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IMPROVING ENERGY EFFICIENCY FOR WIRELESS SENSOR NETWORK USING BI-COMMUNICATION

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Abstract: Wireless sensor network (WSN) consist of several sensor nodes capable of sensing physical phenomena of its immediate environment. Sensor node can be distributed randomly or located in fixed place, either in a large or small geographical area. WSN communicate and transmit data with each other wirelessly, its application areas include medical, military, security, home automation, etc. The power consumption, communication technology and distance between sensor nodes have great impact on the network performance. However, designing WSN and utilizing its energy in order to enhance the life time of sensor node is an important factor. Energy consumption is one of the most common challenges in WSN as it affects the lifetime of the entire network, each sensor node is battery power operated and as such wireless sensor network is depended highly on each node battery. The goal of our research work is to introduce a novel routing protocol called, Bi communication (Bi COMM) to optimize energy consumption and enhance network lifetime in WSN by the use of clustering techniques and Bi communication. This is achieved by reducing the amount of data communication which is needed by sensor nodes and decreasing the communication distance between nodes. The simulation experiment is carried out using network simulator produce in NS3. From the result it indicated that the proposed scheme give better performance in terms of energy dissipation and network life time as compared to Low-Energy Adaptive Clustering Hierarchy (LEACH). It is hoped that this scheme will help improve energy efficiency in sensor node and impact significantly in WSN.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Wireless Sensor Network (WSN) consists of large numbers of low cost battery power sensor nodes (Poonam, 2021). These sensor Node (SNs) function together for the purpose of monitoring, capturing, and transmitting information wirelessly over a short distance within their immediate environment where they are located. In WSNs, processed data received in analogue form about the environment and converted into electronic signals which are transmitted in form of radio wave to a base station (BS) called sink. This base station can either be a fixed or a mobile node that can wirelessly link or connect the sensor network to the Internet or satellite where transmitted data can be accessed by users (Sethi,

2010). The life span of WSNs can be prolonged by reducing energy consumption in the network which is one of primary objectives for designing WSNs routing protocol. WSNs are applicable in various areas such as precision agriculture, preventive maintenance, traffic control, environmental monitoring, tracking of object, surveillance, fire detection, home automation, medical diagnosis, etc. (Liao *et al*, 2012). In spite of all the advantages that the application of WSN offers, sensor network has several constraints such as energy limitation, storage capacity, processing capability, and limited bandwidth. To solve some of these limitations, researchers are working on some of the research issues which includes nodes design, security, and in the area of communication protocol. Hence, the design of effective and scalable routing protocol is a crucial aspect to prolong the lifetime and increase the performance of WSNs (Ebrahim, 2017).

In WSNs, communication can be by multi-hop or single hop method. It is a single hope techniques when the base station are close to the nodes and the nodes communicate directly to the base station, but when the nodes work as relay nodes for the purpose of transmitting data to the base station, it is referred to as multi-hop communication (Poellabuwer, 2010) Figure 1.0 shows single and multi- hop communication.

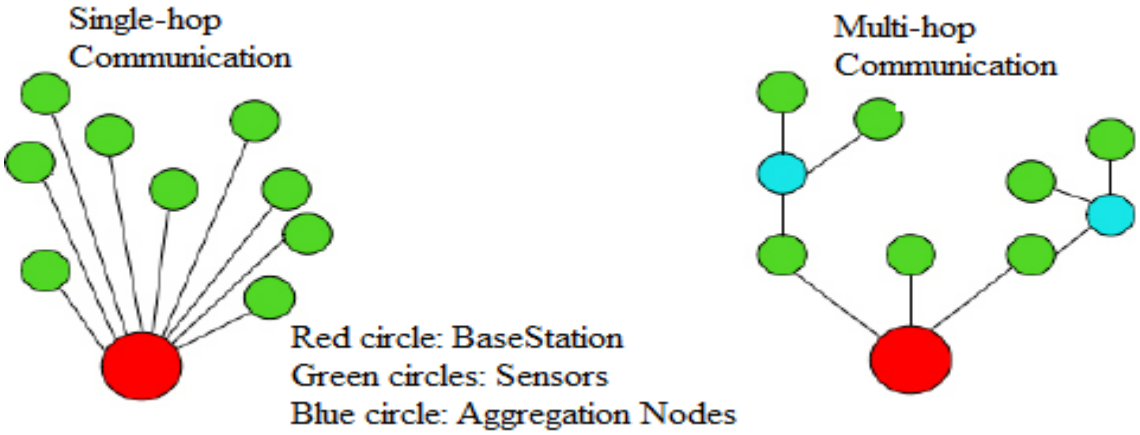

Figure 1.1.1 Single hop and Multi-hop transmission. (Akylidiz, 2010)

1.2 APPLICATIONS OF WIRELESS SENSOR NETWORKS

Wireless sensor network is making great impact and becoming more popular due to its functionalities. They are used in diverse areas ranging from military, agriculture, health, home automation, engineering, environmental, etc.

1.2.1 Healthcare

WSNs have the potential to improve health care while reducing the health care cost. The sensor node has the capability of sensing, computing, and transmitting information to base station. (Farahmad, 2017) noted that WSNs can facilitate continuous monitoring of patient and increase early detection of emergency conditions and disease. (Hadjidi *et al*, 2013)

identified two types of health care application oriented system called vital status monitoring and remote health care surveillance. In vital status monitoring application, sensors are inserted on patient to supervise their vital parameter in order to identify emergency situations which alert doctors to respond promptly. These applications include epilepsy seizure detection, vital sign monitoring in hospital and casualty disaster monitoring. Remote health care surveillance has to do with care services that do not require constant presence of a health care professional. For instance, sensor can be inserted on patient body to collect clinical relevant information to provide support to a physically impaired person or for elderly monitoring (Chang *et al*, 2011). The potential of WSNs has been attributed to early medical diagnosis through real-time tracking in the hospitals (Jeonggil *et al*, 2010). Biomedical sensor has been implemented to monitor the level of glucose in diabetic patient. It has also been used for early detection of cancer by noticing changes in the flow of blood in a certain region of human body (Kumar, 2011).

1.2.2 Transportation System

Studies have shown that WSN has been deployed in transportation system and these areas include traffic light monitoring. In traffic light system, wireless sensors are deployed on our roads and in interception junction's to gather traffic information on the numbers of vehicle and time spent on the queue in order to adjust the traffic light (Tubishat *et al*, 2009).

1.2.3 Safety system

In safety system, wireless sensors are deployed to deal with emergency situation, hazardous driving condition warning, animal crossing, collision detection and avoidance and route guidance to avoid traffic jam during pick hour (Pascale *et al*, 2012).

1.2.4 Military system

WSNs can help to predict and manage unforeseen event such as natural disaster. (Rault, 2015) classified safety and military application into active intervention and passive supervision. In active intervention, nodes are attached to agent temporally and is dedicated to military safety team oriented activities. While on the field, a sensor node is inserted on each team member so that they can be monitored by their leader. This can also be applied during emergency rescue operation (Javaid *et al*, 2013).

With passive supervision, static sensors are deployed for long-term monitoring especially in large areas such as nuclear site to perform target tracking and surveillance. It is also deployed in civil infrastructure to prevent natural disaster such as flooding and volcanic eruption (Stajano *et al*, 2010).

1.2.5 Environmental and Agriculture

WSN application has been deployed in agriculture in variety of areas such as animal monitoring, environmental monitoring and in precision agriculture. In animal monitoring application, it is deployed for surveillance in order to keep track of animals, check their health status and also detect disease outbreak (Huircan *et al*, 2010).

In environmental monitoring application, sensor network are deployed to gather information in a targeted environment which can be used to detect environmental disaster such as coastline erosion, earthquakes and fire outbreak (Nanda *et al*, 2010). Figure 1.2.1 show the application of WSN.

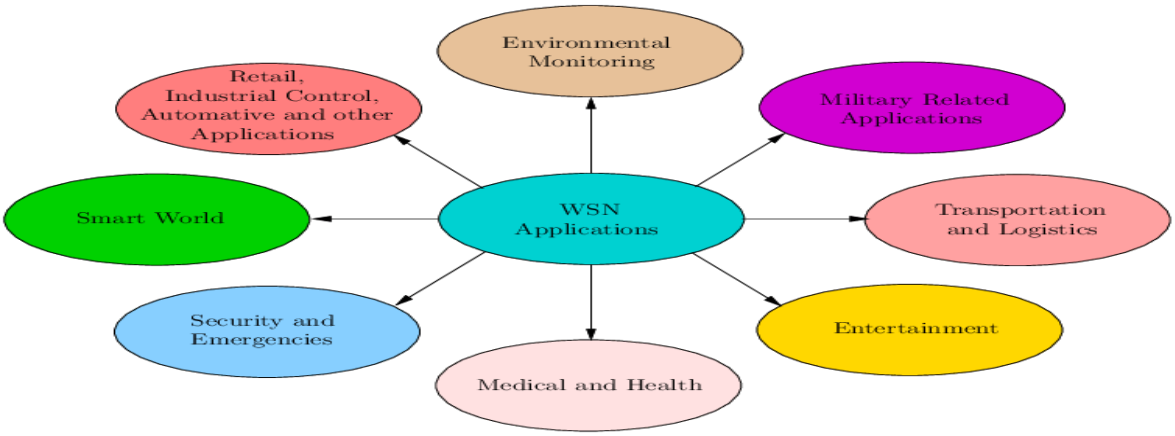

Figure 1.2.1 Applications of wireless sensor network (Halil *et al*, 2017).

1.3 MOTIVATION

Frequent demand of information has prompted the need for the development of new techniques in the way information is transmitted and received. One of these techniques is by the use of wireless sensor network (WSNs). The implementation of this method has also been instigated as a result of the need to monitor physical environment and disaster management such as forest fire detection, landslide detection and air pollution (Olayinka *et al*, 2017). WSNs are deployed in order to communicate and to convey quality information to base station. However, sensor nodes are primarily battery powered devices and as such the energy consumption of these nodes must be properly managed in order to prolong the network lifetime and functionality of the WSN. Energy is consumed in sensor network during sensing, capturing, processing, data transmission and storage. Nevertheless, more energy is consumed during data transmission (Kumara *et al*, 2017). If the energy of the sensor network reaches 15% threshold, it will stop functioning and affect the performance of the entire network. This phenomenon is a challenging issue in WSNs. To overcome this challenge, researchers have been intensifying efforts to minimize energy consumption using different approaches such as new algorithm and techniques on different

communication of the WSNs. Therefore, routing protocol is required to manage the energy of the sensor nodes in order to maximize the network life time.

1.4 STATEMENT OF PROBLEM

Network sustainability in WSN depends mainly on energy resource. However, sensor nodes are battery power and energy is consumed during sensing, processing and communication with other nodes (Zuman *et al*, 2016). In WSN, Energy supply is limited and this constraint affects not only the effective operation of the sensors node but limit the life time of sensors network. In order to overcome these challenges and improve the performance of the network, a great number of energy efficient routing protocol have been proposed for WSN by researchers, some includes (Akram *et al*, 2020). An enhanced energy efficient routing protocol for wireless sensor network. AEEERP Uses matrix and multi-hop to transmit information this method will cause flooding in a large network where the sensor node is far from the base station and more energy will be dissipated. (Kim *et al*, 2021). Sensor Network (WSN) Configuration Method to Increase Node Energy Efficiency through Clustering and Location. It uses physical configuration technique which does not balance energy in the network as more energy will be consume on nodes laying adjacent to base station when it distance increases. (Rasheed *et al*, 2013). Hybrid Multi-Hop Routing Algorithm HYMH. The uses sleep and wake mechanism for node to retain energy but, did consider delay in data transmission. (Rashid *et al*, 2018) Energy Harvesting on Clustering Base Wireless Sensor Network to prolong network lifetime. In their approach, sensor nodes are divided into common nodes and special nodes. The hierarchy will add topology management overhead. (Sunil *et al*, 2017) present Energy- Efficient Routing Protocol using A-star algorithm. In this scheme, they conserved energy by forwarding data packet through an optimal shortest path, but did not consider reliable delivery of packet in terms of failed node. These efforts are all aimed at conserving energy and extend network life time in sensor network. However more work still needed to be done in order to improve the performance of the existing routing protocol in terms of energy efficiency, load balance delay and reliable delivery of data.

1.5 RESEARCH QUESTION

The following question will be addressed in this research:

- How can Bi- communication routing techniques achieve more power conservation in WSN?
- What level of reliability on delivery, load balance and network life time can be achieved using Bi-communication techniques?

1.6 AIM AND OBJECTIVES

The aim of this research work is to propose a routing algorithm that will conserve energy, enhance network life time and ensure speedy reliable delivery of packet in WSNs. The following objectives will be addressed:

- To implement routing protocol and simulate a wireless sensor network using Network Simulation-3 (NS3)
- To optimize the overall energy consumption in WSN through Bi-Communication.
- To compare and evaluate the performance of our proposed routing protocol with that of existing ones in terms of energy efficiency, delay, reliable packet delivery and network life time.

1.7 SCOPE AND LIMITATION OF THE STUDY

This study focuses on energy efficiency and reliability in WSNs. These will prolong network life time and limit nodes communication.

1.8 SIGNIFICANCE OF THE STUDY

The proposed study of optimizing energy in WSN will significantly enhance network life time and improve the efficiency of sensor network that will ensure speedy and reliable delivery of data. This study will provide significant benefit and achievement in the following areas: Medical / health, security surveillance, precision Agriculture, deserter management, traffic control system, monitoring and tracking system, etc.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

WSN has generated a lot of interest in research community in recent years. Its application ranges from environmental, medical monitoring, agriculture, Home automation, etc. However, an operational network is required to achieve application objectives. Hence, energy consumption of nodes is a grate limitation as it affect the network lifetime of sensor network. Sometimes its difficult, expensive or even impossible to replace exhausted batteries due to hostile nature of the terrain as a result of these researchers are making great effort to design energy efficient routing protocol in order to achieve the desired network operation.

2.2 NETWORK DESIGN CHALLENGES

WSN poses some design challenges especially when designing routing protocol. This is because of some of the following limitations (Shio K. *et al*, 2010):

2.2.1 Energy limitation: Energy poses a great challenge for network designers especially in hostile areas. Sensor nodes are limited in energy capacity because they are battery powered. When the energy of the sensor is exhausted the sensor will die and hence it will affect the operation of the network. However, routing protocol design for sensor network should be energy efficient in order to prolong the lifetime of sensor network while guaranteeing good performance.

2.2.2 Limited hard ware resources**:** Sensor nodes have limited processing and storage capacity in addition to energy capacity and as such can only perform limited computation (Singh, 2010). This limitation poses challenges in protocol design for sensor network which most also be considered.

2.2.3 Scalability**:** Routing protocol should be able to scale through large network size to enable communication of sensor nodes in a wider range.

2.2.4 Sensor Node Location: the environmental sensing area must ensure the right placement of each node or else data collection will be difficult. In other words, the position of sensing nodes is important for network performance (Jamal N. *et al*, 2011).

2.3 WIRELESS SENSOR NETWORK ROUTING PROTOCOLS

As a result of recent advancement, several energy saving routing protocols has been design for sensor network in order to prolong it lifespan as more energy dissipation during communication (Merauya *et al*, 2012). Routing protocol is categorized into three: First, Direct communication (DC). Whereby sensor nodes communicate directly to base station. Second category is Minimum transmission energy (MTE) where nodes rout data to base station through intermediate nodes. Third category is the clustering routing protocol which has been proven to be more effective as compared to DC and MTE which is the focus of our research work.

2.4 RELATED WORK

(Fheem and Boudjiit, 2010) present a Multi- Point Relay Base Routing Protocol called. In their approach they divided the sensor network into two categories, the non MPR nodes and the MPR nodes. Residual energy is used to select the MPR nodes. When the MPR nodes are selected, the sink node broadcast location update and the MPR nodes trace the link towards the sender node which enable and create a path to the sink node in order for each sensor node to transmit information. A new location update is broadcast when the sink moves to a new location. However, the sink movement will affect the topological structure initiated by the sink causing more energy to be depleted and affecting the network life time. In recent times, WSN has received significant attention, and energy efficient routing algorithm has been proposed to enhance its network lifetime. In this section we will review the related literature on improving and prolonging WSNs lifetime.

(Kim *et al*, 2010) proposed a Hybrid Multi-hop Routing protocol which combine flat and hierarchical multi hop routing algorithm with data aggregation technique in order to optimize energy consumption and prolong the network lifetime in WSNs. In contrast, it causes extra overhead in the network when the numbers of event increases.

(Razayat, 2010) gives a protocol that help in transmission data in the network based on deadline. However, the protocol reduces transmission time but do not take account of energy consumption in the network.

(Sun *et al* 2010) provides a load sensitive clustering techniques using cost metric and mapping approach to optimize energy in WSN. The authors also proposed mobility based routing protocol to enhance delay and energy efficiency in WSN realizing the need for critical data gathering. The protocol performs well via simulation result but using matric and mapping will cost extra overhead in the network.

(Eu *et al*, 2010) present an opportunistic routing protocol called (EHOR). In their approach, they divide the node into several groups and forwarding selection was based on residual energy. Though, the protocol depends strictly on geographical information of the deployed nodes, he failed to consider possible loops.

(Rand and Zavai, 2011) provide routing algorithm which uses star algorithm to find the optimal path from source node to the sink node base on minimum energy level. If the energy level of the node is less than the threshold level, the node will transmits data, with this, the network load is balanced with regard to the threshold value of the energy and the network life time will be prolonged. Hence, in this algorithm, the latency of data delivery will be reduced as a result of ensuring that the energy level of the node is not less than the threshold level.

(Yao *et al*, 2011) explained routing protocol for WSN called Relative Identification and Direction-Base Sensor Routing. They use triangle rule to determine a sensor node with high energy in order to solve the problem of routing loop and select the shortest distance for routing process to save more energy. The algorithm only aimed at speedy delivery of data through the shortest path without considering reliable delivery of packet

(Ghaffari *et al*, 2011) provide an Energy- Efficient Quality of service (QOS) aware Geographical Routing protocol for WSNs which maximizes network lifetime and use optimum cost function to select the best neighbor node. With consistent location information, the latency of data delivery can be reduced. More so, selecting the best neighbor node may no longer be the best path because of the topological changes.

(Tejomayee Nath, 2011) resent routing protocol for WSN called multi-path on-interest Routing in order to minimize the course breaks recuperation overhead and energy consumption in sensor network.

(Ghosh, 2011) provides in his protocol a formulated path in WSN, the protocol prolong network lifetime and record high data security by sending data to the sink utilizing multi-hope. In scheme, sensor node effectively changed their past query check source at each round of data transmission.

(charian and Nair, 2011) present multipath routing algorithm. In their technique they make use of multiple path and scheduling data transmission rate at each node to extend network life time, prevent congestion and increase reliability. Each node maintain two queues for incoming data and three queues are used in forwarding the data.All the node in the network act as scheduling unit and priority number is assigned to each of them, packet received by nodes are place in the appropriate queue which will later be selected based on priority

number from the queue for transmission. The approach ensures high rate of reliability. Thus, it does not provide a way to detect the failed node and the queuing process can also cause delay in delivery of some packet.

(Peizong and Iwayemi, 2011) explain smart grid consisting of four vital block to conserve energy in WSN. They use decision intelligence, power system infrastructure, sensor and communication infrastructure. These infrastructures are made up of actuation device which are used to band other layers together for reliable data delivery and reduce energy consumption in the network. However, using extra device will increase cost of deploying the network and the device may also have significant effect in terms of energy and management overhead.

(Ren *et al*, 2011) presents, Energy Balance Routing Protocol in which the packet travels toward the sink through dense energy region. They use the concept of potential in physics to construct a mixed virtual potential field in terms of depth residual energy and energy density. The protocol extends network life time but fail to take account of reliability and data delivery.

(Kandris *et al*, 2011) gives hierarchical routing protocol termed, Power Efficient Multimedia Routing protocol for wireless multimedia sensor network used to achieve energy efficiency and quality of service in sensor network. In their approach transmission path to base station is chosen based highest remaining energy. All other possible route are compared after transmission. If the bandwidth for transmission is low the cluster head can decide to drop the packet that are not too significant and deliver the packet that are significant and with this energy is conserved. The algorithm does not consider the fact that dropping of packets because they are not significant may cause distortion in the video which will result in poor quality and also forming cluster at the central can cause extra overhead.

(Shobha, 2012) present routing protocol called Secure Energy Efficient and Dynamic routing protocol for WSN. In the approach he used open shortest part first (OSPF) routing protocol as a gateway to improve energy and reduce secure cost which simplified configuration in sensor network. However, the protocol use OSPF to deliver data. He is concern about fast delivery of data but failed to consider node failure and packet dropping.

(Liu *et al*, 2012) present a cross layer based clustered multi routing protocol. In their approach the nodes are deployed randomly and they are heterogeneous. The cluster formation is initiated by the sink whereby control packet is broadcasted for the purpose of aggregating

data in order to reduce energy consumption. The powerful nodes become the cluster head base on received signal strength CH are classified in different level and data is transmitted through the cluster head. However, the protocol do not maintain the proper path they only have information regarding the neighbor node which is chosen from neighbor list without knowing the present residual energy or its connectivity to other nodes and since this is not ascertain it will affect the network reliability.

(Ebadi, 2012) present a multi hop clustering routing protocol. In his scheme, cluster head was selected based on residual energy and node degree which prolong network lifetime in sensor network.

(Yang *et al*, 2012) proposed an event based routing protocol. In their scheme, two techniques are used to elect CH. First the node closest to the event becomes the CH and the nodes that satisfy certain threshold condition join the cluster head. However, load is not balance among nodes and as such it will lead to network mismanagement, decrease in throughput and network life time.

(Chag *et al*, 2012) proposed a save energy algorithm. In their approach, the cluster head is elected base on node location and average residual energy of the sensor node and residual energy of the sensor node. In this approach, a CH is selected when its residual energy is greater than average residual energy of other sensor nodes. The algorithms conserve energy and extend network life time. However, location information is required for each sensor node which will add to the cost of deploying the network.

(Sasikumar *et al*, 2012) provides a K-means routing protocol for WSN in their techniques. The cluster heads election uses both residual energy level and Euclidean distance of node as criterion for selection of cluster head. When the cluster head energy get depleted, nodes that are closer to the cluster head and have maximum energy becomes the new cluster head. With this, load is balance.

(Rathna and Sivasubramania, 2012) explain routing protocol to help reduce the energy consumption in WSN. They achieved this by reducing the number of times a node has to wake up in a time slot to be in the active state. Hence, switching to sleep mode will hinder fast data transfer and it will make the network inefficient.

(Rajagopalan, 2012) provides Multi Objective Crowding Algorithm to solve the problem of sensor placement in WSN. He maximizes the probability of target detection to minimize dissipation of energy in the network. However, since the number of sensor deployed will be minimized, EMCA algorithm will be suitable in a small network only.

(Zeydan et al, 2012) provides routing protocol called Correlation Aware Routing protocol they constructed data gathering route with the aim of minimizing energy in sensor node. Each route is associated with a maximum cost in terms of it energy consumption and rate of aggregation. At each time of operation, all the nodes examine the resources associated with all the transmission link then select the best route that limit energy consumption. The algorithm will require a lot of computation hence demand large storage capacity which is not suitable for sensor network

(Aslam et al, 2012) provides routing protocol called Centralized Energy Efficient Clustering using three level heterogeneous networks. They divide the network into three equal regions whereby sensor node having the same energy level is deployed in each region. The protocol enhances energy consumption and prolong network lifetime in sensor network. The algorithm failed to consider packet dropping during transmission as a result of unbalance load in the network.

(Rasheed et al, 2013) present Energy-Efficient Mechanism Techniques (E-HORM) to eliminate energy holes. The authors achieved this by the use of sleep and wake mechanism for nodes to retain energy. This approach finds the maximum distance nodes in order to calculate the maximum energy for data transmission. In this technique, the energy level of nodes is first check before data can be transmitted. However, (E-HORM) dynamically maintains the traffic rate base on maximum energy, but fail to consider the delivery rate and the buffer capacity of the active node in order to adjust and predict delivery rate of the active path.

(Haixia and Zhao, 2013), proposed location pairwise key base Secure Geographical and Energy Aware routing protocol to overcome the energy efficient problem in WSN. The protocol prolongs network lifetime but the location of the node needs to be known which will incur extra cost.

(Xiayong, 2013) present routing protocol for WSN term low dynamic time series to minimize energy consumption and memory space in sensor network, higher throughput was achieved but he failed to consider packet delay during data transfer.

In their paper (Weng *et al*, 2013), presented a novel sleep- scheduling technique called Virtual Backbone scheduling which uses over lapped backbone to prolong network lifetimes. Only backbone forward data to the sink while the remaining nodes go to sleep mode in order to conserve and prolong energy. The authors also proposed a new routing protocol using fuzzy approach and A-star algorithm to balance energy consumption and prolong network

lifetime. To determine the routing schedule; each node has to send criteria to the sink. Hence, this will create congestion and result to frequent packet dropping.

(Cuomo *et al*, 2013) explain energy efficient algorithm for sensor network. They combine the procedure of network formulation define at media access control layer and the topology reconfiguration algorithm operating at the network layer using minimum height of the cluster tree to decrease energy consumption, latency and prolong network lifetime in sensor network.

(Zhenbo Shi, 2013) gives routing protocol that help to limit the number of data exchanged between beacon node and unknown node. This scheme decreases energy consumption and localization accuracy in sensor network.

(Thakkar, 2014) proposed routing protocol for WSN which prolong network lifetime by forwarding data to sink with limited energy. The technique is used to anticipate energy delay index to improve network lifetime. He did not consider delay in data transmission.

(Zhang, 2014) propose an energy balance routing protocol called Forward Aware Factor (FAF) In his technique, he used a bounced hub with the attention of connected weight and vitality thickness in order to balance energy in network. The proposed protocol is adapted to non-critical failure and can decrease the likelihood of progressive hub delivery. .

(Daisuke *et al*, 2014) explain Energy Efficient Big Data Gathering in sensor network. In their scheme, they used a single mobile node for the entire network in collecting data, and all the sensing areas are divided into regions. Nodes within the region form cluster base on the degree of dependence and hence use the K-means algorithm to find the centroid of the cluster in order to transmit data to the base station. The protocol reduced energy consumption and prolongs network

(Manjeshwar and Agarwal, 2015) proposed Trustworthy Energy-Efficient Nimo TEEN routing protocol. The technique is aimed at reducing the transmission time. They have the notion that processed data in sensor nodes expand energy less than transmission. In this method, in every round, the cluster head (CH) broadcast to its cluster members (CM) soft and hard threshold. A sensor node can transmit data only when sensed value is more than hard threshold and the difference between sensed current value and previous sensed value is more than soft threshold. The algorithm leads to large number of unnecessary rebroadcast at every round by the CH which result in more energy consumed by sensor node and in turn affects the network life time

(Rani et al, 2015) gives energy efficient chain based on cooperative routing protocol for WSN. In their approach, they use multi-hop data aggregation techniques by forming coordination in hierarchical clustering to reduce transmission distance. Simulation result shows that the algorithm performed very well in terms of energy optimization and delivery time. Lifetime. Thus, do not take account of packet loss as a result of buffer over flow as only one mobile sink is in charge and takes the responsibilities of data collection in the network.

(Qian *et al*, 2015) explain Energy Harvesting Aware algorithm. In their approach, they represent the behavior of sensor nodes as a game, whereby, sensor node with the high harvesting energy assist the low harvesting energy sensor node to keep connectivity of the sensor network and prolong its lifetime. Hence, it causes an unbalance load life cycle of the nodes and decrease first packet arrival time.

(Samara, 2016) provides routing protocol for WSNs. He uses a non- incremental machine learning to give preference to healthier and shorter path which result in less energy consumption. In this techniques, packets are classified as critical, urgent, and normal and different priorities and resource are assigned to them, paths are chosen using mathematical formula based on merit criteria. The protocol is inefficient in the sense that it allocate resources base on how the packet are classified. This classification causes in balance in the network. The protocol also gives preference to shorter path which will lead to drain of energy along the path quickly and later affect the network life time.

Our literature review reveal that several energy efficient routing algorithm has been proposed in the recent past and the found that, the existing routing protocol are still facing energy efficiency limitation issues. In order to improve in the existing algorithm we therefore, proposed Bi-communication routing techniques using both mobile and static sink with concept of clustering algorithm, to optimize energy consumption and extend network life time in WSN.

(Sharma, 2016) gives Multi routing protocol to improve the lifetime, latency and reliability of WSNs by discovering multi paths between source and base station. In his technique, more than one routing path is available to transmit data. Hence, if one path fails an alternative path will be used for data transmission Energy is conserved by switching into sleep mode when sensor node is not involved in routing path. In contrast, the latency of data delivery can also be reduced.

(Shee *et al*, 2016) gives a new cluster base routing protocol called used to reduce energy depletion caused by distance from the base station. In their approach, they subdivided the

entire network into small number of groups based on distance from the base station for the purpose of routing. Each group in the network is made up of cluster member and more cluster are formed as a result of distance from the base station. Simulation result shows that the protocol performed better when applying the same probability to the whole network in terms of network lifetime and energy consumption. When the entire network is subdivided in a larger network there will be management overhead in managing each group during network operation.

(Cengiz, 2016) explain routing protocol for WSN called low Energy Fixed Clustering Algorithm. In his approach, cluster are constructed during set up phase, and sensor node in stay in the same cluster all through during network operation. With these techniques, energy dissipation is decrease significantly and the lifetime of the network is prolonged. Constructing cluster during setup phase may hinder other nodes in the joining process which will limit data transmission by such node.

(Wassim *et al*, 2016) provides routing protocol for WSN called Orphan node LEACH. The use the concept of covering sensor node which are located far from the cluster head is to limit energy consumption in sensor network. The protocol outperformed the LEACH in the case of network connectivity but failed to take account of reliable delivery of data.

(Sujithra *et al*, 2016) gives routing protocol for WSN called Threshold Based Toward Energy Efficient Big Data using transceiver scheduling to increase the lifetime of sensor network. In their techniques, they classified cluster members as active and passive cluster member based on the threshold with the idea of reducing data gathering latency by limiting the amount of data to be transmitted in turn energy consumption will also be reduced and network lifetime will be prolong. They failed to consider the fact that, if the amount of data transmitted is reduced it will affect the efficiency of the network in terms of data delivery.

(Mohammed *et al*, 2017) provide energy efficient routing algorithm by using solar power node to reach energy efficiency. In their work, they prolong the network lifetime by adding super node which uses the concept of rechargeable batteries by solar energy. It is shown via simulation that the protocol has better network stability period, network life time, throughput as compared to LEACH, TEEN, DEEN, and SEP with more effective and stability data packet messages. Thus, it causes an unbalanced life cycle of the nodes in the network.

(Sunil *et al*, 2017) present Energy- Efficient Routing Protocol using A-star algorithm. In this scheme, they improve the network lifetime by forwarding data packet through an optimal shortest path, this path can be discovered with regard to the maximum residual energy of the

next hop. Simulation result shows that the proposed scheme improved network lifetime in comparison with A-star and fuzzy logic protocol. The algorithm gives preference to shortest path and node residual energy to extend network life time, but did not consider reliable delivery of packet in terms of failed node.

(Khajule and Ghungrad, 2017) provides Hierarchical Nearest Neighbor Routing which organizes network into form of cluster using K-means clustering algorithm. In the techniques, they build a routing tree by using a process whereby for each round, the base station selects a rout node and broadcast rout co-ordinate to all sensor node in the network after which nodes select its parent. The algorithm does not consider the network performance and delay in data transmission.

(Rashid *et al*, 2018) provide Energy Harvesting on Clustering Base Wireless Sensor Network to prolong network lifetime and stability. In their approach, sensor nodes are divided into common nodes and special nodes called member node and cluster heads. Member nodes sense data and transmit to cluster head, while cluster head perform data aggregation of all received data and transmit it to base station. The hierarchy will add topology management overhead.

(Guodong *et al*, 2018) explain a loop aware routing protocol for WSN, called La- CTP. In their approach, they use a new parent updating matric and a proactive adaptive scheme to effectively suppress loop occurrence and prolong network lifetime. The protocol was evaluated via simulation and it perform better than other existing once, it require frequent updating which will cause extra overhead.

(Sing *et al*, 2018) explain pouting protocol termed Energy Aware Cluster Base Multi- hop using the principle of clustering and multi hop transmission for transmitting data to base station in order to minimize energy consumption in sensor node. In their approach, they use the concept of sub clustering to suppress those area of sensor nodes where cluster head cannot access data due to the distance. However, the protocol will not be efficient in a dense network as sensor node will be affected by network size that is scaling.

Table 2.4.1 Literature Review Summary Table

Author	Description	Problem Addressed	Method Used	Contribution	Performance Matrix
Ramamurthy (2018)	He proposed routing protocol for WSN were	The research explain the problem of energy	By the use of mathematical proof and the concept of	Result shows that the proposed	The scheme outperformed existing methods in terms of

	the sink is place in an appropriate location in order to minimize the distance from the sensor node	limitation in WSN	Hassian matrix of multi-variable calculation	method improved energy efficiency of about 26% that is from 40 to 66	energy efficiency, throughput and network lifetime
Redha (2017)	Proposed a model aimed at electing a relay node that forward data to the sink at minimum cost	The model explain the problem of finding the minimum cost rout form sensor node to the sink in order to optimize energy	By the use of Linear programming and optimization algorithm	Simulation result shows that the scheme reduce energy consumption In WSN to about 48%	The scheme outperformed LEACH, in terms of network lifespan in WSN
Kharjule (2017)	The propose scheme is a hierarchical protocol which organize network in form of cluster	The research work provides the problem of energy consumption, storage capacity and bandwidth	The author apply K-means clustering algorithm and AHP scheduling techniques	Simulation result shows that K-means based improved network lifetime and maximize storage capacity in WSN to about 37% level. That is from 40 to 77	the result is compared with that of LEACH, Power Efficient Gathering in Sensor Information System (PEGASIS) in terms of energy consumption, network lifetime, bandwidth. The scheme performed better
.Kumar *et al*, (2017)	The propose scheme assumed the network is divided into two energy level of	It explain the problem of non-uniform energy consumption and load balance	Clustering algorithm and categorizing the nodes into advance and normal node	Simulation result using MATLAB shows that the prosed method	The result is compared with LEACH routing protocol in terms of average remaining energy and numbers of

	nodes. The node with higher energy level are called advance node and node with lower energy are refer to as normal node			improved energy efficiency to about 10% that is from 50 to 60	alive node The proposed protocol performed better than existing protocols
Singh and , Jain (2018)	The authors provides routing protocol for WSN They use the concept of sub-clustering to cover for areas of sensor nodes where CH cannot reach to gather information	The research explain the problem of energy limitation in WSN	The authors use the principles of clustering and multi-hop communicatio n pattern for transferring data to the sink node	Simulation result shows that energy efficiency is greatly achieved to about 55% that is from 15 to 60	The performance of the schemed is compared with Service Advertising Protocol (SAP), LEACH, Low Energy Fixed Clustering Algorithm (LEFCA) Centralize Energy Efficient Clustering Routing Protocol (CEEC) and it outperformed the existing protocol in terms of network lifetime and throughput
Ravikiran and Dethe (2017)	They provides a novel hybrid fuzzy routing protocol that is built through integration of fuzzy logic with ABC to	It explain the problem of energy consumption and network lifetime in WSN.	They use ABC optimization with fuzzy rule selection approach to improve energy consumption and prolong network lifetime in	Simulation result shows that the proposed method enhances network lifetime and reduces end-to-end	The protocol is compared with LEACH and other existing routing protocol. The proposed method out performed in terms of delay and network life

	optimize CH selection		WSN	delay to about 61 % that is from 11 to 50	
Farahani (2017)	He presented a routing protocol where by the sensor movement are pre-determined and hence applying changes in the network in order to calculate its performance	The scheme explain problem of energy cost and network life time	The proposed protocol use optimum placement to evaluate criteria on the performance and ranked criteria after weighing with the use of Analytic Hierarchy Process (AHP) algorithm to reduce energy consumption in WSN	The analysis reveal that the method improved the performanc e of WSN. Reduce cost and extend network lifetime to about 48% as compared to existing protocols	The performance of the algorithm is evaluated in terms of energy consumption, delay and reliability ratio. The proposed frame work attain high improvement rate
Hameshwar *et a*l, (2017)	In their research the base station select a root node and broadcast root co-ordinate for all sensor node in the network	The provide the problem energy limitation and network life time	it organizes network into the form of cluster by using K-means clustering algorithm	Simulation result shows that the proposed protocol performed better than existing approaches to about 61% in terms of network life time	The protocol is compared with LEACH, PEGASIS and Tree Base Clustering (TBC) and it outperformed in terms of load balance and network life time
Bandeh (2017)	The research select efficient hop node for packet delivery.	The protocol explain the problem energy consumption packet loss	He categorized packet into two priority high and low priority,	Simulation result shows that the protocol recorded	The protocol shows better performance as compared to CO-LEEBA in terms of energy

	Packets are transmitted using multiple hops that are reliable	and throughput	packet with high priority are transmitted faster than those with low priority	37% increment in energy efficiency and throughput that is from 27 to 50	consumption and throughput

From the literature reviewed, ten are most related to our proposed study and are hereby extracted and summarized in Table 2.4.1. From the table, we observed that various researchers have proposed routing protocol for wireless sensor network (WSN) with the aim of prolonging network lifetime using different approaches. Hence, the researchers were able to extend the performance of sensor network to about 68% increase in terms of energy efficiency, reliability, throughput, and load balance. Thus, as a result of advancement in technology and expansion in the area of application of WSN, there is great need for more improvement in the performance of the existing routing protocol in order to increase the efficiency of WSN, and as such we hereby proposed a Bi-communication routing protocol for WSN in order to improve on the performance of sensor network especially in terms of energy consumption, throughput, reliability, data delivery and network lifetime.

CHAPTER THREE
METHODOLOGY

3.1 INTRODUCTION

In distributed sensor network, source node will have to transmit their data to the base sink node. In most networks, the data has to pass through intermediate sensor node (multi hop environment) before getting to the sink. Sensor network are energy limited hence, the transmission of data can cost significant amount of energy. The network often require efficient routing protocol that reduces the re-transmission of data, which can decrease energy consumption in sensor network and prolong the life time of sensor node (Kumara *et al*, 2017). Minimizing data transmission between nodes using clustering techniques and reducing the communication distance of source and sink node may therefore yield a huge result in saving energy.

In this chapter, we propose a Bi-communication routing protocol, using both mobile and static sink with clustering techniques to optimize energy in sensor network. The protocol is designed to improve the lifetime of the network, latency, and reliable delivery of data.

3.2 NETWORK MODEL

Our proposed routing model in this research work consist of mobile and static sink called Bi-communication protocol which comprises of multiple sensor nodes distributed across the network, divided into grid size within a limited field. However, each sensor node in the network possesses a fixed range of communication R and communication can only be successful within the communication range R. The static sink is stationary while the mobile sink is moving around the network to collect data from Cluster Head (CH) so as to reduce energy exhausted as a result of data transmission. In the network, each sensor node is equipped with resources that will store sensed data and network information, hence, information sensed by individual nodes are transmitted to CH which in turn transmits to either mobile or static sink nearer to it. The decision is made in order to prolong network life time.

3.2.1 Assumptions

The following assumptions are considered for the proposed protocol:

i. Sensor nodes are all stationary after deployment
ii. The sensor nodes are uniformly distributed in the network field with random deployment
iii. Sensor nodes have the same capability (homogeneity) in data transmission
iv. Sensor nodes can calculate their residual energy and compare it with other existing ones
v. There are two sinks; one mobile and one static within the network
vi. Data is always available to be sent by sensor node

3.3 Proposed Protocol

In this research, we proposed a Bi communication routing protocol to limit energy consumption and prolong network lifetime in sensor network. Our approach is a cluster base routing protocol consisting the combination of two sinks, one mobile and one static. The entire network is divided into equal size grid and in grid contains a set of sensor nodes. In each set, clusters are formed and a Cluster Head (CH) is elected base on its residual energy, and each CH has a maximum communication range of radios. In our network model, all the distributed sensor nodes are aware of their location in the network by means of localization model. Hence, location information of mobile and static sink is also known.The nodes are static in the network, while the two sinks are static and mobile. The mobile sink moves around within the network with a stop time in order to collect sense data from CH, the static sink is stationed at the center of the network to also collect sense data from nearer CH and each CH must be connected to at least one sink. Those that are connected to both sink can transmit their data to the nearest sink so as to reduce energy exhausted as a result of data transmission. In the network, each sensor node is equipped with resources that stores sensed data and network information and hence, information sensed by individual nodes are transmitted to CH which in turn transmit to either mobile or static sink nearer to it. The decision is made in order to prolong network life time. The scheme focuses on: Grid and cluster formation, election processes, data transmission, sink management and load balance.

3.3.1 Grid and Cluster Formation

In this approach, the entire network is divided into equal grid size, as shown in figure 3.3.1 the procedure for cluster formation includes cluster head election and joining process between the cluster head and its respective Cluster Member. The formation of cluster is initiated within each grid and we assumed that sensor nodes are aware of their location in the network and at the initial stage they all have equal energy so the sensor node at the center of each grid advertise itself as cluster head. At the end of each round of operation, a new cluster

head is re-elected based on the residual energy of sensor nodes as shown in figure 3.3.3 Periodically, there is intra- cluster communication between nodes and cluster head within each grid to ascertain the level of energy in nodes.

3.3.2 Election process

In our proposed model, number of clusters is formed in each grid. All the nodes are assumed to have equal energy level at the beginning. At the start, sensor nodes at the centre of each grid are chosen as set of Cluster Head (CH). The cluster head sends a short broadcast message within a grid and the sensor nodes reply with an acknowledgement message to its cluster head and starts transmitting data to the cluster head.

However, CH are re-elected only when their residual energy decreases below threshold. The residual energy of each CH should be greater than a threshold value of 15% remaining energy. If the energy level of a cluster head is less than the threshold value, cluster head re-election process will be initiated and a new cluster head is elected.

Consequently, at the end of each round the sensor nodes in each grid calculate their residual energy and compare it with that of other nodes. If a particular nodes residual energy is higher than that of other nodes, the node is elected as cluster head in that grid. The elected node sends a broadcast message declaring itself as the new cluster head and each node replay with an acknowledgement and then starts transmitting data to the new cluster head. At the end of each iteration a new cluster head is elected.

Pseudocode 1: ***Cluster head re-election procedures***

Input*: Residual energy of nodes in a cluster Erx, cluster head CH, threshold value TV, threshold value of cluster head TCH, cluster members CM. Energy percentage of cluster head Enper_ch. Node in cluster (i)*

Step 1 for node i = 1 TO N

Step 2 Calculate center node using K-Means Algorithm

Step 2 if (node i=center) then

node i = CH

Send message CH $\longrightarrow$ *CM*

If received (ACK)

Else resend

Step3 CM transmit data to CH

Step 4 Initialize the minimum threshold value min= (Ei) of CH

Step 5 Compute threshold value

Max-min= (Ei)

Step 6 IF ((Energy level for CH) < (available threshold energy value)) then

CH start election process

Step 7 Compare CH to CM for Erx

Max_Erx = Mx(Ei)

Select node with Mx(Ei)

Node = CH

Step 8 CH send ⟶ msg as CH

Step10 CM transmit data to CH

Step11 go to step 6 and perform all operation continuously

End process

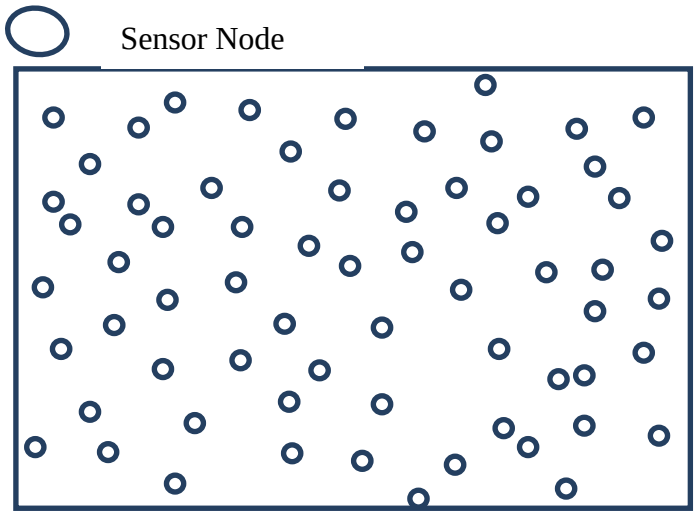

Fig 3.3.1 View of distributed sensor network

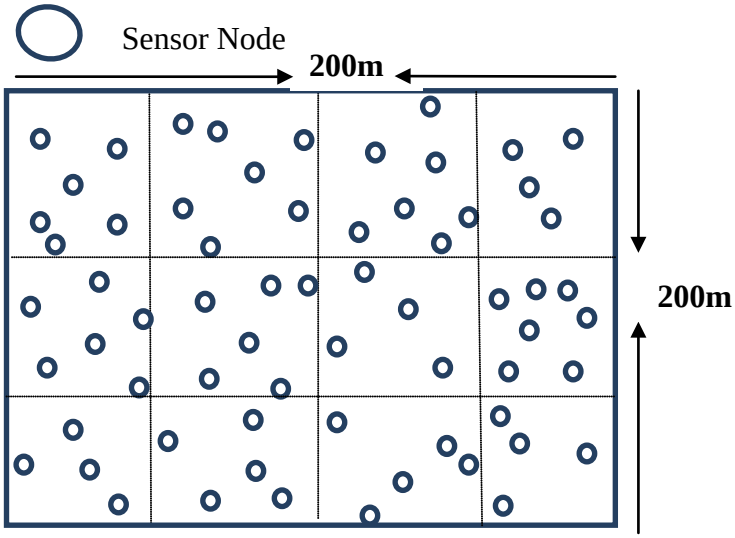

Fig 3.3.2 Virtual grid formation

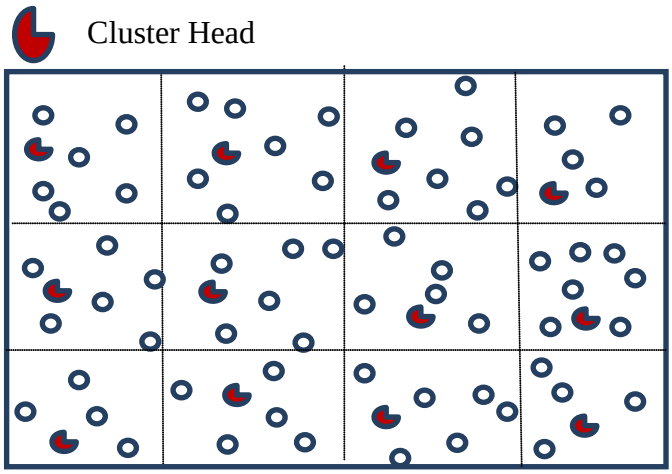

Fig 3.3.3 Cluster Head Selection

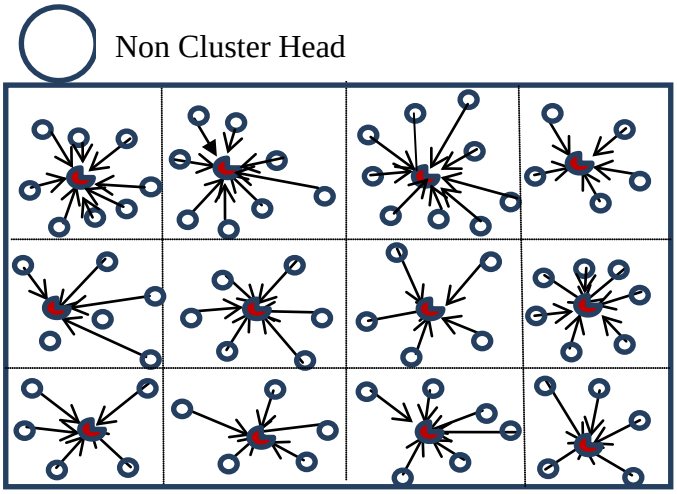

Fig 3.3.4 Joining process and Cluster formation

As shown in figure 3.3.4, after the cluster have been formed, the CHs are considered as the vertices of the formation and a time slot scheduling is designed for CM to collect generated

data and send to CH. The CHs are re-elected only when their energy decreases below the threshold and this is use to balance the load in the network.

3.3.3 DATA TRANSMISSION AND SINK MANAGEMENT

Our scheme uses both mobile and static sink to reduce communication distance between the CH and sink in order to save energy in sensor network.

i For Static sink: the sink is located at the center of the network as shown in figure 3.3.5. At the beginning of each network operation, the sink broadcast a hello packet throughout the network just once to advertise its location in the network. Each CH is connected to at least one sink and it can transmit its data to the sink closer to it, having received the hello message. The hello message contains the following: sink type (that is. static or mobile), the ID of the CH, hop distance between the corresponding sink and CH receiving the message, Having received the message, the cluster head compute the distance if the distance is within the communication range, CH transmit its data to the sink.

ii For mobile sink**:** the mobile sink moves randomly from one point to another in the network to collect data from cluster head, each time the mobile sink stops at a new grid, it also broadcast a hello packet but only at a subset of node in a particular grid. The cluster head replies with an acknowledgement and starts transmitting its data to the mobile sink. Periodically, there is inter-sink communication to ensure that error does not occur during transmission.

Sensor Deployment

Step 1: [**Initialize**]

Let *s* be any point set. *Candidate Set* = {*s*}

The sensor coverage degree of the (i j)th sensing grid is represented by CO(I j). CO(I j) * S(I j) is define as the effective coverage area of the (I j)th sensing grid, where S(i j)

denote the area of the (I j)th grid. The sensing coverage rate of the whole WSN is denoted by SCO.

$$SCO = \frac{COS}{AS}$$

Where **AS** denotes the area of the whole sensing region **COS** denotes the effective coverage area of the whole WSN

$$COS = \sum_{i=1}^{M} \sum_{i=1}^{N} Co(ij) * S(ij) \quad \textbf{EQ 1}$$

Step 2 [Initial Cluster Head selection]

node at the center will become cluster head in the first round **K** is the number of nodes in a cluster **C** is the set of all centroids Assuming C= C1, C2, C3 ---------- CK

Avg min dist $(C_i X_i)^2$ $C_{i \sum} c$

$$C_I = \frac{1}{Si} \sum_{xi\ si} xi \quad \textbf{EQ 2}$$

Step 3 [Cluster Head selection]

Pi(t) is the probability with which nodes I elects itself as the cluster head at the beginning of each round r+1 (which starts at time t) such that expected number of cluster head nodes for this round is k.

$$E[\#CH] = \sum_{i=1}^{N} Pi(t) * 1 = k \quad \textbf{EQ 4}$$

K=# of cluster during each round

N= # of nodes in the network

Each node will be cluster head once in N/K rounds

Probability for each node i to be cluster head at time t

$$Pi(t) = \frac{k}{N - k * (r \bmod \frac{\Delta}{k})} \quad \textbf{EQ 5}$$

Ci (t) =1
Ci (t) = 0

Step 4 [Data Transmission]

To reduce the energy consumption of the sensor node we calculate the shortest distance from the cluster heads to the sink using Euclidean distance measure

$$D = \sqrt{\sum_k \binom{n}{i} = 1 (qi - pi)^2} \quad \textbf{EQ 6}$$

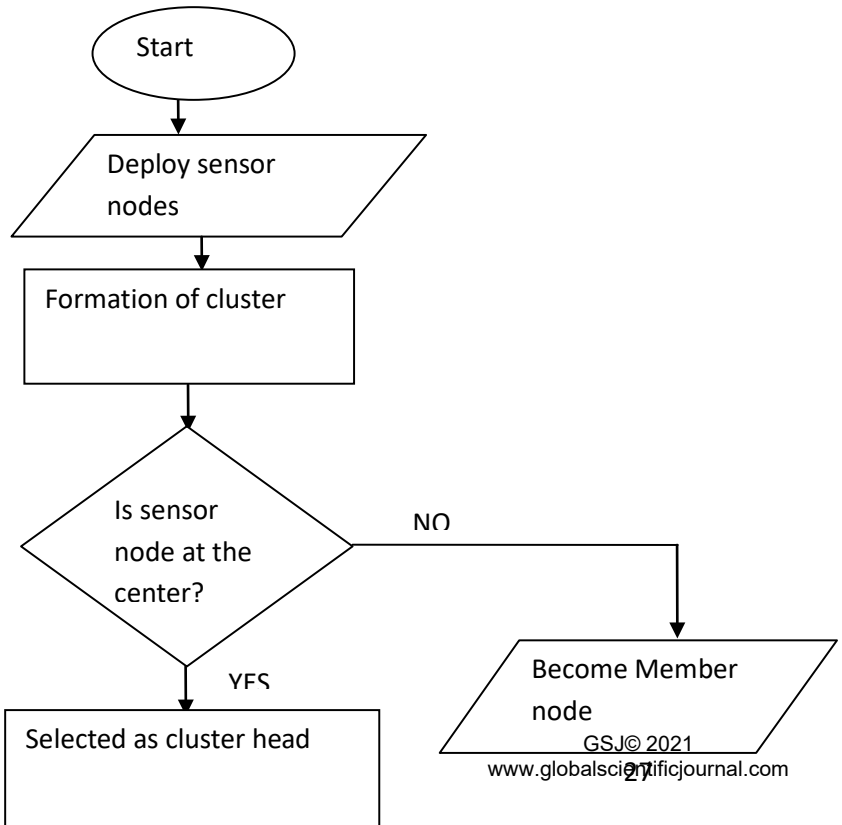

Figure 3.3.5 Flow chart for the propose system

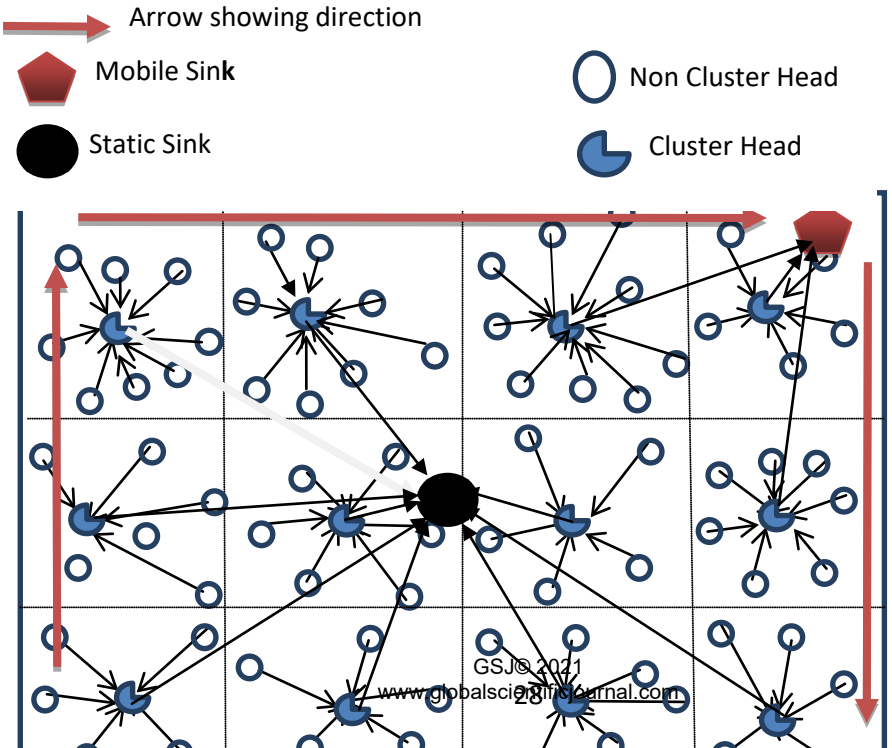

Figure 3.2.5 final view Mobile and Static Sink

In cluster Head (CH)**:** Cluster Member (CM) sends their sensed data to the cluster head for the purpose of conserving energy. The CH aggregates the data and sends it to the nearer sink. In order to transmit data, the cluster head stores the grid distance to the two sinks since data can be transmitted to either sinks. Each CH maintain a simple forwarding table for routing data with some entering containing the following field: Sink type, grid distance and Sink ID.

CHAPTER FOUR
RESULTS AND ANALYSIS

4.1 INTRODUCTION

In this section, we will evaluate the performance of our proposed protocol; Bi-Communication protocol (Bi-COMM) using Network Simulator-3 We will perform experiment by comparing our routing protocol with that of Low Energy Adaptive Cluster Hierarchical (LEACH). The protocol is a well-known routing protocol for wireless sensor network and our choice for the comparison is based on the fact that both protocols belong to the same categories of hierarchical structure routing protocol. Secondly, the former uses a mobile base station while the later uses a static base station. The experiment will be performed with different scenario using the same parameter to show the behavior of our

protocol with that of LEACH with emphasis on energy consumption, and nodes network lifetime.

4.2 PERFORMANCE AND EVALUATION

Network Simulator-3 is use to evaluate the performance of Bi-COMM scheme using the simulation parameter listed in table 4, 2.1. Figure 4.2.1 present the performance evaluation of two schemes Bi-COMM and LEACH in terms of energy consumption. Simulation result shows that Bi-COMM exhibit improvement energy performance when compared with LEACH this is due to it adopted methodology of integrating the concept of

Dual sink and cluster formation contributed to selection of trusted energy efficient route, which enable packet flow to remain consistent for more period of time. But LEACH does not pay attention to energy of nodes. Thus, result in high number of dead nodes that affect the network life time. Similarly, low performance due to multi-hop transmission in LEACH allows nodes to drop more numbers of packets when compared with Bi-COMM.

4.3 SIMULATION ENVIRONMENT

To evaluate the performance of our routing protocol, we will implement it using NS3 which is a highly performance language for technical computing suitable for simulating a wide range of applications in different platforms. NS3 integrate programming, computation and visualization where problem and solution are expressed in a simple familiar way (Bahronz and Ronbeh 2012). NS3 can be used for algorithm development, data analysis, and visualization. It provides a good visualization with a lot of library to implement idea even for a non-programmer. One significant feature of NS3 is the realistic modeling of sensor nodes resulting in the realistic node behavior which makes it attractive for most researchers who want to test their protocol.

PARAMETER	**VALUE**
Network area	500 x 500 meter^2
Number of sensor node	1000
Data packet size	512 byte
Control packet size	33 byte
Initial energy	1J
Sink speed	5, 10, 15, 20, 25, 30, m/s
Static sink	Stationary
Mobility Model	Random way point
Eelsc	50Nj/bit/m^2

Efs	$10P^{J}/Bit/m^{2}$
emp^{s}	$0.0013p^{J}/bit/m^{4}$
Edd	50 nj/bit/ message
Elow	0.2 nj / sec
Routing protocol	Bi-Communication
Length of broadcast message	80-400bits
Simulator time	400 sec
Communication Radius	100m

Table 4.2.1 Parameter and value

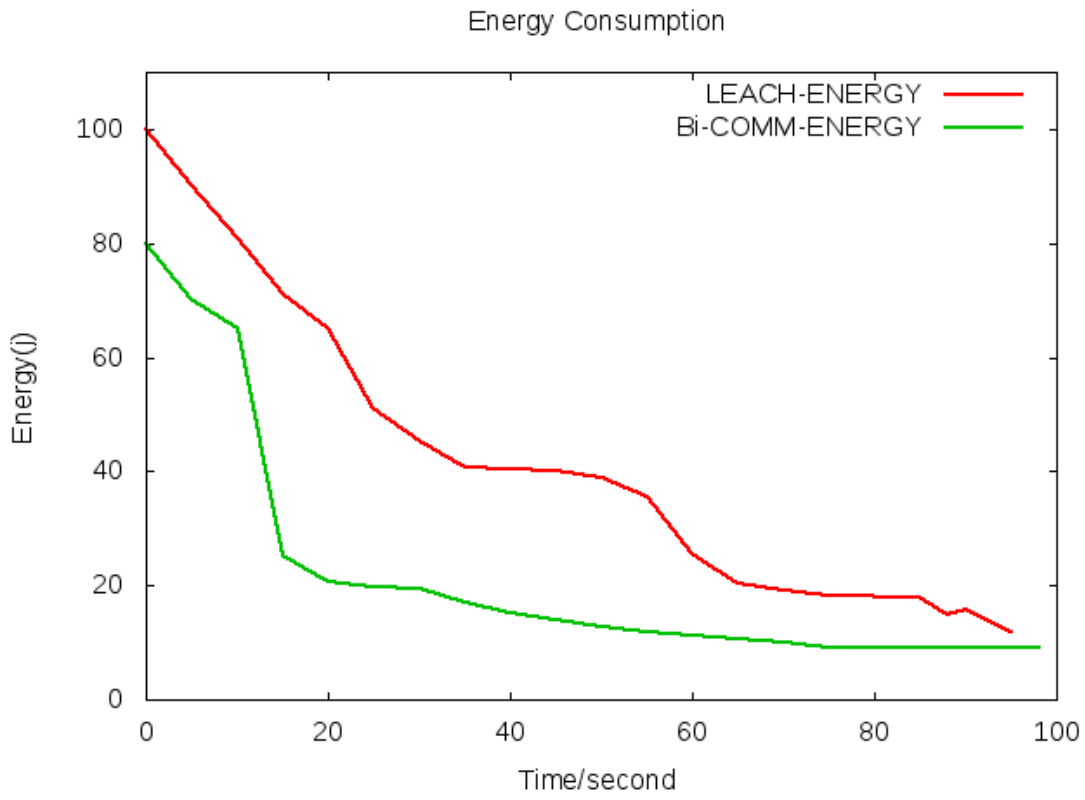

Fig 4.2.1 Energy consumption

4.3.1 AVERAGE ENERGY CONSUMPTION

The simulation experiment in figure 4.2.1 shows energy gain in Bi-COMM and LEACH protocol. The average residual energy of nodes in Bi-COMM is better than that of LEACH. This is because of the grid formation in our protocol which limit wide broadcast and as such, packet transmission by sensor node is restricted within each cluster, and nodes can only transmit their data to the cluster head within the grid which help in

conserving energy. Secondly, the transmission distance is reduced by the use of dual sink which help in conserving energy and in turn prolonging network lifespan.

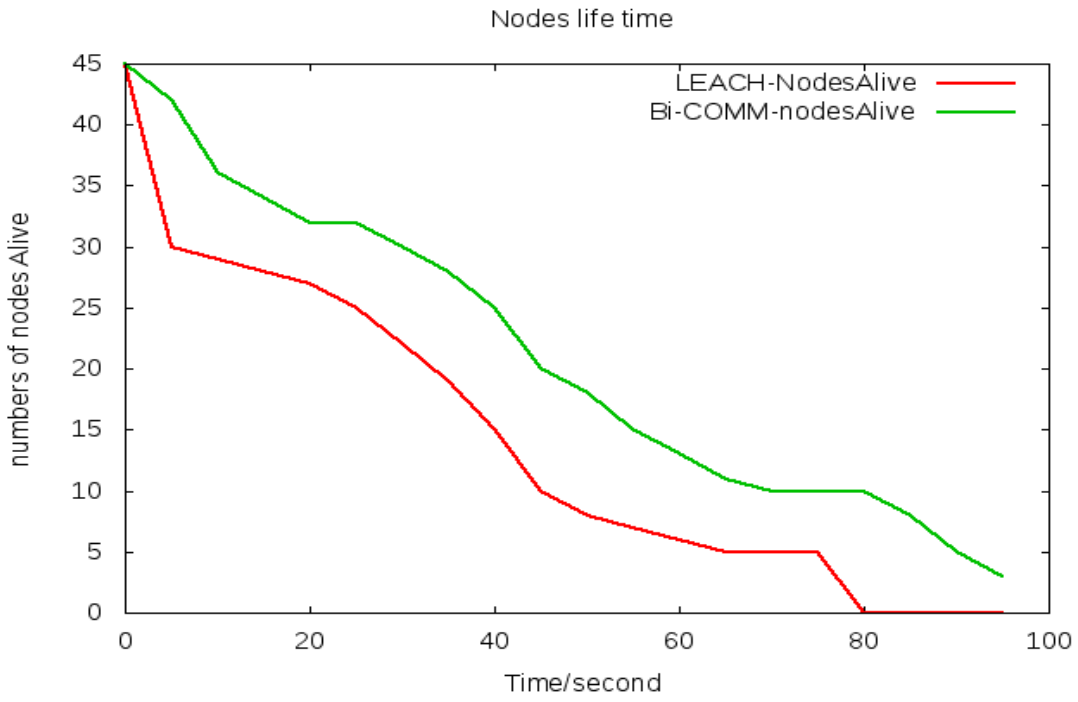

Fig. 4.3.2 Alive Nodes

4.3.2 NUMBERS OF ALIVE NODE

Figure 4.2.2 illustrates the comparison of LEACH and Bi-COMM in terms of alive nodes for 45 nodes. The nodes alive in LEACH decrease gradually and at a certain point in time, the graph shows abrupt decrease and all nodes at 80 seconds of simulation time, which affected the lifespan of the network. This is due to frequent re-clustering which consumed so much energy. But in the case of our proposed approach Bi-COMM Alive nodes are higher than that of LEACH. Nodes were still alive up to 90 seconds during the simulation time as compared to LEACH. This is due to the fact that the cluster head is selected base on energy level and the use of two sink which facilitate data transmission between the cluster head and the sink. Consequently, network lifetime will be expanded because numbers of alive nodes are high. So, we can say that our protocol is more efficient in terms of alive nodes for 40 nodes as compared to LEACH.

CHAPTER FIVE

CONCLUSIONS

5.1 INTRODUCTION

The work presented in this dissertation was inspired by energy limitation, in sensor nodes. In this research, Bi-Communication protocol has been proposed for efficient routing in WSN and evaluation were made through simulations using NS3 Simulator. Simulation were performed in terms of energy consumption, nodes alive, as regard to network lifetime, in order to compare the performance of our protocol with that of existing scheme. Simulation experiment shows that our proposed routing protocol out performed in terms of numbers of alive nodes as time passes as compared to previous scheme. In addition to higher packet delivery ratio of about 16%. And less energy consumption rate in the network..

5.2 SUMMARY

In this dissertation the Bi-COMM routing algorithm is compared with LEACH routing algorithms. The results obtained show that Bi-COMM enhances the network lifetime significantly in comparison with the LEACH routing algorithms. The major reasons of this improvement is that in the Bi-COMM routing protocol cluster heads can communicate to either mobile or static sink using the minimum communication distance between the cluster head and the sink, which decreases the energy consumption in the whole network and increases the network lifetime. Secondly, our routing protocol can increase the network lifetime more than LEACH due to grid formation and a node is selected as cluster head base on energy level. This technique makes the system able to reduce the amount of communication and processing time, and as a result, saves more energy and balance the load in the network. Thus, the network lifetime will increase. In conclusion, the Bi-COMM routing protocol improves some drawbacks of LEACH such as lack of energy balancing and improve the average residual energy of all nodes and the number of alive nodes to about 165% in comparison with LEACH.

5.3 CONCLUSION

In this dissertation, an energy efficient routing protocol for wireless sensor network is presented. The result has been compared LEACH routing protocol. From the outcome, it is concluded that the lifetime and throughput our protocol is 65% and 35% more when compared to LEACH routing protocol. In our protocol network load is optimally distributed and the number of alive nodes are high when compared to LEACH routing protocol.

Therefore, from the simulation result it is concluded that Bi-COMM routing protocol achieves better energy efficiency and enhance network lifetime. Hence, outperform LEACH routing protocol.

5.4 RECOMMENDATION.

The research proposal of this dissertation has opened various challenging research areas which can further be investigated. The proposed scheme addresses the problem of energy efficiency in WSN with the help of efficient routing protocol. This can further be extended to improve energy efficiency specific to real time applications that can offer improve quality of service such as packet loss reliability, latency and throughput. In addition, security requirement is also an emerging area of research in WSN. However, light weight security mechanism that required less computing cost, and low energy consumption can be developed for secure routing. Internet of things (IOT) is another major research area were wireless battery power devices can be connected directly to the internet. This is ongoing were several new protocols has been proposed. Although a lot of work still needs to be done in order to develop current internet protocol (IP) that will fit better to the requirement of low-power wireless device for example better compression scheme that will enable IP traffic to be transferred between low wireless systems.

5.4 FURTURE WORK

The research proposal have opened several challenging research directions that can further be investigated, the proposed scheme addresses the energy efficiency in WSN using routing protocol. The area of security is also an emerging area of research in WSN. A low energy security mechanism that require less computing cost can be developed for a secure routing. Also, in our scheme the mobile base station moves round the network to collect data from cluster head, designing a policy for mobile sink mobility can also be an interesting area. Internet of things (IOT) can also be another research area where wireless battery- power devices can be directly connected to the internet. Routing techniques that explicitly employ fault tolerance techniques in an efficient manner are still under investigation. Further research would be expected to also address issues as regard quality of service (QoS) in real-time applications. Another area of extension is to explore the patterns of the energy consumption for a generic application (e.g., Emvironmement monitoring applications) and produce a detail map of energy consumption relative to a specific application. Another improvement in the tracking results could be brought about by employing all the sensors nodes for detection purposes. Although the scheme is more power consuming, but the results will be more

accurate. The other improvement could be made if we consider that different sensor nodes having different sensing areas. In this case, all sensor nodes have been considered to have the same sensing area which may not be the case. It can be extended in this regard.

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