VALLURUPALLI NAGESWARA RAO VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY
AN AUTONOMOUS INSTITUTE

(Approved by AICTE, New Delhi, Govt of T.S and Affiliated to JNTU, Hyderabad)

Accredited by NBA and NAAC with 'A++' Grade

Bachupally, Hyderabad – 500090

Telangana, India.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SEVEN HABITS OF HIGHLY EFFECTIVE PEOPLE

1. Be Proactive.
2. Begin with the end in mind.
3. Put first things first.
4. Think Win-Win.
5. First Understand, then be understood.
6. Synergies.
7. Sharpen Your Saw.

We have followed the above 7 steps during the course of our project work

K. RUSHI KIRAN KUMAR	**17071A04L2**
K. JULIA	**17071A04L3**
M. SAI SANDEEP	**17071A04L8**
M. LAXMAN	**17071A04L9**

A PROJECT REPORT ON

AN IMPROVED ROUTING PROTOCOL FOR HETEROGENEOUS WIRELESS SENSOR NETWORKS

A Project submitted in partial fulfilment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

K. RUSHI KIRAN KUMAR	**17071A04L2**
K. JULIA	**17071A04L3**
M. SAI SANDEEP	**17071A04L8**
M. LAXMAN	**17071A04L9**

UNDER THE GUIDANCE OF

MRS. G. SAHITYA

Assistant Professor

TAMASŌMA JYOTIRGAMAYA

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VIGNANA JYOTHI NAGAR, NZAMPET SO, PRAGATHI NAGAR, HYDERABAD, TELANGANA 500090

2017-2021

VIGNANA JYOTHI NAGAR, NIZAMPET SO, PRAGATHI NAGAR,
HYDERABAD, TELANGANA 500090
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

TAMASŌMA JYOTIRGAMAYA

CERTIFICATE

This is to certify that the Major project report entitled **"An Improved Routing Protocol for Heterogeneous Wireless Sensor Networks**" being submitted by **K. Rushi Kiran Kumar (17071A04L2), K. Julia (17071A04L3), M. Sai Sandeep(17071A04L8), M. Laxman (17071A04L9)** in partial fulfilment of the degree of Bachelor of Technology in Electronics and Communication Engineering during the academic year 2017-2021.

Certified further, to the best of our knowledge, the work reported here is not a part of any other project on the basis of which a degree or an award has been given on an earlier occasion to any other candidate. The result has been verified and found to be satisfactory.

Internal Guide | **External Examiner**

Mrs. G. Sahitya
Assistant Professor

Head of the Department, ECE
DR.Y. PADMA SAI
Professor

VALLURUPALLI NAGESWARA RAO VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

AN AUTONOMOUS INSTITUTE

(Approved by AICTE, New Delhi, Govt of T.S and Affiliated to JNTU, Hyderabad)

Accredited by NBA and NAAC with 'A++' Grade

Bachupally, Hyderabad – 500090

Telangana, India.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Estd.1995

DECLARATION

I hereby declare that the Major Project entitled **"An Improved Routing Protocol for Heterogeneous Wireless Sensor Networks"** submitted towards the partial fulfilment of the requirements for the award of the degree of **BACHELORS OF TECHNOLOGY IN ELECTRONICS AND COMMUNICATION ENGINEERING**, VNR VJIET. The project is completed under the supervision of **MRS. G. SAHITYA, ASSISTANT PROFESSOR,** Electronics and Communication Engineering Department, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad.

Also, we declare that the matter embodied in this project report has not been submitted by me in full or in any part there for the award of any degree/diploma of any other institution or university previously.

PLACE: Hyderabad

DATE: 02/07/2021

K. RUSHI KIRAN KUMAR

K. JULIA

M. SAI SANDEEP

M. LAXMAN

ACKNOWLEDGEMENT

We wish to express our deep sense of gratitude to **MRS. G. SAHITYA**, Assistant Professor, VNR VJIET for his valuable guidance and constant encouragement in all respects during the course of our project work.

Our sincere thanks to **Dr. Y. PADMA SAI**, Professor and Head of Department of Electronics and Communication Engineering, VNRVJIET, Hyderabad for the encouragement and guidance provided during the course of our project work.

We are thankful to the Principal **Dr. C.D. NAIDU**, VNRVJIET, Hyderabad, for giving us permission to carry out this project.

We are thankful to all the staff members of ECE department, VNRVJIET for helping us during this project.

We are thankful to all the project committee members of ECE department, VNR VJIET for helping us during this project.

Finally, we are very thankful to our family members and our friends for their great moral support.

K. RUSHI KIRAN KUMAR	**17071A04L2**
K. JULIA	**17071A04L3**
M. SAI SANDEEP	**17071A04L8**
M. LAXMAN	**17071A04L9**

INDEX

Contents..Page No.

TABLE OF FIGURES

CHAPTER 1

INTRODUCTION

1.1OVERVIEW OF THE PROJECT

In these recent years, IoT has graded in the forecast of agriculture and automation. IoT, which mostly comprises different technologies. The wireless sensor network is one such big technology. WSN plays a bigger role in revolutionizing the world with its sensing technology. Before the WSN there is only the wired communication through which either sensing or transmitting the data had been done. But after the evolution of technologies like Wi-Fi and 4G the importance of WSN has increased. WSN has emerged as a powerful technology with different applications in different fields which consists of agriculture, military, management, and so on. The most advancement in the IoT was these IoT-enabled devices can communicate data without human intervention. The most key concepts of IoT are Radio Frequency Identification (RFID) and Wireless Sensor Networks (WSN). Nodes communicate with each other through the nodes which are spatially arranged. The communication is established between nodes is wireless and they send the data to the base station.

Communication is established between the nodes through the concept of routing protocols. In this project, we are going to discuss the routing protocol which is the most efficient and advanced protocol to establish communication. The WSN is categorized into two different networks namely homogenous and heterogeneous. We have different routing algorithms for different networks. LEACH, DEEC and more are the routing protocols which are used for the homogenous networks and SEP (stable election protocol) is one of the routing algorithms used in heterogeneous networks. The importance of these protocols comes from not only the communication but they need to

be energy efficient and less power consumptive in terms. We implemented the routing algorithm SEP to observe its constituents like power consumption, energy usage, and data transmission, and the number of dead nodes. All these factors are considered in choosing a routing protocol to implement in the network. By observing the factors of SEP, as it is not much effective protocol and thus implemented the improved or advanced protocol of SEP that is Improved version-SEP.

I-SEP is an algorithm for the Stable Election Protocol, which is an improved algorithm. In this improved version of SEP we have the concept of cluster head formation. It means the group of nodes elects the single node as head and transfer their data to the head. It's the most efficient use of energy as the nodes need not to waste energy in transmitting the information as the transmission is the duty of CH. The number of dead nodes also decreases in the I-SEP protocol as it is less power consumptive. So, it's use over the SEP is more helpful in the longevity of nodes and network. We need to implement the protocol for the purpose of the high network life time and best use of its energy. And implementation of the improved version is done using the MATLAB source and the results are seen through the simulation of the code written for the protocol in MATLAB. We studied the existing algorithm SEP and after finding the difficulties and drawbacks in the factors that we consider in choosing the protocol, we need an improved protocol to overcome these difficulties and implemented the I-SEP.

1.2 MOTIVATION

In recent times, advances in many fields have been taken place. Agriculture is one such field in which technological advances took place in past years. Nowadays, the implementation of technology(software) is one in every aspect of work and comfort. IoT, its application in agriculture is the challenging one as the network nodes are spatially arranged in the harsh conditions of weather. These nodes are placed in such extreme conditions, to monitor the environment for a longer period. For much longer periods of monitoring, there might be many issues regarding the battery power but there is no scope in recharging the battery.

Then here comes the difficulty in operating the nodes for a longer period of monitoring. In regards to this difficulty of monitoring, we need an optimized solution or approach for better farming and analysis of the environment for farming. For such uprooting of these, we studied the existing and widely implemented protocol and we need better implementation of improved versions of the existing algorithms.

The implementation of IoT in agriculture can be understood from the below picture

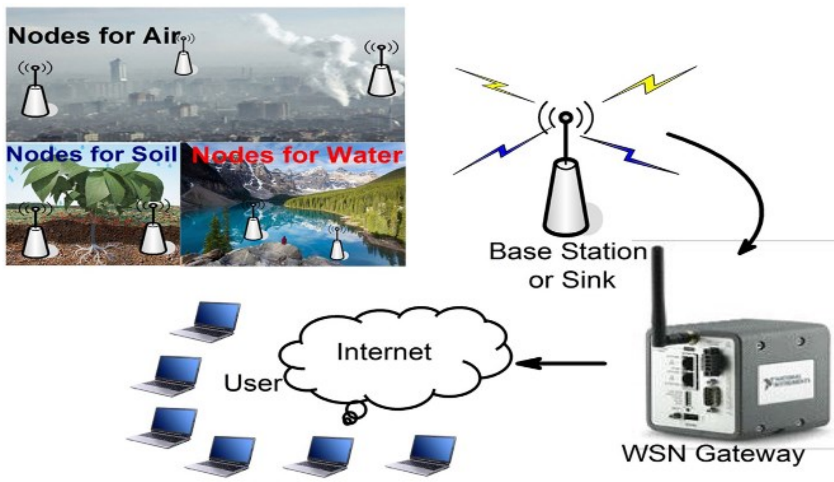


Figure 1 Implementation of IoT in agriculture

As from the picture sensors are used to collect environmental readings and send them to the base station. For this implementation, we need the nodes with initial energies provided and this can be done with the only heterogeneous networks. The major issue in the implementation of technology in agriculture is money. If the implementation of existing protocols is done there will be a huge investment for an outcome as the nodes become dead nodes after the full consumption of its energy.

So, for better farming, we need low-cost sensing nodes and the nodes with the usage of minimal energy and they should long for life. This can be achieved with the introduction of nodes with minimal consumption of energy and low cost. And, there should be an unattended service and minimal maintenance of the nodes introduces in the field for monitoring. Analysis of weather conditions is, much difficult for a human every day so through these nodes, we can collect the factors of environment like humidity, moisture, rainfall, pH level… Taking regard to all these factors and issues we need a better understanding of the implementation and need for better-optimized implementation.

1.3 OBJECTIVE

The major objectives of this project include multiple aspects. We need a network with an optimization that reduces the number of dead nodes and increases the network lifetime. Therefore, we need the implementation of the following outcomes

- The unique picking of cluster heads through the reference of threshold energy
- The proposed method aims to improve the nodes and its network lifetime with the introduction of 3 levels of heterogeneity to the WSN.
- Creating of WSN with advanced, normal, and intermediate nodes with varying energy levels.
- Probabilistic formation of clusters among the 3 level nodes and selecting a CH for each cluster.
- First after selecting the cluster head, the algorithm we are using allots the high energy for the selected head and in later rounds the head selection occurs and the previously selected head will be allotted with low energy because it will become a sensing node as each node as ability to become head for only one round.
- The differentiation in the distribution of energy helps a lot because through this variation we can achieve proper energy allotment for the network.
- We need an estimation for the threshold energy because it needs to be preserved in every node for the use of the network as this energy level helps in energy distribution for longer network life.

These are the objectives that we can observe in the whole project process of implementation. In each objective, we get an outcome that makes the overall outcome look clear. The selection of cluster heads comes in the first step and later we can observe the energy consumption throughput of the algorithm on the simulation basis. Objectives overall include the throughput and CH selection and we need to demonstrate the selection of CH for every round and how the dead nodes are formed. All the objectives can be visually seen through the implementation of MATLAB code. Simulation of the code gives the outcomes of the objectives in the form of graphs. And can be analysed by the information given in the simulated graphs.

1.4 NOVELITY

Novelty of the project comes from its objectives and outcomes. The novelty of the of the project consists of the many unique features that cannot be seen in the other existing algorithms of wireless sensor network. The features which are unique in this project gives its novelty. The following are the unique features of the work

- Produce interruption less and efficient communication between source and destination nodes
- Energy constrained
- Wide transmission range and high computational power
- Network lifetime is high
- It is more efficient and less cost
- Usage of Associated Cluster Head to decrease load on normal nodes
- It is reactive routing protocol
- Energy is consumed more for transmission than sensing.

Above points raise the features of the work that claims to be unique in nature. All the raised points consist different features that has a very good impact in every drawback that we have known in the existing solutions. These are the major features like energy efficient and less power use as well as longer life of the network. These are the impacts or uniqueness of the work.

1.5 IMPORTANCE OF PROPOSED WORK IN THE CONTEXT OF CURRENT STATUS

The proposed work has an important role in the current status of the agriculture, marine, military and many applications. As this technology consists of wireless communication, without human intervention in the working make its importance even more great. We can list the importance of the proposed project or work in the current status through some points.

The importance of the proposed work includes the following

- At present, IOT is increasingly becoming an essential part of our life.
- Our algorithm will be useful in various scenarios, in which one of them is
- Communication between autonomous cars, where each of the vehicles may be far away from each other. In such cases each car can act as a sensor and transmit information which is passed on to the nearby vehicles through a central base station.
- When compared to pre-existing algorithms/Protocols, our project is

1. Beneficial for large-scale application due to energy constraint.
2. Monitoring made easy and cost effective.
3. Good Performance
4. Optimal data delivery

These are the important factors in considering the current status of the technology and the usage of the WSN in the respective fields. We can use this WSN in a very large-scale sectors as well as small scale sectors. As this implementation requires the nodes

1.6 TOOLS USED

The tool used in the whole project is MATLAB. For the implementation of algorithm and for the simulation to observe the analysis through the simulated graphs.

MATLAB

Version: R2013a

CHAPTER-2

LITERATURE SURVEY

This section deals with the survey of existing routing protocols for WSNs & highlight their limitations. The classification of routing protocols can be done in many ways. The fundamental type of classification is shown in the figure below.

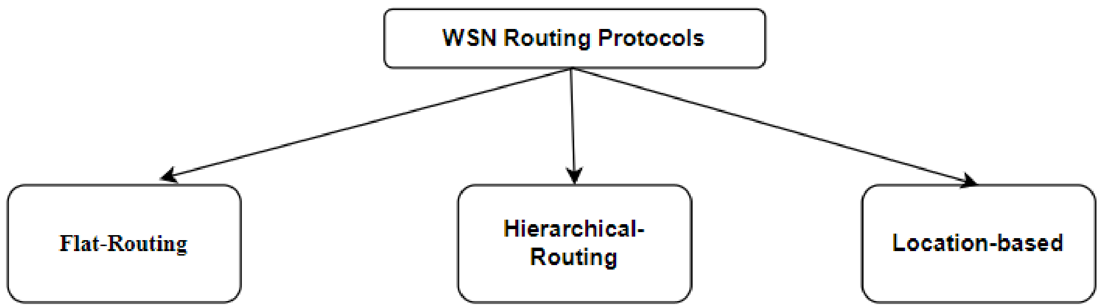


Fig 2: classification of routing protocols

Generally, WSN routing protocols are classified based on the node functions into flat type of routing, hierarchical type of routing, and location-based type of routing.

• With flat type of routing, all the nodes will be assigned the same role or function.

• In hierarchical type of routing, nodes are given other roles on the network.

• Location-based type of routing leverages the position of different sensor nodes to transfer data over the WSN.

Routing protocols are adaptive when some parameters of the system can be adjusted to match the present network state and current power levels. These types of protocols can be classified as QoS-based, request-based, based on negotiation, multipath hop based, or consistency based on protocol behaviour.

These can again be divided into 3 types, pro-active, re-active, and another type hybrid, depending on the path the source takes to get to the destination. The proactive type of routing protocol is that all the routes are calculated well before the actual need arises. In the reactive protocol, routes will be calculated based on the demand. The hybrid type protocol uses both ideas.

If the sensors are static, it is better to use table-oriented routing instead of reactive routing protocols as large amounts of nodes' energy are used to detect routes and establish response protocols. There is another layer of routing protocols called coroutine. Here, in co-ordinated routing, nodes can transmit data to a centralised node where they can be computed and aggregated for further processing, thus reducing routing overhead in terms of power consumption. There are various other types of protocols that rely on time and location information.

2.1 NETWORK STRUCTURE BASED:

The structure of the network plays a gigantic role in the design of various routing protocols.

2.1.1 FLAT-ROUTING :

We consider the flat type of routing first. Each node in a flat network usually has the same function, and the multiple sensor nodes work united in order to complete the sensing duty. As there are so many of these nodes, assigning a global identification to each one is impossible. This paradigm has resulted in data-centric routing, in which the BS delivers information to only one particular servers.

Heintzelman et al. initiated the Sensor Protocols for Information where the information available at each node is advertised to every other node in the network, thus assuming that all nodes in the network could be possible base nodes. This makes it easier for the user to query for the required information from any of the nodes he can access. This protocol is intended to eliminate flaws such as flooding and gossiping that can occur in other protocols. The key principle is that sharing data detected by a node may consume more resources than sharing meta-data, which is simply a descriptor of the data detected by the node. Each node's resource management keeps an eye on its resources and adjusts their functionality as needed. Ontonagon wiwatetal introduced directed diffusion as a common data aggregation methodology for WSNs in [3]. As all the data that is collected is stored as key-value pairs, directed diffusion can be treated as DC. MCFA algorithm [4] takes advantage that routing protocol to the external BS that is fixed, is always known. As a result, a sensor node does not require a unique Identity or the need to maintain a routing table. Rather, each of the nodes keeps track of the cheapest route between itself and the base station. Each signal that the sensor node needs to forward is broadcast to its neighbours. COUGAR [5], another data-centric protocol, sees the network as a massive, distributed database system. This provides a query system independent of the network layer. But this system has a few drawbacks. For starters, adding a query layer to each of the sensor nodes may result in more energy usage and memory storage. Second, synchronisation among nodes is essential before transmitting data to the leader node to achieve successful in-network data computation.

2.1.2 HIERARCHICAL ROUTING:

Hierarchical type of routing, also known as clustering, was first developed for wired networks and has several advantages in terms of scalability and communication efficiency. As a result, hierarchy-based routing is also used in WSN to minimize energy consumption on routing. The nodes with higher energy levels can be used to process information and transmit them to longer distances in a decentralised architecture, whereas low-power nodes can be employed to perform near target detections. In other words, forming a cluster and allocating certain duties to the cluster head can result in a significant improvement in the system parameters such as scalability, lifetime, and energy efficiency. Hierarchical routing is a trusted approach to reduce consumption of energy inside a cluster and to reduce the frequency with which messages are sent to the BS by conducting data aggregation and fusion. Hierarchical routing is primarily double-layer routing, with one of the layers selecting the cluster head and the remaining layer focused on routing.

LEACH, a hierarchy-based clustering technique for sensor networks, was presented by Heintzelman et al. [6]. (Low Energy Adaptive Clustering System), LEACH is a cluster-based protocol that is used to create distributed clusters. LEACH assigns the cluster leader (CH) function to various sensor nodes at random and rotates it to share the energy load evenly among the network's sensors. The cluster head (CH) node in LEACH transmits aggregate data packets to the base station to compress the data of each cluster's nodes and decreases the size of data that needs to be transmitted to the base station. To reduce burst and collisions between clusters, LEACH employs TDMA/CDMA MAC. Data collection, on the other hand, is centralised and performed on a regular basis. Therefore, this is ideal when continuous monitoring for a sensor network is required. Even though LEACH can extend the network lifetime, there are still a few difficulties with the assumptions utilised in this protocol. This assumes that all nodes have sufficient power to reach the BS if necessary, as well as that each node has the processing capability to handle multiple MAC protocols. As a result, it is inapplicable to networks spread across wide areas.

A portion of nodes in a heterogeneous wireless sensor network [7] of n nodes have the extra energy of factor, and these nodes are termed as advanced nodes. The election probability of each node weighted for the election of a CH according to their relative energies is the focus of the SEP algorithm. It provides a longer duration of stability with greater performance than the LEACH protocol. TEEN and APTEEN [8],[9] simulations have revealed that these two methods outperform LEACH. The most significant disadvantages of these two are the overhead and complexity associated with creating clusters at various locations and how to handle attribute-based function name for the queries.

2.1.3 LOCATION BASED ROUTING PROTOCOLS:

Sensor nodes are addressed by their positions in this type of routing. Based on incoming signal strengths, the distance between neighbouring nodes can be determined. By transmitting such information between neighbours, relative coordinates of surrounding nodes can be derived [13], [14], [15]. GAF [16] is an energy-aware location-based routing algorithm that was intended especially for mobile ad hoc networks, but it might also be used in sensor networks. A virtual grid is created by first dividing the network region into fixed zones. Nodes work with one another to fulfil diverse roles inside each zone.

2.1.4 CHALLENGES IN EXISTING SEP ALGORITHM:

Each cycle in the SEP algorithm starts off with the election of cluster heads and the formation of new clusters. As a result, large amounts of energy are expedited on the routing overhead and the performance of the linked devices will deteriorate. If a node is CH in the present cycle, it will not be able to participate in the CH election in the next round even though it has enough energy. Due to this, a node with lesser energy may be elected as CH resulting in decreased lifetime of the network. The formation of new clusters in every round consumes more energy in the form of ACK (acknowledgement) and ADV(advertising) messages to the CHs rather than useful information being sent.

CHAPTER 3

WIRELESS SENSOR NETWORKS

3.1 INTRODUCTION TO WIRELESS SENSOR NETWORKS

With the passage of time, these wireless sensor networks are getting prominence. Some applications need the rapid information transfer having a little interruption, although having the extensive use of these networks. Plenty of applications need a premium of throughput and they do not bother about the latency of the network. It depends on the application's importance based on which the variable is selected . The understanding of network and it's structure as well as the routing protocols of the networks is critical, and it should be according to the user requirements and accepted by the user. At last, utilising a WLAN and a ZigBee-based Wireless Sensor Network, a performance comparison of several routing methods is performed.

3.1.1 WIRELESS SENSOR NETWORKS

Wireless sensor networks, made up of elements known as sensor nodes, have been made viable because to advancements in wireless communication. Sensor nodes are low-power, small-size, and low-cost devices that can sense, communicate, and compute. The sensors setup themselves and link with each other for data gathering as soon as they are installed in the network forwarding the information to the Base Station which is established to collect data from nodes.

These networks can also be defined as the network made up, potentially short and low-complexity devices known as nodes which have the ability to sense the environment and communicating gathered data from the monitored area; the gathered data can be sent directly or through multiple hops to a sink, which can then use it locally or connect to other networks through gateway nodes.

We can understand the installation of nodes and base station and how the data is transmitted over internet to user in remote location can be understood through the picture below.

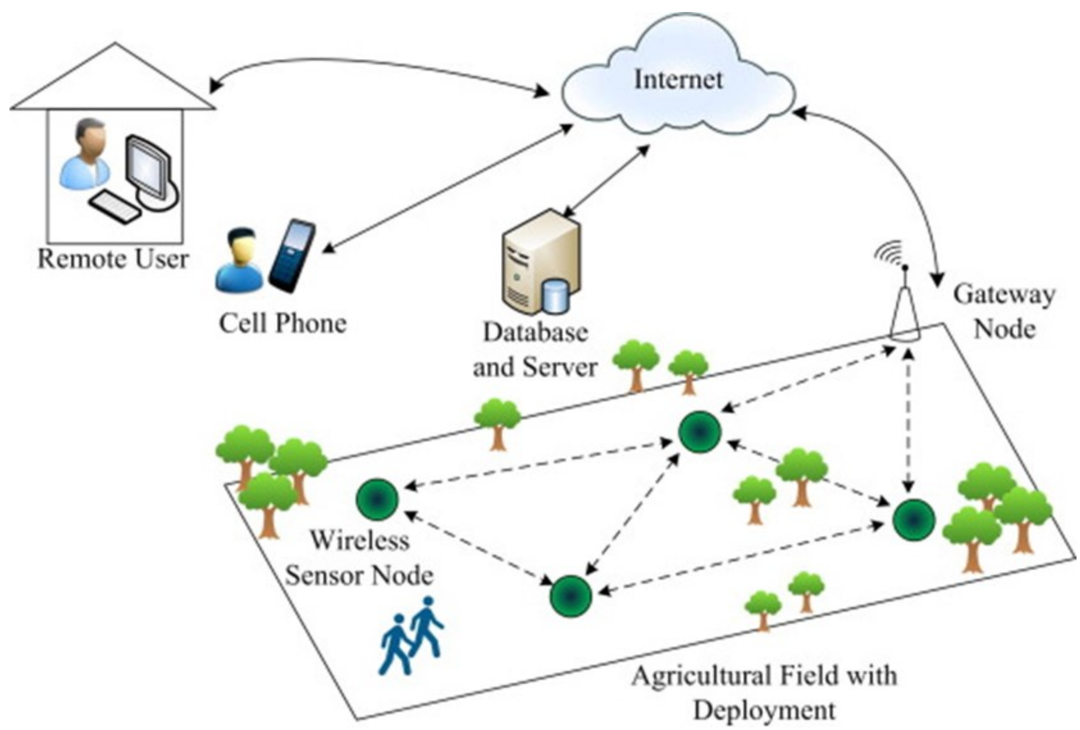


figure 3: Wireless sensor network

3.1.2 COMPONENTS AND BLOCK DIAGRAM OF WSN

As indicated in Figure 2, the important and major components of a sensor node has a sensing unit for sensing, a processing unit for processing the data, a transceiver, and a power unit for supply of power to the network. The sensing device detects a physical amount, which is subsequently converted to a digital value using an ADC (Analog to Digital Converter). Following that, the processor is used to perform more calculations, and the transceiver is used to broadcast and to get data from the elements known as nodes or Base Station. In any sensor node, the power unit is the most visible unit. For unsupervised applications, the battery cannot be changed once it has been depleted. Other devices, such as the Mobilizer, Power Generator, and Location Finding System, are application-dependent.

We can understand the internal components of node from the below picture

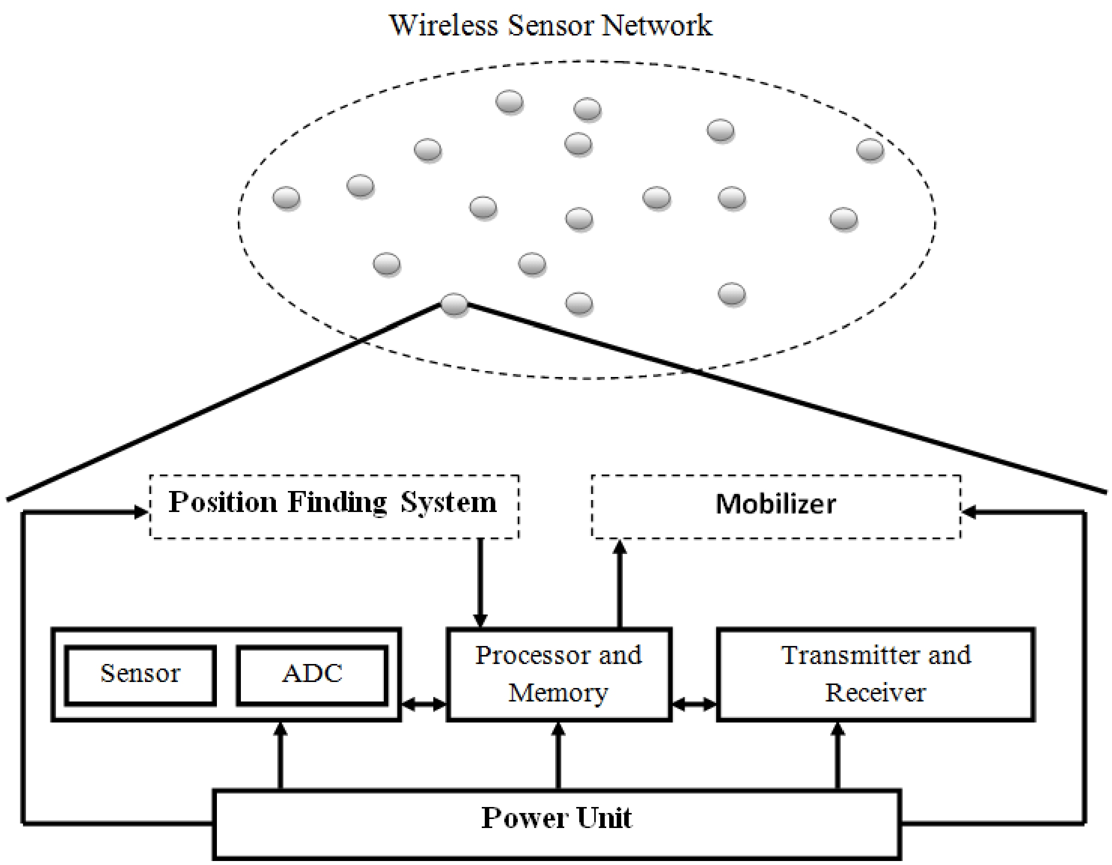


Fig 4 Block Diagram of WSN

3.1.3 CHALLENGES IN WSN

One of the main design aims of WSNs is to conduct information communication while attempting to extend the network's longevity and to stop connection deterioration using the aggressive management in the energy unit while distribution. Many problematic elements have an impact on topology control in WSNs. Before WSNs can establish efficient communication, these obstacles must be addressed.

A) Node deployment

The performance of topology control techniques in WSNs is affected by the deployment, which is depend on the application . Deterministic or randomised deployments are also possible. These sensing nodes are installed using human involvement and info is transmitted through known pathways in deterministic deployment. Arbitary node deployment, on the other hand, scatters the nodes at random, resulting in an ad hoc architecture.

B) Energy consumption without losing accuracy

In this environment of wireless technology, sensor nodes might deplete their energy supply by conducting computations and transferring data. As a result, energy-efficient communication and computing are critical. The life of a sensing node is strongly influenced with the life of the battery.

C) Data Reporting Model

The application and it's time censorious of the transmitting the collected data determine the data sensing and reporting capabilities of WSNs. Time-driven (continuous), event-driven, query-driven, and hybrid data reporting are the four types of data reporting. The time-driven transmission approach is ideal for its uses that need to check data on a regular basis. As a result, these sensing nodes will turn on the sensors of usage for sensing and transmitters at a regular interval for better use, detect the surroundings, and broadcast the data of interest.

D) Node/Link Heterogeneity

Researches assumed that all the sensing nodes were of homogenous type, meaning that they all had the same computational, communication, and power capabilities. However, a sensor node's purpose or capabilities might vary depending on the application.

E) Fault Tolerance

Because of the lack of power, damage internally, or due to an environmental interference, some sensor nodes fail or become dead. The defeat of sensing nodes should not have an impact on the sensor network's overall mission. MAC and topology management algorithms must support the development of new links and routes to the data gathering base stations if several nodes fail.

F) Scalability

The number of sensing nodes put in the region of sensing might be thousands, or even millions. Any topology control method that works with this many sensor nodes must have ability to handle it. Furthermore, sensor network routing control algorithms must be scalable enough to adapt to environmental occurrences. Many sensors stay in the sleep mode until the need of data happens, with data from the few remaining sensors gives a coarse quality.

G) Security

In some applications, communication between nodes must be sufficiently secure to ensure secrecy. It is mostly essential when dealing with military applications such as battlefield monitoring, military activities, and so on.

CHAPTER – 4

SYSTEM MODEL

An upgraded routing approach was designed with energy economy and energy balance as the most important considerations in creating any routing algorithm in a WSN. In order to maintain control of the situation, with three-level heterogeneity in terms of energy dissipation, the notion of data in a heterogeneous network is introduced.

The I-SEP (Improved Stable Election Protocol) has two key characteristics: it is a reactive routing protocol, whereby transmission consumes more energy than sensing and is only performed when a certain threshold is achieved, and it contains three levels of heterogeneity.

To fully clarify the entire technique, we will focus on the energy model and how the ideal number of clusters can be calculated. Nodes with various energy levels for three levels of heterogeneity are:

1) Normal Nodes

2) Intermediate Nodes

3) Advance Nodes

All nodes are considered static in this situation. The initial node energy is taken into account. Advance nodes have the most energy, whereas regular nodes have the least. The intermediate nodes are those that sit between lower-energy nodes, such as regular nodes, and higher-energy nodes with advanced capabilities.

LEACH improves I-SEP, which is a reactive clustering routing protocol. Each cluster's cluster head (CH) collects data from its cluster members. The CHs combine and process data before sending it to the BS or a higher-level CH. The advantage of clustering routing protocols is that all nodes just need to communicate data to their CH, and only the CHs need to aggregate data. It conserves energy. To ensure that energy consumption is distributed equitably, each node takes turns as the CH. The random selection process is used in the CH election. After clusters are formed, CHs assign cluster members a time window during which they can send their data.

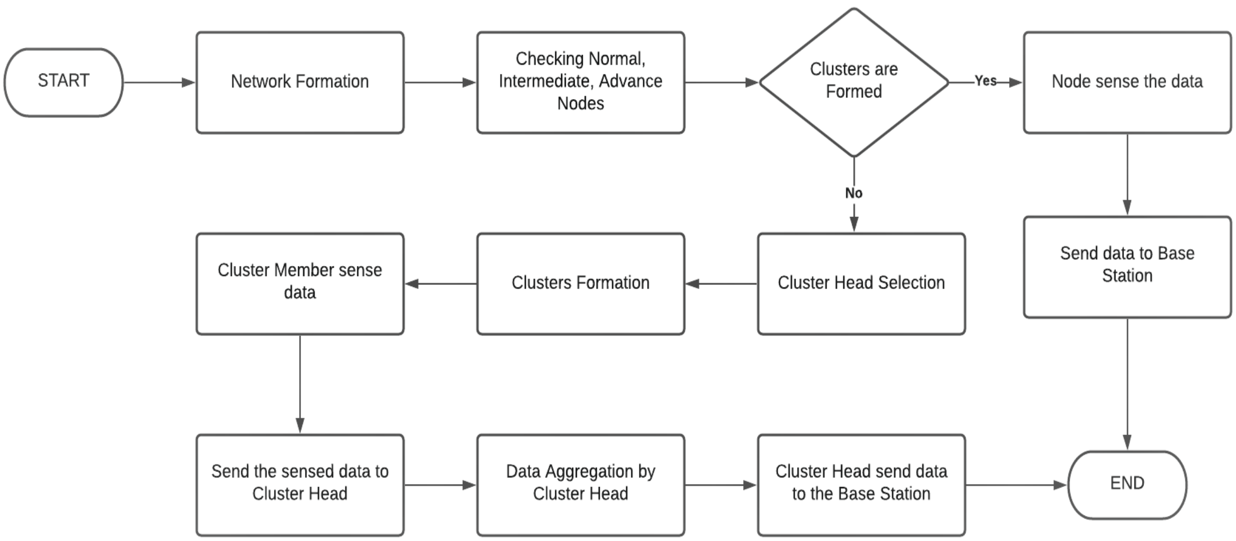


Fig. 5 System model

Unlike LEACH, CHs broadcast HT and ST to their members in the I-SEP routing protocol to regulate the amount of data transmitted. Only when the current value of the sensed attribute is larger than the value of HT will the nodes communicate sensed data to CH in the current round. The detected property is then saved in the internal variable sensed value (SV). Nodes constantly sense the attribute; it is only conveyed when the next value departs from SV by an amount equal to or greater than the ST. By discarding minimal change of detected property, the ST minimises the frequency of data transmission. The value of ST can be adjusted to meet the needs of the users. Setting a smaller ST improves network accuracy at the expense of higher energy usage. As a result, users must modify the size of ST to control the trade-off between energy efficiency and precision.

There are different steps in the procedure of the implementation of I-SEP. They are:

Stage 1: Available Channel Detection

Each node performs the available channel detection process and lists the available channels at the available channel detection step. Node I for example, detects the M(i) accessible channel list, which is a subset of M.

Stage 2: Cluster Head Election

Every node is given a random number between 0 and 1, and then a threshold formula T is computed (n). The node decides to become CH if the random number is less than T(n). Eq. (2) is used to calculate T(n):

$$T(N) \ = \{\frac{p}{1 - p * (rmod\left(\frac{1}{p}\right))}, \qquad if \ N \ \in \ G1\,0, \ Otherwise$$

where P is the current round number and r is the percentage of nodes that become CHs in each round. G is the set of nodes that were not elected as CH in the previous 1/p rounds. The CH election process will be repeated at the end of each round to ensure that every node can be elected as the CH. It guarantees that nodes consume energy in a consistent manner.

Stage 3: Clustering

When CH is chosen, it sends a message to all other nodes announcing its election as CH. Ordinary nodes choose to join the cluster with the most powerful signal. Then it sends a message inviting others to join the CH.

Stage 4: Data Transmission

Nodes constantly monitor their surroundings. Cluster me mbers receive HT and ST from CHs. In the data transmission step of the TEEN routing protocol, member nodes transfer data to CHs in their designated time slot while adhering to the HT and ST constraints. Stages 1–4 are re-started after a round time.

4.1 The optimization of I-SEP routing protocol in WSN

In a WSN, routing protocols are often low-cost and prioritise low latency as a main performance metric. However, in order to achieve low cost and latency, the CWSN routing protocol must account for spectrum dynamics. Maintaining the regular operation of the original route will make the route and spectrum more stable, reducing the routing path switching and routing research as much as possible.

CH random election is one of the I-SEP routing protocol's drawbacks. The election of CH is uncontrolled, with a high level of randomness. The I-SEP routing optimization technique (advanced threshold-sensitive energy efficient sensor network (A-TEEN) protocol) is presented in this research. First, determine the noise in the electromagnetic environment, based on the application requirements, which define the bandwidth and channels accessible. The number of unoccupied channels is used by A-TEEN as a weight in the chance of each node becoming a cluster head. The node that detects the most idle channels have a better chance of becoming CH.

Let b denote the subset of nodes that have been assigned an intermediate energy level with times higher power than normal ones, with $\beta = \alpha/2$. The initial energy delivered to the normal nodes is denoted by E0. $E0(1 + \alpha)$ and $E0(1 + \beta)$ energies are found in advanced and intermediate nodes, respectively. As a result, the total energy of each node type can be expressed as

$$E_N = nE0(1 - a - b)$$

$$E_I = nbE0(1 + \beta)$$

$$E_A = naE0(1 + \alpha)$$

where EN, EI, and EA are the standard, intermediate, and advanced node energies, correspondingly As a result, the total energy of the three node types is stated as

$$E_{Total} = nE0(1 - a - b) + nbE0(1 + \beta) + naE0(1 + \alpha)$$

$$= nE0(1 + a\alpha + b\beta)$$

The CH election is similar to the LEACH and SEP elections in that it is held every two years. Based on their probabilities, a threshold value for CH selection is calculated for each type of node. Let G1, G2, and G3 represent the number of nodes in each category who did not perform as CH in earlier epochs, and r represent the current round. Using p(N), p(I), and p(A) as examples the probabilities of normal, intermediate, and advanced nodes to be elected as CHs, respectively.

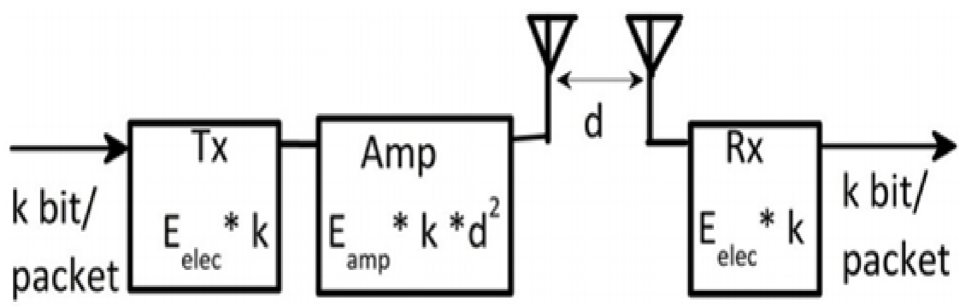


Fig.6 Radio Communication System of First Order.

For normal nodes:

$$p_{(N)} = \frac{p}{1 + a\alpha + b\beta} \tag{6}$$

$$T(nN) = \{\frac{p(N)}{1-p(N)(r mod 1/p(N))}, \; if\; nN \in G1\; 0,\; Otherwise\; ; \tag{7}$$

For intermediate nodes:

$$p_{(I)} = \frac{p(1+\beta)}{1 + a\alpha + b\beta} \tag{8}$$

$$T(nI) = \{\frac{p(I)}{1-p(I)(r mod 1/p(I))}, \; if\; nI \in G2\; 0,\; Otherwise \tag{9}$$

For advance nodes :

$$p_{(A)} = \frac{p(1+\alpha)}{1 + a\alpha + b\beta} \tag{10}$$

$$T(nA) = \{ \frac{p(A)}{1-p(A)\left(\frac{rmod1}{p(A)}\right)},\ if\ nA \in G3\ 0,\ Otherwise \tag{11}$$

Now, from (6), (8), and (10), The average total CHs each round can be calculated as follows:

$$n(1 - a - b)p_{(N)} + nap_{(A)} + nb_{(I)} = np \tag{12}$$

The consequence of CHs in a heterogeneous environment is equal to that of the LEACH protocol, which may be deduced. The energy dissipation is, however, better controlled due to the heterogeneous energy level.

In the heterogeneous network, communication follows the model presented in Fig. The energy dissipation will be computed using the multipath fading model if d (Euclidean distance between sending and receiving nodes) is less than or equal to a reference distance d0 (where $d_0 = \sqrt{Efs/Emp}$); otherwise, the free-space model is utilized. Assume a symmetrical communication channel where a sensing node's energy spent transmitting "k" bits per packet can be calculated.

$$E_{Tx}(k, d) = E_{Tx\_elec}(k) + E_{Tx\_mp}(k, d)$$

$$ETx(k,d) = \{Eelec \times k + Efs \times k \times d2,\ d \leq d0 \quad Eelec \times k + Emp \times k \times d4,\ d > d0\ ,$$

Emp and Efs are the transmission amplifier parameters for the multipath fading and free-space models, respectively [33]. If a transmitter or receiver expends Eelec amount of energy per bit, a sensor node must expend ERx(k) energy to receive a packet of k bits, which is given as

$$E_{Rx}(k) = E_{Rx\_elec}(k) + kE_{elec}$$

To calculate the threshold boundary for CH election, the energy dissipation is evaluated in each cycle. The suggested approach seeks to calculate a threshold energy value that must be maintained by all sorts of nodes in order for the network to last as long as possible.

Even though the average number of CHs is the same for LEACH, SEP, and ESEP. However, because of the energy heterogeneity in TSEP, energy dissipation is minimised.

The phenomenon of cluster change occurs at the start of each round. In the case of TSEP, the CH broadcasts the following parameters at cluster change time, they are

- **Report Time (TR) :** Time span during which each node sends reports one after the other.
- **Attributes (A) :** The physical parameters that are being delivered with the information.
- **Hard Threshold (HT) :** The absolute value of a detected property over which the node will send data to CH. When the measured value reaches or exceeds this threshold, the node activates its transmitter and sends the data to CH.
- **Soft Threshold (ST) :** The smallest measured value at which the nodes turn on and emit their transmitters.

Every node is constantly monitoring the environment. The transmitter has been activated and data is communicated to CH when parameters from the attribute set hit a hard threshold value; nevertheless, this is the first time this circumstance is satisfied. This sensed value is saved in a Sensed Value internal variable in the node (SV). Then, for the second and subsequent times, nodes will transmit data if and only if the sensed value exceeds the hard threshold value or if the difference between the current perceived value and the value stored in the SV variable is equal to or greater than the soft threshold value. As a result, by taking these two limits into account, the number of data transmissions can be reduced, as communication will be slower.

Some of the most important aspects are listed below:

1) Time-sensitive data is delivered to the user almost instantly.

2) Nodes continue to sense indefinitely, but transmission is not done frequently, resulting in substantially lower energy use than proactive networks.

3) When a cluster changes, the values of the soft threshold, TR, and A are sent out again, allowing the user to choose how often and what parameters to sense based on the criticality of the sensed characteristic and application.

4) Because characteristics are communicated at cluster change time, the user can adjust them according to their needs.

One of the significant drawbacks of this technique is that if the threshold is not met, the user will receive no information from the network, and even if one or all of the nodes dies, the system will be unaware of it. As a result, it is ineffective for applications that require data to be updated on a regular basis.

CHAPTER 5

IMPLEMENTATION

5.1 Implementation of a WSN

The Wireless sensor network is simulated using a Matlab code by implementing a three level heterogeneity, Normal, intermediate and advanced nodes.

The base station is situated at the centre of the WSN with unlimited energy. The probability of a node becoming a cluster head is designated a value of 0.1.

Initially all the nodes are assigned a type "N". Based on the probability and other parameters m and n , the nodes are divided into different types and assigned energy levels.

The standard parameters used for the implementation are listed in table-1. The standard distance for transmission of information is calculated as `do=sqrt(Efs/Emp);` , Where Efs is free space energy and Emp is amplification energy.

The sink is not a part of the sensors in the network. So, it is considered an extra node and the values are assigned accordingly.

To suffice for the extra load a cluster head faces for data aggregation, an amplification factor 'G' is introduced. When the whole amplification energy is used ,the node can no longer be a cluster head.

5.2 Election of cluster heads.

Based on the probability and threshold calculation, a cluster head is selected. The distance from the node to the sink is calculated and used to calculate the energy expended for data transfer to base station.

The code below shows the election of cluster head from one of the normal nodes. The energy is calculated based on the expressions mentioned in the system model.

The protocol being a reactive protocol, the data is transferred from only when the sensed value has breached threshold.

5.3 Associated cluster head

A normal node cannot withhold the data transfer energy if it is far away from the base station. So, a bridge is required when this condition occurs.

For this purpose, a normal node with enough energy is selected and the distance between the node and nearest cluster head is calculated.

Also, the distance between normal node and Sink is calculated. If the distance is greater, this node can act as associated cluster head for the normal node situated far away from the base station.

CHAPTER 6

SIMULATION RESULTS AND DISCUSSIONS

All the Simulations were completed in MATLAB, Version R2013a Here, n = 100 which indicates the sensor nodes were arranged in a network with parameters of Xm=100m2, Ym=100m2 i.e., 100×100 m2. The Base Station is positioned at the middle possessing limitless energy. The network parameters utilized are recorded in the below table.

6.1 NETWORK PARAMETERS

PARAMETERS	VALUES
Emp (Receiving Energy dissipated)	0.0013pJ/bit / m4
Efs (Free space model Energy dissipated)	10pJ/bit/m2
Do (Reference distance)	87 meters
Eda (Energy Dissipation : Aggregation)	5nJ/bit
K (Packet size)	4000 bits

Table 1 Network Parameters

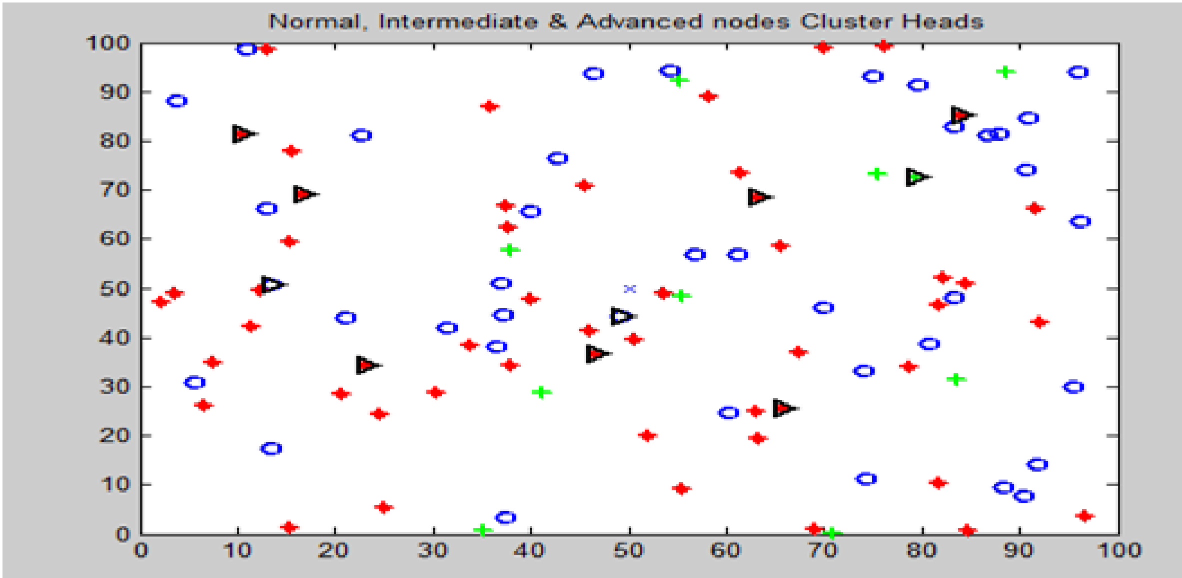


Fig.1(a) Proposed network model

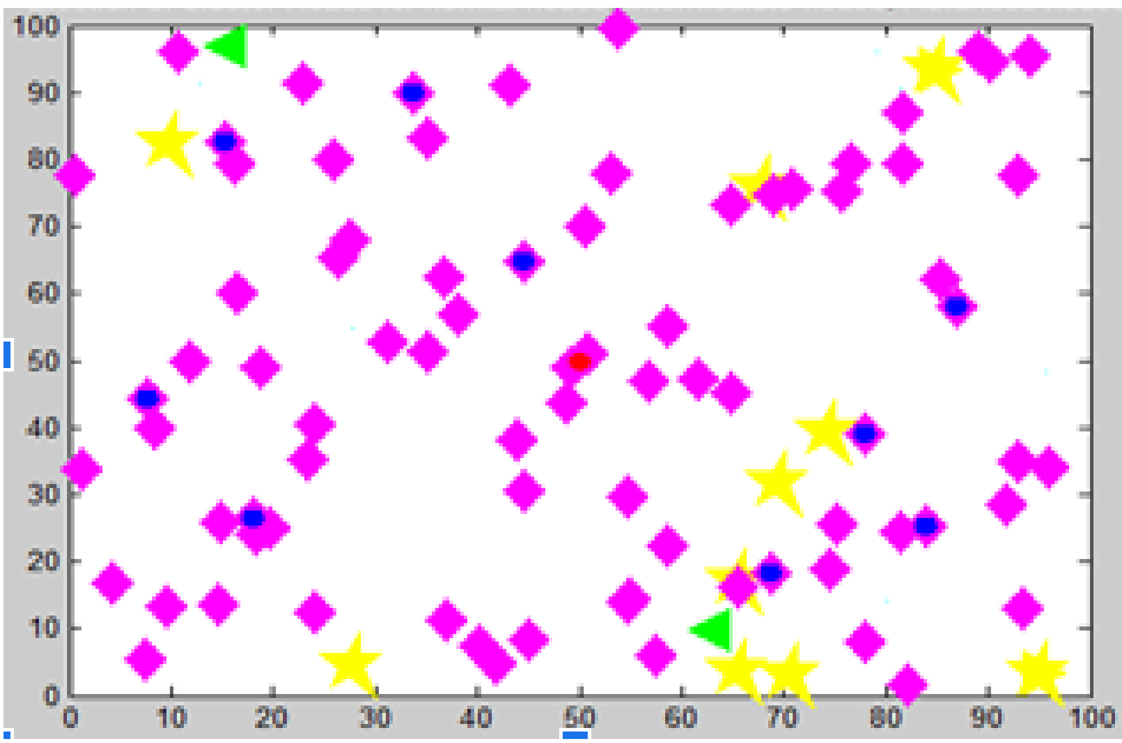


Fig.1(b) SEP Network Model

Fig.1 indicates the behaviour of the proposed model in contrast with SEP arises the two level heterogeneity, the values of “a” and “α” are fluctuated while “b” keeps a consistent value of 0.5. Initially, α = 1, a = 0.1, rmax=8000(maximum number of rounds)**.** Here, Blue colour indicates Normal Nodes, Red colour indicates Intermediate Nodes, Green colour indicates Advanced Nodes, Black colour in Triangle shape represents a Cluster head. Fig.1(b) indicates the behaviour of the proposed model in comparison to I-SEP that follows two level heterogeneity, the values of “a” and “α” are varied while “b” maintains a constant value of 0.5. For the first instance α = 1, a = 0.1, rmax=3999(maximum number of rounds) ,xm=100, ym=100**.**Here, pink colour indicates Normal Nodes, Yellow colour indicates Advanced Nodes, Green colour in Triangle shape represents a Cluster head. Red coloured node in the middle is the Sink node, with highest energy.

6.2 DEAD NODES:

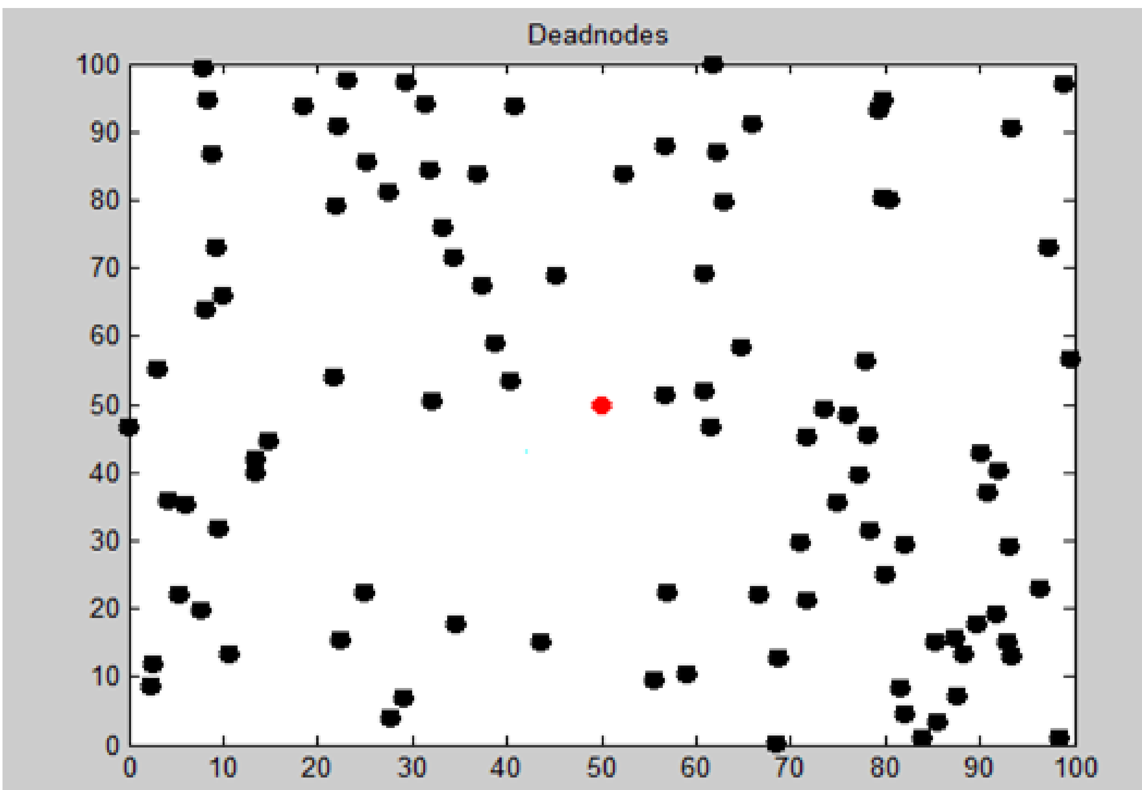
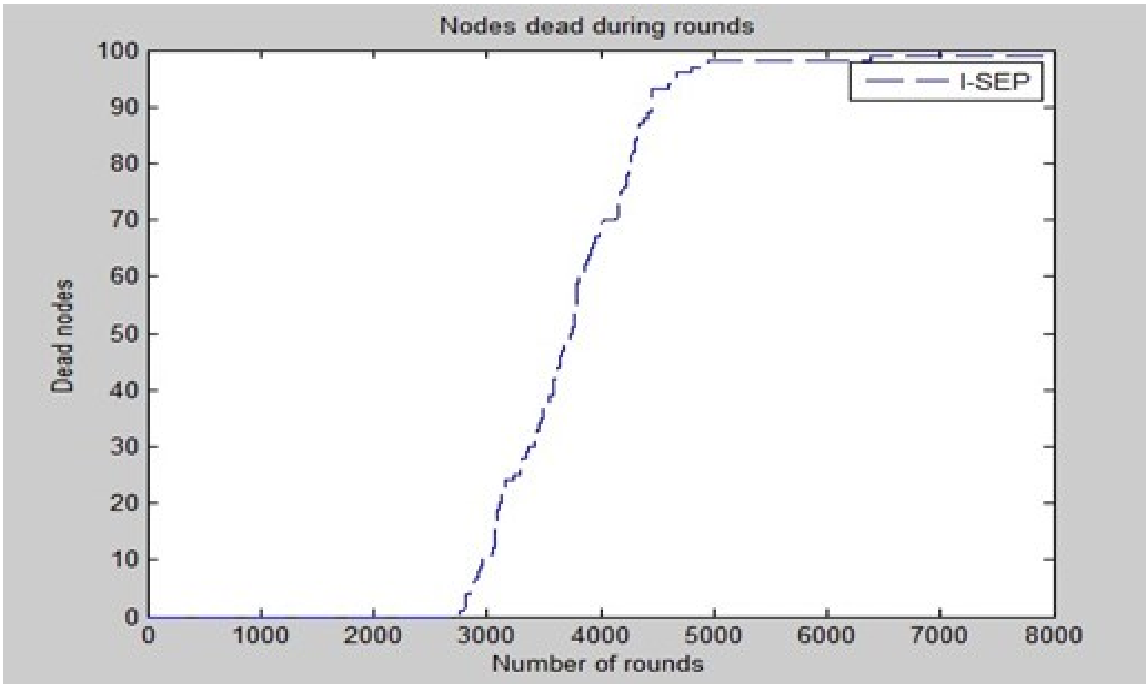


Fig.2(a) Dead nodes in I-SEP



2(b) Dead nodes in I-SEP

Fig.2(a) Indicates Dead nodes in I-SEP, the red colored node at the center in Fig. 2(a) is the base station with unlimited energy. As the large amount of energy is applied to the advanced nodes, the amount of dead nodes are extremely low in this case when contrasted with intermediate and normal nodes. Meanwhile, the normal nodes are dead at a quicker rate. In this manner, the intermediate and advanced nodes are chosen as Cluster Heads which stretches the lifetime to large number of rounds and increments the Cluster head count. As the dead nodes are increased, the amount of alive nodes decreases as in Fig.3. Here, the number of rounds ‘r’ is 8000. With b=0.5 , a=0.1, α =1.

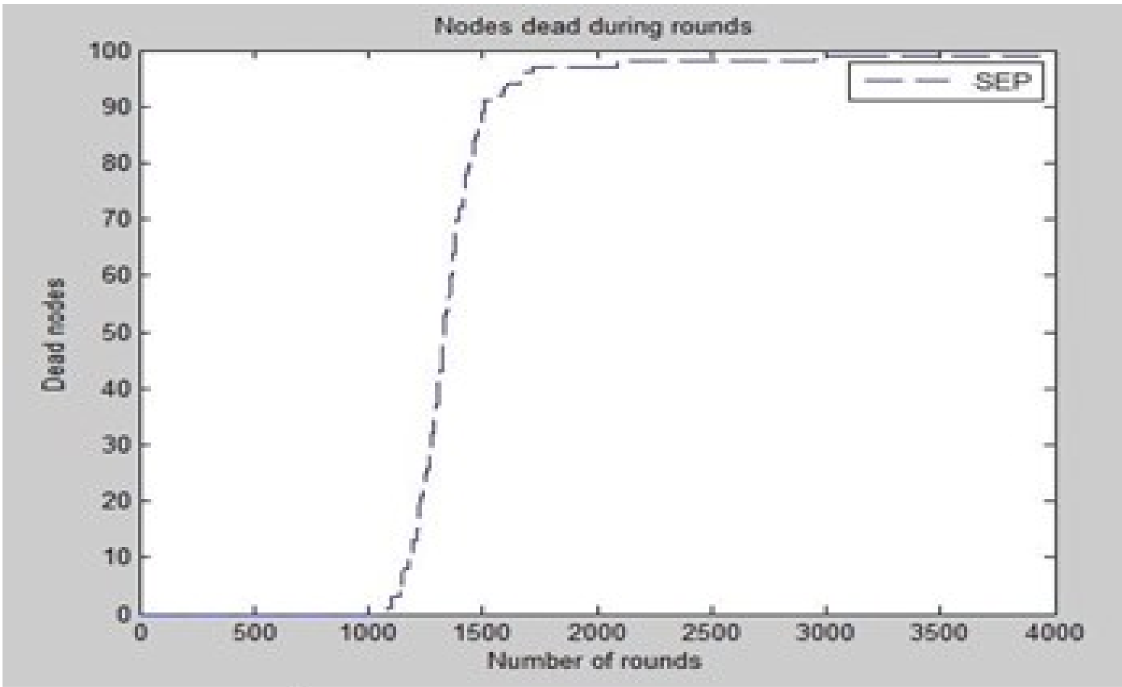


Fig.2(c)Dead nodes in SEP

Fig.2(c) Indicates Dead nodes in SEP, the red coloured node at the centre is the base station with unlimited energy. As the large amount of energy is applied to the advanced nodes, the amount of dead nodes are extremely low in this case when contrasted with intermediate and normal nodes. Meanwhile, the normal nodes are dead at a quicker rate. In this manner, the intermediate and advanced nodes are chosen as Cluster Heads which stretches the lifetime to large number of rounds and increments the Cluster head count. As the dead nodes are increased, the amount of alive nodes decreases as in Fig.8. Here, number of rounds 'r' is 3999. With b=0.5 , a=0.1, α =1.

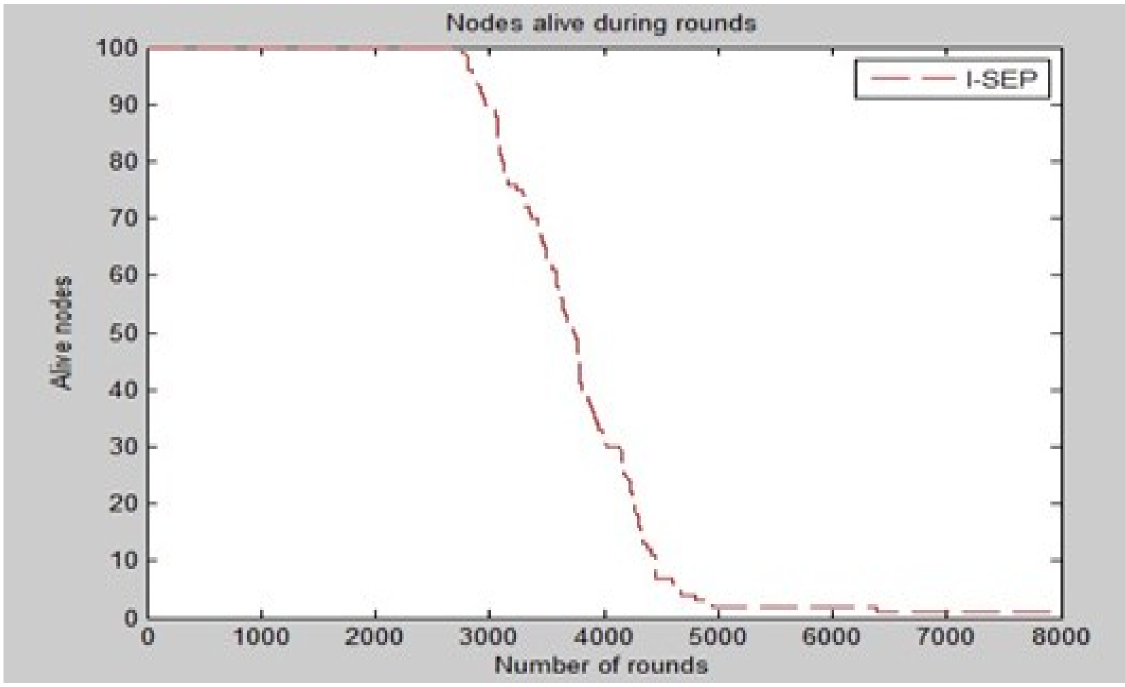


Fig.3(a)Alive nodes for rmax=8000 in i-sep

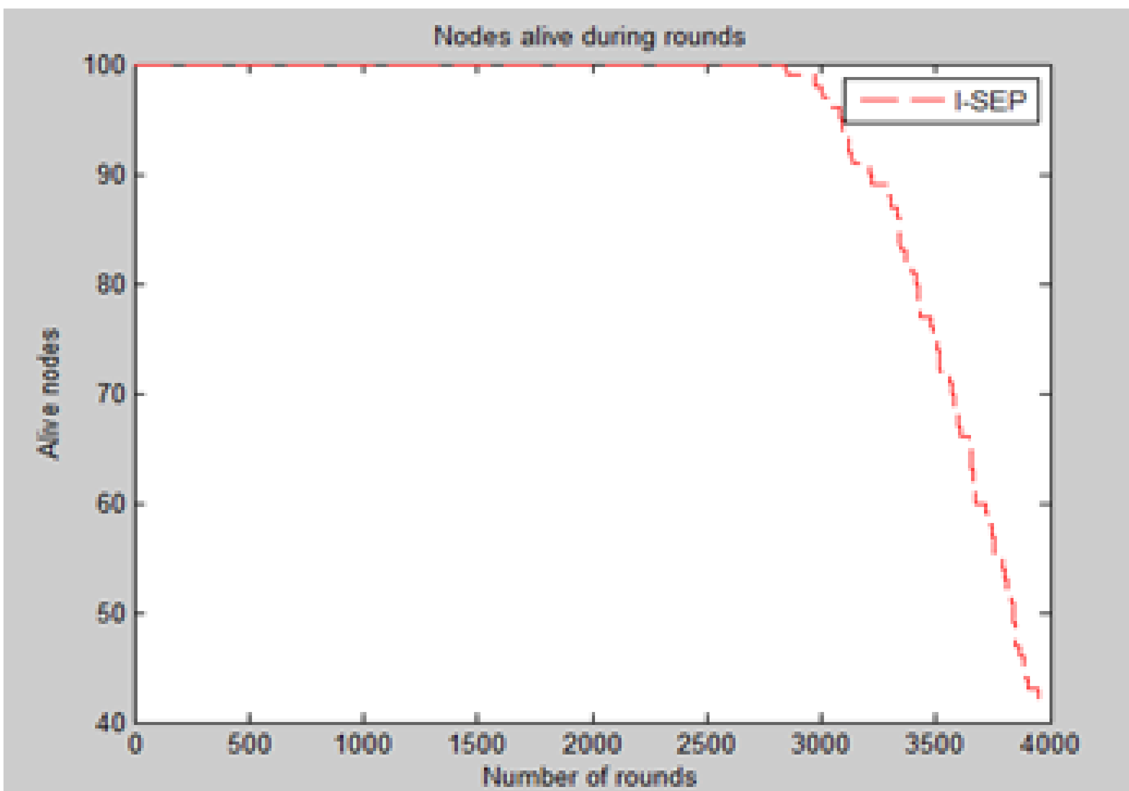


Fig.3(b)Alive nodes for rmax=4000 in i-sep

Fig.3(a) Indicates the decrease in the amount of not dead nodes since iteration of the loop increases. Here, when the amount of dead nodes increments, amount of alive nodes are decreased. Here, number of rounds 'r' taken is r= 8000 and the maximum number of rounds 'rmax' is 8000. With the dimensions of 100 x 100m2. Similarly, in Fig.3(b) the rmax is decreased by 4000; the only difference is that the graphs can be seen clearly as the maximum number of rounds is increased.

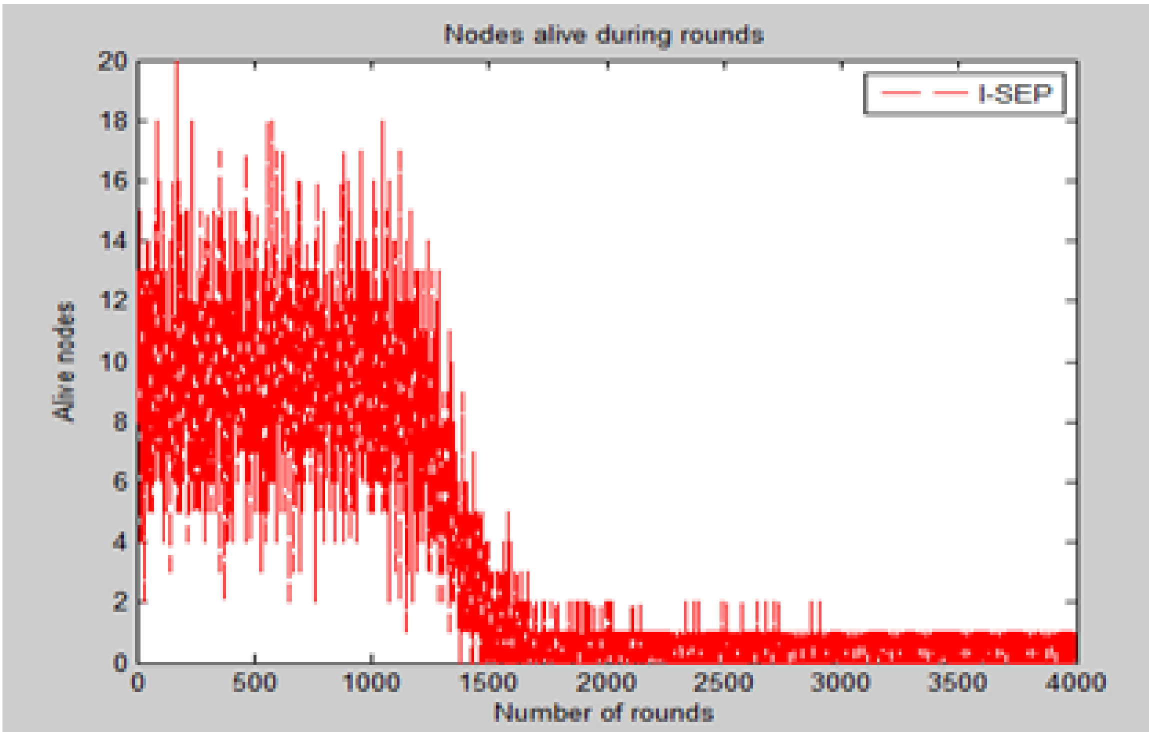


Fig. 3(c) Alive nodes in SEP

Fig.3(c) Indicates the decrease in the amount of not dead nodes since iteration of the loop increases. Here, when the amount of dead nodes increments, amount of alive nodes are decreased. Here, the number of rounds 'r' taken is r =3999 and the maximum number of rounds 'rmax' is 3999. With the dimensions of 100 x 100m2. As we observe the difference between the I-SEP and SEP, it shows that the distortions are more in SEP. So, we prefer using I-SEP.

6.3 THROUGHPUT

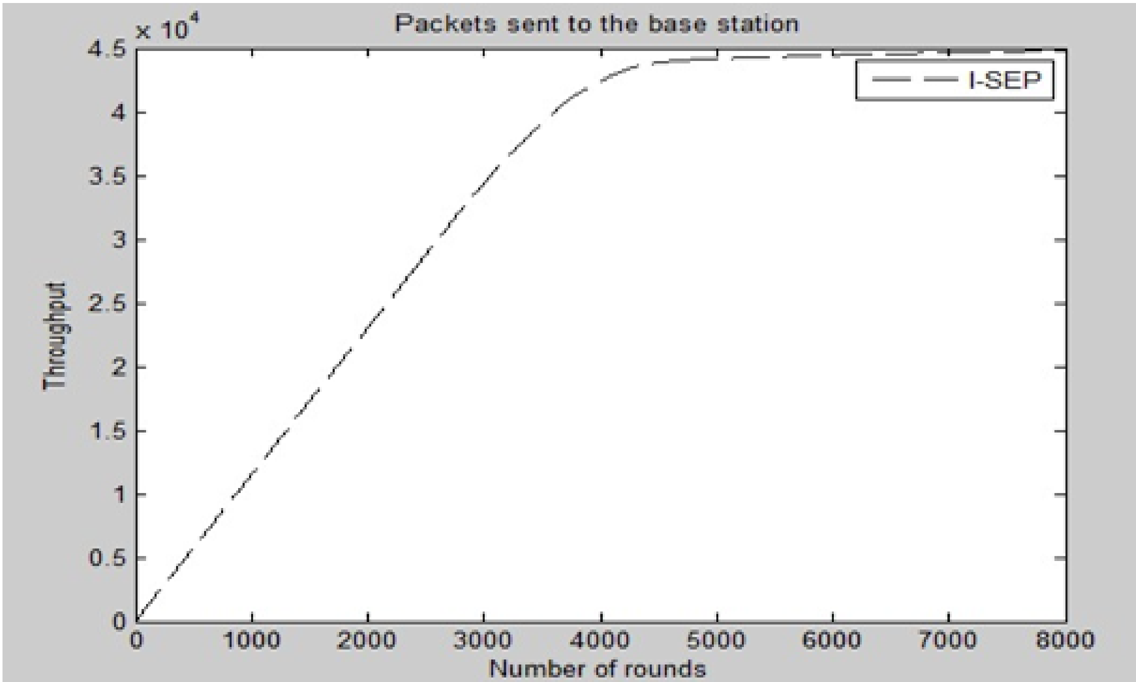


Fig.4(a) Throughput for rmax=8000

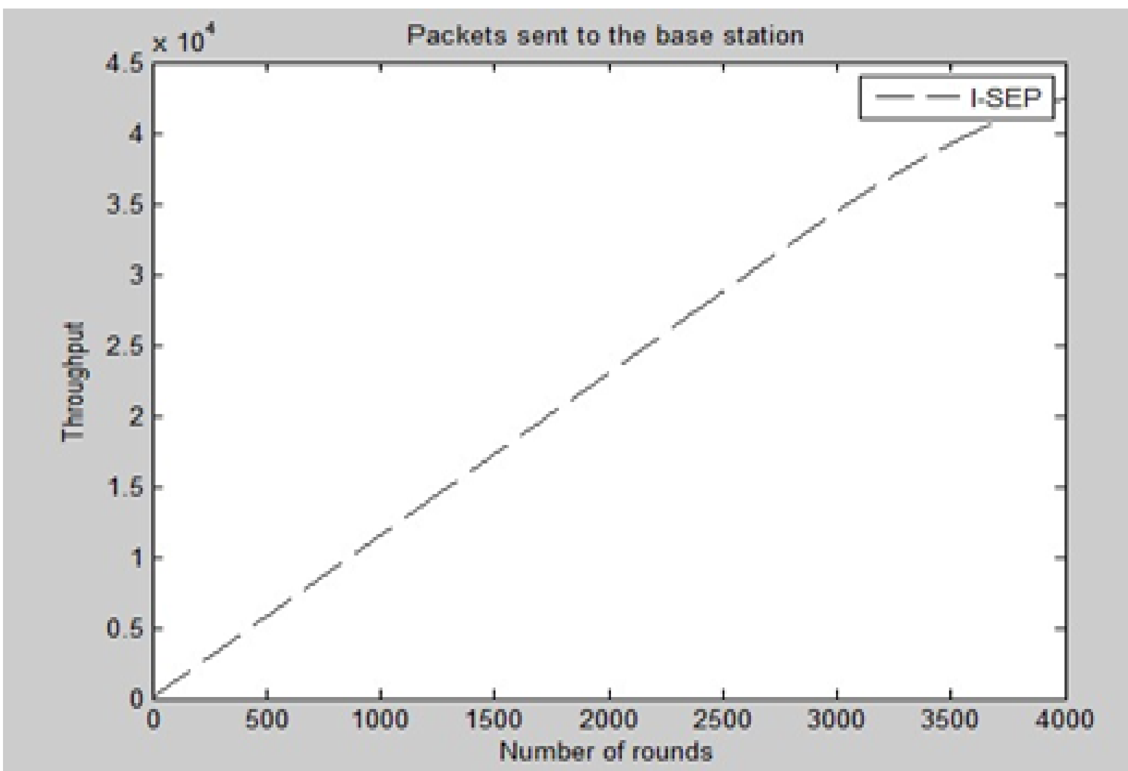


Fig.4(b)Throughput for rmax=4000

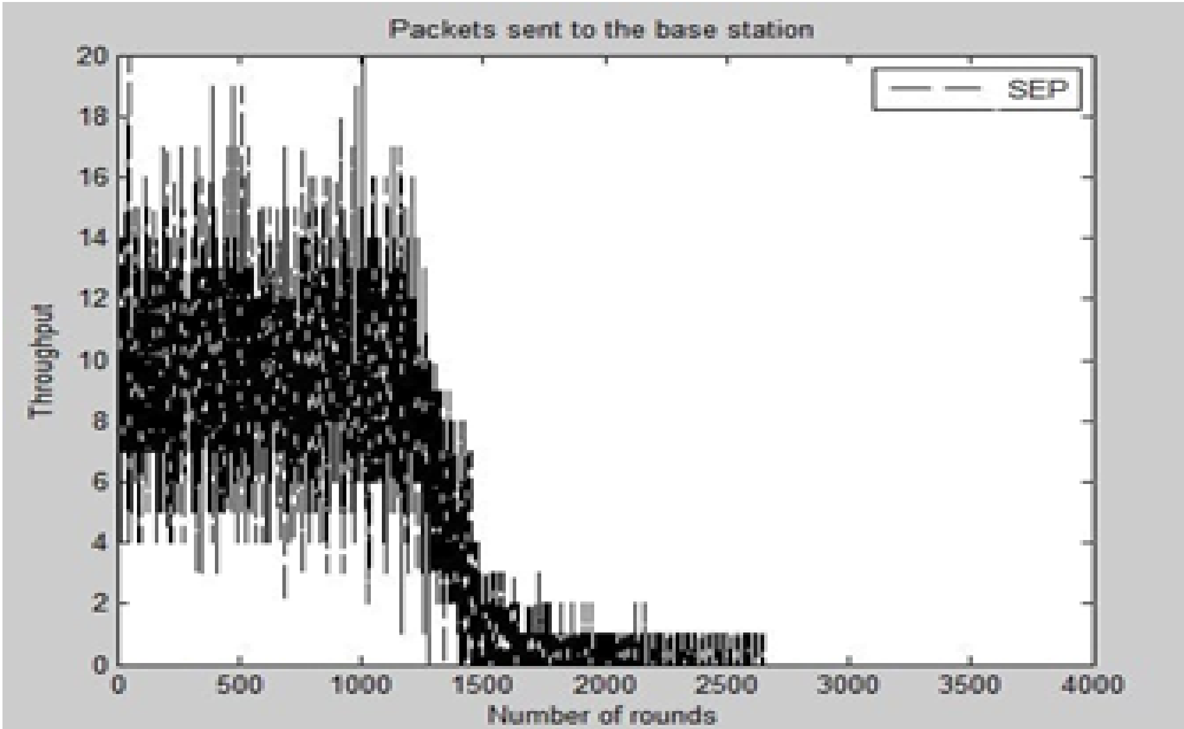


Fig.4(c) Throughput in SEP

Fig. 4(a) Indicates Throughput for a = 0.1 in I-SEP. For the maximum number of rounds taken as 8000. throughput is the key factor for construction of a routing protocol in wireless sensor network. Throughput is an amount of information that a node can receive, transfer information to the BS within the specified period. so, this can be done by introducing a threshold limit within a Cluster Head selection process. The throughput increments for Improved SEP in contrast with the SEP Protocol. By inserting a threshold value in order to stay in the Cluster Head having enormous residual energy assists to preserve energy individually. These nodes will help in communicating the information for more time. When we put α = 1, the throughput for I-SEP increments as 50percent in contrast to SEP 4(c). As the number of rounds increases, the graph can be seen clearly. The efficiency for all routing algorithms is analysed by determining amount of data packets linked to sink node / Base Station having a very less packet drop ratio. It is known as “network throughput”. The 10percent of advanced nodes within the network, throughput & network lifetime were analysed in SEP.

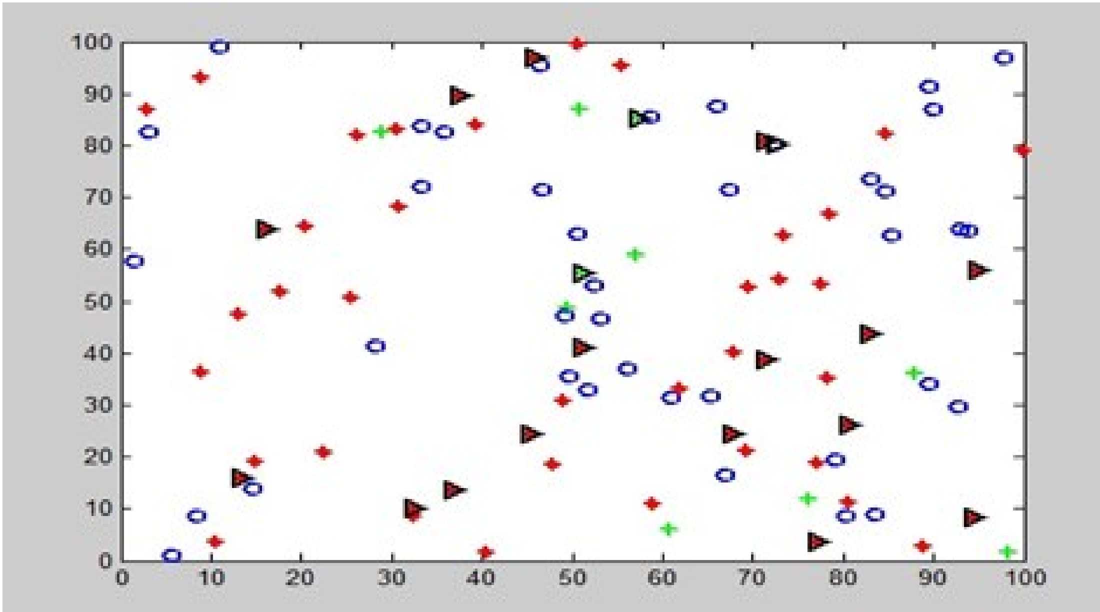


Fig.5 Advanced, intermediate and normal nodes in I-SEP

Fig.5 Shows the I-SEP Protocol with n = 100 sensor nodes inserted within a network with the parameters Xm=100m2, Ym=100m2 i.e., 100×100 m2. The sink node is positioned in middle with unlimited energy. A very large number of rounds taken were rmax=4000 ,value of b=0.5.The Network parameters taken were same as in table 1.

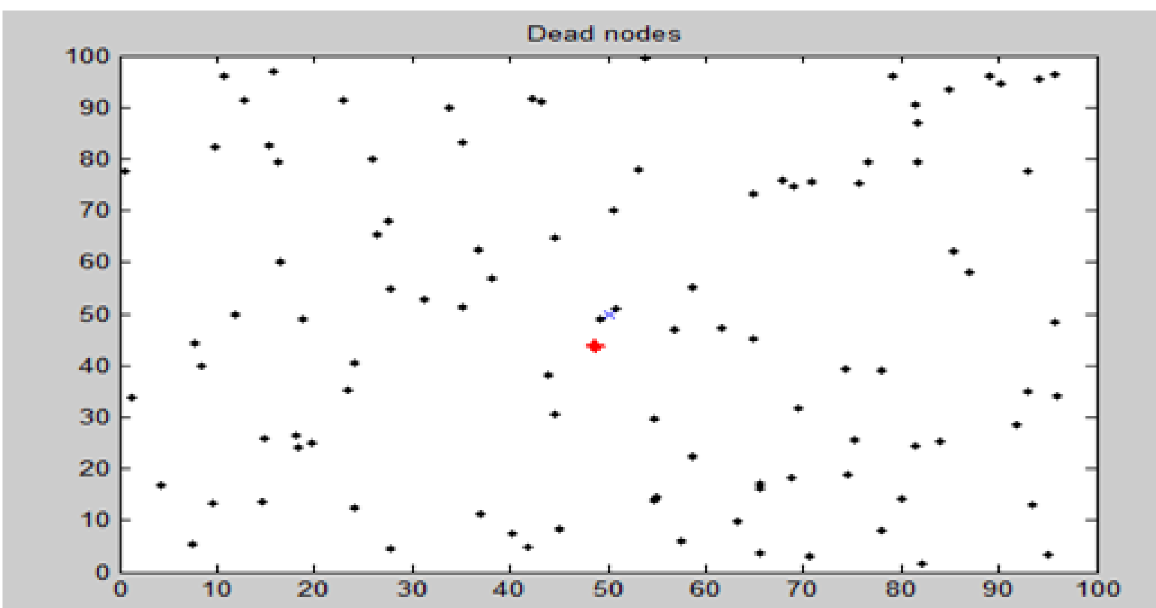


Fig.6(a) Dead nodes in I-SEP for rmax=4000

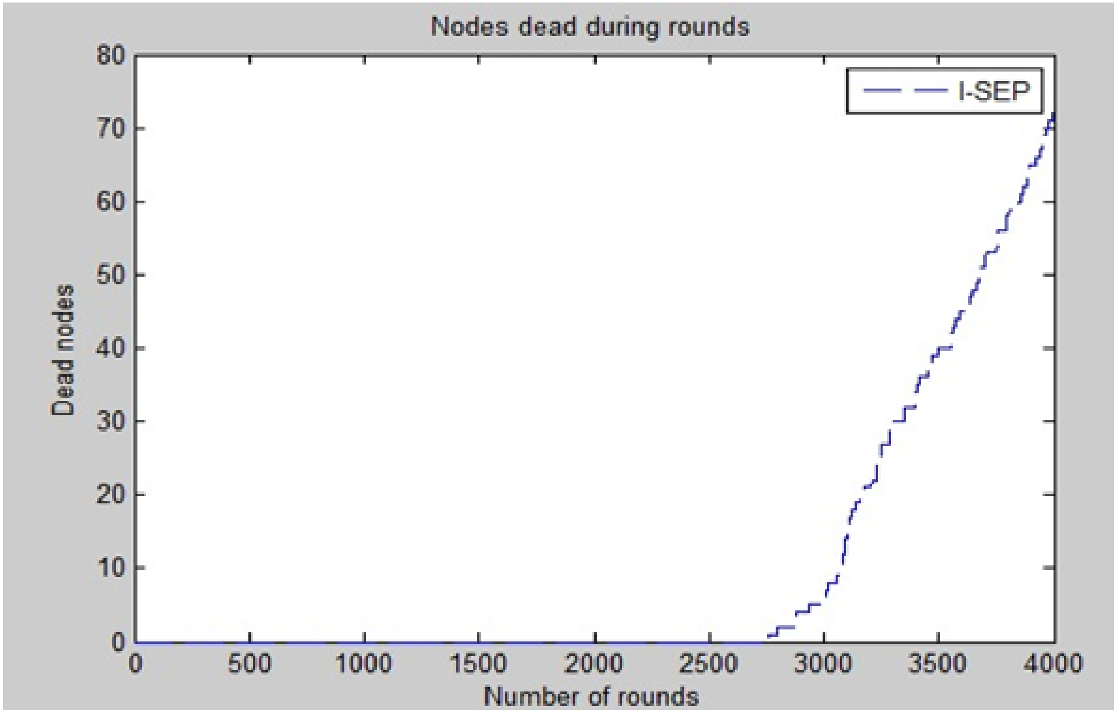


Fig. 6(b) Dead nodes in I-SEP for rmax=4000

Fig.6(a) Indicates Dead nodes in I-SEP, the red coloured node at the centre in Fig. 6(a) is the base station with unlimited energy. As the large amount of energy is applied to the advanced nodes, the amount of dead nodes are extremely low In this case when contrasted with intermediate and normal nodes. Meanwhile, the normal nodes are dead at a quicker rate. In this manner, the intermediate and advanced nodes are chosen as Cluster Heads which stretches the lifetime to large number of rounds and increments the Cluster head count. As the dead nodes are increased, the amount of alive nodes decreases as in Fig.3(b).Here, the number of rounds ‘r’ is 4000. With b=0.5,a=0.1,α=1.

6.4 COMPARING THE 2 PROTOCOLS OF SEP AND I- SEP:

• I-SEP indicates that it is far good compared to SEP.

• I-SEP, has stability period way more when compared to SEP and also all other protocols

• I-SEP shows greater throughput than SEP.

- Network lifetime of I-SEP is more when compared with SEP.

- Throughput decreases when compared to SEP because we are implementing a threshold based data release approach here.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

Stability period, network lifetime, throughput were the main elements for constructing an efficient routing protocol, I-SEP in a heterogeneous WSN. To evaluate I-SEP algorithm, considerable simulations are performed in order to make sure that the benefits of developing the I-SEP in the real time. This algorithm is shown in a way which suits best in a heterogeneous network having the sensors possessing more than a single energy level (Normal, Advanced, Intermediate). This I-SEP protocol is a improved version of Stable Election Protocol (SEP), and this is suits best in Internet of Things. All the operations and results prove that I-SEP protocol beats all the other protocols like Stable Election Protocol based on lifetime and throughput for other values of node density. This I-SEP distributes the energy levels among the Cluster Heads and the other nodes, all these enable in conservation of energy with in a network. Thus, In comparison with SEP, proposed protocol I-SEP, because of the three (Normal, Advanced, Intermediate)levels having the heterogeneous behaviour, with a reactive routing network protocol leads to the growth in the stability period & the network life.

7.1 Future Scope:

By introducing an improved algorithm in a moving network having the nodes moving from point to point at a constant velocity might get improved . There can be situations when the cluster head still has enough energy but the new cluster head is selected. This results in energy wastage in the form of new cluster formation and change in routing information. A power based threshold to minimise the cluster formation frequency can greatly increase the network lifetime.

CHAPTER 8

REFERENCES

[1] W. Heinzelman, J. Kulik, and H. Balakrishnan, "Adaptive Protocols for Information Dissemination in Wireless Sensor Networks," Proc. 5th ACM/IEEE Mobicom Conference (MobiCom '99), Seattle, WA, August 1999. pp. 174-85.

[2] W. R. Heinzelman, and H. Balakrishnan, "Negotiation based protocols for publishing information in wireless sensor networks," Wireless Networks, Volume: 8, pp. 169-185, 2002.

[3]C. Intanagonwiwat, R. Govindan, "Directed diffusion: an expandable and robust communication paradigm for sensor networks," Proceedings of ACM MobiCom '00, Boston, MA, 2000, pp. 56-67.

[4]F. Ye, A. Chen, S. Liu, L. Zhang, "A scalable solution to minimum cost forwarding in large sensor networks," Proceedings of the Tenth International Conference on Computer Communications and Networks (ICCCN), pp. 304-309, 2001.

[5]Y. Yao and J. Gehrke, "The cougar approach to in-network query processing in sensor networks," in SIGMOD Record, September 2002

[6]] W. Heinzelman, and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks," Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00), January 2000

[7]G. Smaragdakis, I. Matta, and A. Bestavros, "SEP: A stable election protocol for clustered heterogeneous wireless sensor networks," Comput. Sci. Dept., Boston Univ., Boston, MA, USA, Rep. BUCS-TR-2004-022, 2004. [Online]

[8] A. Manjeshwar and D. P. Agarwal, "TEEN: a routing protocol for improved efficiency in wireless sensor networks," In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2001.

[9] A. Manjeshwar and D. P. Agarwal, "APTEEN: A hybrid protocol for efficient routing and comprehensive information retrieval in wireless sensor networks," Parallel and Distributed Processing Symposium., Proceedings International, IPDPS 2002, pp. 195-202.

[10] A. P. Abidoye and I. C. Obagbuwa, "Models for integrating wireless sensor networks into the Internet of Things," IET Wireless Sens. Syst., vol. 7, no. 3, pp. 65–72, Jun. 2017

[11]S. Dutt, S. Agrawal, and R. Vig, "Cluster-head restricted energy efficient protocol (CREEP) for routing in heterogeneous wireless sensor networks," Wireless Pers. Commun., vol. 100, no. 4, pp. 1477–1497, 2018.

[12]D. Mahmood, N. Javaid, S. Mahmood, S. Qureshi, A. M. Memon, and T. Zaman, "MODLEACH: A variant of LEACH for WSNs," in Proc. 8th Int. Conf. Broadband Wireless Comput. Commun. Appl. (BWCCA), 2013, pp. 158–163.

[13] N. Bulusu, J. Heidemann, D. Estrin, "GPS-less low-cost outdoor centrailizations for very small devices," Technical report 00-729, Computer Science Department, University of Southern California, April. 2000.

[14] A. Savvides, C-C Han, and M. Srivastava, "Dynamic fine-grained localization in Ad-Hoc networks of sensors," Proceedings of the Seventh ACM Annual International Conference on Mobile Computing and Networking (MobiCom), July 2001. pp. 166-179.

[15] S. Capkun, M. Hamdi, J. Hubaux, "GPS-free positioning in mobile ad-hoc networks," Proceedings of the 34th Annual Hawaii International Conference on System Sciences, 2001 pp. 3481-3490.

[16] Y. Xu, J. Heidemann, D. Estrin, "Geography-informed Energy Conservation for Ad-hoc Routing," In Proceedings of the Seventh Annual ACM/IEEE International Conference on Mobile Computing and Networking 2001, pp. 70-84.

[17]I. Stojmenovic and X. Lin. "GEDIR: Loop-Free Location-Based Routing in Wireless Networks," In International Conference on Parallel and Distributed Computing and Systems, Boston, MA, USA, Nov. 3-6, 1999.

major project report

ORIGINALITY REPORT

26%	16%	19%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Trupti Mayee Behera, Sushanta Kumar Mohapatra, Umesh Chandra Samal, Mohammad S. Khan, Mahmoud Daneshmand, Amir H. Gandomi. "I-SEP: An Improved Routing Protocol for Heterogeneous WSN for IoT-Based Environmental Monitoring", IEEE Internet of Things Journal, 2020 Publication	4%
2	jwcn-eurasipjournals.springeropen.com Internet Source	3%
3	Toscano, Emanuele, and Lucia Lo Bello. "Power-Efficient Routing in Wireless Sensor Networks", Industrial Information Technology, 2009. Publication	2%
4	Submitted to VNR Vignana Jyothi Institute of Engineering and Technology Student Paper	2%
5	shodhganga.inflibnet.ac.in Internet Source	2%

6	A. Kashaf, N. Javaid, Z.A. Khan, I.A. Khan. "TSEP: Threshold-Sensitive Stable Election Protocol for WSNs", 2012 10th International Conference on Frontiers of Information Technology, 2012 Publication	2%
7	www.coursehero.com Internet Source	1%
8	Submitted to nith Student Paper	1%
9	Submitted to Kumoh National Institute of Technology Graduate School Student Paper	1%
10	www.slideshare.net Internet Source	1%
11	Trupti Mayee Behera, Mohammad S Khan, Sushanta Kumar Mohapatra, Umesh Chandra Samail, Md Zakirul Alam Bhuiyan. "Energy-Efficient Routing for Greenhouse Monitoring Using Heterogeneous Sensor Networks", 2019 International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), 2019 Publication	<1%