Hybrid Clustering Shortest Path Routing Protocol (HC-SPRP) for WSN

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THESIS COMPLETION CERTIFICATE

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DEDICATION

To My Father, Mother, all my family, and friends.

ACKNOWLEDGEMENT

Being thankful to almighty Allah who is the best creature and belongs to all the powers of the universe and grandeur. This research work has emerged in the final shape. I am tremendously appreciative of my supervisor, Dr.Shahzad Hassan, for the direction, definite support, valued time, persistent energies, encourage me during this thesis work. I propose my special regards and prayers to those all who helped me at any stage in the completion of this effort. The most important is I bound to say to all those honors people who trusted me, have a great contribution in my confidence and without their support, I could never succeed in my aim specifically my Parents. In the end, I feel proud and would like to thank all my friends who supported my all effort thesis work. ALLAH almighty blesses them with endless pleasure!

ABSTRACT

Energy efficiency and stabilizing the network lifetime is one of the biggest priorities in a wireless sensor network. The life cycle of the sensor node mainly relies on limited batteries due to its tiny size. To exchange the information unceasingly from the wireless sensor's nodes to the base station (BS) as a result their energy is exhausted. The Investigators have planned many techniques [7] [53] over the past to drop off the energy demand of nodes. The Clustering approach is very beneficial to avoid the additional energy drop of nodes in Wireless Sensor Networks. The prime focus of our research to extend the network lifetime of WSNs by implementing a chain-based Energy Efficient technique "Hybrid Clustering Shortest Path Routing Protocol (HC-SPRP) and compare the results with HMPBC, CCMAR, AZ-SEP, and Heterogeneous. The comparative simulation of these protocols is carried out via simulation tool "MATLAB". Our result analysis proved that the intended protocol enhanced the network life period and increases the stability period of alive nodes, network longevity, throughput, improves power consumption with the help of Dijkstra Algorithm.
Our proposed routing protocol outshine in large areas in comparison with the HMPBC, CCMAR, AZ-SEP, and Heterogeneous.

Keywords: Heterogeneous WSNs, Clustering; CH; Advanced clusters, Shortest Path Routing Protocol, BS, Chain Base Protocol.

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WSN - Wireless Sensor Network
WSNs - Wireless Sensor Networks
HC-SPRP - Hybrid Clustering Shortest Path Routing Protocol
CH - Cluster Head
CHS - Cluster Heads

LIST OF SYMBOLS

N - Nodes
E - Energy
J - Joule

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless sensors [54] are the combination of specific roles with constraint battery utilize for monitoring some specific area. For communication purpose all the alive sensor nodes forming a wireless network which is known as Wireless Sensor Network(WSN). WSNs are widely used in a lot of applications like commercial, environmental, healthcare, medical, and agriculture [1]. Transmission takes place between nodes and Base Station (BS). WSN nodes having restricted battery and it is essential to optimize the energy utilization of nodes [55] to increase network stability. Various methods have been proposed to prolong the network lifetime [2] [3] [4] but clustering is a very efficient method among all. Cluster splitting up the whole network and plan a group of small networks. In WSNs one node is nominated as a Cluster Head (CH) for collection of data from cluster's members and transmits the aggregated data to BS. Due to the virtual organization, networks split into smaller groups. Clustering management is very easy [2]. Clusters are classified into Homogeneous and Heterogeneous WSNs. Homogeneous clusters are made up of normal nodes in which all the sensor nodes are identical in terms of energy level and hardware fabrication. Heterogeneous clusters consist of advanced nodes which are higher in terms of energy as compare to normal nodes. Our research is focused on heterogeneous clustered WSNs. Cluster's constitutions in heterogeneous WSNs are based on their energy level. Different algorithms have planned for CH selection [14] [15] [16] [52]. The Clustering approach is efficient and productive to save the energy of nodes but overheads are faced by the CHs as multiple tasks are performed by the CHs. Low Energy Adaptive Clustering Hierarchy (LEACH) [36] is the clustering algorithm was the first step toward homogeneous clustering. An inventive form of LEACH does not consider heterogeneous WSNs. LEACH considers that every node can send a data packet to BS which is not possible in many realistic scenarios. In LEACH all the nodes are self-organized.CH aggregate the received data from the member nodes and pass the aggregated data to the BS. In LEACH Selection probability of ordinary node as CH in very early rounds is there and early death of CH can make the whole network unstable.

LEACH-C [17] is an Augmentative approach of LEACH. LEACH-C [17] based on a centralized algorithm. The Steady-state phase of LEACH-C is identical to LEACH and each node informs BS about its recent location and residual energy as well. When BS finds the CH and clusters, so this information broadcasts by BS which includes CH ID of every individual sensor node. In recent times some protocols and algorithms have been proposed for the said purpose “Modified LEACH Protocol for Heterogeneous Wireless Networks” [1]. In this protocol, normal nodes and advanced nodes are randomly spread over the area. In this scheme, CH selection has been done randomly but only advanced node selected as CH. In [3] [4] different protocols proposed by the researchers for energy efficiency [49]. This demonstrates that energy efficiency is still an open area for researchers and there is a need for more development. The chain-based PEGASIS approach [11] [40] decreases the energy utilization. PEGASIS is an improvement over leach and the first developed chain based technique in WSNs. The sensors nodes in PEGASIS organize themselves to form a Chain. If there is any node died the chain is reconstructed and bypass the dead node. In PEGASIS CH node is selected and transmits data in multi hops fashion to the BS. Multiple chain-based techniques [17] [19] [20] [21] have been developed which have improved the WSNs lifespan. Adoption of this approach can save the energy of nodes but overheads should face by CHs in form of additional tasks such as, transmission of aggregated data to the BS on behalf of every node under that CH. Due to these additional functions, CHs are more energy-hungry as compare to member nodes because a considerable amount of energy is wasted in communication which minimizes the WSN lifespan. A brief survey in [22] proposed by the author on chain-based routing protocols.

We are designing a routing algorithm [63] to achieve a better result. In our research work, we focus on saving energy of CHs in WSNs to prolong the network lifetime and stability period. The designed algorithm consists of several small monitoring zones where sensor nodes are randomly distributed. All the nodes compile the information of the small zones. For the said approach, we have designed a Hybrid Clustering shortest path routing protocol (HC-SPRP) where the field area is divided into several zones. The cluster is used a single-chain structure to prolong the network lifespan and the Dijkstra algorithm is adopted for communication among CHs. The selection of CHs will be in the transmission based on the maximum remaining energy and no selection of CHs before transmission. The nodes with the maximum remaining energy will become the CHs in the current round. Our research work is focused on Heterogeneous WSNs by using the following approaches:

(i) Election of Cluster Heads Based on their maximum remaining energy.
(ii) All the advance nodes transmit data directly to the BS to avoid the maximum consumption energy of Normal CHs.

(iii) Lessen the communication paths between CHs and BS by Using Dijkstra algorithm to save the energy.

Dijkstra algorithm is one of the superior algorithms [23] [24] [25] [26] which calculates the shortest path between nodes. It calculates the path by taking the sum of all edges and calculates its actual weights. The path which is selected by Dijkstra is the shortest path. All the shortest routes are decided by the BS by applying the Dijkstra algorithm. According to this Algorithm the distance of the source node will always be zero and the minimum unknown distance from the source node to any other node will be infinity.

1.2 Problem Statement

Hybrid Multi-Hop Partition-Based Clustering Routing Protocol (HMPBC) [43] is a chain-based technique. A single-chain structure is using maximum number of hops in every single chain for transmission. The nodes exist near the BS may drain out quickly due to maximum transmission energy consumed by every single Hop (CHs). Every final CH of every single-chain consume maximum energy and the performance of WSN is getting low due to the failure of every single node in a chain. Finally, this will affect the whole WSN as shown in fig 1.1. In the said approach [43] the highlighted sub-problems are listed below:

(i) Multiple Numbers of hops is there from farthest nodes to BS.
(ii) Energy consumption of all nodes near the BS is in great amount and early death of nodes is Occur.
(iii) There is no limit of Hops in data transmission from the farthest node to BS.
(iv) In the said approach [43] adoption of MST algorithm utilization energy is maximum due to depth-first and this may impact whole WSN.

We are designing such protocol to reduce the path of every single-chain, limit the no of CHs in every single transmission and extend WSNs lifespan. This may also avoid every single round time delay of the election procedure of WSN to get an effective result.

To attain the above-highlighted results, we have planned the "Hybrid Clustering shortest path routing protocol" where only advanced nodes are deployed near the BS. In our scheme CHs are selected based on their maximum remaining energy. In our proposed scheme, data transmission will be carried out in hop by hop fashion. There will be a single-chain structure among CHs which will help in transmission. In our approach, Normal CHs will send data to only advance CHs and further these advance CHs transmit direct data to BS.

(i) Minimum Spanning Tree Algorithm (MST) is replaced with Dijkstra Algorithm.
(ii) Dijkstra picks edges with the smallest cost at each step and covers a large area of the network.
(iii) Dijkstra is useful when you have multiple target nodes but you don't know which one is the closest.
(iv) Dijkstra is optimal in cases where you don't have any prior knowledge of the field and cannot estimate the distance between each node and the target.

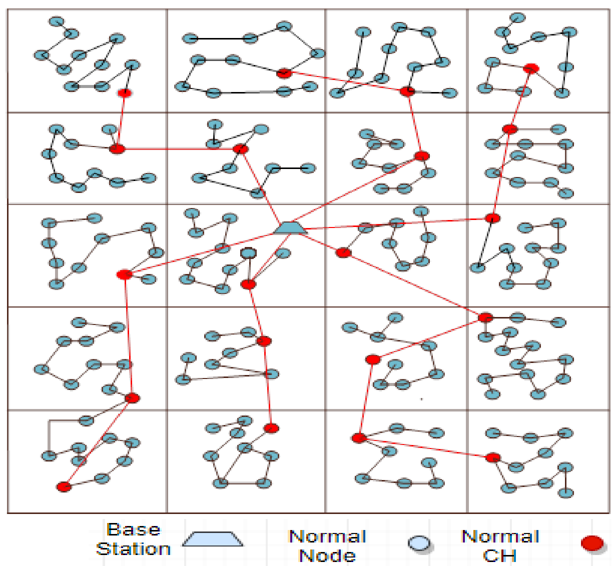

Figure No 1.1 Hybrid Multi-Hop Partition-Based Clustering Routing Protocol (HMPBC) [43].

1.3 Applications of Our Research Work

WSNs extend its usage due to high speed growth in the applications of wireless technology. This can be divided into the following categories and is shown in fig 1.2 as below.

(i) Precision Agriculture:
It is used for pressure, temperature, and a reliable environment for crop agriculture.

(ii) Traffic Monitoring System:
It is used for real-time assistance in traffic monitoring systems to prevent traffic congestion and parking system. Line change alerting and speed monitoring, locations of the vehicle are applications of WSN.

(iii) Environmental Monitoring Systems:
It is used for real-time alerting and preventing events during any adversity like temperature warnings, earthquake, flood, forest fire, gas leakage, etc.

(iv) Health care Monitoring Systems:
It is used for monitoring physiological signals that help to prevent the risk that happens to human life.

(v) Military Surveillance:
It is used to help in the early detection of enemies.

(vi) It is also used for the following alerts.
1. Avoid man plan attacks
2. Mining rescue Soldiers monitoring

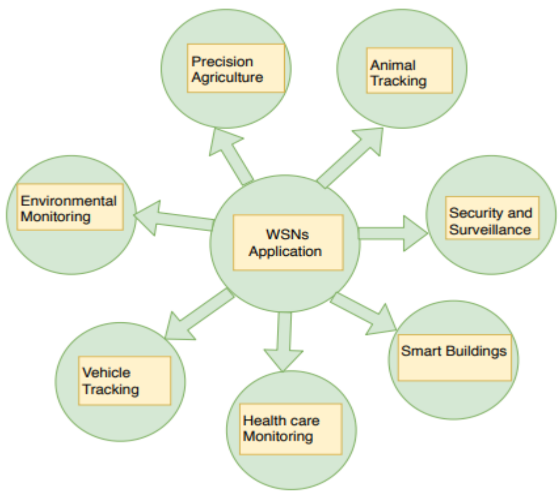

Figure No 1.2 WSNs Applications

1.4 Objective and Scope of Research Work

The core performance parameters of "Hybrid clustering Shortest Path Routing Protocol for WSNs" are listed below:

(i) Prolonging the network life by deploying advanced clusters near the BS.
(ii) Maximized network life with maximum timespan by Reducing the nodes consumption energy proficiently.
(iii) Reduced the node's power consumption during hop to hop data transmission.
(iv) Minimizing the number of hops during data transmission.
(v) Extend the network lifetime by establishing the Dijkstra algorithm.

1.5 Thesis Structure

Chapter 1 briefly presented the wireless sensor network and its applications. Chapter 2 gives detail of literature reviews like its types and benefits. Chapter 3 gives a detailed description of Wireless Sensor Networks. Our proposed research has been explained in Chapter 4 briefly i.e. detailed work of our scheme, algorithm, and mathematical representation. The Simulation results of graphically has been explained in Chapter 5. The Research thesis ends up with the conclusion in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Multiple models [9] [10] [13] [17] [38] have been discovered to Extend WSNs's lifespan and every researcher has different aim to extend the previous work. leach [35] is the old and initial protocol has been discovered. LEACH is a homogeneous protocol and consider various parameters like Time Division Multiple Access (TDMA), load balancing, improved connectivity and delay reduction, network extension. In SEP [28], the author assumes that the base station is not energy-constrained where localization is provided also overall length is known. In SEP Nodes are not mobile and cluster election is distributed in two hierarchal level. Weight of election probabilities is based on initial energy in the comparison of average energy in the network. This consequently increases the stability period of the network, which is a necessary requirement in many real-world applications where reliability is concerned. Results prove that SEP outperforms in multiple environment. Multiple researches [39] [40] [41] have been replaced PEGASIS and LEACH [31] [32] [33] [34] [35]. The extended form of leach is PEGASIS [39] [40], HEED [37] and DEEC [45]. PEGASIS is a distributed routing protocol for WSNs. Unlike traditional clustering, it forms chains from the sensor node to the sink. The Greedy algorithm is run on the sensors to form chains. After sensing the data, each node forwards data to its immediate neighbor which resides in the same chain. Hoping from one node to the next in the chain. Data eventually reaches the corner node in the chain which ultimately forwards to the base station with the help of long-distance direct communication. Though PEGASIS eradicates much of overhead involved in clustering. Multiple hops are possible in the chain from the first node to the last node. In PEGASIS packet delay can be increased in some cases. HEED is an extension of LEACH. The difference between HEED and LEACH lies in CHs selection mechanism. Unlike LEACH, rather than selecting CHs based on a random number. Its selection based on the residual energy of the sensor node. Therefore, the energy level of the CHs in HEED is relatively more than the cluster's member nodes. Another distributed clustering mechanism is EECS [43] cluster size of EECS is based on the distance from the BS and possesses no rotation unlike in HEED. The EECS technique is specifically tailored to solve the problem that nodes which reside in distant clusters consume more energy than the nodes which are near to BS. Though it does direct communication between CHs and BS. EECS demands global information. Also, the selection of a set of nodes before the competition could result in CHs selection which is not optimal. TECP-TC [6]is a Chain based Protocol for supporting Time-Critical applications for reducing energy consumption and time transmission delay of Time-Critical data. It purely works on periodic data collection. it is a threshold-sensitive protocol and generating a chain of nodes. It aims to receive non-time critical data from their neighbor and transmit the non-time critical data to the next neighbor. TECP-TC is not good in the environment where periodic reports are not important. Teen [12] is a reactive as well as proactive protocol for the time-critical. In Teen All the CHs broadcasting hard and soft thresholds to the nodes. Whenever the sensed data attribute is in the range of interest the hard thresholds allow the nodes to transmit the data. When there is no change in the sensed value then the soft threshold is functioning and reducing the number of transmissions. Teen is not proved good for the environment where periodic reports are essentials. In [5] “A stochastic election approach for heterogeneous wireless sensor networks” the author proposed a semi-centralized technique prolonging the network life on low time cost including optimal CHs for each round. Stochastic technique maximizing the CH threshold of nodes in an appropriate manner. Search for each round and node is reporting about its remaining lifetime along with data.CH collecting this data from the member node and pass it to the BS. In [2] maximized the lifetime by introducing “An Energy-Aware Chain Oriented Sensor Network protocol” which is a chain-based technique that improved the performance with the help of duty cycling. There are three hierarchical levels in the network but the author has worked on 2^{nd} and 3^{rd} hierarchical chain levels. In “An Energy-Aware Chain Oriented Sensor Network protocol” node constructing chain and randomly elect chain leader. Nodes which are near to BS construct first hierarchical chain while the nodes far from BS and near to first chain level fall under 2^{nd} hierarchical chain. The outermost nodes which are far away from BS construct the 3^{rd} hierarchical level. The author has used a rotation algorithm and the CH of the chain rotating among different chains for a specific level after some rounds. In [4] the author presented an algorithm of low-cost localization for heterogeneous and multi-hops sensors networks. This protocol is the extended lifespan of the sensor network by minimizing traffics. In this technique, the whole network is consisting of homogenous sensor networks. All the sensor nodes are identical in battery-voltage format. In this technique Data transmission/receiving on a long area and as a result, high energy is utilized. All the nodes deplete their energy in very early rounds which causes the whole network unstable. In the discussed techniques multiple protocols are proposed whose purely aims to enhance the lifetime of the wireless networks. Deng/Hu [27] has been proposed a multi-hop Load

Balancing Group Clustering (LBGC) algorithm to extend the life span of a heterogeneous WSN which purely based on SEP, LEACH, and DEEC. SGCH.CCMAR[30] combined both PEGASIS and LEACH to extend the lifespan of WSNs. In CCMAR a mobile agent is collecting all the information from the sensor network. The first Phase is following leach while the 2nd phase follows PEGASIS. Energy Efficient Cluster-Chain based Protocol [2] and [29] is a chain-based protocol associating the nodes into a paradigm form [53]. Every node collects data from the previous one and conveys the data message to the next. A Chain is generated between CHs and finally transmit the gathered data to the BS by the final CHs. Clustering-Tree topology control is a heterogeneous energy forecast (CTEF) [71] technique. This technique is discovered for reduction energy, securing network stability, load balancing, and ensuring network quality. In this technique network energy is calculating in every round by applying central limit theorem and normal distribution technique. The Selection of CHs is based on the cost function and their distances. In every cluster, CHs are selected as a relay node for data transmission to complete multi-hop communication and reduce network load. Z-Sep (Zonal-stable election protocol) [48] is an extended form of stable election protocol. In this scheme, there are two transmissions take place. One is single-hop while another is multi-hops. The Network is divided into three zones i.e. sensors of the minimal battery are implanted in Zone 0. High energy sensors are randomly implanted near the first zone. Remaining high energy nodes are implanted randomly in the 2nd Zone. The lifespan of the WSNs can be unstable, as normal nodes deplete their energy in early rounds due to direct communication. In [31] the author proposed the “Advance Zonal Stable Election Protocol” is a heterogeneous scheme and an extended form of Z-SEP protocol. This technique reduces the energy of the sensor network. The area is dividing into 3 equal zones. Ordinary sensors are deployed near the BS which can send direct data to the BS while advanced nodes are implanted far away from BS in zone 1 and zone2 respectively. In zone 1 and 2, which consist of a advance node, have high energy than normal nodes. The Advance node sends data to BS using the clustering technique. In advance nodes, clusters are formed and in that one node is selected as CH, and rest are a member of that cluster. Member nodes sense data and send it to CH. CH then aggregates data, processes it, and sends it to BS. Communication of CH with BS consumes a lot of energy as they are far away BS.

In “Hybrid Multi-Hop Partition-Based Clustering (HMPBC) [43]”BS is deployed in the center of the field. An Initial node using the Greedy algorithm and select the nearest node. In the same way, all nodes come into chain form and get the path for communication to reduce energy consumption. HMPBC uses the same technique of EECS and PEGASIS. PEGASIS [11] [18] [39] [40] is a distributed routing protocol forming chains by using the Greedy algorithm for transmission between nodes and BS. An energy-efficient clustering scheme in wireless sensor networks(EECS) [42] divided the area into zones. The nodes having high residual energy will be eligible to be CHs.

We are designing an algorithm for such applications which is difficult to access the monitoring area. For the said purpose monitoring region is divided into multiple small regions where sensor nodes are deployed and gather the information of the regions. We design a Hybrid Clustering Shortest Path routing protocol (HC-SPRP) for the said environment. In our technique shortest path and a single-chain structure generating with the help of Dijkstra algorithm which extends the WSNs lifespan. CHs are selecting based on their maximum remaining energy after transmission.

2.2 Motivation

Wireless sensor networks comprise of tiny nodes operating on constrained batteries and restricted capabilities of sensing to communicate with each other and with BS as well. These sensors having low processing capabilities, small storage, conveying information, embedded batteries with constrained power. Some barriers are faced by the sensors during multiple task completion. Several organizations and military discovered various researches in WSNs. There are multiple applications in battlefield surveillance. In health applications, WSNs play an important role i.e. sensors having the ability to operate unattended tasks as customers want quick feedback on their problems. WSNs connect staff to the data and improve customer service by an urgent response to the patient files. WSNs also having a lot of applications to sense the environmental variations i.e. temperature, pressure, and humidity that affect and bring climate change. Though WSNs are progressively equipped to grip over some of the complicated functions like data aggregation, information fusion, transmissions, computations activities in-network processing. These functions can be possible to fulfill by using the energy of the sensor efficiently and prolong the WSNs stability period. These sensors are more prone to energy drainage. The sensor's battery is fixed and irreplaceable and impacts the whole WSNs performance if the battery energy is not utilized appropriately. Multiple types research has been discovered. Some protocols for extending the lifespan of WSNs have discussed briefly in section 3.2.1.

2.3 Methodology

Simulation of our protocol is carried out on MATLAB. MATLAB is the high enactment technical computing programming language designed for visualization, simulation, and plotting of mathematical data. We have simulated the nodes in the 200*m* x 200*m* area. The total number of nodes including normal and advanced nodes is N = 400 and one BS is located in the center. We have compared our results with primary parameters as well as with the secondary parameters. Simulation of our proposed protocol in MATLAB has proved the efficiency and long-Life span of WSN. We have compared our simulation results with, Total Energy Consumption, Total Energy left of Network, Energy Consume by CHs, Packet Received by BS. Evaluation results of HC-SPRP, compare our Proposed Scheme with more than 3 hops. A Clustering-tree Topology Control Based on the Energy Forecast for Heterogeneous Wireless Sensor [44] Networks and Hybrid Multi-Hop Partition-Based Routing Protocol, Hybrid and Multi-Hop Advanced Zonal-Stable, Clustering Routing Protocol “HMPBC” has given in Chapter 5.

2.4 Assumptions

A key assumption of our WSNs is that the designed network has no prior infrastructure. It is surely the struggle to create such a framework in difficult or inaccessible atmospheres.

(i) Aim of our research to focus on major factor i.e. energy consumption factor in WSNs.
(ii) All the network area is divided into equal zones.
(iii) BS is assumed to be located in the center of the WSNs.
(iv) There are 20 zones and each zone is capable of having 20 nodes individually.
(v) There are 80 advance nodes implanted near the BS. Four advanced clusters are assumed to be generated around the BS while remaining clusters consist of 320 nodes.
(vi) There are two types of communication possible in our network i.e. single-hop communication and multi-hops communication.
(vii) Normal CHs will send data to advance CHs by using multi-hops communication and advance CHs will forward all the network data to BS using single-hop communications.
(viii) BS is responsible for all the processes of algorithm and network structure generation.

(ix) All the CHs are updating dynamically in each round and packet is flowing within the network that will follow a target node.

(x) Each link is Bi-directional.

(xi) Deployment of the nodes will be in the area of 200 by 200 sq. and there will be a proper transmission radio range.BS flooding an advertising packet to all the nodes to show its presence. Every node advertises the receiving packet in its range.

(xii) The BS gathers data from sensor nodes and interacts with a user who is interested to monitor the activities simultaneously.

(xiii) BS has smart features i.e. data transmissions, processing, memory, and energy reservation capabilities.

CHAPTER 3

WIRELESS SENSOR NETWORKS

3.1 Introduction

Wireless Sensor Networks (WSNs) is a collection of Specialized transducers. WSNs comprises of Many types of sensors that are usually used for monitoring of pollutant levels, wind directions, the intensity of sound, vibrations, and vital body functions. Due to rapid growth in WSN technology and efficient WSN service, wireless sensor networks become the preferred choice. WSNs can be deployed in a structured and unstructured format. The distribution of structured WSNs is usually in a Pre-organized style. This type of network is easy to manage and has more stability compared to unstructured WSNs where Sustainment and error detecting is difficult to control [55]. WSNs functionalities can be affected by Multiple factors and aspects which are mentioned below.

(i) Instability
(ii) Scalability
(iii) Maintenance
(iv) WSNs topology
(v) Cost
(vi) Environmental Deployment

Instability issues occur when nodes collecting information and forwarding this information to BS. To meet the requirements of the instability issue [8] for WSNs fault-tolerant will be considered foremost [55] [56] [57]. Nodes deployment environment is highly affected nodes performance. It plays a key role in WSNs Functionality and changes the performance of WSNs. Nodes deployment inside the building Preserve safe from external environment. Another important component for WSNs is scalability for WSNs pattern. WSNs model needs to be scalable and adjustable for future additional nodes [58]. Cost is another challengeable factor for deploying WSN i.e. nodes in WSNs as per requirements need to be cost-effective. Another important and effective factor on which the WSNs functionality depends is WSNs topology maintenance [59] [60]. Abundant nodes make the WSNs nodes very impenetrable [61] and there is a need for the planned topology to prove better and fulfill the topology maintenance needs as discussed [62]. The excellence of WSNs is executing and presents a large amount of data into valuable and useful aggregated information.Fig.3.1 Indicates typical communication in Wireless Sensor Network.

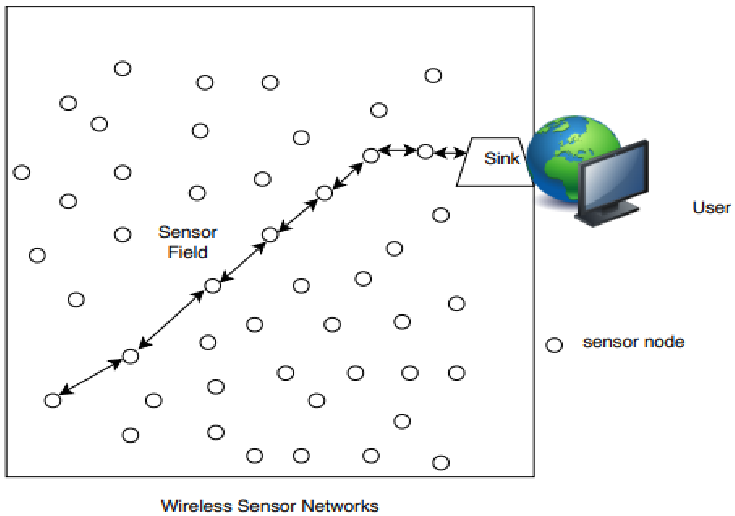

Figure No 3.1 WSNs Communication

The Architecture of Sensor node:
Sensor nodes parts can be classified into Multiple Unit [3]:

(i) Communication Unit (Tx/Rx)
(ii) Processing Unit
(iii) Sensing Unit
(iv) ADC/DAC Converters
(v) Power Supply
(vi) Temporary Storage Unit

The basic node Sensor architecture is shown in Figure 3.2. the Sensing unit consists of sensors which are interacted with the environment where sensors are deployed. For the conversion process, the sensed data is forwarded to ADC/DAC converters. For further processing, the converted digital data is received by the microcontroller and performs the required processes. Executed data is transferred to the next unit to perform communication and finally transmit to the BS complete communication process. On the receiver side, the data is received by the receiver from CH or BS and transferred for processing tasks to the processor. A lithium battery is used for energy purposes. The tiny mass of the node can accommodate a small lithium battery.

The lifetime of the sensors entirely dependent on its battery. There are two main parts where most of the power consume i.e. communication and processes execution unit. Node dies when the node battery drains out. The sensors are deployed randomly in WSNs where data transmission, aggregation/fusion, efficient and effective communication is required between sensors nodes and BS. One BS is placed in the network field. Transmission to the BS can be possible in a single/multi-hops way. The BS is not mobile and connects the WSNs to the Wide area network from which the user has access and can monitor the data. Routing is very important to differentiate the network from another wireless sensor network. The most important priority in WSNs is energy efficiency due to its limited battery of nodes, storage element, node size, computational power. These factors affect the amount of energy of individual nodes. A classical WSN architecture has shown in Figure 3.2 [74]

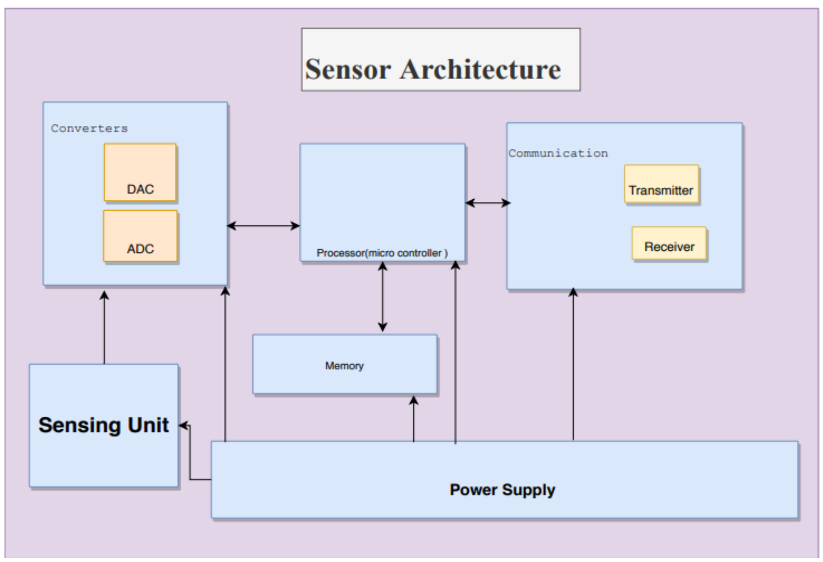

Figure No 3.2 Sensor Architecture

3.2 Types of routing in WSNs

a) LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH [31] is one of the effective, dynamic, popular, and approach. LEACH is using a randomized rotation mechanism for CHs election that based on probability. It is considered the first clustering hierarchy protocol. Leach uses a stochastic algorithm [5] for every single round in which each node forwards its information to the CH and CH aggregate the received data. This compressed data is finally transferred to the BS. The leach function is divided into two rounds. Every single round is further divided into sub-phases. Every single round consisting of two states first is set up while the second is the steady-state phase. The initial phase is generating clusters and 2nd phase delivering data to the base station. The steady-state phase is longer than the setup phase and more overheads are faced. After the selection of CH nodes decide respective clusters for the next task depending on the Received Signal Strength (RSS). CHs compresses the data received from member nodes and forwards it to BS. Time Division Multiple Access (TDMA) is used in LEACH to avoid clusters and inter-cluster communication. LEACH indicates that if a node is already performing the task of CH in the previous round it will not be a CH in the next round. However, LEACH has a fatal flaw as it does not consider energy in the selection. In the case of a heterogeneous network, it cannot perform load balancing in the network. Furthermore, LEACH considers that every node can send a data packet to BS which is not possible in many realistic scenarios.

b) EEHC (Efficient Hierarchical Clustering Algorithm)

EEHC [71] splitting the whole network into multiple hierarchical clusters [69]. There is Single-hop communication between CHs and BS to attain better energy efficiency. Cluster size is purely dependent on the distance from the BS. Two types of levels are existing i.e. highest level 'h' and lowest ‘l’. There is no iteration exists in this scheme. All the nodes broadcast their residual energy to neighbor nodes. Selection is based on their residual energy i.e. node with more energy are selected to be CH. This scheme is explicitly planned to resolve the issue for those nodes which are at a distance from the BS and consume more energy. Although it is based on single-hop communication and demand for global information. The drawback of this protocol is the error/contention-free environment.

c) HEED (A Hybrid Energy-Efficient Distributed Clustering)

HEED [37] is a hybrid, distributed technique discovered for energy-efficient clustering based on ad-hoc networks [50] [51]. A significant factor of HEED is multiple broadcasting levels. The HEED ends up with a fixed amount of repetitions that don't depend on network width. The nodes can control the power of transmission which is independent of node abilities and distribution. Advantages: Lengthens network lifespan: This Scheme reveal several attractive features like data Scalabilities, aggregation, and Fault tolerance [46] as well. Disadvantages: This scheme has 2-levels of hierarchical design.

d) TEEN (Threshold Sensitive Energy Efficient WSNs Protocol)

TEEN [44] is especially discovered for reactive types of networks. It follows such a method in which every cluster changes the CH transmission individually for member nodes. The main attributes are a hard threshold (HT) and a Soft threshold (ST). Every node receives two values; soft and hard threshold. If the value of the attribute is less than the hard threshold, it's forwarding it suppressed there to save transmission energy. If sensed data is different from last sensed data, it is then forwarded to the sink. For this purpose, a soft threshold is used to check the difference between the current value and the last value. TEEN is best suited for applications where users demand trade-off functionality e.g. switching from accuracy to energy efficiency and vice versa. TEEN cannot perform in many situations. For example, sensing temperature on a daily basis.

Advantages: Less energy consumption and exceptionally matched for time-critical data sensing.

Drawback: The communication is not possible among nodes if the specified threshold value cannot be fulfilled.

e) APTEEN (Adaptive Periodic Threshold Sensitive Protocol)

APTEEN [72] is the enhanced version of TEEN specially developed for the hybrid network environment. Its function to enable both reactive and proactive networks. The key purpose of enhancing TEEN to APTEEN is to handle different queries of the network along with studying the delays that occur in processing. APTEEN supports three types of queries that are given below.

- To analyze past One-time queries.
- Analyze the whole network.
- It follows a TDMA schedule to significantly add a query that handling with a querying technique for heavy loads.

Advantages: Enhance the lifespan of the whole network.

f) EEICCP (Energy Efficient Inter-Cluster Coordination Protocol)

EEICCP [64] is a routing protocol using a multi-hop/single hop scheme and distributes the energy load among all the nodes of the network. It consists of homogeneous nodes. This protocol consumes more energy in single-hop transmission as compared to multi-hop communication. The said protocol merges two phases. 1) Election phase. 2) Transmission phase. The initial phase is the Election phase in which the clusters are generated by multiple layers. The lower cluster consists of one cluster coordinator (CCO), in which the number of clusters is fixed. Thus, each CH and CCO assigned a cluster id. The assigned id is broadcasted by the cluster among the nodes. CCO also share their id. After that transmission phase is started and CCO collects the information from the members and pass it to BS. In the election phase, the cluster heads and the cluster coordinators are elected. The energy of all the nodes is the same. Heads are elected by the nodes and the co-coordinators are elected by the cluster head. The cluster head sends an advertisement message to the nodes and the nodes send an acknowledge message to the cluster head. Advantages: Exceedingly energy efficiency. Divide the whole energy loads among the network nodes.

Disadvantages: Including Medium cluster stability, Limited scalability, increasing the number of nodes will increase the size of the cluster which affect and increase the power consumption of CCO.

g) TECP-TC (Threshold-Chain-Based Protocol)

TECP-TC [6] reduces transmission delay of time-critical application in Wireless Sensor Networks. Sensor nodes are organized as a set of a horizontal and vertical chain. In every chain, a node is selected as the chain head. TECP-TC allows the sensor nodes to send their sensed data periodically and react immediately to sudden changes in the value of a sensed attribute. When the sensed data value by a sensor node is equal to or greater than the threshold value, it is considering a change in the value of measured. The sensed data are considered as time-critical data and should be transmitted to the base station. Non-time critical data are transmitted to the chain heads of horizontal chains. TECP-TC adopts a chain based data transmission mechanism to send non-time critical data packets from the chain heads to the BS. Disadvantages: TECP-TC is not good in the environment where periodic reports are not important.

h) EDEEC (Enhanced Distributed Energy Efficient Clustering)

EDEEC [73] focuses on the clustering based routing technique. EDEEC mainly consists of three types of nodes and extending the lifetime & stability of the network. EDEEC uses probabilities for CH selection which depends on nodes remaining energy, the average energy of network discussed in DEEC [45]. In each round, the node decides whether to become a CH or not based on threshold value and the number of times the node has been a CH so far. This decision is taken by nodes by choosing a random number between 0 & 1. If the number is less than threshold T(s), the node becomes a CH for the current round.

i) PEGASIS (Power Efficient Gathering Sensors Information System)

PEGASIS [39] is a chain-based protocol. The extended form of leach is PEGASIS, HEED [37], and DEEC [45]. There is a chain head in PEGASIS. Every CH of the chain aggregates the receiving data and then transmits the aggregated data from one hop to another. The forwarded data is fused on the end of every hop and send to BS. Due to multiple hops, PEGASIS is not good in enhancing the data transmission delay.

j) CCM (Chain-Cluster Based Mixed Routing)

CCM [61] follow PEGASIS protocol and taking benefits from both PEGASIS and LEACH protocol [1]. This protocol work on two phases, one is chain-based routing in which nodes generate a chain and transmit data to the chain head.2nd Phase of the CCM consists of two steps Voting CH and Data Transmission. The voted CH send fused data to the BS. This type of clustering consumes more energy due to the long-distance of the chains.

k) Z-SEP (Zonal-Stable Election Protocol)

Z-SEP [48] is extending SEP. A hybrid scheme using direct transmission and transmission via CH. The Network is divided into three zones. In this Scheme, ordinary sensors are implanted in the first Zone.2nd and 3rd zones consist of high energy. The lifespan of the WSNs is unstable as normal nodes deplete their energy early due to direct communication.

l) AZ-SEP (Advance Zonal Stable Election Protocol)

The author proposed AZ-SEP [31], a heterogeneous scheme is an extended form of Zonal-SEP protocol. The said protocol minimizes communication energy and the cost of communication. The whole region is split into 3 equally areas. Ordinary sensors deployed near the BS. Ordinary nodes generate no CH and transmit direct data to BS. Advance nodes implanted far away from BS in area 1 and area 2. Advance nodes perform direct communication via CHs.

m) HMPBC (Hybrid Multi-Hop Partition-Based Clustering)

HMPBC [43] is a single-chain structure inside the cluster. CHs selection is based on maximum remaining energy. Nodes are self-organized and minimum spanning tree algorithms established by BS. BS is implemented in the center of the field and initial node using the greedy algorithm for selecting the nearest node. In the same way, all nodes come into the chain and get the path for communication to reduce energy consumption. The drawback of this protocol is discussed in the problem statement.

Table No 3.1 Comparison of WSN Protocols

Protocol	Communication with BS	Localization Requirements	Clustering Mechanism
LEACH	Direct	No	Distributed
HEED	Multi-hop	No	Distributed
HMPBC	Multi-hop	Yes	Distributed
EEHC	Direct	No	Distributed
PEGASIS	Multi-hop	Yes	Distributed
TEEN	Multi-hop	Yes	Distributed
APTEEN	Multi-hop	Yes	Centralized
TECP-TC	Multi-hop	Yes	Centralized
PEACH	Multi-hop	Yes	Centralized
DEEC	Direct	No	Distributed
EEICCP	Multi-hop	Yes	Centralized
CCM	Multi-hop	Yes	Centralized
Z-SEP	Multi-hop	Yes	Centralized
AZ-SEP	Multi-hop	Yes	Centralized

3.3 Clustering

When all the nodes are deployed a WSNs is originated from the deployed nodes. Usually, there are two ways of communication to perform data transmission i.e. single and multiple hops. Direct data transmission is more consuming. Data transmission is taking the support of hops for communication. Data pass from one CH to another by generating multiple hops and transmission is completed from the farthest node to BS. To avoid the energy efficiency problems, researchers have discovered multiple solutions and all the deployed nodes of WSNs split into groups entitled as clustered as shown in Figure No 3.1.1.

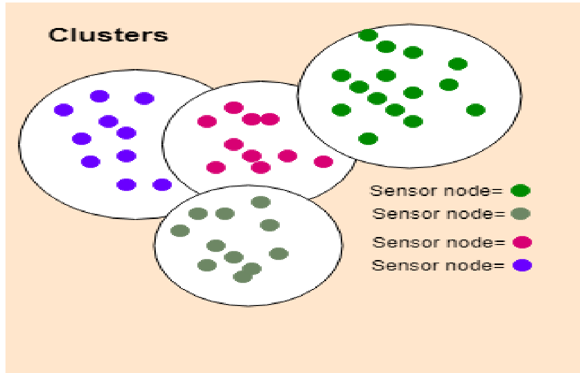

Figure No 3.1.1 Clustering

Clustering is a precarious task in WSNs for energy proficiency and network stability. Logical Cluster in wireless sensor networks is effective and use for network life-enhancing. In the Recent era distributed methods of clustering are being succeeded concerns with network lifespan and energy efficiency. In wireless network, clustering has great significance to accomplish multiple difficulties in scalability, energy, and network stability. The exchanging of information of local cluster nodes is controlled by a controller referred to as CH. see Figure No 3.3.2.

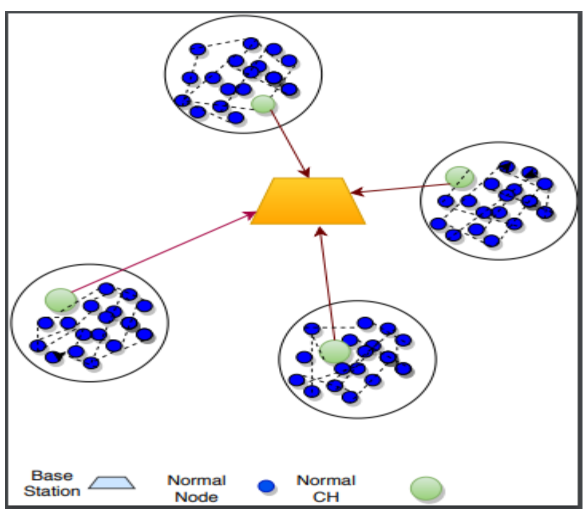

Figure No 3.3.2 Data transmission B/W BS and CHs

3.3.1 Clustering Objectives

In the cluster technique, there are some objects which are discussed below [66]:

(i) Accept and allow data aggregation.
(ii) Restricts data transmission.
(iii) Lenience usability
(iv) The logical backbone for inter-cluster routing is the function of CHs.
(v) Cluster design provides an efficient, small, accurate, and stable network.
(vi) Enhancing network lifespan.
(vii) Reduce network load.

Why We Need Clustering?

Clustering is grouping down the whole sensor network into small networks based on their similarities. The structured networks comparatively having more benefits than a flat network. We need clustering (structured network) which is easy to manage like data aggregation, reducing communication overheads, reduce power consumption, and extend sensor network lifetime.

3.3.2 Types of Clustering

In WSNs two methods are used to create clusters i.e. Bottom-up approach or agglomerative approach and divisive approach. In the agglomerative nodes are merged based on their resemblances. The second approach is called divisive approach or a top-down approach. In divisive approach nodes initially belong to the same cluster and each node creates its cluster. divisive approach is not used commonly. Some well-known types of clusters are given bellow:

a) LEACH (Low Adaptive Clustering Hierarchy)

LEACH [31] dictates that if a node is selected as CH in one round, it cannot be selected again in this round. However, LEACH has a fatal flaw. Since it does not consider energy in the selection and cannot perform load balancing in the network. Furthermore, LEACH considers that every node can send a data packet to BS which is not possible in many realistic scenarios.

b) WBCP (Weight-Based Clustering Protocol)

WBCP [68] is a type of clustering uses some of the factors to restrained energy and distance between CH and nodes and then count for how many times a sensor node has been nominated as a CH. The aim of this type of Clusters such a design that reduces amount of consumption in sensor network. This Weight Based clustering technique is particularly for a heterogeneous network. There are two well-known goals of this Weight Based Clustering which is discussed as below: -

- To enhance the nodes lifespan by picking out the nodes
- Having maximum remaining energy.
- To ignore selecting low initial energy nodes as CH.

c) K-means algorithm

K-means [67] Clustering algorithm consists of two factors to select CH. One factor is Euclidian distances and 2^{nd} is the remaining energies of sensor nodes. All nodes forward their data to a central sensor node that saves the information in the content list. It uses the k-means clustering algorithm for forwarding the gathered data to the BS. This technique operates well in distributed method instead of centralized.

Why we need Clustering?

Clustering is grouping down the whole sensor network into small networks based on their similarities. The structured networks comparatively having more benefits than a flat network. We need clustering (structured network) which is easy to manage like data aggregation, reducing communication overheads, reduce power consumption and extend sensor network lifetime.

3.3.3 Advantages of Clustering

Clustering approaches have more advantages than flat networks.

(i) Scalable and Adaptable:
The clustered network is more scalable. The scalable network is more adaptable and can manage the future increased demand.

(ii) Minimize Radio Transmission Signals:
Another positive factor of clustering is that it decreases the radio transmissions towards the BS.

(iii) Cooperative and Informal Manage:
Clustered sensor networks are more cooperative to manage informally.

(iv) Logical:
Clustering provides logical organization, reduced network traffic and exhibits a scalable result.

(v) Minimum Energy Utilization:
Clustered sensors nodes increase overall network performance by limiting the energy utilization of nodes.

(vi) Maintenance:
A cluster formation scheme is very beneficial for network maintenance.

(vii) Predictable Data:
The clustering formation scheme is very essential as data transmission is unpredictable in a flat network.

(viii) Defined Nodes:
Network performance is growing worse when network nodes are undefined.

3.3.4 Clustering Challenges

Cluster Challenges are given below:

(i) Ensuring Connectivity:
One of the important objectives in clustering is connectivity when a node communicates to its CH in an intra-clustering scheme**.**

(ii) Delay:
In the Cluster formation scheme, a proper mechanism should apply to lessen delay during the CH selection process.

(ii) Optimal Frequency:
An optimal frequency is essential in the CH rotation process.

(iv) Security:
Security is an important factor in the cluster formation scheme as WSN can be easily attacked due to external threats. An optimal security mechanism needs to be considered.

(v) Energy Efficiency:
Forming a cluster scheme it is essential to consider an energy-efficient mechanism [3].

3.3.5 Clustering Parameters

There could be many parameters that can be used to form clusters. Some of the clustering parameters are given below.

(i) Communication inside a cluster
(ii) Node mobility
(iii) Types of nodes being deployed

(iv) Clustering formation approach
(v) Inter and Intra-cluster communication.

CHAPTER 4

PROPOSED PROTOCOL

4.1 Introduction

In our scheme, we have focused on the "Hybrid Clustering Shortest Path Routing (HC-SPRP)" for WSN. Several efficient steps have been applied to enhance the lifespan of our network with outstanding supply packets ratio to BS. Points for the said purpose of our research work are discussed below.

(i) Reduced number of hops.

(ii) Advanced nodes are implanted near the BS that forwarding direct data to BS.

(iii) No direct transmission by normal CHs to BS.

(iv) Limit number of hops to 3.

(v) Replaced Minimum Spanning Tree Algorithm by Dijkstra Algorithm.

In our proposed scheme the single-chain structure within the cluster and cluster head selection. These nodes are self-organized and Dijkstra Algorithm is established by BS. Furthermore, Advance CHs sends the gathered data direct to the BS and lessen the aggregation and fusion of multiple hops.

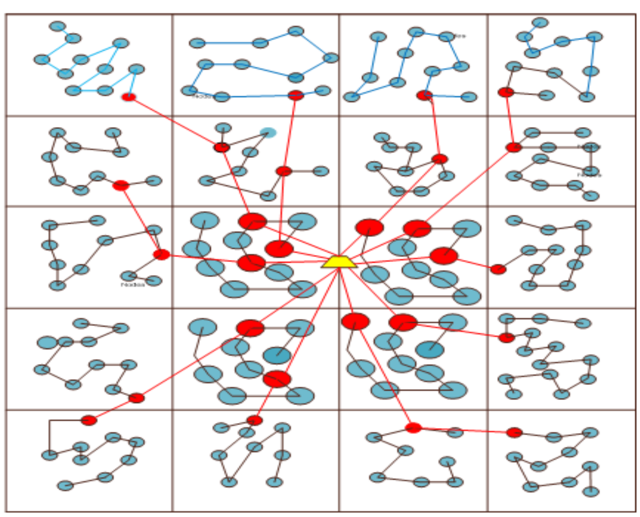

Figure No 4.1 Proposed Scheme

4.2 Network Model

The section describes our network model Scheme. There are multiple tasks are to be performed. Our implanted Heterogeneous nodes are showing that our scheme is totally for Heterogeneous network. The given model and deployment of nodes describe the layout of our scheme as shown in fig 4.2 and 4.1. The first type of nodes with maximum energy near the BS i.e. advanced nodes. The second type of nodes is normal nodes having a small amount of battery. These ordinary CH nodes transmit data only to advance CHs. Supposing an initial number of nodes are n=400 where h represents a fraction of advance nodes having high energy while the remaining nodes out of (n-h) are known as normal nodes. All the nodes are implanted in the dimension of 200m×200m area. BS is located in the center of the area having distance d^{max} *and* d^{min} from the nodes.

d^{max}= Distance of the farthest node from BS.

d^{min} = Distance of the nearest node from BS.

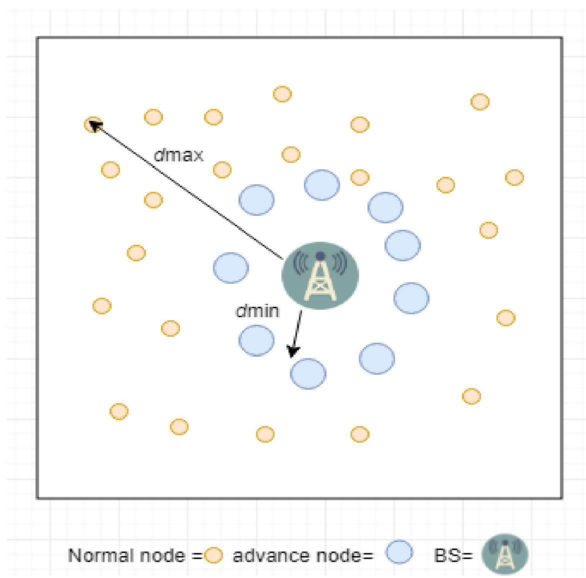

Figure No 4.2 Scheme Layout

The maximum emission power of the node communicates with all nodes (including BS) in the network.

4.3 Energy Consumption Model

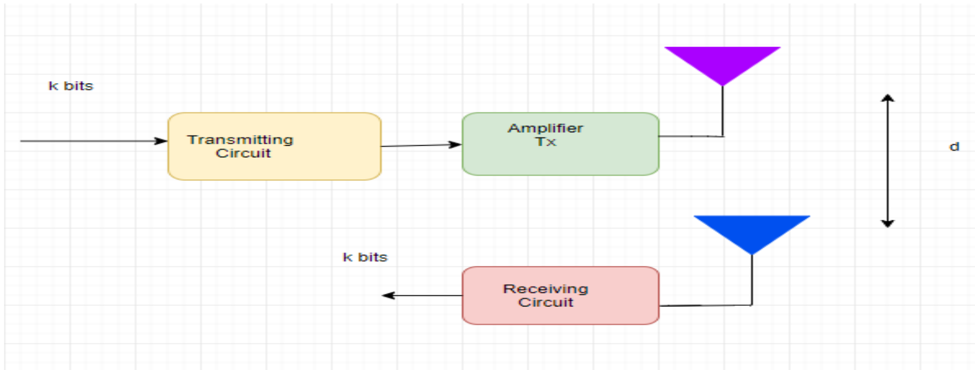

Figure No 4.3. Energy Consumption Model [75]

Imagine the energy dissipation model as shown in fig 4.3. The energy used to transmit s bits' data on a distance d from node to node transmission as given below.
Etx=(α1+α2dn)×s

α1 represents dissipation energy (transmitter electronics per bit), α2 is the dissipation energy of the amplifier transmitter. Setting the power amplifier to make ascertain power at the receiver and applying Power control for inverting the loss. For long-distance transmission, there will be a significant energy dissipation in a sensor. For this reason, we suggest a multi-hop heterogeneous technique.The Single-hop technique can be applying only in small networks. Normally sensors are facing overheads when using the long route. For this reason, different multi-hops routing techniques [4] have been used to communicate in the long haul. Furthermore, the energy consumption is high in single-hop approaches. To improve energy efficiency, we are applying the chain-based approach.

The Power Consumption for k Bits and Distance d:
To calculate the energy for K-bit transmission, the equation is given below:

(i) For k-Bits Transmission
The energy used to transmit q-bit data at distance d for each sensor node is
$E_{Tx(q,d)} = (qE_{elec} + q\varepsilon fsd^2)$.......(A)

(ii) For k-Bits Receiving:
The energy is used to receive data for each node is:
$E_{Rx(q)} = qE_{elect}$.................. (B)
E_{elec}= electronics energy.

εfs = power loss of free space.

E_{txelec}= transmission energy.

E_{rxelec}= reception energy.

E_{amp} = transmit amplifier energy.

(iii) CH Selection Probability

According to [31] the selection probability for normal and advanced nodes is given below:

$P_{nrm}=\frac{P_{opt}}{1+\alpha m}$……………………….(C)

$P_{adv}=\frac{P_{opt}}{1+\alpha m}\times(1+\alpha)$…………….(D)

(iv) The residual energy of the Advance node

$E^{res,x}=E^{intial,x}-E^{continue,a}$……...(E)

(v) Probability of nodes to become CHs can be found as:

$P(t)=\frac{E^{res}}{E^{avg}}\times\frac{D^{max}}{D^{bs}}$……………(F)

E^{res}= residual energy of the node at that time.

D^{bs} = the distance from the node to the BS.

D^{max} = value factor

E^{avg} =Average energy of all nodes in the network and is calculated

(vi) Average Energy

Average energy for all sensor nodes in the network can be calculated as: $E^{avg}=\frac{\sum_{i=1}^{n}\times E^{res}}{n}$...............(I)

n = total alive nodes during wireless sensor network initiation.

Table No 4.1 HELLO Packet to Source Node from BS.

Two Byte Data Packet ID	One Byte Source Node ID	Four Byte E^{res}	1 Byte HOP/min	1 Byte D/FBS

Table No 4.2 HELLO Packet to Neighbor from Source Node.

1byte Neighbor node ID	4 byte Link /R	Four byte E^{res}	One byte HOP^{min}	Four byte N/Hcost

Initially, BS flooding “HELLO” to all sensors. After broadcasting data is generating and this data (HELLO) send to “neighbor”. Information in the HELLO packet is shown in the table.

$HOP^{min}a$=*minimum(* HOP*)/* $b\varepsilon N_n + 1$……………(J)

HOPb =minimal hop count

DFBS = Distance from BS calculated during network initialization. When neighbor CH node received “HELLO Packet”. There is a new information table generated as shown below:

(vii) Next Hop

$NH^{value}=\frac{R^{res}}{D^s}$……………..(K)

NH^{value}=Next hop values between two nodes (directly Proportional to Residual energy and inversely proportional to the distance from the BS).

(viii) Total Network Lifespan

Total network lifetime of a network can be found below [31]

R= $\frac{E^{total}}{E^{round}}$……………(L)

E^{total} = Total energy of the network

E^{round}= Energy consumption during each round

(ix) Average Energy

The average energy of the network [46]

E'(r) = $\frac{1}{N}E^{total}(1- \frac{R}{N})$………(M)

R = Total network lifetime

N=Total number of CHs

4.4 Election Mechanism

The efficient selection of every individual CH is very serious in WSNs. If the CH is elected indecently then nodes having low energy can be selected as CH repeatedly. In such case nodes energy gets depleted and WSNs life may be unstable early. Multiple types of research have discovered multiple researches for energy efficiency and proper criteria for CH selection. In our proposed scheme we introduced such a mechanism for CH selection in which election [56] will be made totally based on residual energy. In our scheme, high energy node will get a chance to be CH in every single round and their energy will not be drained out early as compared to the earlier Scheme. Figure 4.4 shows the election mechanism of HC-SPRP.

Assuming the Initial number of nodes n=400 where m is a fraction of n having $\mathcal{B}$ times extra energy is known as high energy nodes i.e. advance nodes. For example, set of "m" will be m= {m1+ $\mathcal{B}$, m2+ $\mathcal{B}$, m3+ $\mathcal{B}$, m4+ $\mathcal{B}$, m5+ $\mathcal{B}$} while the remaining (m-n) nodes are called ordinary nodes.

There are two conditions for selecting high energy nodes as CH. Use the following election mechanism for electing CH in HC-SPRP:

1st Condition

If there is only one High Energy node in a cluster, it will be elected as CH. Probability of that High Energy node to become CH is:

$$Prob_{CH}=\frac{1}{m-n} \times (1+\mathcal{B}) \text{.................(N)}$$

2nd Condition

If there are more number of High Energy nodes in cluster, then direct data transmission will be based on distance from BS. The node having less distance from BS will transmit direct data to the BS. Probability for this case is:

$$Prob_{CH}=[\frac{d_s}{d_{n1}+d_{n2}+d_{n3}\text{.............}+d_{nx}}]\text{.................(O)}$$

$$Prob_{CH}=[\frac{1}{m-n} \times (1+\mathcal{B})]$$

$$Prob\text{(d and CH)}=prob[\frac{d_s}{d_{n1}+d_{n2}+d_{n3}\text{.............}+d_{nx}}].prob[\frac{n}{m-n} \times (1+\mathcal{B})\text{after } prob]\text{.......(P)}$$

Here

m=high energy nodes in the cluster.

m-n=ordinary nodes.

$\mathcal{B} =$ Represents extras energy of nodes as compared to normal nodes.

d_s = short distance from BS to CH.

d_{n1} = distance from BS to CH.

d_{n2} = distance from BS to node 2.

4.5 Communication Model

In our scheme, the BS is located at the center of the field in the dimensioned area of 200*m* x 200*m*. Using the "Pythagorean Theorem" to find the max distance between BS and the farthest node represented by d_{max}.

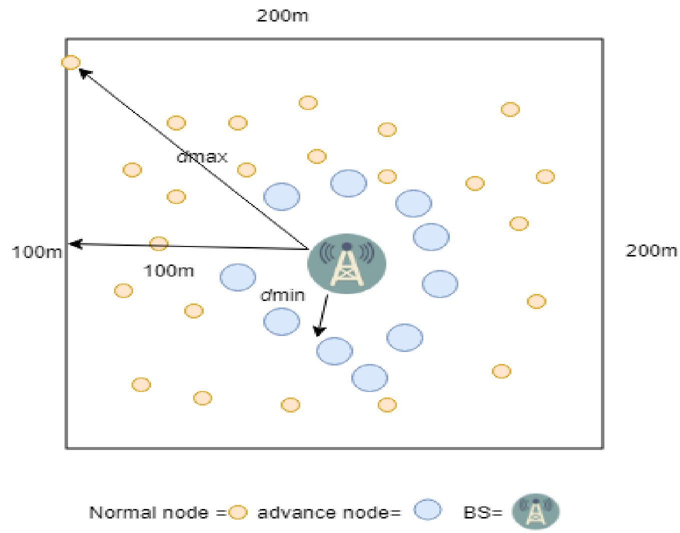

Figure No 4.4 Election Mechanism Criteria

Using Pythagorean Theorem

$(Dmax)^2 = (x)^2 + (y)^2$ → (i)

$(Dmax)^2 = (100)^2 + (100)^2$

$(Dmax)^2 =$ 10000+10000

$(Dmax)^2 =$ 10,000

$Dmax =$ 141m

4.6 Modes of Communication

Our scheme is set the value $d_O = 20m$ for advance CHs which is sending data directly to the BS. The conditions are given below:

$d_{min} \leq d_O$(Direct Communication between Advanced node and BS).

The 2nd condition:

While $d_{min} > d_O \rightarrow$ (Communication between Ordinary CHs and Advanced CHs).

In wireless network, data transmission task is the most consuming therefore CHs are helping to carry out this task. To perform these tasks multiple times, CHs drain out their energy early. These multiple transmissions shorting the stability period. In our research scheme, we have applied the Dijkstra Algorithm to relax CHs from multiple times fusion and data aggregation tasks to decrease energy consumption. In the current era, multiple discoveries [70] proved Dijkstra Algorithm efficient for data transmission. The algorithm is initially established by BS and consequently increased WSNs lifespan.

4.7 Dijkstra Algorithm

In HC-SPRP the operation of The Dijkstra's Algorithm to avoid longest route and find the shortest path from target nodes to BS. Dijkstra Algorithm Packets formats are given below:

Table No 4.3 Packet Format of Dijkstra Algorithm

Originating Node-id	Energy Threshold bit(l/O)	Hop Count to Sink	TOS

(i) Originating node id: this Id is consisting of 10 bits. It is a unique id assign for 400 nodes of the whole network.

(ii) Energy threshold bit EJ: it is 1-bit 1/0 which shows that originating node energy either above or below the threshold value.

(iii) Hop count: its size is 16 bits. It starts from 0 and incremented for each transmission/hop.

(iv) TOS: its size is 4-bits. The role of TOS is controlling packet, data packets, and out-of-service packet.

CHAPTER 5

PERFORMANCE EVALUTION

5.1 Simulation Environment

We simulate HC-SPRP in MATLAB. MATLAB is a highly effective computing programming language that is used for Modeling, Simulation, and prototyping, Data analysis. It is using for exploration, visualization, Scientific and engineering graphics. In our scheme, we focus on performance, like to measure WSNs stability, lifetime, and energy of heterogeneous Sensor Network. Simulation of HC-SPRP in MATLAB showing a long stability period as compare to HMPBC, AZ-SEP, CCMAR, Heterogeneous. We have applied the following parameters to obtain results for HC-SPRP. Simulation Parameters are given in table 5.1.

Table No 5.1 Simulation Parameters Used in Our Scheme.

S. No	Factor	Value
1	WSN area dimension	$200m \times 200m$
2	Number of Nodes n (Ordinary and High Energy Nodes)	400
3	BS Location	Centre
4	Message size (Maximum)	500*bytes*
5	Initial Energy of Ordinary Nodes (n -h)	5*Joules*
6	Initial Energy of High Energy Nodes	h(1J)
7	Electronic Circuitry Energy E_e	$50nJ / bit$
8	Amplifier Energy Amp_e	$0.0013\ pJ/ bit / m^2$
9	Originating node id	10 bits
10	DIJKSTRA Routing Info field	100*byt*
11	Energy threshold bit	1J
12	Data sensing period	32.8ms
13	Rounds (Maximum)	2000
14	Zones	20

5.1 Results

Lifetime comparison of HC-SPRP, HMPBC, and CCMAR, AZ-SEP is plotted as shown in fig 5.1. It shows that our proposed HC-SPRP can sustain the network lifespan till 3000 rounds and except all nodes of other protocols are drain out before 2200 rounds. This means our protocol is performing better than others.

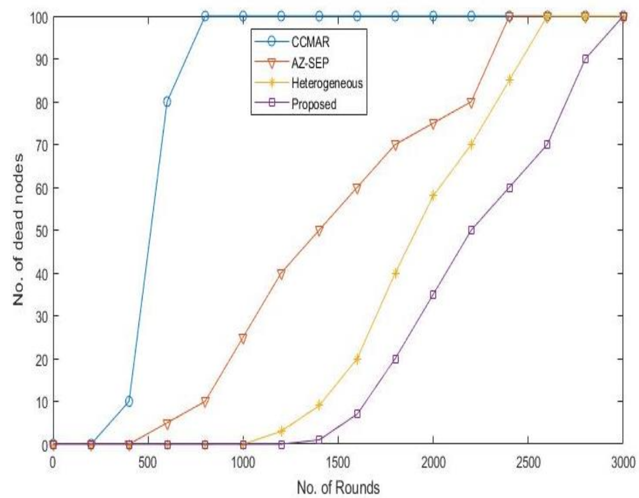

Figure No 5.1 Lifetime Comparison HC-SPRP, HMPBC, CCMAR, AZ-SEP

5.2 Energy Consumption

The CHs energy consumption per round of the HC-SPRP protocol compares with CCMAR, AZ-SEP in Fig 5.2. The results in the graph show that the average energy consumed by CH per round (J) of HC-SPRP is very less than CCMAR and AZ-SEP.

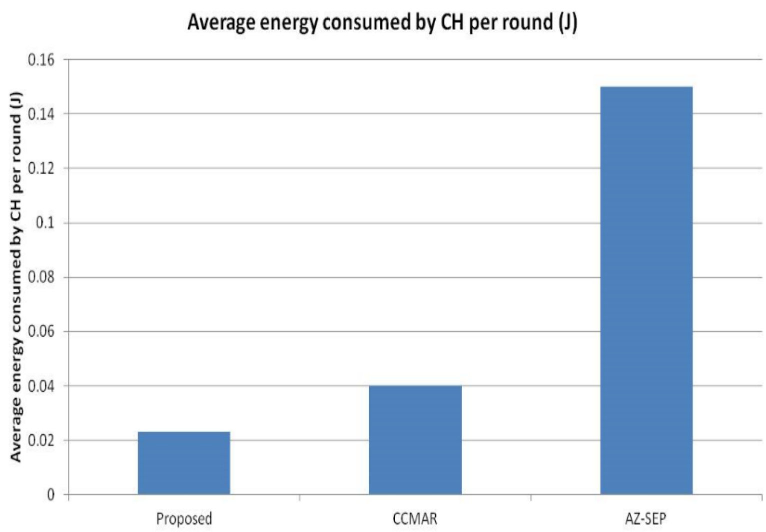

Figure No 5.2 Average Energy Consumption Per Round.

5.3 Total Energy Consumption of Network

Comparing total energy Consumption of Network of HMPBC and our proposed Scheme as given below in fig 5.3. The graph shows that the HMBC nodes drain out after 1500 rounds while our proposed scheme(HC-SPRP) is stable till 3000 rounds. It means the performance of our scheme is outstanding.

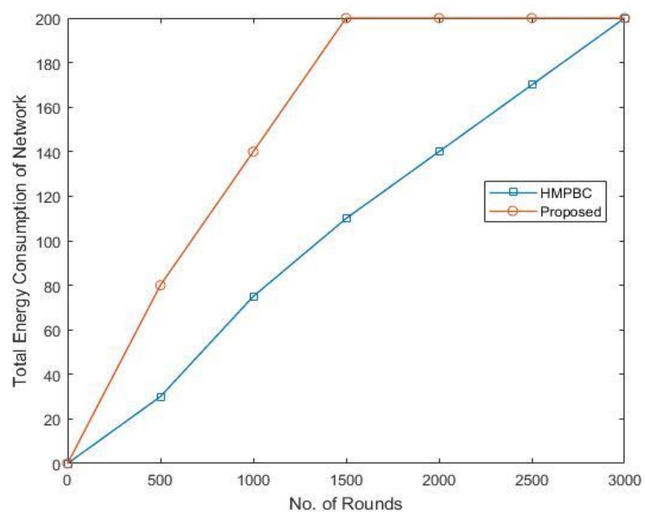

Figure No 5.3 Total Energy Consumption of Network

5.4 Total Energy Left of Network

Comparing the total left energy of the Network of HMPBC and our proposed Scheme. Our proposed Scheme (HC-SPRP) is stable till 3000 rounds while HMPBC nodes drain out after 2000 rounds as given below in fig 5.4

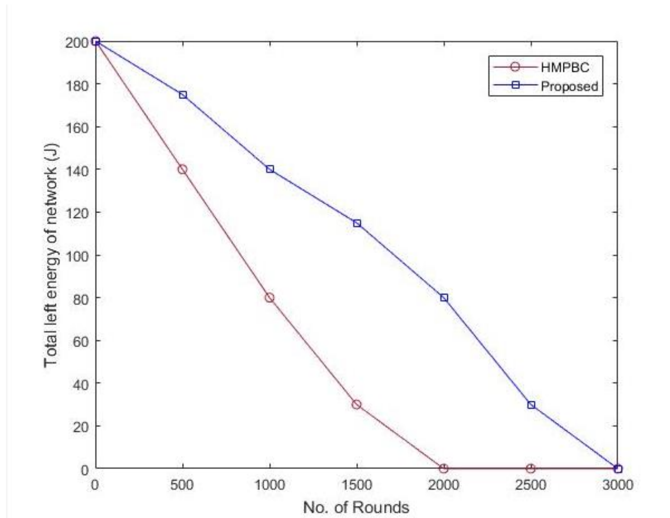

Figure No 5.4 Total Energy Left of Network

5.5 Packet Received by BS (Comparison of HC-SPRP and Heterogeneous)

Comparing Packet Received by BS of HC-SPRP and Heterogeneous [44] as given below in fig 5.5. As the communication starts packet receiving by BS increases. The graph shows 410,000 packets are received by BS for 3000 rounds. It means the throughput of our proposed scheme (HC-SPRP) is higher than the heterogeneous (Secondary parameter).

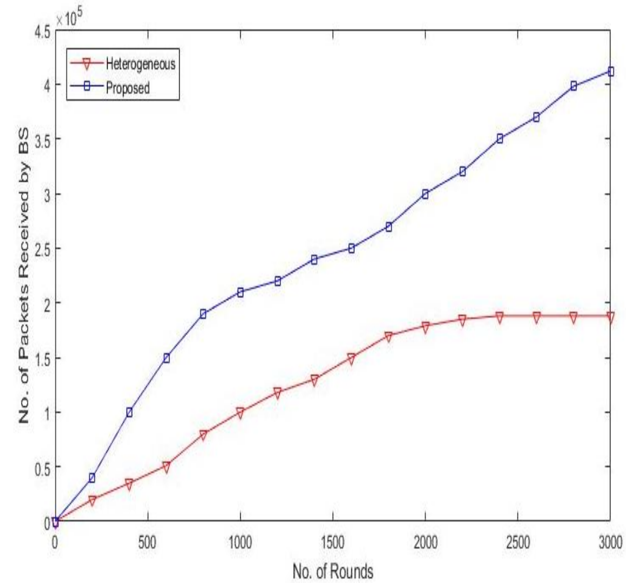

Figure No 5.5 Nodes Packet Comparison Received by BS of HC-SPRP and Heterogeneous

5.5 Compare our Proposed Scheme with More than 3 Hops.

If a node is far away and it transmits the data in more than 3 hops, then what is the affect energy consumption? If a node is far away and transmits the data in more than 3 hops, then it will effect on energy consumption. As the data transmission, receiving, and aggregation is faced by each hop. When the number of hops increases, the energy consumption of data transmission, receiving and aggregation is increasing and it will affect the energy consumption. Fig 5.7 shows the maximum energy consumption of hops more than 3.

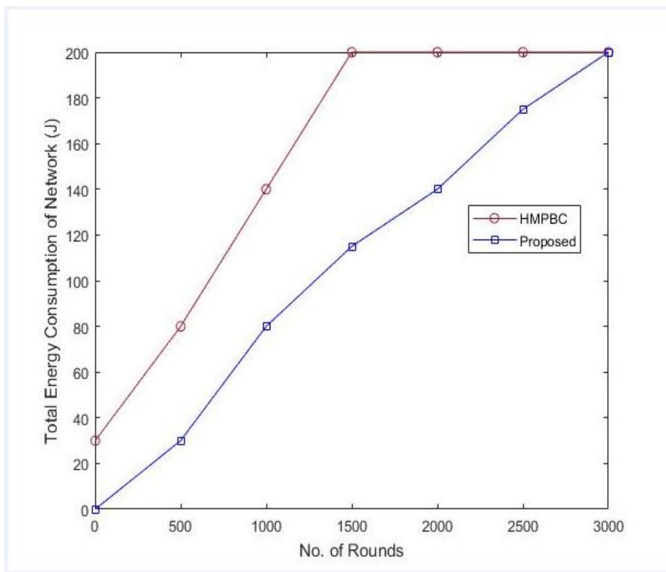

Figure No 5.6 Compare our Proposed Scheme with More than 3 Hops

CHAPTER 6

Conclusion

In this work, we proposed a Hybrid-Clustering Shortest Path Routing Protocol (HC-SPRP) for heterogeneous WSNs. Results of simulations show that HC-SPRP is performed outstandingly in challenging areas. Our research is more related to HMPBC and compares with all the parameters of HMPBC. Our scheme also compared the proposed protocol with secondary parameters like CCMAR, AZ-SEP, and Heterogeneous. HC-SPRP selects CHs based on the residual energy of sensor nodes. All nodes are elected as CHs with the help of the Dijkstra Algorithm. Final Results in the above chapter 5 show that the performance of HC-SPRP in challenging environments is outstanding and increased the stability period of WSNs. HC-SPRP consumption energy is less than HMPBC, CCMAR, AZ-SEP and Heterogeneous. Our scheme can be improved by the use of Q-learning. Using Q-learning, the important data will be receiving by the BS from the zone head on priority basis.

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