less computational power, and less memory.

• Additional services, such as location information, may be required in the wireless sensor networks.

• Communication is typically data-centric rather than address-centric, meaning that routed data may be aggregated/compressed/prioritized/dropped depending on the description of the data.

• Communication in sensor networks typically takes place in the form of very short packets, meaning that the relative overhead imposed at the different network layers becomes much more important.

• While nodes in traditional ad hoc networks compete for resources such as bandwidth, nodes in a sensor network can be expected to behave more cooperatively, since they are trying to accomplish a similar universal goal, typically related to maintaining an application-level quality of service (QoS), or fidelity.

1.2 Design Issues

In general, wireless ad-hoc networks most closely resemble the sensor network abstraction [7]. Although wireless ad-hoc networks are similar to WSNs, WSNs have several additional design issues and constraints:

- Firstly, sensor networks can contain the thousands of nodes and thus scalability is one of the major issues for this type of network.
- Secondly, sensor nodes in a WSN are severely constrained by the power, memory and computational capabilities which although serves as a factor in Wireless Ad-hoc Networks, is not that severe. Power efficiency is a critical constraint for WSNs. Once deployed, sensor nodes with finite power sources and limited recharging capabilities should be able to sustained the operation for months at a stretch .
- Thirdly, in the WSN only relevant data should be sent after compressing it as much as possible. The decision of condensing data and sending it to the base station should be made at node levels, i.e., in the sensor nodes and cluster-heads. The said issue is not that critical for Ad-hoc networks.
- Fourthly, in the case of Ad-hoc networks, routing in general takes place between any pair of the nodes whereas WSNs are meant for the purpose of sensing and gathering information and thus routing follows some distinct patterns [13] [8].

These patterns can be classified as given below -

(1) Many to one:The Sensor nodes in each cluster send the sensed data to the cluster-heads, which in turn aggregates the data and transmits it to the base station.

(2) One to many:The Base station or cluster-head multicasts (or broadcasts) different control and association signals to the sensor nodes.

(3) Local communication: In some topologies, the form of communication isdesired for nodes to discover and co-ordinate with each other. Protocolslike GAF (Geographical Adaptive Fidelity) [12] use this type of approach.

1.3 Sensors Types and Characteristics

There are different types of wireless smart sensors currently in use [10]. A morerepresentative example is the sensor nodes of the smart dust project developed at UCBerkeley [5]. Figure 1.2 shows a general hardware platform description.

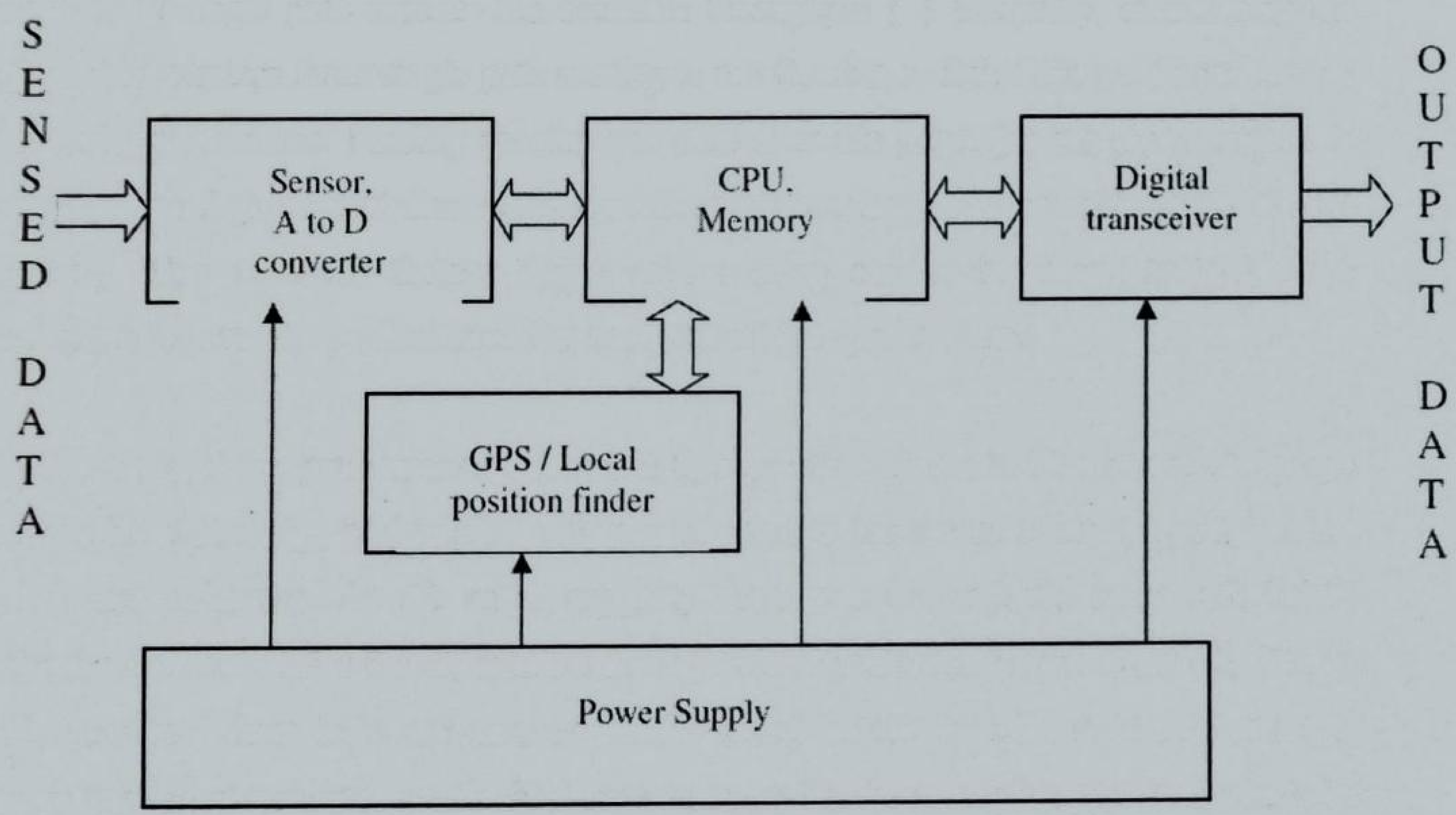

Figure 1.2: Sensor hardware platform

Different characteristics of sensor nodes includes the size, battery consumption,the powerlevel, lifetime of the operation, movement characteristics (indicating whethernodes arestationary or mobile), position characteristics (indicating whether the nodes are embeddedpower Supply)

Chapter 2

Wireless Sensor Networks

2.1 Characteristics of Wireless Sensor Networks:

The WSNs have some different characteristics in comparison to other type of wireless networks that affects the network performance. These characteristics such as node density makealgorithms and protocols unique for WSNs. For instance, the number of sensor nodes in WSNs can be extremely higher than ad hoc networks and nodes are densely deployed. Node deployment,node capabilities, node density, energy constraints, are all specific features of WSNs that affect network design and performance. Besides the node deaths occur frequently due to the battery depletion or a failure and this leads to topology changes.

2.2. Density and Node Deployment

The Node deployment can be either deterministic or self-organizing, which depend on the application. In deterministic method, nodes are placed on pre-determined locations and data routing is executed over pre-determined paths. It's also available to add some extra sensor nodes after the initial deployment in order to recover or support the network. On the other hand, in self-organizing WSNs, nodes are scattered randomly over the application area to form a network in an ad hoc manner.

2.2.1. Network Topologies

The IEEE 802.15.4 standard supports two types of the topologies as shown in Figure 2.1. In star topology, there must be at least one FFD as PAN coordinator to control devices in its respective PAN. The coordinator node is responsible for the controlling the PAN and communicating to the other PAN coordinators. In peer-to-peer topology there must be at least one PAN coordinator and nodes have to be in the communication ranges of one another to establish a link. In such a network every node acts as a router and supports multi-hop routing.This kind of topology is used in the mesh networks whichhave complex topology.

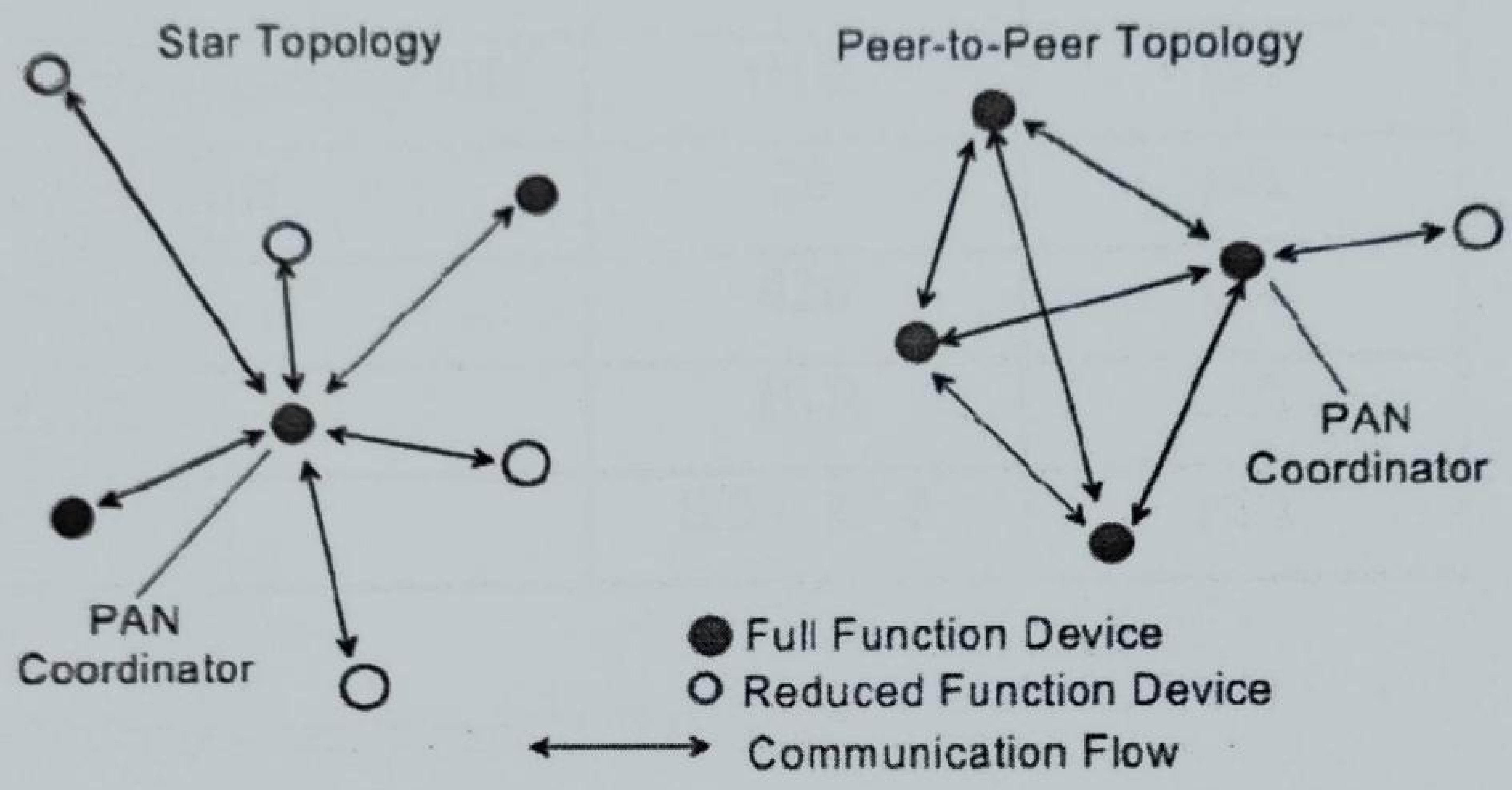

Figure 2.1 Star and peer-to-peer topologies and devices

2.2.2. Power Consumptions

A sensor node is a micro-electronic device having limited battery capacity. Network lifetime depends on battery lifetime of the sensor node, because it's impractical to replace batteries of nodes that dispersed over inaccessible application areas. For instance, a Telos mote which has integrated CC2420 NIC is powered by two AA batteries (2.1 - 3.6V DC). Thus, the energy-efficient power management is highly critical for sensor networks.

Dynamic power management capability is an important requirement for the designing a sensor node. Thus, an eventdriven power consumption will extend sensor node lifetime. The Sensor nodes have different level of power consumptions for their states such as idle, sleep, receive, transmit etc. When we look at the TI CC2420 NIC datasheet, receive and transmit currents are extremely higher than idle current and sleep current (Table 1). IEEE 802.15.4 compliant devices have sleep modes and spend most of its time with sleeping, unless they receive or transmit a packet.

State	Value	Unit
Voltage Regulator Off	0.02	µA
Power Down	20	µA
Idle	426	µA
Receive	18.8	mA
Transmit	8.5 – 17.4	mA

Table 2.1 Power Consumption of TI CC2420 NIC

2.2.3. Heterogeneous Elements

The IEEE 802.15.4 defines two different types of the device with different capabilities. The FFD nodes have ability to act as PAN coordinator as a router and communicate with other coordinators or a simple devices, on the other hand RFD nodes have very simple task as communicating and sensing with a coordinator as shown in Figure 2.1.

In addition to mobility, these nodes are embedded on vehicles such as UAVs, buses or robots and do not suffer from the energy constraints. Compared to sensor nodes, these mobile nodes have rich system resources.

2.3. Application Areas of WSNs

The WSNs have lots of application areas because of the diversity of sensing devices used in the applications. These devices have the ability to sense and detectthe thermal, acoustic, infrared, humidity, temperature, pressure, noise etc. phenomenon in the environment.

Every wireless sensor node characteristics depend on the requirements of applications. The categorization of application areas for WSNs is given below;

- Military applications.
- Environmental applications.
- Health applications.
- Smart home applications.
- Industrial applications.

The application space of WSNs shows that node density, network scale and sensor types change in large scale interval depending on the type of application.Large-scale application areas sometimes require thousands of sensor nodes, but in some applications such as smart home devices, a few sensor nodes can be sufficient.

2.3.1 Military Application

The WSN can be used in various fields of military. Its self-configuration, unattended operation, fault tolerance make it very useful for military application.

(i). **Battlefield Surveillance**: Critical terrains, approach routes, paths can be coveredwith the sensor networks and by using its data activities of the opposing forces can be examined. As the operations progress and new plans are prepared, new sensor networks can be deployed for the battlefield surveillance.

(ii). **Monitoring Friendly Force Equipment and Ammunition**: The Commanders canmonitor the latest condition of its own force by using the WSNs. Each vehicle, equipmentand ammunitions are attached with a sensor which sends the current status to the sinknode from which the commander can monitor the situation.

(iii). **Nuclear Biological and Chemical Attack Detection**: The WSN can be deployed infriendly region and it can generate an alarm when it detects any Nuclear Biological andChemical Attack and it decrease the casualties at a large degree.

2.3.2. Environmental Applications

The WSNs are also convenient to environmental applications such as monitoring animal movements, flood detection, forest fire detection, air pollution monitoring etc. due to the characteristic of deployment into the inaccessible areas. Some environmental applications such as forest fire detection, solar cell equipped sensor nodes are used in order to provide network longevity.

Environmental application of WSN include tracking the movements of birds, small animals, and insects; monitoring environmental conditions that affect crops , macro instruments for large-scale Earth monitoring and planetary exploration, chemical/ biological detection, precision agriculture, biological, Earth, and environmental monitoringin marine, soil, and atmospheric contexts, meteorological or geophysical research, bio-complexity mapping of the environment and pollution study etc.

(i) Bio Complexity Mapping of Environment: A bio-complexity mapping of theenvironment integrate information across temporal and spatial scales. Although satelliteand airborne sensors can observe large bio-diversity (e.g., spatial complexity of dominantplant species) but they cannot be able observe small size bio-diversity, which

2.3. Application Areas of WSNs

The WSNs have lots of application areas because of the diversity of sensing devices used in the applications. These devices have the ability to sense and detectthe thermal, acoustic, infrared, humidity, temperature, pressure, noise etc. phenomenon in the environment.

Every wireless sensor node characteristics depend on the requirements of applications. The categorization of application areas for WSNs is given below;

- Military applications.
- Environmental applications.
- Health applications.
- Smart home applications.
- Industrial applications.

The application space of WSNs shows that node density, network scale and sensor types change in large scale interval depending on the type of application.Large-scale application areas sometimes require thousands of sensor nodes, but in some applications such as smart home devices, a few sensor nodes can be sufficient.

2.3.1 Military Application

The WSN can be used in various fields of military. Its self-configuration, unattended operation, fault tolerance make it very useful for military application.

(i). **Battlefield Surveillance**: Critical terrains, approach routes, paths can be coveredwith the sensor networks and by using its data activities of the opposing forces can be examined. As the operations progress and new plans are prepared, new sensor networks can be deployed for the battlefield surveillance.

Chapter 3

System Architecture

The concept of network lifetime is one of the most important area of interest for the research in wireless sensor networks. Nodes deployment is the first step in establishing the sensor network. Sensor nodes are battery powered and randomly deployed in target area. After the deployment sensor network cannot perform manually. Optimizing the energy consumption is one of the major tasks in Wireless Sensor Networks is to prolong the network lifetime. To address these issues much work has been done in this area during the last few years. If the sensor nodes are deployed uniformly, the sensor nodes near the sink send their own data as well as the date collected by other nodes away from the sink in multi-hop fashion. In this case, the sensor nodes near the sink consume more energy than the node away from sin and die more quickly. As a result, the network will disconnect when 90% of nodes are alive having sufficient energy left unused. In this work, we investigate and try to remove the energy void problem. The energy imbalance in these protocols has been analyzed and the knowledge about the present sleep and awake mechanism of nodes has been taken into consideration to enhance the network lifetime for the Wireless Sensor Networks. The sleep and awake process has been focused here to eliminate the energy void problem. Further extensive simulations to investigate and confirm the performance of the proposed techniques has been done to obtain the comparative results.

3.1 Channel Propagation Model

As per the theory of electromagnetic wave received power is a decreasing function of the distance between the transmitter antenna and receiver antenna. There may be a direct line-of-sight (LOS) path between the transmitter and the receiver and this model is called Friis Free Space Propagation Model[17]. However the receiver may not locate in the LOS of the transmitter. As a result of that, E.M. wave will bounce off objects in theenvironment and arrive at the receiver from different paths at different times. The receiver receives the superposition of these multiple copies of the transmitted signal coming from different path. Each signal will experience differences in attenuation, delay and phase shift while travelling from the transmitter to the receiver. This can result in either constructive or destructive interference, amplifying or attenuating the signal power received at the receiver. This phenomenon is called multipath fading which can be roughly modeled as a power law function of the distance between the transmitter and receiver and two-ray model can be used for this.

Let Pt is the power delivered by the transmitter antenna in watt. For a moment assuming that the transmitter antenna is omnidirectional, lossless, then the received power density (w/m^2) at receiver end at a distance d from the transmitter antenna is

$$S_r = \frac{Power}{Area} = \frac{P_t}{4\pi d^2} \quad W/m^2 \qquad (3.1)$$

But any practical antenna has its own directivity. Here the directive gains of transmitter and receiver antenna are respectively Gt and Gr where both Gt and Gr are less than unity. The power density received actually because of directive gain of transmitting antenna is

$$S_r' = \text{power density} \times \text{Gain} = \frac{P_t}{4\pi d^2} \times G_t \qquad (3.2)$$

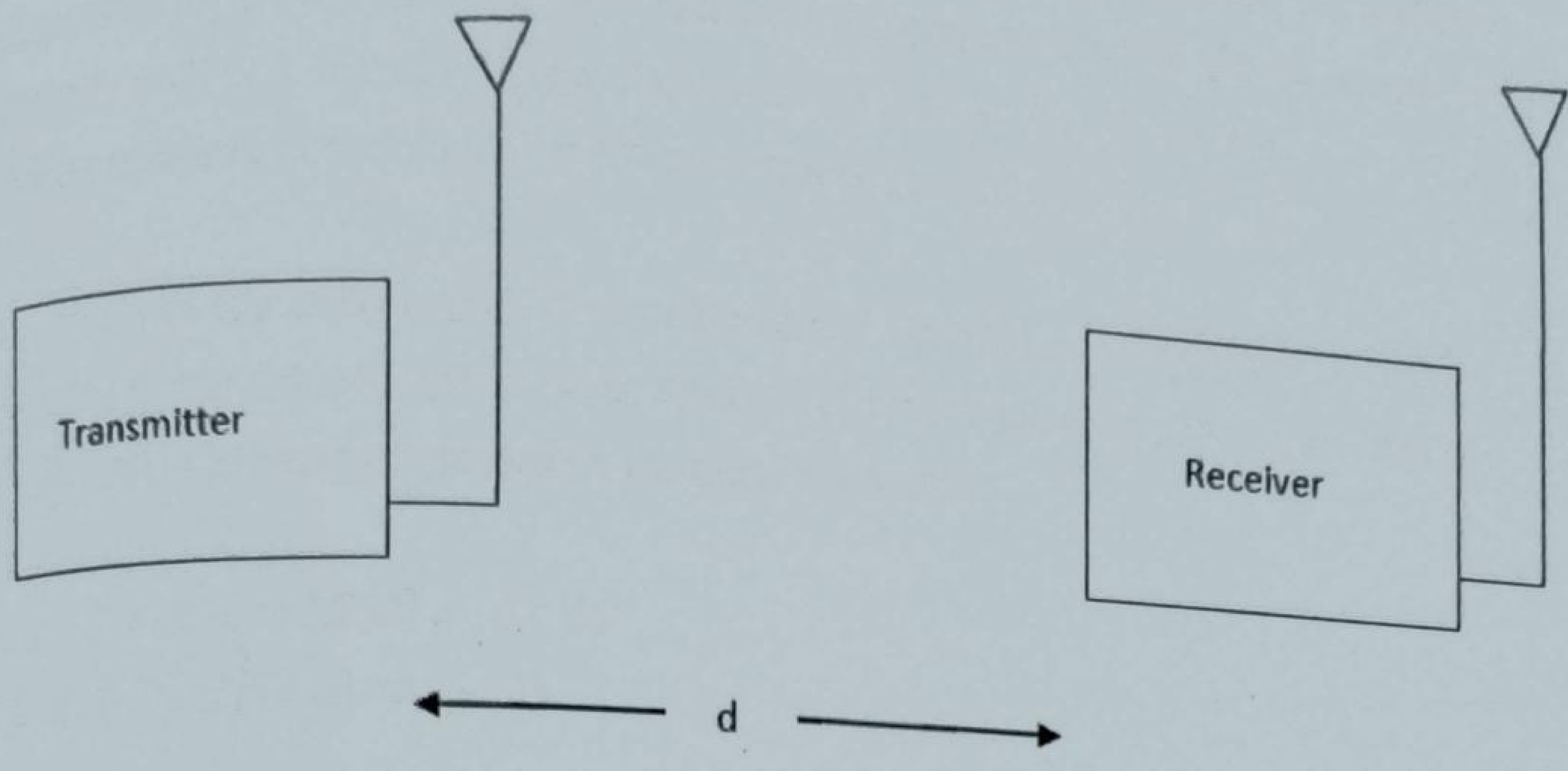

Figure 3.1: Friis Radio model

3.2 Radio Model for Energy calculation

The radio energy dissipation model is shown in Figure (3.2). It is assumed that both Friis free space (fs) and multi-path (mp) losses rely on the transmitter amplifier model and the respective node distances (d).

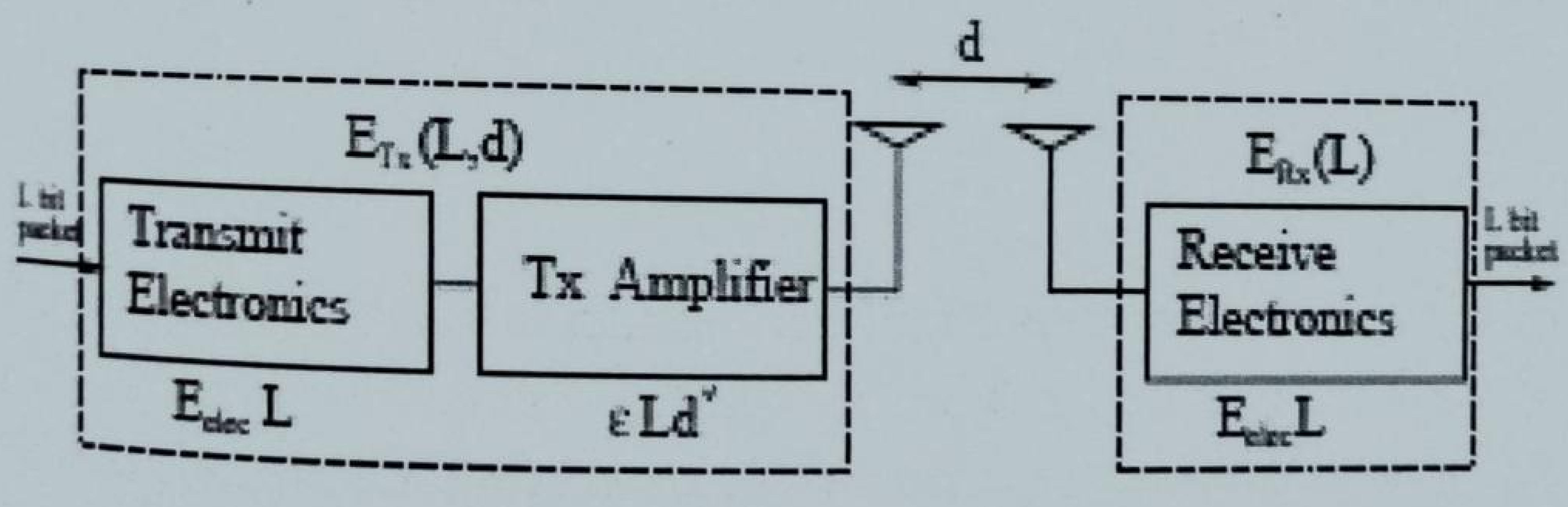

Figure 3.2: Radio Energy Dissipation Model

For relatively short distances the propagation loss can be modeled as inversely proportional to d2 whereas for longer distances the propagation loss can be modeled as inversely proportional to d4. Power control can be used to nullify this loss by setting the power amplifier to ensure a certain power at the receiver.

According to the radio energy dissipation model illustrated in figure and in order to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting an L-bit message over a distance d, the energy expended by the radio is given by:

$E_{TX}(L,d) = LE_{elec} + LE_{fs}d^2$ if $d < do$

$LEelec + LE_{mp}d^4$if $d > do$ (3.3)

whereEelec is the energy dissipated per bit to run the transmitter(E_{TX}) or the receiver circuit(E_{RX}). The E_{elec} depends on many factors such as the digital coding, the modulation, the filtering, and the spreading of the signal. The energy dissipated per bit in the transceiver electronics to be E_{elec} 50 nJ/bit. The terms fs and mp are path loss constant for Friis free space model and two ray model respectively and depend on the transmitter amplifier model The notation $d_{crossover}$ is the distance threshold for swapping amplification models, which can be calculated using the equation :

$d_{crossover}= \sqrt{\frac{\epsilon fs}{\epsilon mp}}$ (3.4)

3.3 Clustering:

Clustering is an approach to reduce communication between nodes and therefore minimize energy consumption. Researches show that clustering improves total performance of wireless sensor networks, such as communication overhead and network longevity etc. Clustering hundreds of nodes into many controllable smaller groups may eventually increase the performance of the network. Partitioning a network into many clusters will reduce the amount of traffic and the amount of energy consumed in network

[9]. Since energy efficiency is very important for network lifetime, clustering becomes crucial. If a sensor node needs to reduce its energy consumption, it should send its data packets to cluster heads firstly, instead of sending them directly to the sink

Sensor nodes could be grouped together based on their energy levels, sensed data types, proximity to each other or many other parameters. There are many efficient proposed ways for selecting cluster heads. However, as a starting point of the selection process, there should be two basic criteria; (1) nodes should have a unique identifier and (2) these identifiers should be uniformly distributed among nodes [13]. Some of the methods used for cluster head selection are; choosing nodes which are closer to the base station, choosing nodes randomly, or choosing the nodes that have highest or lowest parameters than neighbors, in which parameters could be residual energy level, neighbor count, package count, sensed value, unique identifiers etc. However, using simple clustering algorithms is not always efficient. If simple clustering algorithms such as selecting nodes with lowest or highest identifiers are applied, same nodes will be selected as cluster head many times.This results in quick energy drain of these selected nodes. Therefore, selection of cluster heads is also crucial to distribute load evenly among other nodes in order to minimize energy consumption. Some of the reasons for using clustering in wireless networks such as; to perform data aggregation in order to reduce total energy consumption and reduce the total number of packets transmitted, to disseminate queries to members, or to form an effective routing algorithm for the network. Also, clustering can be performed in single-level, which is the mostly used approach, or multi-level clusters can be performed - which is creating clusters inside a cluster.

Data aggregation is collecting data from member nodes, and transmitting the final data in a single packet to sink node. Data aggregation is widely used in clustering approach, because data from member nodes are collected by cluster heads and sent to the sink in a single packet, in order to reduce network traffic. When a sensor node receives two packets from two different source nodes, it can process incoming data packets and calculate the average readings, in order to send the final value as a single data packet. Another choice for a sensor node to aggregate data is to merge two different readings into

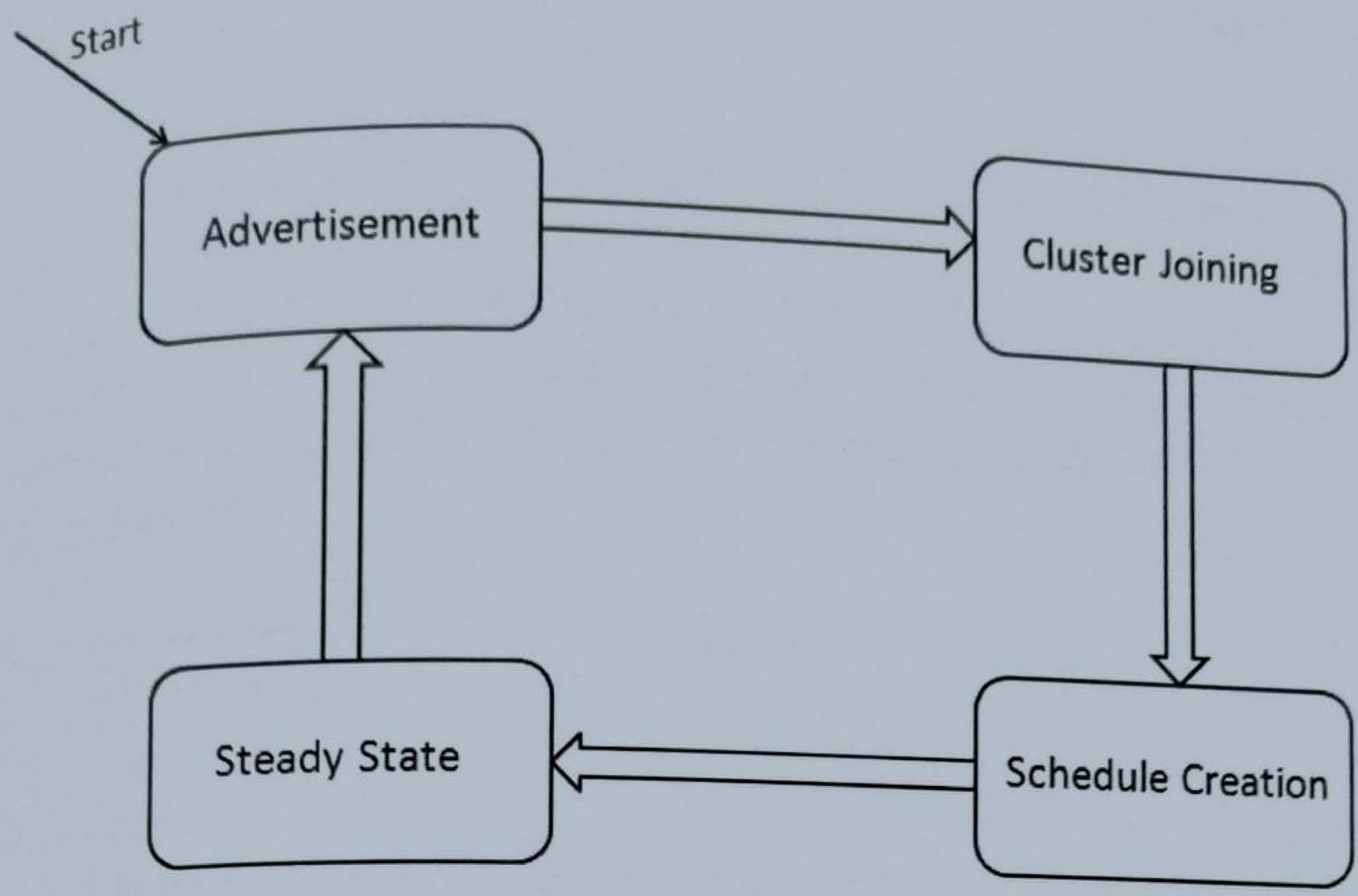

Figure 3.3: State Diagram of LEACH

3.4.1 Advertisement Phase:

In the advertisement phase Cluster-heads are chosen by some election rule. The algorithm is designed to choose a certain number of cluster k during each round and to distribute the energy dissipation among all the nodes in the network. But a cluster-head node is more energy-intensive than a normal node. A CH node must receive data from all nodes in the cluster, perform signal processing and transmit the data to the BS which may be far away from the CH. So evenly distributing the energy load among the network requires a cluster forming algorithm which should be designed such that nodes can become CHs approximately same amount of time, assuming all the nodes start with equal amount of energy. The CHs should be spread throughout the network to minimize the distance between normal nodes and CH.In Leach, CHs are elected from the sensors at the beginning of a round with a certain probability Pi(t) . This probability is chosen such that the expected number of cluster-head nodes for this round k.

$$E_{CH} = \sum_{i=1}^{N} Pi(t) = k \quad (3.5)$$

Where N is the total number of sensor nodes in the network. If it is assumed that all nodes should be CHs an equal number of times during the network lifetime then on average each node should be a CH once every N/k rounds. For selecting a CH, each sensor node generates a random number between 0 and 1. If the number is less than the threshold Pi(t), the sensor node selects itself as a CH for current round, the threshold is presented a follows:

$$P_i(t) = \frac{k}{N-k(mod\left(\frac{N}{k}\right))} \quad \text{if } C_i(t)=1 \quad (3.6)$$

$$= 0 \quad \text{if } C_i(t)=0$$

Here k is the predetermined percentage of CHs r is the number of round passed, and$C_i(t)$=1,if , ith node have not become a CH in the most recent (r mod(N/k)) rounds and $C_i(t)$=0, if it has become a CH in the recent round. Using this threshold, each node will be a CH at some round within every N/k rounds. After N/k rounds, all nodes are once again eligible to become CHs. Therefore only nodes that have not become CH recently and which have more energy than the nodes which have become a CH recently, may become CHs at (r+1) round. After r rounds, (k × r) number of nodes are expected to become CHs. So, the expected number of nodes that are not selected for CHs in the first r rounds is (N – k ×r). After (N/ k) rounds, all the nodes are expected to become CH at least once. As Ci(t) = 1 if node i is an eligible candidate to become CH, and is 0 otherwise. The term $\sum_{i=1}^{N} Ci(t)$represents the total number of nodes that are eligible to become a cluster-head at time t.

$$E(\sum_{i=1}^{N} Ci(t)= N - k(mod\left(\frac{N}{k}\right))(3.7)$$

Now, the expected number of cluster-heads per round, is given as:

$$E(CH) = \frac{k}{N-k(mod\left(\frac{N}{k}\right))} \text{ x } N - k(mod\left(\frac{N}{k}\right))(3.8)$$

Equation 3.4, when divided by n, gives:

$$T(n) = \frac{p}{1-p\left(r.mod\left(\frac{1}{p}\right)\right)} \quad \text{if } n\epsilon G \qquad (3.9)$$

$$= 0 \quad \text{otherwise}$$

Where G is the set of nodes that have not been CHs in the last 1/p rounds and p = k/N i.e. percentage of number of CHs from N nodes. Now each node chooses a random number between 0 and 1. If the number is less than the threshold T(n), the node will turn into a CH for the current round. Using this threshold, each node will be a CH at some round within 1/p rounds. After 1/p rounds, all nodes are once again eligible to become CHs.

3.4.2 Cluster-Set up Phase

Once the cluster-heads have been elected among the sensors using the probability equation, cluster-head inform other nodes in network that they have been chosen CH for this current round by broadcasting an advertisement message. The transmit power of this advertisement message should be high enough so that all nodes in the network can hear this. Each non-CH decides to which cluster it belongs, by choosing nearest CH that requires the minimum communication energy, based on received signal strength of advertisement message.After each node has determined to which cluster it belongs, it must inform the CH node that it will be a member of the cluster. Each node transmits this information back to the CH again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on. The CH node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the CH node creates a TDMA schedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster.

3.4.3 Schedule Creation

The CH node receives all the messages for nodes that would like to be included in the cluster. Based on the number of nodes in the cluster, the CH node creates a

TDMAschedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster.

3.4.4 Steady State

During the steady-state phase, the sensor nodes can begin sensing and transmitting data to CHs. The radio of each non-CH node can be turned off until the nodes allocated transmission time. The CH node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the CH node performs signal processing functions to compress the data into a single signal which is called data, aggregate and then sending it to the sink.

3.4.5 Data Aggregation

Data aggregation which is also known as data fusion can combine several unreliable data measurements to construct a more accurate signal by enhancing the common signal and reducing the uncorrelated noise. Data aggregation can be performed on all the unprocessed data at the BS or it can be performed locally at the cluster-heads. If the energy for communication is greater than the energy for computation performing data aggregation locally at the cluster-head can reduce the overall system energy consumption since much less data needs to be transmitted to the BS. To prove this, an analytical method is discussed. Suppose that the energy dissipation per bit for data aggregation is EDA and the energy dissipation per bit to transmit to the BS is ETX. Also assume that every L bits that must be sent to the BS when no data aggregation is performed only 1 bitmust be sent to the BS when local data aggregation is performed. So, the energy toperform local data aggregation and transmit the aggregate signal for every L bits of data is :

$$E_{withDA} = L \times E_{DA} + E_{TX} \qquad (3.10)$$

The energy to transmit all L bits of data directly to the BS is:

$$E_{noDA} = L \times E_{TX} \qquad (3.11)$$

Therefore performing local data aggregation will be more efficient than sending all the unprocessed data to the BS when

$E_{withDA} < E_{noDA}$ (3.12)

$L \times E_{DA} + E_{TX} < L \times E_{TX}$ (3.13)

$E_{DA} < \frac{L}{L-1} E_{TX}$ (3.14)

proves that data aggregation performed locally at the cluster-head can reduce the overall system energy consumption.

3.5The Optimized LEACH

The nodes are randomly deployed in the network. Initially, all the nodes are having intial energy, Eo. Initially, after the node deployment the neighbour node discovery takes place. For each node, wanting to be the cluster-head chooses a value, between 0 and 1. This random number is compared with the threshold value in stochastic algorithm for election of CH's.The node regions are divided into clusters and data is aggregated and sent to cluster heads (CH's), these cluster heads then forward this data to the base station. The selection of Cluster head is done as described:

The base station transmits a starting message packet to all the nodes. This message and all the nodes respond to it. The sensor nodes are required to forward their location, id and energy information to base station over the network. This is followed by base station sending another packet to inquire about the node as to which logical zone, they currently belong to. This packet valuable message for the nodes as their logical positioning depends on this message packet. Nodes near BS connect themselves with BS. Other nodes are divided in two regions and use clustering topology. CHs are elected in each region separately. Let 'r' represent the number of rounds to be a CH for the node Si, we call it epoch. each node elect itself as a CH once every r = 1/p rounds. At the start of first round all node in both regions has equal energy level and has equal chance to become CH. After that CH is selected on the basis of the remaining energy of sensor node and with a probability p alike LEACH, in each round, it is required to have n x p CHs. A node can become CH only once in a epoch and the nodes not elected as CH in the current round feel right to the set C. The probability of a node to (belongs to set C) elect as CH increases in each round. It is required to uphold balanced number of CHs. At the start of each round, a node Si belongs to set C autonomously choose a random number between 0 to 1. If the generated random number for node Si is less than a predefined threshold T(s) value then the node is becomes CH in the current round.

3.5.2Scheduling

Scheduling is an important concept in clustering. When some nodes are elected as cluster heads and other nodes become member of their corresponding cluster head, member node starts communication with cluster heads. So, it can become fairly impossible for the cluster heads to respond to each and every node in the cluster. Thus a time division is assigned by the cluster heads to all the nodes. All the associated nodes transfer data to cluster heads in its own scheduled time slot. While a particular node is transmitting, all other nodes stay idle. Nodes thus can know their own transmission schedule and need to be turned on only at times its transmission time. This method thus saves lot of energy for the individual nodes and for the network as a whole.

3.5.3Steady-State Phase:

The steady state phase refers to the actual operational phase of the network. The cluster heads receive data packets from their respective associated nodes and forward this data packet to the base station. The process continues until the nodes die out of their energy after a certain number of rounds, called the lifetime of the network.

Once the clusters are created, the sensor nodes are allotted timeslots to send the data. When a node receives data from one its neighbours, it aggregates it with its own data. It uses a heuristic function to make this decision and the heuristic function is given by,

$$h = K (Eavg / h\ min * t) \qquad 3.15$$

The path with highest heuristic value is chosen or else the path with the next highest heuristic value is chosen.

After the paths are chosen, then their minimum energies are compared for efficient transmission.

It uses a energy relation to make this decision and the relation is given by,

$$Emin > threshold, \text{ where } Emin = Eavg / const \qquad 3.16$$

CHAPTER 4
SIMULATION RESULTS

The implementation of the proposed algorithm has been done in MATLAB software using its various toolboxes, MATLAB graphics functions and basic programming structure of the software. MATLAB is a high end technical programming language which is used extensively in industrial and academic research. It contains an easy to use programming language which is pseudo code or algorithm based. Itmeans that the algorithm or pseudo code easily converts into a workable program. The toolboxes give an added advantage for programmers. The toolbox is a package or collection of built in domain specific functions which are ready to use. There are about more than hundred toolboxes in MATLAB which makes the task of scientists, researchers and students' task easier working in these domains.

The implementation results and simulation are discussed and analyzed in detail. Network software setup requires certain parameters derived from the radio model of a typical Wireless Sensor network architecture as has been described in Chapter 3. The various equations defining the energy dissipation process in the wireless sensor network has been implemented in the software. The various network modelling parameters with their values are shown in the Table 4.1. For this simulation the network area is 200mx200m. The base station is placed at location x=100, y=100 in the network area. The division shows the different cluster formation in the network area. The number of nodes is taken to be 200. The network is simulated for 2500 rounds. The rounds are equivalent to a certain time scale. After every round the energy dissipation factor from different sources is accumulated to calculate the average energy left in each node.

Table 4.1: **Network Simulation Parameters**

Parameters	Values
Network Area	200m
Threshold distance, d0	$sqrt(E_{fs}/E_{mp})$
Energy consumed in the electronics circuit to transmit in or receive the signal, E_{elec}	50 nJ/bit
Energy consumed by the amplifier to transmit at a short distance, E_{fs}	10 pJ/bit/m_2
Energy consumed by the amplifier to transmit at a longer distance, Emp	0.0013 pJ/bit/m_4
Data Aggregation Energy, EDA	5 nJ/bit/signal
Initial Energy, E0	0.5 J
Selection Probability	0.1

The selection probability for a node to become a cluster head is taken as 0.1, i.e. out of all the available nodes 10 percent can become cluster heads.

4.1: Algorithm:

The pseudocode or algorithm for software implementation of this research work is thoroughly explained in this section.

1. Set network parameters as given in table 4.1

   X & Y co-ordinates of the network area: xm=200; ym=200

   Location of Base Station BSx=100, BSy=100;

Number of nodes for simulation: n = 200;

Assign selection probability, p=0.1;

2. Set energy Parameters as given in table 4.1
3. Initialise random node positions
4. Assign initial cluster heads =0.
5. Assume that base station is also a node sp total no of nodes is n and with base station it is n+1.
6. Initialize Counter for dead nodes, alive nodes, first dead node and packets transmitted by the nodes.
7. Initialise counter for sleep nodes as zero and threshold energy for sleep or inactivity as, th=0.00000000000001. The inactive nodes are checked and counter for inactive nodes is incremented in each loop, as per below:

```
if(S1(i).E<=th&& S1(i).E>0)
s1=s1+1;
end
```

8. The remaining nodes are taken as the active nodes and participate in the clustering process, as per the equation given in chapter 3.
9. The cluster heads are seleceted and the distance is calculated to derive the energy dissipation in each round.
10. The remaining nodes(non cluster heads) are associated with the cluster heads for transmission of data packets by finding out the minimum distance from each nodes to the available cluster head in each node.

```
for c=1:1:cluster1-1
        temp=min(min_dis,sqrt( (S1(i).xd-C(c).xd)^2 + (S1(i).yd-C(c).yd)^2 ) );
if( temp<min_dis )
min_dis=temp;
        min_dis_cluster1=c;
end
end
```

11. Calculate the residual energy, packets transmitted and number of dead nodes after each round and update the respective counter variables.
12. Plot the various data graphically.

4.2: Simulation Results:

The simulation results have been plotted as graphs between various parameters obtained and the number of rounds as shown in below figures.

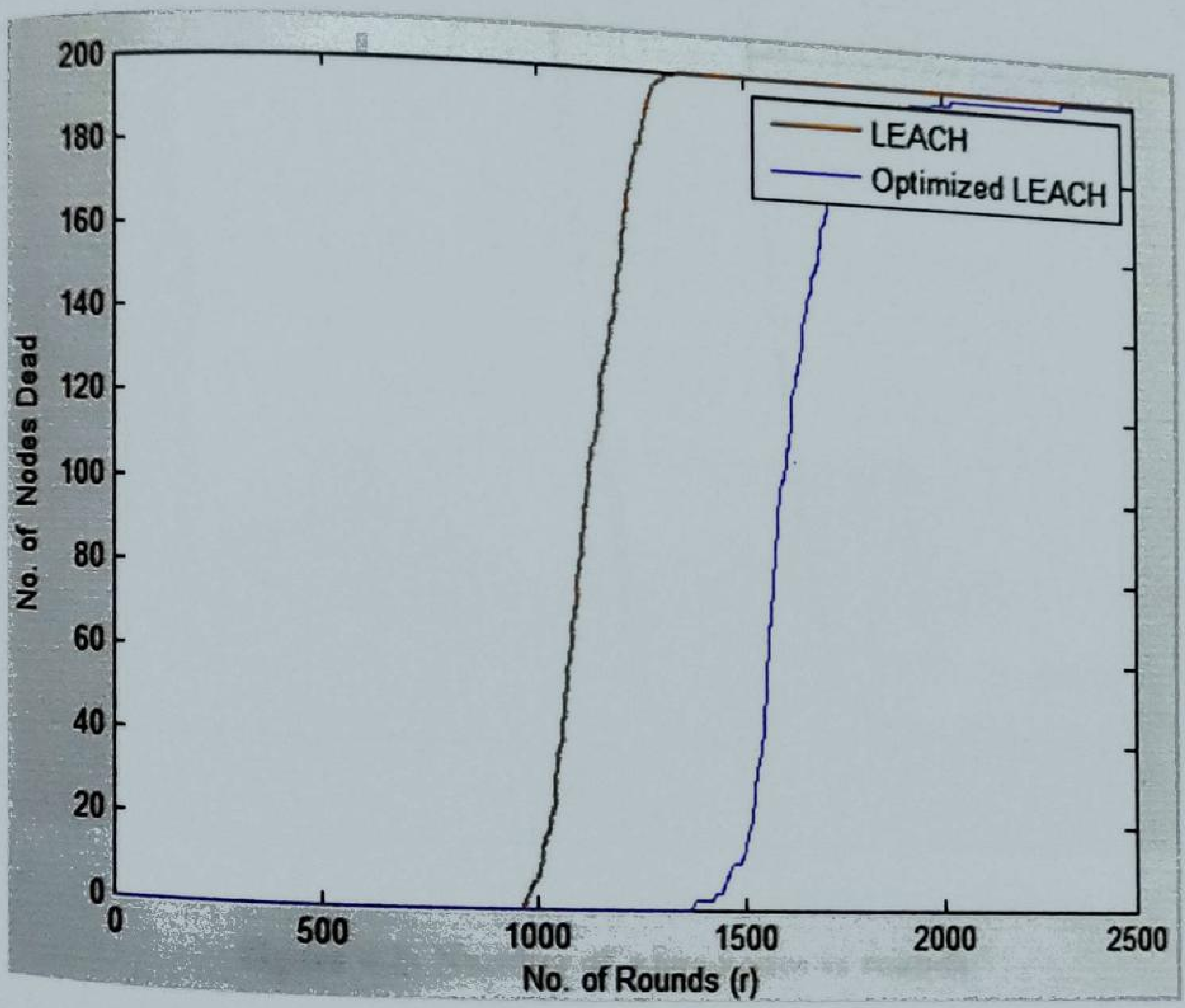

Figure 4.1: Number of Dead nodes vs rounds

The above figure 4.1 shows the comparison of the modified LEACH protocol proposed in this research work with that of the LEACH protocol. As shown from the figure 4.1 the modified LEACH method has a considerable improvement in terms of nodes getting inactive or dead. The first dead node in the LEACH protocol under similar simulation parameters and network parameters occurs at around 941 rounds whereas in the modified

LEACH algorithm the first dead node occurs at around 1395 rounds. This is a notable improvement in the lifetime of the network. Similarly, the nodes die out completely at around 1400 rounds in LEACH protocol whereas in the modified LEACH protocol the network dies out a t round number 2247. This further affirms the effectiveness of the modified LEACH protocol. The below figure shows the number of alive nodes plotted against the number of rounds.

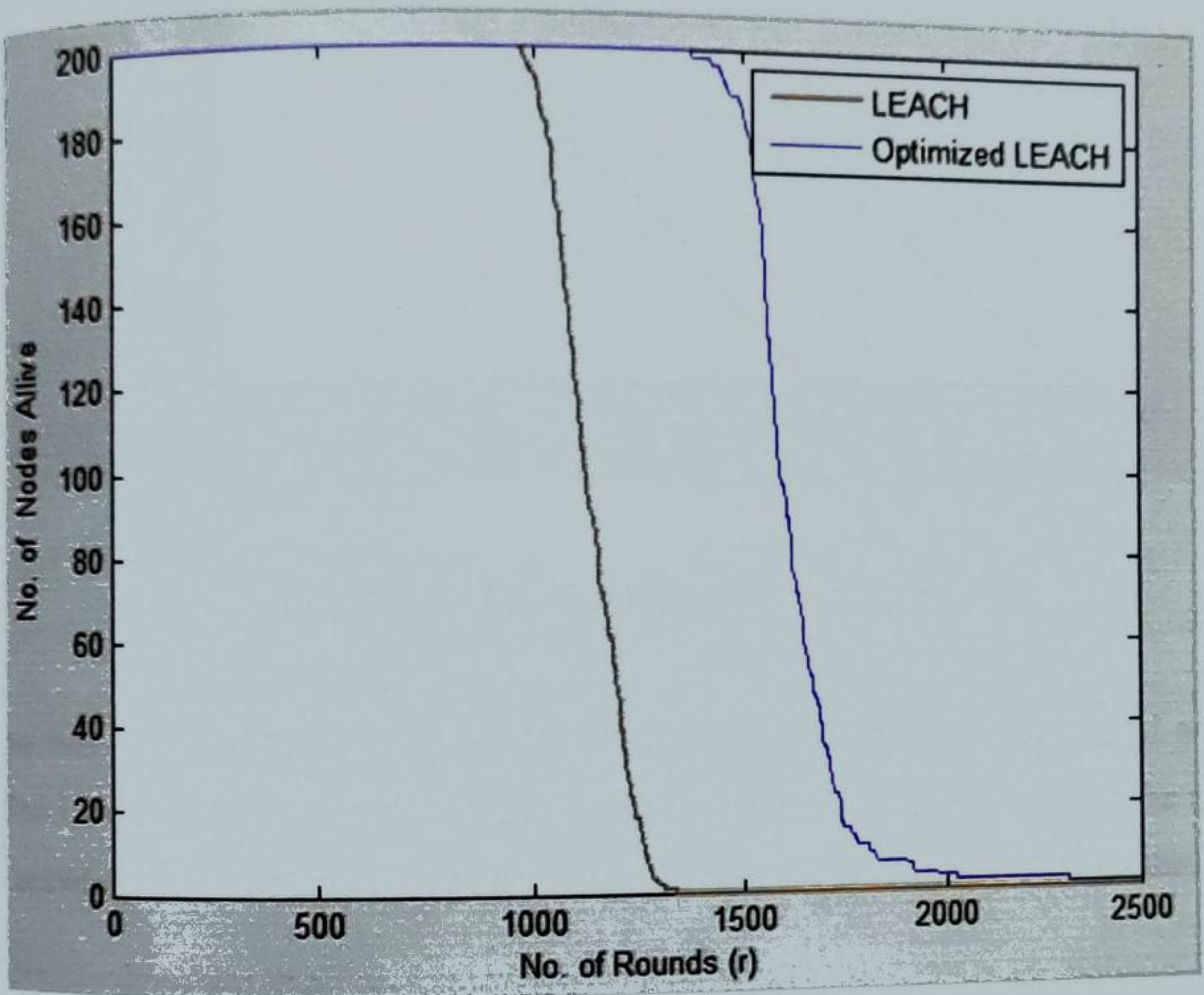

Figure 4.2: Number of Alive nodes vs rounds

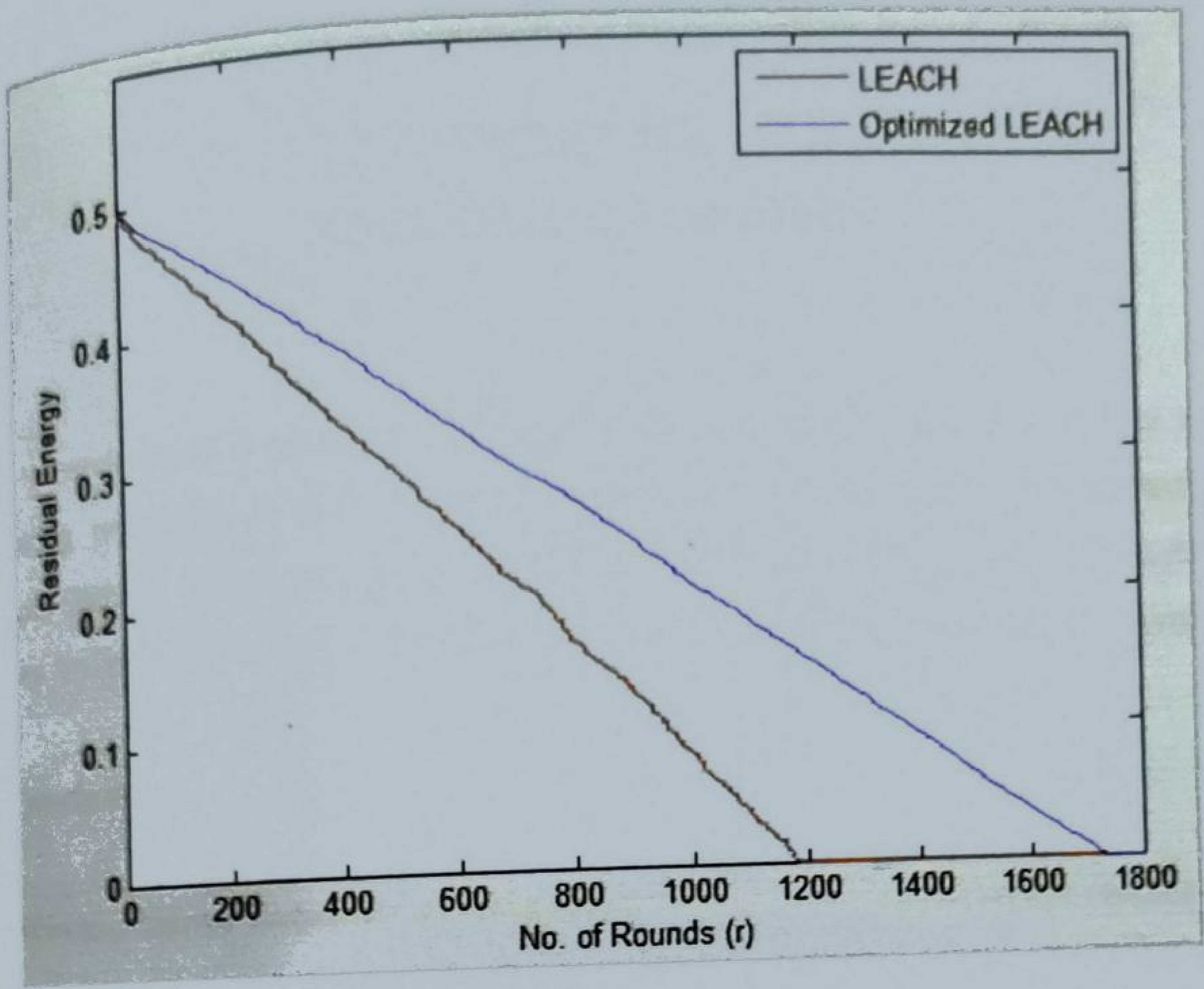

Figure 4.3: Residual Energy vs rounds

The residual energy graph giving a comparison between the LEACH protocol and the modified LEACH protocol is shown in the figure 4.3. As shown in the graph the energy of the networks is increased in the proposed protocol and hence the network lifetime.

Chapter 5:
Conclusion and Future Work

This research work is aimed at studying the Wireless sensor Networks and its various clustering protocols. It also aimed at suggesting novel algorithm for increasing the network lifetime by improving the battery life of the sensors. The below sections describe the key findings of this research work and give a brief summary of the research work.

5.1 Conclusion

The Wireless Sensor Networks are always constrained with limited power sources and at the same time the power requirements are towards the higher side with a lot of task assigned to the tiny battery powered sensor nodes viz. sensing, collecting data, sending data packets to the base station etc. All these functions are quintessential for any network and consume a lot of battery power. Thus, the design of communication protocols is always focused on saving the energy of sensor nodes to increase the energy efficiency of such networks.

The current research work is also focused on suggesting a protocol, which is based on optimizing the energy utilization. They follow a standard LEACH based clustering to send their data packets to the respective cluster heads which in turn send it to the Base Station.The algorithm was successfully implemented on MATLAB software tool, with some standard parameters as available in various previous research methodologies. The results were compared against the LEACH protocol and has shown a considerable improvement in number of alive nodes after 2500 rounds. The number of dead nodes is less as compared to the LEACH protocol, thus showing that this proposed method is more effective and increases the overall network existence time.

5.2 Future Work:

The Wireless Sensor Network paradigm has always focused on Additional and advanced strategy to improve the performance of the wireless sensor network and make the network more efficient. One of the approaches can be that to include the geographical information of the nodes in the network formation. Studies can be made further to include this information in between the clusters as well so as to improve the inter-cluster information. The working of the current proposed algorithm can also be studied and verified by other researchers on varying kinds of network structure to check its feasibility of the proposed work.

References

1) G. Vijayalakshmi, S. Hema and S. Geethapriya, "Secure Data Aggregation & Query Processing in Wireless Sensor Networks using Enhanced Leach Protocol", International Journal of Emerging Science and Engineering, Vol. 2, No. 1, pp. 51-56, 2013.
2) M. Umashankar and C. Chandrasekar, "Energy Efficient Secured Data Fusion Assurance Mechanism for Wireless Sensor Networks", European Journal of Scientific Research, Vol. 49, No. 3, pp. 333-339, 2011.
3) Kumar Padmanabh and Sunil Kumar Vuppala, "An Adaptive Data Aggregation Algorithm in Wireless Sensor Network with Bursty Source", Wireless Sensor Network, Vol. 1, No. 3, pp. 222-232, 2009.
4) interagency workshop on research issues for smart environments," IEEE Personal Communications (October 2000) 36–40.
5) V. Bhoopathy and R. M. S. Parvathi, "Energy Efficient Secure Data Aggregation Protocol for Wireless Sensor Networks", European Journal of Scientific Research, Vol. 50, No. 1, pp. 48-58, 2011
6) Vaibhav Pandey, Amarjeet Kaur and Narottam Chand, "A review on data aggregation techniques in wireless sensor network", Journal of Electronic and Electrical Engineering, Vol. 1, No. 2, pp. 1-8, 2010.
7) Nandini. S. Patil and P. R. Patil, "Data Aggregation in Wireless Sensor Network", IEEE International Conference on Computational Intelligence and Computing Research, 2010.
8) Kiran Maraiya, Kamal Kant and Nitin Gupta, "Wireless Sensor Network: A Review on Data Aggregation", International Journal of Scientific & Engineering Research, Vol. 2, No. 4, pp. 1-6, 2011.
9) Sung-Hwa Hong, Jeong-Min Park and Joon-Min Gil, "Performance Evaluation of a Simple Cluster-Based Aggregation and Routing in Wireless Sensor Networks", International Journal of Distributed Sensor Networks, Vol. 2013, Article ID: 501594, pp. 1-9, 2013.
10) Manjeshwar and D. P. Agarwal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2001
11) Manjeshwar and D. P. Agarwal, "APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks,
12) "Parallel and Distributed Processing Symposium., Proceedings International, IPDPS 2002, pp. 195-202.

13) U. Sajjanhar, P. Mitra, —Distributive Energy Efficient Adaptive Clustering Protocol for Wireless Sensor Networks‖, Proceedings of the 2007 International Conference on Mobil Data Management, pp. 326 - 330, 2007.
14) ElbhiriBrahim,SaadaneRachid,Alba-Pages Zamora, DrisAboutajdine, —Stochastic Distributed Energy-Efficient Clustering (SDEEC) for heterogeneous wireless sensor networks‖, ICGST-CNIR Journal, Volume 9, Issue 2, December 2009.
15) Inbo Sim, KoungJin Choi, KoungJin Kwon and Jaiyong Lee,—Energy Efficient Cluster header Selection Algorithm in WSN‖, International Conference on Complex, Intelligent and Software Intensive Systems , IEEE, 2009.
16) Ma Chaw Mon Thein, Thandar Thein —An Energy Efficient Cluster-Head Selection for Wireless Sensor Networks‖, International Conference on Intelligent Systems, Modeling and Simulation, IEEE 2009
17) Dilip Kumar, Trilok C. Aseri, R.B. Patel, —EEHC: Energy efficient heterogeneous clustered scheme for WSNs‖, ELSEVIER, Computer Communications, 32 (2009) 662–667
18) Yingchi Mao, Zhen Liu, Lili Zhang, Xiaofang Li, —An Effective Data Gathering Scheme in Heterogeneous Energy WSNs, International Conference on Computational Science and Engineering,2009.
19) E.M. Petriu, N.D. Georganas, D.C. Petriu, D. Makrakis, and V.Z. Groza, "Sensor-based information appliances," IEEE Instrumentation and Measurement Magazine (December 2000) 31–35.
20) G.D. Abowd, J.P.G. Sterbenz, "Final report on the
21) S. Hammadi and C. Tahon, "Special issue on intelligent techniques in flexible manufacturing systems," in IEEE Transactions on Systems, Man and Cybernetics, May 2003, pp. 157 - 158.
22) L.Chou, L. Gen-Chung, "Location management using fuzzy logic control for wireless networks," in International Conferences on Info-tech and Info-net, Oct. 2001, pp. 339 - 344.
23) M.N. Halgamuge, S.M. Guru, A. Jennings, "Energy efficient cluster formation in wireless sensor networks," in 10th International Conference on Telecommunications, Mar. 2003, pp. 1571 - 1576.
24) L. Reznik, V. Kreinovich, "Fuzzy and probabilistic models of association information in sensor networks," in proc. IEEE International Conference on Fuzzy Systems, Jul. 2004, pp. 185 - 189.
25) "The Net's Original Fuzzy Logic Archieve – Since 1994," [Online]. Available: www.austinlinks.com/Fuzzy/. Demirbas M., Arora A., Mittal V., Kulathumani V. Design and analysis of a fast local clustering ser¬vice for wireless sensor networks. IEEE.

26) J. Wan, D. Yuan, and X. Xu. A Review of Cluster Formation Mechanism for Clustering Routing Protocols, 11th IEEE International Conference on Communication Technology(ICCT),pp. 611-616, 2008.
27) Mainwaring, Alan, et al. "Wireless sensor networks for habitat monitoring." Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications.ACM, 2002.
28) Burrell, Jenna, Tim Brooke, and Richard Beckwith. "Vineyard computing:Sensor networks in agricultural production." Pervasive Computing, IEEE 3.1 (2004): 38-45.
29) Ye, Mao, et al. "EECS: an energy efficient clustering scheme in wireless sensor networks." Performance, Computing, and Communications Conference, 2005.IPCCC 2005.24th IEEE International.IEEE, 2005.
30) Li, Chengfa, et al. "An energy-efficient unequal clustering mechanism for wireless sensor networks." Mobile Adhoc and Sensor Systems Conference, 2005.IEEE International Conference on.IEEE, 2005.
31) Heinzelman, Wendi Rabiner, AnanthaChandrakasan, and Hari Balakrishnan. "Energy-efficient communication protocol for wireless microsensor networks."System Sciences, 2000.Proceedings of the 33rd Annual Hawaii International Conference on.IEEE, 2000.
32) Lindsey, Stephanie, and Cauligi S. Raghavendra. "PEGASIS: Powerefficient gathering in sensor information systems." Aerospace conference proceedings, 2002.IEEE.Vol. 3.IEEE, 2002.
33) Younis, Ossama, and Sonia Fahmy. "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks." Mobile Computing, IEEE Transactions on 3.4 (2004): 366-379.
34) Loscri, V., G. Morabito, and S. Marano. "A two-levels hierarchy for low-energy adaptive clustering hierarchy (TL-LEACH)." IEEE Vehicular Technology Conference.Vol. 62.No. 3.IEEE; 1999, 2005.
35) Jafri, Mohsin Raza, Nadeem Javaid, AkmalJavaid, and Zahoor Ali Khan. "Maximizing the Lifetime of Multi-Chain PEGASIS Using Sink Mobility." World Applied Sciences Journal 21, no. 9 (2013): 1283-1289.
36) Jennifer Yick, Biswanath Mukherjee, and Dipak Ghosal. Wireless sensor network survey. Comput.Netw., 52(12):2292–2330, August 2008.
37) Kamalrulnizam Abu Bakar MarjanRadi, Behnam Dezfouli and Malrey Lee. Multipath routing in wireless sensor networks: Survey and research challenges. MDPI Sensors, 12(1):650–685,January 2012.
38) J. N. Al-karaki and A. E. Kamal.Routing techniques in wireless sensor networks: A survey.IEEE Wireless Communications, 11(6):6–28, December 2004.

39) Kemal Akkaya and Mohamed Younis. A survey on routing protocols for wireless sensor networks. Ad Hoc Networks, 3:325–349, 2005.

40) Dongjin Son, BhaskarKrishnamachari, and John Heidemann.Experimental study of concurrent transmission in wireless sensor networks. In Proceedings of the 4th international conference on Embedded networked sensor systems, SenSys '06, pages 237–250, New York, NY, USA, 2006. ACM.

41) HarneetKour, Ajay Sharma." Hybrid Energy Efficient Distributed Protocol for Heterogeneous Wireless Sensor Network", International Journal of Computer Applications (0975 – 8887) Volume 4 – No.6, July 2010

Annexure IV
BBDU-PG-FORM 02

BABU BANARASI DAS UNIVERSITY, LUCKNOW

CERTIFICATE OF THESIS SUBMISSION FOR EVALUATION (Submit in Duplicate)

1. Name : ....AMITOSH PANDEY...

2. Enrollment No. : ...11704540647...

3. Thesis title: ...A NOVAL APPRUACH FOR REDUCING ENERGY....... CONSUMPTION IN ROUTING PROTOCOL FOR CLUSTERED ....WIRELESS SENSOR NETWORKS.........................

4. Degree for which the thesis is submitted: ...M.TECH...

5. Faculty of the University to which the thesis is submitted

   ....

6. Thesis Preparation Guide was referred to for preparing the thesis. ☑ YES ☐ NO

7. Specifications regarding thesis format have been closely followed. ☑ YES ☐ NO

8. The contents of the thesis have been organized based on the guidelines. ☑ YES ☐ NO

9. The thesis has been prepared without resorting to plagiarism. ☑ YES ☐ NO

10. All sources used have been cited appropriately. ☑ YES ☐ NO

11. The thesis has not been submitted elsewhere for a degree. ☑ YES ☐ NO

12. Submitted 2 spiral bound copies plus one CD. ☑ YES ☐ NO

Amitosh Pandey
(Signature of the Candidate)
Name:..AMITOSH...PANDEY...........
Roll No ...1170454001.................
Enrollment No.:11704540647...

Annexure V

BBDU-PG-FORM 01

BABU BANARASI DAS UNIVERSITY, LUCKNOW

CERTIFICATE OF FINALTHESIS SUBMISSION

(To be submitted in duplicate)

1. Name : ....AMITOSH PANDEY.......................................
2. Enrollment No. : ....11704540647.......................................
3. Thesis title: ...A NOVAL APPROACH FOR REDUCING ENERGY CONSUMPTION IN ROUTING PROTOCOL FOR CLUSTERED WIRELESS SENSOR NETWORKS..........
4. Degree for which the thesis is submitted: ....M.TECH.......................................
5. School (of the University to which the thesis is submitted) ....SCHOOL OF ENGINEERING..........
6. Thesis Preparation Guide was referred to for preparing the thesis. ☑ YES ☐ NO
7. Specifications regarding thesis format have been closely followed. ☑ YES ☐ NO
8. The contents of the thesis have been organized based on the guidelines. ☑ YES ☐ NO
9. The thesis has been prepared without resorting to plagiarism. ☑ YES ☐ NO
10. All sources used have been cited appropriately. ☑ YES ☐ NO
11. The thesis has not been submitted elsewhere for a degree. ☑ YES ☐ NO
12. All the corrections have been incorporated. ☑ YES ☐ NO
13. Submitted 4 hard bound copies plus one CD.

(Signature(s) of the Supervisor(s))

Name(s):...Akhilesh Kr. T. Maurya....

(Signature of the Candidate)

Name:....AMITOSH PANDEY

Roll No .....1170454001.................

Enrollment No.:..11704540647.....

Scanned by TapScanner

PLAGIARISM REPORT

Student Name	:	Amitosh Pandey
Roll No	:	1170454001
Thesis Title	:	A Novel Approach for reducing Energy Consumption in Routing Protocol for Clustered Wireless Sensor Networks.
Guide	:	Associate Professor Akhilesh Kumar Maurya Babu Banarasi Das University, Lucknow

Plagiarism Report Detail :

88.45 % Unique Contents

11.54 % Plagiarism

This report is within the permissible limit of plagiarism. This may be allowed to be submit their report to the concerned authority.

Amitosh Pandey
Student Signature

Department of ECE Engineering

Master of Technology

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

A Review of Wireless Sensor Networks and Clustering Topologies

Amitosh Pandey[1], Akhilesh Kumar Maurya[2]
[1]Deptt. of ECE, BBD University, Lucknow
[2]Associate Professor, Deptt. of ECE, BBD University, Lucknow

Abstract: Wireless sensor networks (WSNs) are a combination of wireless sensor nodes, which have computation capabilities with sensing of various physical and environmental conditions. Recently, WSNs have found usage in a number of application areas including medical, defense, surveillance, farming etc. One of the important research aspects in WSN has been towards adequate and effective mechanisms for data forwarding to enhance the energy efficiency in networks. In this paper, a survey of various topologies related to Wireless Sensor Networks has been presented. Also, a review of various existing energy efficient routing protocols has also been presented.

Keywords: Wireless Sensor Network, Routing, LEACH.

I. INTRODUCTION

Wireless Sensor Nodes involves various sensor nodes to form an extensive system. The sensors can detect ecological conditions like sounds, temperature, weight, course and so on. These sensor nodes communicate with each other or to the base station (control station) after sensing. Such sensor nodes are comprised a compact electronic modules which needs to be small and lightweight [1]. The underlying exploration of WSN was persuaded by the military applications. However, WSN has been progressively been utilized in non-military personnel applications. A sensor node most commonly consists of microprocessor or microcontroller based processing unit, sensing circuitry, a battery and a transceiver. A sensor unit is additionally separated into two sub units which are known as sensors and ADC. The analog signals produced by the sensors depending on the observed phenomenon is converted to digital signals by the ADC and then passed into the processing unit. Handling unit comprises from capacity, which is utilized for briefly capacity of data and passes the data to different hubs to perform detecting task. Handset passes information to different hubs present in the system from the present hub. The power unit comprises of vitality sources, for example, batteries and sunlight based cells [4]. To make sensor nodes versatile, an assemble gadget is utilized which makes the hub versatile to the earth.

Sensor nodes collect the sensed data for a period of time and can send it to the nearest base station themselves through direct delivery. Although this is the most common approach, the use of this method leads to heavy network traffic and as the nodes are limited by energy, this reduces the network's lifetime. The sensor network consists of a sensor field in which the sensor devices or nodes in this field are scattered. Multi-hop techniques and router-based infrastructure can be used to preserve a substantial amount of energy over the network's long run. The dynamic parameters present in this type of network are restricted following few of the parameters that could dynamically change depending on the application:

A. Power Availability.
B. Nodes Positioning.
C. Reachability.
D. Type of Task.

Clustering or hierarchical protocols were designed to address issues of energy management in WSNs. The clustering based protocols are based on the concepts that the nearby nodes form a cluster or group of nodes. Each node in the cluster forwards its data packets to an elected node known as cluster head which then forwards it to the base station. This increases the energy

II. LITERATURE SURVEY

Clustering techniques were developed to address issues of energy management in Wireless Sensor Network. A pioneering work in this regard is the Low Energy Adaptive Clustering Hierarchy (LEACH)[5]. LEACH is a clustering-based protocol that uses randomized local cluster base station selection and rotation also called as cluster heads for transferring data to the sink node, in order to preserve energy evenly between the sensors in the network. Cluster head rotation is also a tool for fault tolerance [1]. The

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

sensors organize themselves into clusters to randomly elect themselves as heads in an epoch using a probabilistic method. The LEACH protocol, however, is not heterogeneous in the way that sensors die faster than a more uniform energy setting [10], when there is an energy difference at some threshold between these nodes in the network. A probability-based clustering algorithm was proposed in the Distributed Energy-Efficient Clustering Algorithm (DEEC) [12]. DEEC chooses cluster heads based on information about the relationship between each node's residual energy and the network's average energy. However, this knowledge requires additional energy consumption information to be shared between the sensor nodes. Stable Election Protocol (SEP)[13] is another heterogeneity-aware protocol that does not require sharing of energy knowledge but is based on assigning weighted node election probabilities to be elected cluster head based on their respective energy. This approach ensures that the selection of the cluster head is randomly selected and distributed on the basis of each node's fraction of energy, thus ensuring uniform node energy use. H-DEEC and MH-DEEC [16], two variations of DEEC are the routing protocol for heterogeneous networks has been proposed as energy-conscious adaptive clustering protocols. In H-DEEC, based on initial and residual energy, the network is divided into two parts. Normal nodes choose to be cluster heads and Beta nodes collect data from cluster heads and use multi-hopping to send it to base station. Unlike SEP and DEEC, in a heterogeneous wireless sensor network, H-DEEC and MH-DEEC perform better. Moreover, it also considers the problem of locating base station outside the network.

III. MATHEMATICAL MODEL OF WSN

In many research on wireless sensor networks, the first order radio model is used. Energy is dissipated while transmitting and receiving data and energy consumption for short-range communication is d2 when propagation is in line of sight and d4 for long-range due to multi-path fading. It works on the measurements of the route and there is constant sensing resulting in a steady volume of data being transmitted to the sink. In an analytical implementation, the following assumptions are considered:

A. Base station is fixed: densely deployed and static wireless sensors. There is a predetermined number of clusters for the WSN. They will pass the data on the predefined path in which the cluster heads are numbered according to their distance based on the signal strength received (RSS).
B. Some sensors are further away from the base station, which is why the cluster head consumes the d4 energy for direct transmission of l bit data. Thus, data is passed through multiple hops and reaches the base station very close to the base station by cluster
C. Links are symmetrical, i.e. the same power level is required for communication between any two nodes. It is considered that there are no modifications in topology. Thus, to transmit a message of length to a distance d, the energy is given as:

If $d<d_0$ $$d_0 = sqrt(E_{mp}/E_{fs}) \quad (1)$$

If $d \geq d_0$ $$Et_x(k,d)=E_{elec}*k+E_{mp}*k*d_4 \quad (2)$$

Reception Energy: $$E_{tx}(k,d)=E_{elec}*k+Emp*k*d_4 \quad (3)$$

$$E_{rx}(k)=E_{ele}c*k \quad (4)$$

Where Eelec is the energy dissipated in transmission and reception, Efs and Emp are free space and amplifier enegy respectively.

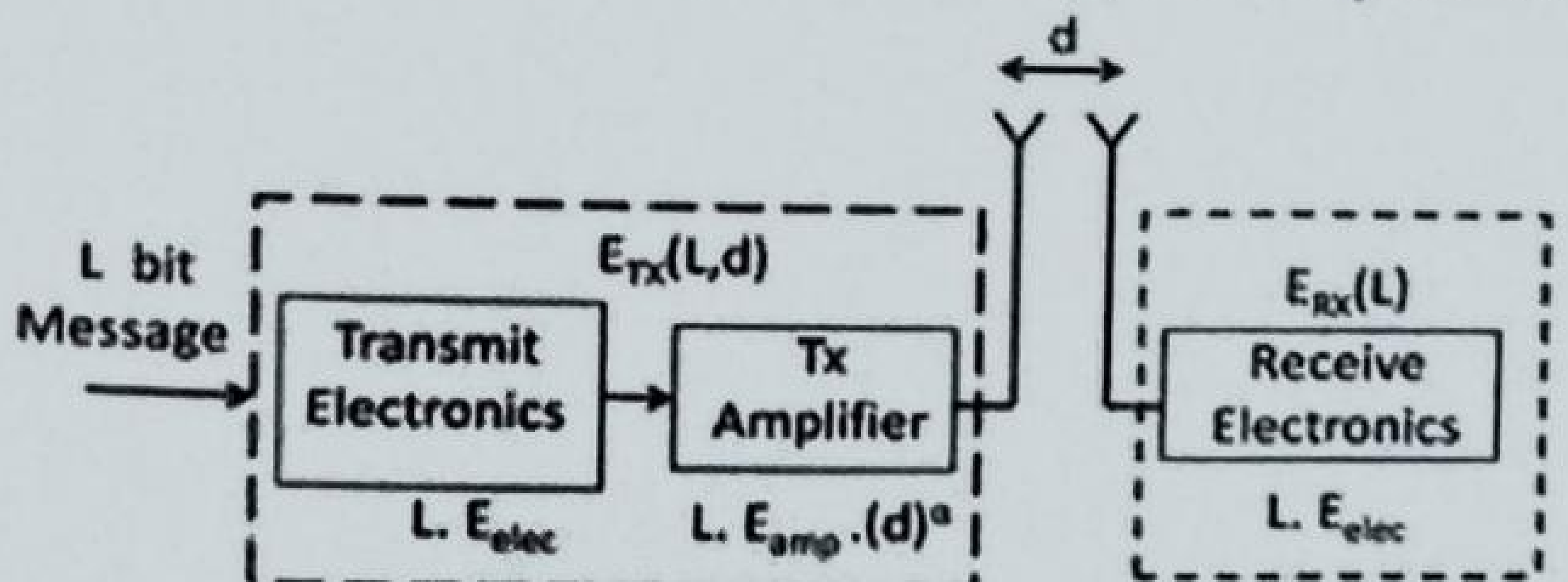

Fig 1: The First order radio model

The diagram above shows a pictorial representation of a radio model of first order. For each data bit transmitted, the transmitter and receiver use the same type of electronic circuitry and therefore their energies are accumulated as 'Eelec'. The nodes of the sensor are therefore symmetrical to one another.

IV. CONCLUSION

Wireless Sensor Network Technology is an efficient means to provide relatime sensing in a number of applications. The sensor nodes have a compact architecture according to the needs where they are used and are fitred with limited energy resources. Thus efficient utilisation of these resources calls for effecirnt planning of the packet forwarding schemes. In this paper, a review of the various concepts related to WSN has been presented alongwith a brief overview of the various packet forwarding or routing protocols. This study will further be backed up with a novel proposal for clustering in WSN.

REFERENCES

[1] Y. M. Hasn and S. A. Hussein, "Energy Efficient Routing Protocols for Wireless Sensor Networks Abstract: Designing An Energy Efficient Routing Protocol For Wireless Sensor Network (WSN) Has For," IOSR J. Electron. Commun. Eng., vol. 11, no. 2, pp. 2278–2834, 2016.

[2] M. A. Matin and M. M. Islam, "Overview of Wireless Sensor Network," Wirel. Sens. Networks - Technol. Protoc., pp. 3–24, 2012.

[3] A. A. Anasane and R. A. Satao, "A Survey on Various Multipath Routing Protocols in Wireless Sensor Networks," Procedia Comput. Sci., vol. 79, no. 20, pp. 610–615, 2016.

[4] J.M. Rabaey, et al., (July 2000), "PicoRadio supports ad hoc ultra low power wireless networking," IEEE Computer, Vol. 33, pp. 42-48.

[5] Heinzelman, Wendi Rabiner, Anantha Chandrakasan, and Hari Balakrishnan. "Energy-efficient communication protocol for wireless microsensor networks." System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on. IEEE, 2000.

[6] I.F.Akyildiz,W.Su,Y.Sankarasubramaniam,E.Cayirci, (Dec 2002), "Wireless Sensor Networks:A survey", Elsevier science B.V.

[7] Shio Kumar Singh, M P Singh and D K Singh, (August 2010), "A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in wireless Sensor Network," Int J. of Advanced Networking and Applications Volume:02, Issue:02, Pages:570-580.

[8] R. H. Katz, J. M. Kahn and K. S. J. Pister, (August 1999), "Mobile Networking for Smart Dust," 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'99), Seattle, WA.

[9] Lindsey S. and Raghavendra C., "PEGASIS: Power-Efficient Gathering in Sensor Information Systems, in Proceedings of IEEE Aerospace Conference, vol. 3, pp. 1125- 1130, 2002.

[10] Akshay, N.Kumar, M.P., Harish, B. and Dhonarkar and S., "An efficient approach for sensor deployments in wireless sensor network" International Conference on in Robotics and Communication Technologies (INTERACT), 2010.

[11] Arati Manjeshwar, Agrawal and D.P., "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks" Proceedings 15th International on Parallel and Distributed Processing Symposium, 2000.

[12] N. Israr and I. Awan. Multihop clustering algorithm for load balancing in wireless sensor networks. University of Bradford, UK.

[13] G. Smaragdakis, I. Matta, and A. Bestavros. SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks. In Proceeding of the International Workshop on SANPA, 2004

[14] Javaid, N.Ullah, M.Djouani, K., "Identifying Design Requirements for Wireless Routing Link Metrics," Global Telecommunications Conference (GLOBECOM 2011), 2011 IEEE , vol., no., pp.1,5, 5-9 Dec. 2011.

[15] N. Javaid, A. BiBi, K. Latif and M. Ishfaq, "Investigating Quality Routing Link Metrics in Wireless Multihop Networks" Springer's Annals of Telecommunications, 2013

[16] M. Y. Khan, N. Javaid, M. A. Khan, A. Javaid, Z. A. Khan, U. Qasim, "Hybrid DEEC: Towards Efficient Energy Utilization in Wireless Sensor Networks", World Applied Sciences Journal 22 (1): 126-132, 2013.

[17] Javaid, N., Bibi, A. Khan, Z. A.,Djouani, K., "On using multiple quality link metrics with Destination Sequenced Distance Vector protocol for Wireless Multi-hop Networks," Electrical & Computer Engineering (CCECE), 2012 25th IEEE Canadian Conference on , vol., no., pp.1,4, April 29 2012-May 2 2012.