IMPROVED ZONE BASED DIVISIONAL HIERARCHICAL ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS

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A thesis submitted in fulfillment of the
requirements for the award of the degree
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DEDICATION

Every challenging task need some type of self-dedication, struggle and in addition to this need guidance from beloved elders which are assets and have deeper place in our heart.

My humblest effort I Dedicate it

To

My Beloved grandmother

My loving Parents,

My brother

&

My Sweet Sisters

Whose Support, love, affection and Encouragement makes me to achieve such success in my life…

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In the name of Allah (SWT) the most Merciful and the most courteous all praises to Allah (SWT) for giving me the power and courage for completing this thesis.
I would like to thank my advisor and supervisor Dr. Shahzad Hassan for their valuable effort for helping and supporting me throughout the process. Without his effort it's very difficult for me to completing my thesis in time.

Secondly, I would like to thank my beloved parents for their support and love in every circumstance. Without their love and support I would not imagine I can do it. Especially my mother she is a role model for me. She provides a lot of continuous support throughout my thesis process. I cannot imagine this accomplishment without the moral support of my mother in this thesis process.

Thirdly I would like to thank my all friends whom support, and valuable help makes my thesis to complete in time.

ABSTRACT

WSNs consists of spatially distributed set of autonomous nodes which are extensively used in surveillance and monitoring purpose. WSNs has limited battery power and limited resources and this battery power cannot be replaced and recharged. Due to the on-going demand of energy conservation of sensor nodes there is a need of efficient routing mechanism through which energy of the sensor nodes should be conserved. Many routing protocols used for this purpose, but clustering technique is an efficient topological control mechanism which can effectively improve the scalability period and lifespan in WSNs. Clustering techniques are distinguished between static and equal or as dynamic and unequal clustering techniques. In clustering environment, the nodes which are closest to the BS drain out their energy very rapidly because they not only send their own data but also transmit the data which has to be passed from it. This type of scenario caused the hot-spot issues in the WSN. Hot spots issues mainly appear to those locations where there is a lot of traffic on the nodes. In these locations the nodes deplete there energy very quickly and the transmission is interrupted. Some of the dynamic and unequal clustering techniques are good and mitigate the hot-spot issues but they have a lot of different critical issues like coverage overhead, network connection issues, un-balanced energy utilization among the SNs and network stability issues. So static and equal clustering technique is something efficient for mitigating hot spot problem. But in some extent static and equal clustering technique also have hot-spot issues while we are considering the number of clusters in a zone and hence it decreases the lifetime of the network system and its stability. This document proposes a systematic and efficient protocol by using static and equal cluster environment called the “Improved Zone Based Divisional Hierarchical Routing Protocol” (IZDHRP) for eliminating the hot-spot or energy-hole issues as faces in (ZDHRP) protocol. The performance of our proposed method is evaluated using MATLAB simulations in an efficient way. Three cases are implemented which are 8 clusters, 16 clusters and 24 clusters. The results of these three cases obtained from simulations shows that our proposed scheme is efficient and increases the lifetime and throughput as compared to other benchmark protocols.

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LIST OF ABBREVIATIONS

WSN	-	Wireless Sensor Network
WSNs	-	Wireless Sensor networks
SN	-	Sensor node
SNs	-	Sensor Nodes
BS	-	Base Station
CH	-	Cluster Head
CHs	-	Cluster Heads
CM	-	Cluster Member
CMs	-	Cluster Members
PCH	-	Primary Cluster Head
SCH	-	Secondary Cluster Head
ACH	-	Assistant Cluster Head
MCH	-	Main Cluster Head
IZDHRP	-	Improved Zone Based Divisional Hierarchical Routing Protocol
ZDHRP	-	Zone Divisional Hierarchical Routing Protocol
ZC	-	Zone Controller
ZCs	-	Zone Controllers
R.E	-	Residual Energy
T	-	Threshold
FND	-	First Node Dead
PNA	-	Percentage Node Alive
LND	-	Last Node Dead
HND	-	Half Node Dead
R.N	-	Relay Node

CHAPTER 1

INTRODUCTION

A WSN is developed by spatially distributed SNs and these types of sensor nodes have limited energy, limited processing and have very less communication power and energy capacity [1]. In most of the cases these types of SNs distributed in a very intense and harsh environment and the main focus is to sense the information and send these type of sensed information to the end user or system.

In contrast to the other traditional networks such as ad-hoc network, WSN has a lot of limitation such as battery power, memory limitation and other computation factors. Due to this type of severe limitation in sensor networks there should be some efficient mechanism in which the battery power of the sensor networks managed in a systematic way such that the lifespan of the network system improved efficiently and wisely.

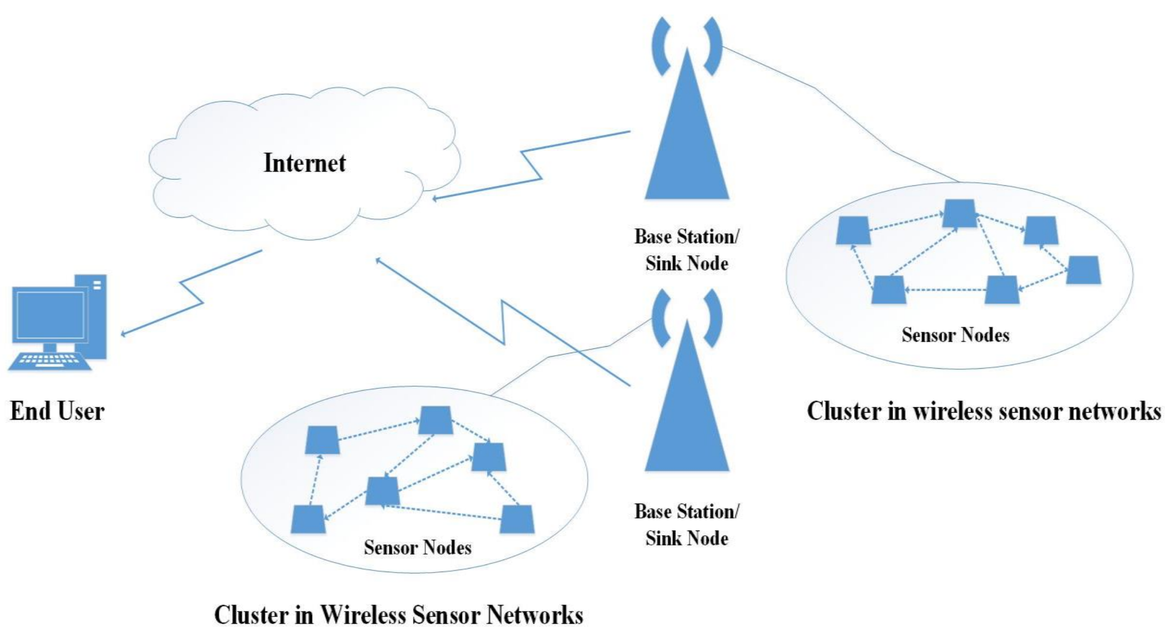

Fig 1.1: Wireless Sensor Network (WSN)

Fig (1.1) describes the WSN system in which SNs are assembled in a systematic way called clusters and these SN send data to the BS and then received by the end user at the end state.

In WSNs sensor nodes perceive the information from the surrounding environment, process this sensed information called data and forward this data to the closest node till the data is reached to the sink node/base station (BS) [2]. In sensor networks the most important role of the BS is to collect all the aggregated data from the SNs and then has the ability to analyze this data in a systematic way and then make concrete decision on the basis of this data. WSNs can be categorized as continuous and event based [3] [4]. In continuous based category, the set of aggregated data is collected and analyzed. After this, aggregated data is described periodically and there are no changes in this type of data. In other type of category which is called event based in which set of reports sends only when a type of event is occurred periodically. In WSNs on the basis of the applications mechanism the distribution of the SNs can be in different ways which are homogeneous sensor deployment or heterogeneous sensor deployment, mobile sensor deployment or stationary sensor deployment and deterministic sensor deployment or randomized sensor deployment.

Wireless sensor networks (WSNs) has broadened the sensing capability, enhance the reliability and provide efficient precision in contrast to the previously existing ad-hoc networks. The sensor nodes have limited battery power and they have to be deployed in unreachable or uncertain areas, so it is very difficult and unfeasible to recharge or replace the battery [5]. In WSN due to the ongoing demand of the energy conservation among the sensor nodes there is an essential requirement of the data aggregation mechanism and as well as the energy efficient routing protocols [6, 7]. In WSNs the most important challenge which a network system face is the energy-efficiency challenge. In WSNs the sensor nodes have less amount of battery power and this type of battery power cannot be replaced because SNs deployed in areas where there is difficult to replace the battery power. WSNs has a very limited lifetime [7, 8].

Clustering mechanism is one of the most vital solution which has been developed and proposed by a lot of researchers in sensor networks. In sensor networks if we want to enhance the network lifespan and network-stability and moreover want to increase the efficiency of the network system there is a need of mechanism called clustering mechanism. Clustering mechanism has the ability to manage and organized the network system into set of clusters. Clustering technique is an efficient way to understand the hierarchical topology which is most important for routing the data in a network system which can monitor the system constantly and gather the data periodically in which the sink node is located far away from the sensing location.

These clustering techniques are most efficient for increasing the life span and the stability period [9] of the WSNs and in addition to the most vital mechanism for topological control. In cluster-based network the whole network is partitioned into different clusters and each set of cluster has a defined set of nodes. Each type of cluster consists of cluster members and as well as each cluster has a leader which has the responsibility of transmitting the data to the other neighbor node or sink node. This leader is called the cluster head (CH). In a sensor network system, the collection of cluster heads (CHs) form the foundation of the entire network system. In each type of cluster, the cluster head (CH) has a lot of responsibilities like data aggregation, data forwarding, nodes organization, task management, task allocation and also data authentication.

The energy utilization of the cluster heads (CHs) is much extensive as compared to the sensor nodes (SNs). There is a need of mechanism in which high-level burden of the cluster heads (CHs) allocated to all type of sensor nodes. Due to this fact in most of the clustering protocols there is a mechanism of cluster head (CH) rotation. By doing this CH rotation mechanism there is a balance of energy utilization among the cluster members in entire network system. Each sensor node in the respective cluster collect the data from the surrounding environment and send this sensed data to the CH. The CH has the ability that it aggregate the data and forward this data to the next CH and then to the BS [10, 11]. The base station processes this aggregated data and make decisions based on these types of data.

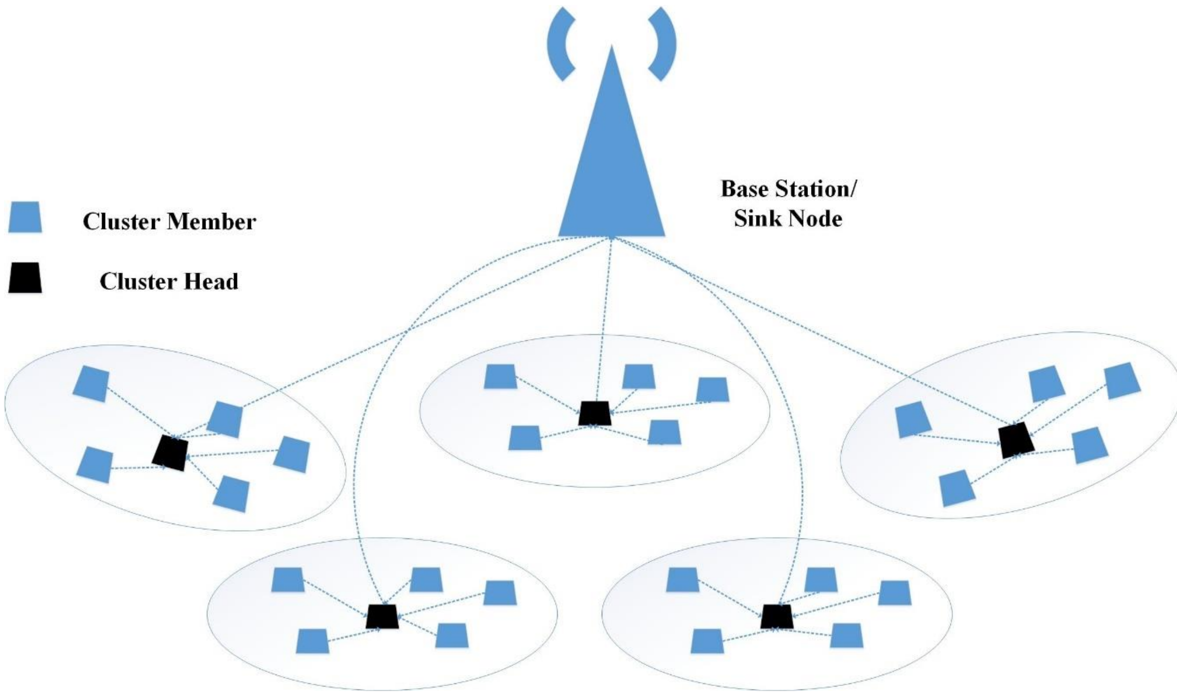

Fig 1.2: Clustering in Wireless Sensor Networks (WSNs)

Clustering techniques provided the systematic mechanism in which the network activities are organized well time. The sleep time of the sensor nodes in the respective clusters are established to mitigate the collisions in the network. Management activities are efficiently comprised and the resource allocation to the nodes are efficiently handled by using clustering techniques. By using clustering techniques the aggregated data is transmitted and the unnecessary packets are avoided so the burden on the transmitted node is less [12].

Fig (1.2) above explain the clustering process in the WSN in which SNs are grouped in a systematic way and this grouped process is called clustering. In cluster-based network there are two type of network traffic which is involved in the network system that is intra-cluster communication and inter-cluster communication. Intra-cluster is a type of communication which is to be held inside the cluster and this can be single-hop or multi-hop. Inter-cluster is a type of communication which is to be held between the cluster node and relay node. In intra-cluster communication CHs have the responsibility to transmit the aggregated data to BS either directly or with the assistance of another CH node. In WSNs single-hop mechanism is adopted to a specified distance which is set to be defined in the first order radio energy model. Multi-hop mechanism is started after that specified distance and due to the limited transmitting capability of the SNs the multi hopping is energy balanced and energy efficient technique [13].

In clustering technique both communication model such as single-hop communication and multi-hop communication have unavoidable energy dissipation among the cluster members, and this give rise to the situation where some sensor nodes die permanently and hence reduces the life span of the networks. In single hop communication (as describe in Fig 1.3) the SNs which has longest distance from the BS has to transmit the data with using long distance and hence the node dies earlier. In other condition such as multi hop communication (as shown in Fig 1.4) the sensor nodes which are closest to the base station has to transmit the data other than its own data and the nodes dies faster this is called the hot spot problem [14] or energy hole problem [15]. Due to this hot spot problem no set of data is forwarded to the BS and this causes collapse of the complete network system. Experiments results in [16] provides the vital information that over ninety percent (90%) of the energy of the whole network remains un-utilized if the lifetime of the network is dropped out due to the hot spot issues.

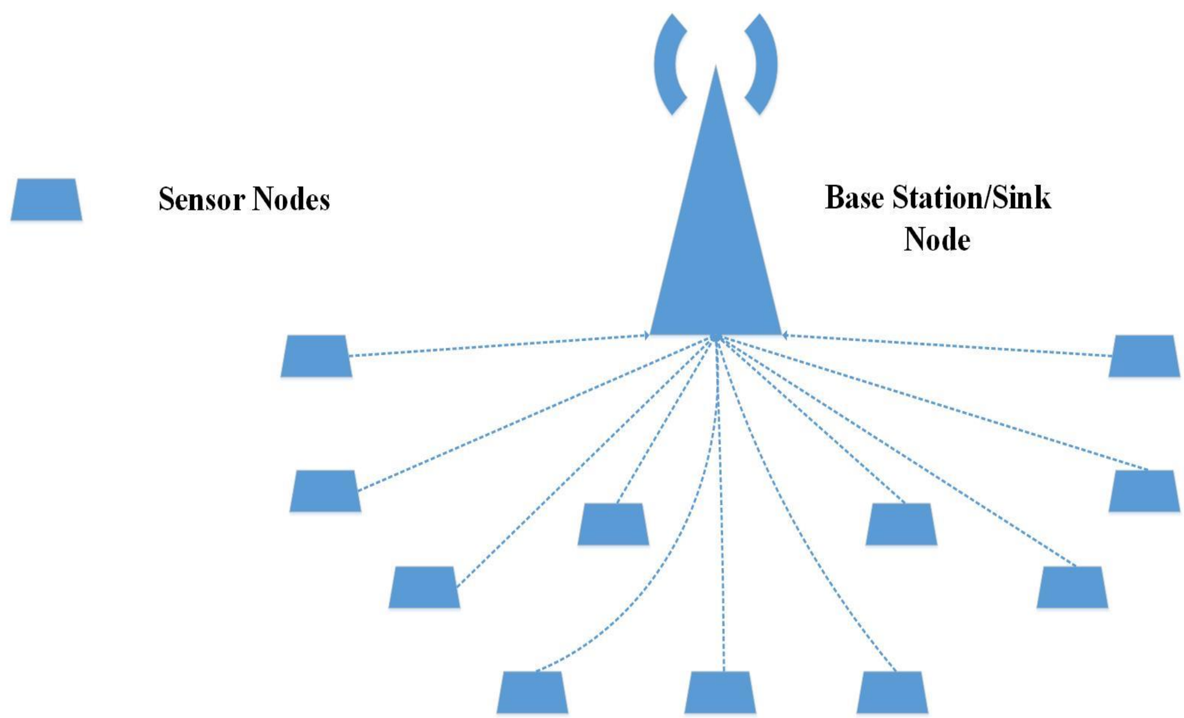

Fig 1.3: Single Hop Communication

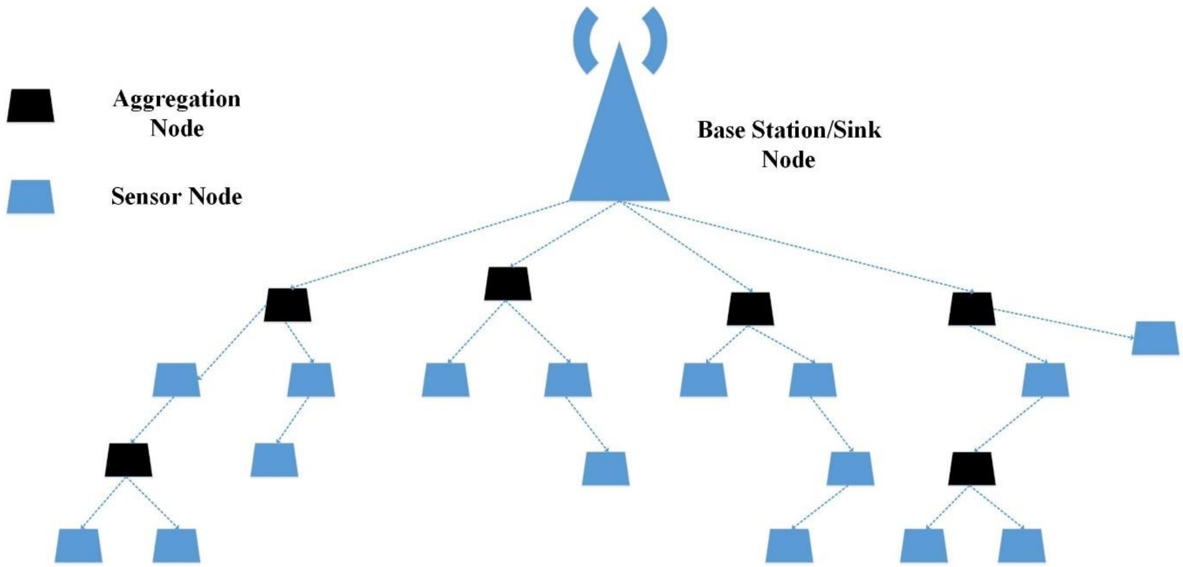

Fig 1.4 : Multi-hop Communication

This hot spot problem makes the network transmission of the system to a disturbing condition. Transmission is interrupted because the number of nodes which are taking in the participation of the data transmission is die due to the excess of transmission from that nodes. In order to alleviate the hot spot issue many authors has discussed the energy imbalance issue by implementing the unequal type of clustering techniques [17, 18]. In unequal clustering techniques the set of clusters closer to the BS has smaller cluster size in contrast to the clusters which are far away from the BS. The smaller cluster size near the BS preserve the energy for inter-cluster communication.

Most of the dynamic unequal cluster technique improves the hot spot issues but they have also lot of other issues like overhead along with coverage, connectivity and network stability issues. So static and equal clustering technique is used, and this technique can consume minimal amount of overhead. But static clustering technique also have issues while mitigating hot-spot and to balance the energy utilization among the SNs. The number of clusters in a zone is the main issue in the static clustering technique while mitigating the hot spot problem and in addition to increases the lifetime and the network stability. Increasing the cluster size makes the node closest to base station to deplete their energy fast and produces hot spot issues and decrease in cluster size increases the intra-cluster communication cost and nodes dies due to excess of communication and hence produces hot spot issues.

To overcome these issues in static and equal clustering we have propose a protocol called the Improved Zone Based Divisional Hierarchical Routing Protocol (IZDHRP). This protocol alleviates the hot-spot issues faces in ZDHRP scheme. This protocol (IZDHRP) has the ability that it can provides an efficient multi hopping routing mechanism to alleviate the hot spot issues and balanced the energy utilization in clustering process for both intra-cluster and inter-cluster mechanism so that in this case the rate of early death of node should be reduced.

1.1 Application

The application of this protocol Improved Zone Based Divisional Hierarchical routing protocol (IZDHRP) has the ability to efficiently increase the animal and habitat monitoring like Zebra-Net and Great Duck Island. Biologist in this case want to monitor and learn habitats of animal in this case such as herd's size (how many animals are in the area), mobility patterns (sleeping, running, grazing) and other routine habitat (watering).

This protocol increases the efficiency of the environmental surveillance like humidity, temperature, volcanic surveillance. This protocol has the ability to increase the efficiency in underwater sensor network systems and also structural based surveillance such as building monitoring and home automation. Fig (1.5) below explain the Zebra-Net sensor network for Habitat monitoring and explain the communication process in Zebra-Net.

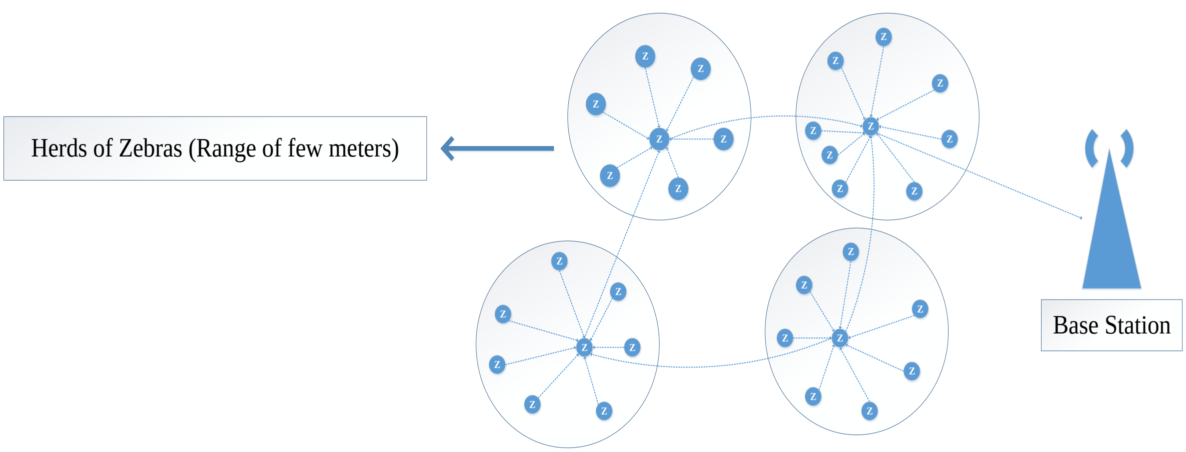

Fig 1.5: Zebra-Net Sensor Network for Habitat Monitoring

1.2 Example

In particular WSNs application SNs has the ability to monitor and surveillance the required area and space in which SNs are deployed. These SNs can monitor and surveillance the required area and forward the results to the BS and BS extract the information which is forwarded and collect by the SNs. These SNs are deployed in scatter form through air drop expecting that this covers a lot of area. This set of results produces hot-spot issues due to the excess use of single node which forward this data and also the type of data passing from it and hence deplete their energy fast. Our proposed protocol Improved Zone based Divisional Hierarchical Routing protocol (IZDHRP) has the ability to remove this energy-hole issue and enhance the lifespan and stability. Fig (1.6) explain the surveillance application of the sensor node deployed in an agriculture field in a systematic manner.

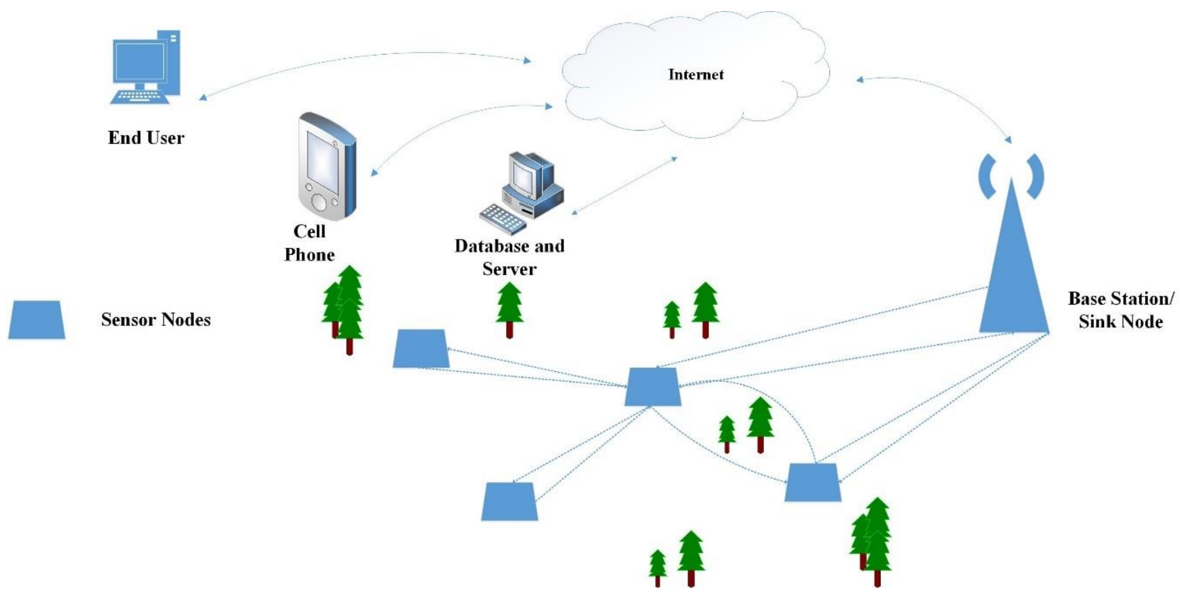

Fig 1.6: Wireless Sensor Networks (WSNs) Surveillance Application

1.3 Proposed Approach

The following section provide and evaluate the potential proposed solution of the problem which we have encounter.

In order to eliminate the hot spot or energy-hole issues and also enhancing the lifespan and stability of the network system, we are proposing the development of a protocol called the Improved Zone based Divisional Hierarchical Routing Protocol (IZDHRP) for WSNs. In our proposed method we will eliminate the control traffic during the clustering mechanism in such a way that it reduces the mess of nodes for the competition of cluster head selection. A powerful BS is installed at the center and this BS is the most powerful node in our network system and has the ability to managed and organized all the tasks in our network system. The base station has all the information of the sensor node like their energy status, residual energy, energy density and other factor in a systematic way. Dual CH scheme is developed and the main focus of it to balance the energy utilization among the clusters. The CHs are PCH and SCH in our proposed network system. A network area is dividing into four zone which is Zone A, Zone B, Zone C and Zone D. Each zone has a resource rich node called the Zone Controller (ZC). Zone controller act as an interface between the BS and CHs. Zone controller also has the ability to balance the load of the CHs and makes the network system energy efficient.

1.4 Motivation of the Research Work

- In the current body of research done in the area of wireless sensor networks we have seen that there is no particular attention is given on the mitigation of hot-spot or energy-hole issues.
- Hot-spot or energy-hole issues are still an open critical problem in the wireless sensor networks (WSNs).
- Some of the protocols such as unequal clustering mechanism in wireless sensor networks (WSNs) have mitigate the hot-spot or energy-hole issues but they are not effective and have produces a lot of other issues.
- Network lifetime and stability period is decreases by the hot-spot or energy-hole issues in a wireless sensor network (WSN).
- Energy consumption is un-balanced among the sensor nodes due to the hot spot or energy hole issues.

So, the motivation behind this research is to focus on developing a protocol which has the ability to alleviate the hotspot issues and also enhance the lifespan of the network system by balancing the energy utilization among the nodes.

1.5 Objective and Scope of Research Work

The main objective of our scheme "Improved zone based divisional hierarchical routing protocol" (IZDHRP) is to realize the following effective performance specification.

- Increasing the stability period of wireless sensor networks (WSNs) and its reliability by avoiding the hot-spots or energy-hole issues.
- Provide a mechanism for balanced energy utilization among all the nodes so that chances of early death of nodes should be avoided.
- Increases the network lifetime and stability by providing an efficient and systematic clustering technique.
- Provided a systematic mechanism for increasing the through-put of the whole network system.

Moreover, our proposed mechanism will eliminate the issues of network connectivity, overhead along with coverage and un-uniform energy utilization among the SNs by providing a well-organized clustering technique which overcome and alleviate the hot-spot issues.

1.6 Organization of Thesis

The remaining part of our document is enlist as, the chapter 2 describes the Literature Review of our document, chapter 3 describes the Problem Statement in our document, chapter 4 describes the System Description in our document, chapter 5 describes the Network Model and Proposed Scheme, chapter 6 describes the Proposed Algorithm in our document, chapter 7 describes the Performance Evaluation and Results in our document and chapter 8 describes the Conclusion and Future Work. All these chapters are extensively explained and elaborates the content involved in it with efficiency.

CHAPTER 2

LITERATURE REVIEW

WSNs is a collection of resource constrained tiny sensing devices called SNs. These types of SNs deployed in a particular geographic region. Each sensor node has the ability to monitor and supervise a specific event such as temperature, wind pressure, weather aspects volcano eruptions and forward the collective data to the BS. WSNs has the ability to provide extensively efficient sensing capability, greater consistency and precision as compared to the previous ad-hoc network systems. WSNs are efficient as compare to the previous ad-Hoc network system. WSNs are deployed in environment like battlefield, huge forest, intense weather condition and also under-water all these scenarios are crucial. In this type of hostile environment there is no mechanism for replacing and recharging the battery power of the SNs. So, in this case WSNs has inadequate battery power and these battery powers cannot be replace and recharge so due to this finite lifetime of the battery power it gives rise to the need of energy efficient routing protocols for WSNs.

In a WSNs clustering techniques are most efficient and valuable routing protocols for periodically collecting and sending the sensed data to the BS. Clustering techniques are used to efficiently enhance the stability of the WSNs, prolonging the network lifespan and prolongs the energy efficient resources. Cluster-based routing protocols comprises of multi-hopping mechanism. Due to this multi-hopping mechanism CHs which are closer to the BS has to forward the data passing through it and also, they have to send their own data and because of this cluster heads deplete their energy faster and causes the hot spot issues. Due to this hot spot issues the whole network life span and the stability is also disturbed. This hot spot problem drains out the energy of the SNs which are closer to the BS much faster and in long run the overall network system is get partitioned and halt.

In recent years many proficient algorithms have been developed for alleviating the hot spot problem and also prolonging life span and stability of the network system by balancing the energy utilization among the nodes and making the network system efficient. Following are some proficient protocols which we will discussed here in a systematic way. We will discuss hot spot issues related schemes and these schemes are set to be consists of three categories which are Dynamic and Unequal clustering, Static and equal clustering and Hybrid clustering techniques. These three types of clustering techniques protocols for mitigating hot spot and energy hole issues are extensively elaborate in our literature.

All set of proficient protocols related to hot-spot or energy hole issues reviewed systematically and should be discuss in our literature. Protocol mechanism, parameter used in these types of protocol, its zone formation cluster head selection mechanism and routing parameters all would be discussed in a proper manner. Following figure (2.1) describes the chronological diagram of the literature review. All the protocols which we will discussed is described in the following diagram and provide an extensive view of our literature review.

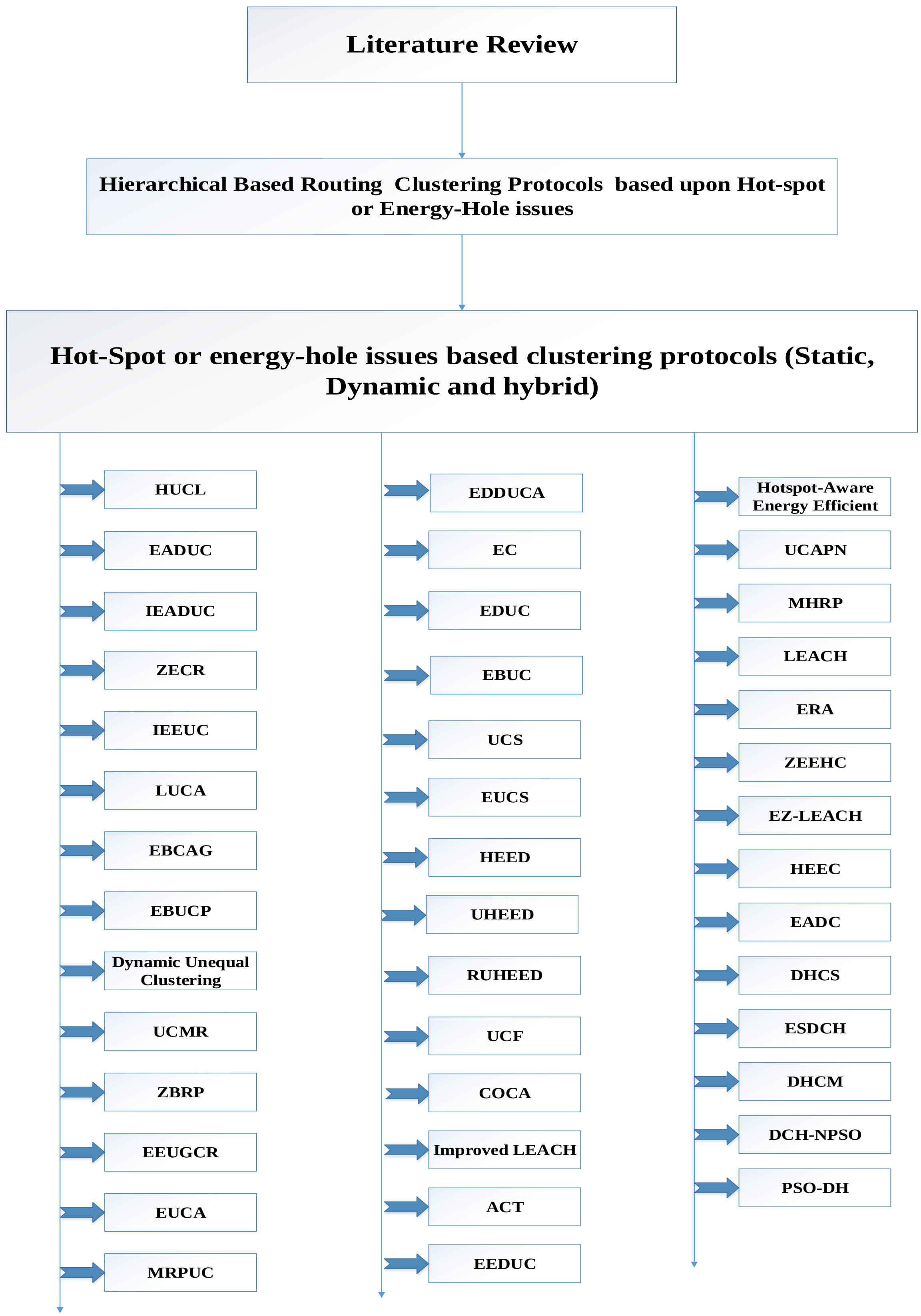

Fig 2.1: Chronological diagram of Literature Review

In WSNs clustering is determined to be the most proficient scheme for enhancing the stability and the lifespan of the network system. Clustering is a process in which SNs are grouped in a systematic way called clusters and each type of cluster has a leading CM called the CH and other set of cluster nodes are called CMs. Each set of SNs or CMs perceive the data from the surrounding environment and forward these data to the CHs.

These CHs has the ability to receive all the cluster members data and aggregate these data received from all the CMs and send this data to the BS. As CHs has all the responsibilities like forwarding the data, aggregating data and also record management of the SNs so in this case a lot of energy is consumed by the CHs. So, there is a need of CH rotation mechanism so that energy is balance among all the SNs systematically. In single-hop communication mechanism the set of CHs which are far away from the BS needs a lot of energy for forwarding the data so that's why CHs far away from the BS have more energy as compared to the CHs closer to the BS. But in multi-hop mechanism the CHs which are closer to the BS consume their energy faster as compared to the CHs which are far away from the base BS.

Hot spot problem is occurred when the CHs which are closer to the BS has to send their data and the type of data which are passing through it and hence due to this load of heavy relay traffic these types of nodes deplete there energy faster as compared to the other node and causes hot spot problem. This hot spot issues halt the network system completely and there is a communication blackout in the entire network system. Due to this hot spot issues the network stability and network life-time is decreases. Network system get partitioned due to this issue and the coverage area of the SNs get lost. Many of the researcher has developed the protocols for eliminating this issue by using dynamic and unequal clustering protocols. In Dynamic and unequal clustering protocols nodes closer to the BS have very small sized clusters as compared to the SNs which are far away from the BS so that in this case CH nearer to the BS deplete less energy. But these types of protocols have a lot of different critical issues like transmitting power issues, overhead along with coverage, un-balanced energy utilization among the SNs and stability issues. So static and equal clustering technique is something efficient for alleviating hot spot problem. This static and equal clustering technique can consume minimal amount of overhead. But in some extent static and equal clustering technique also have hot-spot or energy-hole issues while we are considering the number of clusters in a zone and hence it decreases the lifetime of the network system and its stability.

Following are some proficient protocols which we have reviewed based on eliminating hot-spot or energy-hole issues.

In recent years an efficient mechanism is proposed for eliminating the hot spot or energy hole issues which is describes in [19]. HUCL protocol comprises of both static and equal clustering and dynamic and unequal clustering. In this protocol cluster heads (CHs) are selected based on the principle of residual energy, distance from the base station (BS) and number of the engaged sensor nodes (SNs). In this protocol the overall network system consists of set of rounds and each set of rounds consists of two types of stages. First type of stage is called Setup stage and the second type of stage called data transmission stage. In order to avoid the overhead in network system the set of data transmission stage consists of major slot and set of these major slots are partitioned into number of minor slots and each set of minor slot have set of cluster members (CMs) which forward the data to the cluster head (CH). This cluster head CH send the aggregated data to the base station (BS) and each major slot consists of a new cluster head (CH) also and the current cluster head (CH) tell the new cluster head (CH) about its sensor nodes and all information in the transmission phase. This protocol provides a systematic technique to balance the energy consumption and mitigate the hot-spot or energy hole issues.

An efficient clustering protocol for elevating hot-spot or energy hole issues is discussed in [20]. In which the authors proposed the protocol called Energy Aware Distributed Unequal Clustering (EADUC). The number of cluster heads (CHs) elected through this algorithm provided the efficient meaning of energy balanced among all the nodes and efficient coverage to all the sensor nodes. This protocol elects the cluster head on the principle that consists of average residual energy of the surrounding sensor nodes and the residual energy of the SN itself. It developed the cluster of uneven sizes to mitigate the hot spot issues. The cluster head (CH) which is closest to the base station (BS) has smaller number of clusters which is used to efficiently balance the energy consumption and makes the network energy preserved for inter cluster communication. The whole network system is partitioned into set of rounds. Each set of rounds consists of two types of stages. First stage is called set-up stage and second type of stage is called data transmission stage. Set-up stage in this protocol is further partitioned into three types of stages which are data collection stage, cluster head election stage and clusters developed stage. In data transmission stage, data is collected from cluster members (CMs) and send it to the cluster head (CH). Cluster head (CH) aggregate this data and send this type of data to the base station (BS). In this protocol (EADUC) there are no isolate points. Clusters are formed in such a way that isolate points removed in this protocol and increase the lifetime and network stability.

In [21] the authors of the paper proposed and evaluated a protocol called Improved energy aware distributed unequal clustering protocol (IEADUC). This protocol (IEADUC) is the improved and extended form of EADUC protocol. EADUC protocol has the ability to eradicate and eliminate the energy-hole problem in a multi-hopping environment. In EADUC protocol there is two parameter which is most important and considered which are residual energy of the nodes and distance of clusters to the BS. With the help of these parameters, CH is selected, and network is partitioned. In this protocol (IEADUC) there is addition of one step while electing CH which is considering the neighborhood nodes in addition to above steps. In this protocol while selection of next hop for data forwarding the RN is used for this mechanism. In this protocol the data transmission stage is expanded on each set of rounds and in each set of rounds there is a data collection mechanism with help mini-slot and major-slot. The RN has the ability to formulate the set of tables which consists of energy utilization of nodes instead of location and distance information used in the EADUC protocol. This protocol also uses the concept of introducing same cluster for number of rounds such that in this case cluster overhead is reduced. This protocol increases the network lifetime and network stability and reduces the hot-spot issues.

In [22] the authors proposed a protocol called zone divided and energy balanced clustering routing protocol (ZECR). This algorithm partitions the area in several types of zones and uses the unequal clustering techniques to alleviate the hot-spot issues. This type of hot-spot issues produced by the nodes which are closer to the BS and these types of nodes send the data passing through it and also its own data and due to this factor nodes deplete their energy faster and created hot-spot issues. The method of CH selection is based on the principle that the nodes can only be selected as a CH that has energy which is defined in the protocol it means that the energy should be equal to respective standard that defined in the protocol. RN for inter cluster communication is selected based on high residual energy so that the data is transferred to the BS efficiently. This protocol eliminates the hot-spot issues and increase the network lifetime and network stability.

In [23] the author proposed the protocol called improved energy efficient unequal clustering (IEEUC). This protocol (IEEUC) is the improved form of (EEUC) protocol. EEUC protocol is also an unequal clustering protocol and it systematically balanced the energy consumption to great proportion, but it has some limitation while balancing the energy among the SNs. It only balanced the energy to the set of nodes which are distributed evenly. IEEUC protocol has improved and extended this (EEUC) protocol in great extent in which IEEUC not only depend upon the physical orientation of the SNs but it also depends upon the distance of the SNs to the base station (BS). This protocol consists of unequal clustering technique to alleviate the hot-spot issues. The number of cluster closest to the BS have small number of size and preserve more energy as compared to the cluster far away from the BS. In this protocol the SN competition radius changes as the number of hops to the BS. It also developed the concept of node degree, and it should be applying in the network where the SNs are irregular. In (EEUC) protocol same size of the cluster at same distance from the BS may have different number of SNs but in this protocol (IEEUC) this problem is mitigated.

In [24] the authors of the paper proposed the protocol called location based unequal clustering algorithm (LUCA). In this protocol there is an unequal cluster mechanism which is established based on the location factor. Due to this location factor mechanism the clusters are changes respectively. The cluster size in the protocols changes with respect to the distance of the SNs from the base station (BS). This protocol forms the smaller clusters near the BS to preserve the energy and balanced the energy among the nodes and larger cluster away from the BS and the whole process is done to alleviate the hot-spot issues. So, in start of the process each SN in the cluster has a specific back off timer. When the SNs received any request of the CH joining the nodes accept it as a CH. If there is no request, then each node select himself as a CH and send the advertisement. The protocol manages the unequal clusters which consists of location from the BS. It uses the GPS technique for determining the location. In this protocol we can systematically overcome the issue of equal clustering drawbacks and make the network system energy efficient.

An efficient clustering protocol using gradient based routing for eliminating hot spot or energy hole problem is discussed in [25]. In which authors proposed a protocol called the Energy Balancing Unequal Clustering Approach for Gradient based routing (EBCAG). The protocol divided the nodes into unequal set of clusters and each set of SNs has the ability to preserve a gradient value. The gradient value in the protocol is set to be formulated as the minimum number of hops to BS. The cluster size in this protocol is depending on the set of gradient values of the CH of respective clusters. The selection of the CH based on the principle that first a tentative CH is selected with random probability of the nodes becoming a CH. If a CH which is tentatively selected has a maximum residual energy is set to be updated as a final CH. The CH in an unequal clustering collects the data from the SNs of its respective clusters and send the aggregated data to the BS on the descending gradient of the CH. This protocol increases the life span of the network and alleviate the hot-spot issues.

In [26] authors proposed a protocol called the energy balanced unequal clustering protocol (EBUCP). In this protocol there is three types of nodes which are deployed in the circular area of the network system and the nodes are called normal nodes, advance node and super node. This protocol confirms that there are no isolated nodes consists of the formation of unequal clusters. This protocol consists of two steps in first step the radius of the cluster is formulated. In second step the CH selection process is contains and provides the detail that there are no isolated nodes in the network system. The protocol is partitioned into multi-layer mechanism in which circular area is divided into set of multi-layers. In these types of multi-layers in circular rings each layer has a balanced energy consumption mechanism. Due to this balance energy consumption hot-spot issues eliminated in this protocol and makes the network system energy efficient. This protocol has the ability that it increases the network lifetime and network stability.

In [27] the authors proposed an energy-aware protocol called the dynamic unequal clustering protocol and the main purpose is to avoid the hotspot issues and prolonging the network lifetime and network stability. In this protocol the cluster size is variable it means that unequal clustering is used for preserving the energy of the nodes. In this protocol the CH selection mechanism is based on the node's residual energy and the distance of the nodes to the BS. The protocol consists of three steps, the first step is the cluster size allocation the second step is the sensor nodes placement and the third step is the CH selection process. The CH selection mechanism is based on the residual energy and the distance of the nodes to the BS. In this protocol after the CH selection mechanism the energy of the CH is gradually downed, and the CH reselection is done within the cluster. This reselection of the CH mechanism balanced the energy consumption among all the nodes.

In [28] the authors proposed a protocol called the unequal clustering multi hop routing protocol (UCMR). In this protocol each set of cluster has different cluster size, this cluster size is based on its distance from the BS. In this protocol to makes the energy consumption less and prolonging the network lifetime and stability an efficient multi- hopping technique is used. This protocol reduces the hot-spot or energy hole issues with the help of unequal clustering mechanism. In this protocol unequal clustering mechanism manages the network with cluster sizes. The cluster near the BS has small size to preserve energy as compared to the cluster which is for away from the BS. The protocol is not only depending upon the physical information as we have in other unequal clustering techniques, but it also depends upon the distance between the SNs and BS. Moreover, this protocol (UCMR) consists of degree of nodes.

In [29] author proposed a protocol called the zone based routing protocol (ZBRP). The main purpose of the scheme is to enhance the network lifetime by minimizing the energy consumption among the nodes and elevate the hot spot issues. It consists of clustering technique and network space aspect to eliminate the hot spot issues. The protocol has the ability to combine the aspects of both unequal clustering mechanism and edge-based routing in a systematic way such that there is an efficient network resource implementation. In this protocol the CH selection is depending on the random back of time in each round. The set of nodes closer to the BS having higher residual energy and previously sending less data is selected as the RN. The protocol formulates un-even sized clusters and these types of clusters has very small overhead while we considering the location information. In this scheme there is a very simple and efficient multi-hopping mechanism and this mechanism has the ability to alleviate the hot-spot issues. The protocol has the ability to balance the energy utilization in both intra and inter-cluster communication and increase the network lifetime and network stability by making the network system efficient.

In [30] author proposed a protocol called the energy efficient uneven-grid based clustering routing protocol (EEUGCR). This proposed protocol consists of centralized technique in which the BS is responsible for all type of tasks such as CH selection, cluster formation and RN selection criteria. The BS in this protocol partitioned the whole network into set of unequal sized clusters. The cluster size is based on its distance from the BS. Greater the distance from the BS the size of clusters is increases and closer to the BS the size of clusters is smaller for preserving more energy. In the proposed protocol due to the lot of energy dissipation of the cluster near the BS the grid clustering method is introduced so that the hot-spot issues are alleviated. This protocol also has the ability for load balancing among the cluster nodes. In this protocol the BS due to centralized mechanism has the ability to formulate the centroid of the cluster and average energy of each set of clusters. The set of nodes in the clusters which are closer to the centroid is selected as the CH. Each CH in a cluster has the responsibility to send the data to the upper level layered CH. This process reduces the hot-spot issues in the network system. At the end data is send to the most upper level layer and from this layer data is send to the BS through data mules. Data mule nodes has the responsibility to collect the aggregated data and send this data to the BS. The key importance is to eliminate the hot spot issues and increases the life span of the network system.

In [31] the authors proposed a protocol called the enhanced unequal clustering algorithm (EUCA). This protocol is the enhanced form of the UCA protocol. In UCA protocol CHs closer to the BS has to forward more data as compared to the other so the energy of the CHs closer to the BS drain out very quickly and causes the hot-spot issues. In this protocol we have enhanced the UCA protocol in-order to overcome this burden. The clusters closer to the BS are smaller in size as compared to the far away from the BS so that less energy is consumed in this case.

In [32] the authors proposed the protocol called multi-hop routing protocol with unequal clustering (MRPUC). The main purpose of this protocol is to develop an unequal clustering technique to enhance the network lifetime and network stability. Nodes closer to

BS have smaller cluster size in order to avoid hot-spot issues. The selection of CH is based on the node which have higher residual energy in the system. The number of clusters which are closest to the BS kept small so that they preserved the energy in intra cluster communication and forward the packets for inter cluster communication. When the set of SNs in a network system want to join the cluster, these types of SNs not only consider the distance of the cluster from the BS but also consider the residual energy of the CH. In this protocol the RN which is selected is based on the principle that the node which is selected have minimum energy consumption for forwarding the data packets and have efficient residual energy to makes the node not to die earlier. This protocol has the ability to increase the network lifetime by using an efficient multi-hopping technique.

In [33] the authors proposed a protocol called energy degree distance based unequal clustering protocol (EDDUCA). The scheme consists of unequal clustering technique for preserving the energy of the nodes closer to the BS. Due to the unequal clustering mechanism, the size of the cluster closer to the BS kept smaller as compared to the clusters which are far away from the BS. The purpose of this is to enhance the balanced energy utilization and efficiently increase the network lifetime and stability. The scheme uses the efficient technique to makes the set of clusters unequal sized. In this technique the number of clusters which have same distance from the BS have the same cluster sizes. In this scheme number of CHs adjacent to BS preserve more energy and extends the balanced energy utilization and increases the life span and stability of the network. CH election is based on residual energy, the degree of the nodes and the distance of the CH from the BS.

In [34] the authors proposed a distributed clustering protocol called the energy efficient clustering (EC). The scheme maintains the sizes of the clusters based on the distance of the clusters from the BS and as well as prolonging the lifetime of the network by reducing the energy utilization. The scheme enhances the network lifetime of the system and in addition alleviate the hot spot issues which is produces due to the depletion of nodes near the BS. In this protocol tentative CHs are selected as randomly, and the final CH is selected based on the highest residual energy. It also proposes an energy efficient multi-hopping algorithm for data gathering and describes the end to end energy utilization among the SNs.

The inter cluster routing protocol developed the balanced energy scenario and produces the less amount of overhead due to the route discovery mechanism.

In [35] the authors proposed a protocol called the energy driven unequal based clustering protocol (EDUC). The scheme consists of the unequal clustering method and CH rotation mechanism. In this scheme unequal set of clustering method is responsible for the balance of energy consumption among the nodes. The CH rotation mechanism is used for the dissipation of energy among the cluster nodes. The number of clusters which are closest to the BS has smaller size and thus preserve the energy while in other case the clusters which are away from the BS has greater size. In this protocol every node should perform a CH node such that the energy is balanced throughout the network. This scheme balanced the energy among all the nodes in a cluster environment and alleviate the hot spot issues.

In [36] the authors proposed and evaluated a protocol called the energy balance unequal clustering (EBUC). This protocol consists of unequal clustering technique that is most often used for periodic data collection. This protocol provides the mechanism in which the CH preserved the more energy and hence in this case avoided the hot-spot issues. So, in this case CHs in these clusters preserved a lot of energy while we are considering intra-cluster communication and used these preserved energy for inter-cluster communication and overall, there is balanced energy utilization in a network system. For Inter-cluster communication mechanism, the CH has the ability to relay the data with the help of RN. The residual energy of the SNs and the distance to the BS gave the RN. This RN collect the aggregated data from the CHs and relay this data to the BS. This RN is an intermediate node between the CHs and the BS. This protocol alleviates the hot spot issues and balanced the energy consumption among the nodes.

In [37] the authors of the paper proposed and evaluated a protocol called unequal clustering size (UCS). This protocol (UCS) has the ability that it can efficiently balance the energy among the CH nodes. So, in this case network lifetime and network stability is increased uniformly. The protocol provides the mechanism that CH nodes has the ability to completely adjust their location in such a way that the size of the cluster and the load balancing among different CHs should be managed properly. CHs are efficient nodes among different SNs, and the loss of CH is very crucial it means that we have a loss of data which is going to pass from this CH. So, in order to overcome this issue, this protocol proposed a mechanism in which clusters size are set to be achieved in such a way that there is a balanced energy utilization among the nodes and also it eliminates the hot-spot issues.

In [38] the authors of the paper proposed and evaluated a protocol called enhanced unequal clustering (EUCS). In this unequal clustering technique, the clusters which are closer to the BS has smaller cluster size as compared to the clusters which are far away from the BS. The CH selection mechanism consists of the nodes which have highest residual energy and also the distance of it from the BS. In order to balance the energy utilization among the SNs and removing the burden from one node there is a need of CH re-election mechanism. So, in this scheme the CH re-election mechanism has the ability to balance the energy utilization among the nodes. The CH re-election process start when the CH in current situation has lessen energy as compared to the threshold value which is defined. This protocol has the ability that it can prolong the lifetime and stability and also reduces the hot-spot issues.

In [39] the authors of the paper proposed and evaluated a protocol called Hybrid energy efficient distributed clustering (HEED). The main purpose of this protocol is to prolong the network lifetime and stability and balanced energy consumption among the nodes. The CH selection process in this scheme is based on the hybrid approach. First parameter consists of residual energy and the second parameter consists of the degree of the node in order to select the CH. CHs has the ability that it can collect the data from all the SNs and forward this collected data to the other CHs or to the BS. When a node depletes its energy and drop out from the network system then for load balancing in the protocol the CH role is rotated among the nodes. Due to this CH rotation mechanism there is a balanced energy dissipation among the nodes.

In [40] the authors proposed and evaluated a protocol called unequal clustering (UHEED). This protocol has the ability that it can mitigate the hot-spot issues and improves the energy balanced utilization among the nodes and prolonging the network life span and stability. UHEED protocol is the modified form of the HEED protocol. HEED protocol uses hybrid scheme for CH selection and comprises of residual energy of the nodes and the degree of the respected nodes in equal clustering manner. While in UHEED it consists of unequal size clusters mechanism and these types of cluster is formed with set of parameters such that distance of the CH from the BS. In this scheme the size of the clusters are kept smaller near to the BS as compared to the size of the clusters which are far away from the BS. Due to this type of cluster formation the intra-cluster communication cost closer to the BS reduces. The clusters are smaller near to the BS and there is less burden on the CHs as compared to the CHs which are far away from the BS. In HEED protocol the hot-spot issues are not completely mitigate due to the equal cluster mechanism and in UHEED protocol the hot-spot issues are mitigated with the help of unequal clustering mechanism.

In [41] the authors proposed and evaluated a protocol called rotated unequal clustering protocol (RUHEED). This protocol has the ability that it can overcome the energy hole issues in the network system. This protocol is the extended form of UHEED with more addition to the rotating CH node while in the CH election mechanism. The CH is rotated in a specific manner among the nodes of the same cluster. This CH rotation is depending upon the node which has highest residual energy in the cluster. This scheme has the ability that it consists of three phases. These phases are CH selection, formation of the clusters and the rotation of the CH.

In [42] the authors of the paper proposed and evaluated a protocol called fuzzy based clustering mechanism for mitigating hot-spot problem in WSNs. This scheme has the ability to develop a systematic unequal clustering technique using the fuzzy logic mechanism. The main focus of this algorithm is to prolong the life-span and stability of the network system and also alleviate the hot-spot issues. In most of the protocols the CH selection in first step is done randomly and after first iteration the CH is selected based on the set of residual energy. High residual energy of the nodes are selected as the CHs. In this protocol the selection of CH is not only depends upon the residual energy of the nodes, but it also depends upon other systematic information of the set of nodes. In this scheme the cluster size adjacent to the BS is lesser as compared to the clusters which are far away from the BS. These adjacent clusters preserved their energy in intra-cluster communication and use this energy for inter-cluster communication and in this load is balanced among the nodes.

In [43] the authors of the paper proposed and evaluated a protocol called construction of optimal clustering architecture (COCA) for WSNs. The main purpose of this protocol is to prolong the network lifetime and stability and also mitigating the hot-spot issues. Unequal clustering mechanism is established and developed in most of the algorithm for alleviating the hot-spot issues. But there is no proper mechanism in these protocols that on which conditions and parameters the size of clusters is set to be maintained and how much size of the cluster is set to be defined near the BS and far away from the BS. This scheme developed a mechanism for optimal cluster formation in which the energy utilization mechanism in all clusters are even. Due to this even energy utilization the hot-spot issues are alleviated systematically. In second part of the protocol a CH rotation mechanism is developed in such a way that the energy which is consumed during intra-cluster communication is lessen and hence it overcome the hot-spot issues. In general CHs which are closer the BS has to forward more data as compared to the CHs which are far away from the BS and hence, they deplete their energy faster. In this protocol to overcome this issue there is a need of construction of smaller and more clusters near the BS. So, in this case there is a lot of CHs closer to the BS and balanced the energy utilization in intra-cluster communication and preserve the energy for inter-cluster communication. In this protocol near the BS there is formation of equal sized unit and due to this equal size units, the more energy is balanced among the SNs. In most of the cases intra-cluster communication cost is smaller as compared to the inter-cluster communication cost and due to this CHs preserved their energy in intra-cluster communication and can use it in inter-cluster communication. Due to this there is a balanced energy utilization among the SNs. This protocol efficiently covered the drawbacks of the unequal clustering and provide an efficient mechanism for alleviating the hot-spot issues.

In [44] the authors of the paper proposed a protocol called the Improved LEACH protocol for WSNs. The LEACH protocol is a classical protocol which is developed for energy efficiency. This Improved LEACH scheme has more efficient set-up phase. The clusters have unequal size and these unequal size clusters have the ability to preserve the energy. The CH in the cluster send the data directly to the BS without any assistant of any other node. The CH selection is based on the round robin principle and the selection of time slot is predefined. In the data transmission phase, the SNs of the respective cluster uses TDMA time slot scheme to send the data to the CH and the CH uses the CSMA technique to send the aggregated data to the BS. Improved LEACH protocol is more stable protocol and increases the life span of the network system. This protocol alleviates the hot spot issues and is well efficient for the large-scale WSNs.

In [45] the authors of the paper proposed and evaluated a protocol called arranging cluster size and transmission range (ACT) for WSNs. This protocol provides an extensive mechanism for arranging the set of clusters and its transmission. This protocol has the ability to prolong the network lifetime and network stability and also remove the hot-spot issues. This protocol developed an efficient technique for arranging the clusters in a systematic way. This scheme describes that size of clusters are depend upon the distance of the clusters from the BS. Clusters which are closer to the BS has smaller cluster size as compared to the clusters which are far away from the BS. This protocol reduces the energy consumption of the CHs which are closer to the BS. In previously the CHs which are closer to the BS exhausts so quickly because they have to relay a lot of data coming through it. The scheme reduces the extra burden which are facing the CHs closer to the BS in an efficient way. The scheme ensures that there is a balanced energy utilization among the nodes. This scheme consists of three stages such as cluster development stage, data transmission stage and cluster maintenance stage.

In [46] the authors of the paper proposed and evaluated a protocol called energy efficient distributed unequal clustering (EEDUC) protocol for WSNs. This protocol focus on the development of mechanism through which lifetime and stability of the network system increases and also remove the hot-spot issues. The scheme has the ability to collect the periodical data in a systematic way so that there is a balanced energy utilization among the SNs. In this protocol CH is selected based upon some type of efficient intra-cluster parameters. In this scheme each type of SN in a cluster established a waiting time. This waiting time in this protocol consists of the residual energy of the SNs and also the number of adjacent nodes in a cluster. With the help of this waiting time selection of CH is done in a cluster in this protocol. The hot-spot problem in most of the protocols are removed with set of different techniques applied in these protocols. In this protocol while removing the hot-spot there is unequal clustering mechanism in such a way that clusters near the BS has smaller cluster size as compared to the clusters which are far away from the BS and hence load on CHs near the BS is lessen. In this case CHs preserved the energy in intra-cluster communication and used this energy in inter-cluster communication. But there is a defect in this technique which is that there is a lot of energy utilization also while relaying the data from CH to RN and RN to BS. So, in this scheme we are focusing on controlling the relay traffic and also developing a distributed clustering mechanism.

In [47] the authors of the paper proposed and evaluated a protocol called hot-spot aware energy efficient clustering approach for WSNs. This protocol has the ability to prolonging the lifetime and network stability and also removed the hot-spot issues in an efficient way. In this protocol unequal clustering mechanism is formulated and these unequal clustering depends upon the distance from the BS. It means that clustering size is depends upon the distance of the cluster from the BS. Due to this type of cluster mechanism the hot-spot issues are mitigated and there is a balanced energy utilization among nodes in all type of clusters. In this protocol there is a two-tier mechanism in which CH is put under the higher tier and the SNs puts under the lower tier. Each set of SNs has the ability to send the data to the higher tier which is CH and the CH has the ability to send the aggregated data to the BS. CHs in a network system has the ability to forward the data to a long distance and hence need a lot of energy in this case. Due to this, CHs deplete their energy faster and there is a re-election of CH mechanism so that there is a balanced energy utilization among all the nodes. In initially the CH is selected based on the residual energy of the node in a cluster environment. If a node fallen in more than one cluster range, then nodes has the ability to select the CH which has low intra-cluster communication. This low intra cluster communication is set to be consider by the cluster size and the number of adjacent nodes in a cluster network.

In [48] the authors of the paper proposed and evaluated a protocol called energy-aware unequal clustering algorithm for prolonging the network life-time (UCAPN) for WSNs. The main focus of this protocol is to alleviate the hot-spot issues and also prolonging the network life-time and stability and moreover it has the ability to balance the energy utilization among the nodes. This scheme partitioned the network into clusters of unequal sizes. This protocol select the CHs based on the set of residual energy of the adjacent nodes and developed an unequal clustering mechanism. In this protocol the set of clusters which are near to the BS has smaller cluster sizes as compared to the clusters which are far away from the BS. Due to this type of smaller cluster sizes near the BS there is less amount of energy utilization in intra-cluster communication mechanism. This smaller cluster mechanism preserved an efficient amount of energy in intra-cluster communication mechanism and utilized in the inter-cluster communication mechanism so that in this case there is a balanced energy utilization among the nodes systematically. For data transmission this protocol developed a mechanism in which one CH in a cluster choose the nearest CH for data forwarding, unlike send it to the CMs so that the CMs preserved energy for it. This protocol systematically balanced the energy utilization among all the SNs.

In [49] the authors of the paper proposed and evaluated a protocol called energy efficient multi-hop hierarchical routing protocol (MHRP) for WSNs. The main purpose of this protocol is to efficiently enhance the network lifetime and network stability and moreover remove the hot-spot issues. In this protocol CH selection process is based on SNs with highest residual energy and systematic set of routing paths which are selected based on the residual energy and the distance between the nodes. This protocol divides the network area into different set of region or zones and CH is selected based on the residual energy of the SNs and for data forwarding process there is a mechanism for multi-hopping communication. This protocol has the ability that it can distribute the working of CH on different nodes after each round such that the network lifetime and stability increased because nodes do not die due to the excess of load.

An efficient and classical clustering protocol is discussed in [50]. In which the authors proposed and evaluated a protocol called LEACH. This protocol consists of the cluster-based mechanism in which it consists of the random rotation of the CH so that in this case the energy is balanced among all the SNs. This scheme consists of set of localized cooperation and has the ability to broaden the network system efficiently. The CH has the ability to forward the set of fused packets to the BS via single hop. There is no other type of energy standard for the selection of the CH. The distribution of the CH is roughly and there is no proper control on the CH location. The selection of the CH is based on the probabilities and not a proper distributed manner. In this scheme there is a very much chance of becoming the node a CH which has very low energy. When this type of node is dead then the complete cluster in which this type of node exists should be nonfunctional. The LEACH protocol performs the set of mechanism that node sends the data using single hop communication.

In [51] the authors of the paper proposed and evaluated a protocol called energy aware routing algorithm (ERA) for WSNs. The main purpose of this protocol is to increase the network lifetime and stability and improves the balanced energy utilization among the nodes. This algorithm has the ability to efficiently elect CH based on the residual energy. For selection of CHs initially each node uses a time slot based on the set of residual energy of the nodes. For clusters formation process in this protocol the set of SNs send a message to the adjacent CH based on residual energy and its distance from the BS. Data forwarding from CH to BS is based on series of CHs on which data is forward and hence data reached to the BS. This protocol has the ability to balance the energy consumption among the CHs during the data forwarding process.

In [52] the authors of the paper proposed and evaluated a protocol called zone based energy proficient hierarchical clustering convention (ZEEHC) protocol for WSNs. The main purpose and focus of this protocol is to increase the network lifetime and balanced energy consumption among the nodes. In this type of protocol, the network system is divided efficiently into desirable size of zones in order to increase the stability and network lifetime of the network system. In this protocol there is a concept of multi-hop propagation of information from CH or ZH to RN and then to BS. In this protocol CMs send the data to the CH of its respective cluster and this CH aggregate the data and send the aggregated data to the RN of the respected zone. This data is relayed through the RN and delivered it to the BS. This type of information propagation has the ability to balanced energy consumption among the nodes and burden on nodes reduces due to this mechanism. ZEEHC protocol has the ability to increase network lifetime and stability by using very low energy in WSNs.

In [53] the authors of the paper proposed and evaluated a protocol called improvement on LEACH (EZ-LEACH) for WSNs. The LEACH protocol is the building block of the hierarchical routing protocol. It is the first energy efficient protocol in a network system systematically. A lot of systematic set of clustering protocols are derived from this building block LEACH protocol. The main purpose of this protocol is to enhance the LEACH protocol for making it more energy efficient. The first step of protocol is network formation in which network is divided into set of four logical zones. CH is selected in this protocol in such a way that the node in a zone which has centrality factor has the ability to send its location to the BS. Then BS select the CH node which is closed to the central node. The residual and average energy is also considered for selection of CH. This protocol increases the network lifetime and network stability and is energy efficient protocol.

In [54] the authors of the paper proposed and evaluated a protocol called hierarchical energy efficient clustering algorithm (HEEC) for WSNs. The main purpose of this protocol is to increase the network lifetime and network stability by reducing and eliminating the energy consumption and moreover provide a load balancing mechanism. This scheme developed a new clustering protocol and CH selection mechanism. The CH is selected based on the set of residual energy of the SNs and the distance to the BS. CH selection process also consists of the node alive status in such a way that the node has the ability to transfer data to the BS. This scheme also introduces the re-electing of the CH. As the BS check after first round the energy status of the CH and compared it to the other node if it has less energy like aliveness and residual energy then re-electing process is continued. This load balanced makes the network system energy efficient.

In [55] the authors of the paper proposed and evaluated a protocol called cluster based routing protocol with non-uniform node distribution for WSNs. This scheme consists of two main parts first is EADC scheme and second is cluster-based routing phenomena. This EADC scheme has the ability to established clusters which are even sized and using process of competition ranges in such a way that there is balanced energy consumptions among the nodes systematically. In second part of the protocol in order to balance the energy consumption among the CHs, a cluster based systematic routing protocol is developed. In this protocol in order to systematically balance the energy consumption among the CH there is set of mechanism which is established in such a way that intra-cluster and inter-cluster energy consumption is adjusted. The CH selection mechanism consists of nodes with highest residual energy and also the average residual energy of the adjacent node is set to be considered for the selection of CH. The main focus of this protocol is to efficiently balance the energy utilization among the nodes and also increasing the network lifetime and stability systematically.

In [56] the authors of the paper proposed and evaluated a protocol called energy efficient dual head clustering scheme (DHCS) for WSNs. The main purpose of this protocol is to make the network system energy efficient and increases the network lifespan and stability. Dual CH mechanism is established in which two CHs are considered which has the ability of network route management, data relaying, data aggregation process, cluster maintenance process and set of intra-cluster and inter-cluster communication mechanism. The addition of these two CHs makes the network system efficient and there is a load balance in the network system and also CH re-election mechanism is removed. The dual CH selection mechanism consists of set of criteria in which first CH is selected based on the residual energy of the node. The node with highest residual energy is selected as first CH. The second CH which is called aggregated head is selected by the first CH and which is used for data aggregation, cluster formation and other set of clustering operation.

In [57] the authors of the paper proposed and evaluated a protocol called energy saving dual-Cluster Head protocol (ESDCH) for WSNs. The main purpose of this protocol is to makes the network system energy efficient and enhance the network lifetime and stability. In this protocol, each set of SNs has the ability that it can arrange itself into clusters. Each type of SNs has the ability that it can set the states of the SN into sleep state or active state based on the residual energy of the nodes. This protocol considers the dual CH mechanism and the purpose of this dual CH is to balance the load in the whole network system systematically. Primary CH is chosen which has the highest residual energy in the cluster and after that Secondary CH is chosen from the remaining nodes in the cluster and also which are nearer to the Primary CH. Primary CH has the ability that it can collects all the data from the SNs and provide some aggregation mechanism and send this to the BS. Secondary CH is only active when the working of the Primary CH is interrupted. This protocol has the ability that it can balance the energy consumption among the nodes systematically.

In [58] the authors of the paper proposed and evaluated a protocol called Dual Head Clustering mechanism (DHCM) for WSNs. The main purpose of this protocol is to makes the network system energy efficient and also increase the network lifetime and stability. This protocol has the ability that it can uses the dual CH mechanism. This dual CH mechanism balance the load in the whole network system and makes the network system energy efficient. The set of communication between CHs and the BS uses the multi-hop mechanism and due to this CHs, which are nearer to the BS get burden with heavy relay traffic and nodes dies out and the network system get partitioned. In order to overcome this issue, we have developed a dual CH mechanism and this mechanism balanced the load and makes the network system energy efficient. Both CHs have different responsibilities in the network system. One CH is used for data collection from all the nodes and other CH has the responsibility of data relaying and also data aggregation mechanism. This protocol has the ability that it can balance the energy utilization among the nodes systematically.

In [59] the authors of the paper proposed and evaluated a protocol called energy distance aware clustering protocol with Dual cluster heads using Niching Particle Swarm Optimization (DCH-NPSO). The main purpose of this protocol is to makes the network system energy efficient and enhance the network lifetime and network stability systematically. In this protocol dual CH mechanism is established and has the ability that it can balance the energy utilization in the whole network system. Two CHs are selected in each cluster and these CHs balanced the load in each cluster. Master CH and Slave CH are two CHs which are selected in each cluster. Master CH has the ability that it can collects all the data from the CMs and provide some type of aggregation mechanism and send this data to the Slave CH. Salve CH has the ability that it can relay the data to the BS. Master CH has the ability that it cannot communicate directly to the BS and hence balance the energy utilization in the network system.

In [60] the authors of the paper proposed and evaluated a protocol called double cluster-heads clustering algorithm using particle swarm optimization (PSO-DH). The main purpose of this protocol is to makes the network system energy efficient and increases the network lifetime and network stability by balancing energy consumption among the nodes. This protocol provides a mechanism of selecting two CHs using the PSO technique. This protocol has the ability that it cannot only provide a systematic mechanism of CH selection, but it also provides a balance energy consumption mechanism among the nodes. In this protocol after the clusters formation intra-cluster communication is begin. Two types of CHs are selected which are Master CH and Vice CH. Master CH has the ability that it can collects the data from all the CMs and provide some aggregation mechanism and send it to the Vice CH. Vice CH receive this aggregated data and relay it to the BS. Master CH cannot directly communicate with the BS and in this case there is balance energy consumption in the clusters.

2.1 Comparison of various Hot-spot issues related Protocols

Table 2.1: Comparison of various Hot-spot issues related Protocols

SR. No	Techniques	Communication Type	Mobility	Node Type	Clustering Type	CH Election	Role Relay/Aggregation
1	HUCL	Multi-Hop	No	Homogeneous	Hybrid Clustering	Available energy, Distance to the sink node and Adjacent nodes	Yes
2	EADUC	Multi-Hop	No	Heterogeneous	Unequal Clustering	Deterministic	Yes
3	IEADUC	Multi-Hop	No	Heterogeneous	Unequal Clustering	Residual energy, Surrounding nodes	Yes
4	ZECR	Multi-Hop	No	Heterogeneous	Unequal Clustering	Residual Energy	Yes
5	IEEUC	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
6	LUCA	Multi-Hop	No	Homogeneous	Unequal Clustering	Random	Yes
7	EBCAG	Multi-Hop	No	Homogeneous	Unequal Clustering	Deterministic	Yes
8	EBUCP	Multi-Hop	No	Heterogeneous	Unequal Clustering	Residual Energy, Average Energy	Yes
9	Dynamic Unequal Clustering Protocol	Multi-Hop	No	Homogeneous	Unequal Clustering	Residual Energy	Yes
10	UCMR	Multi-Hop	No	Homogeneous	Unequal Clustering	Deterministic	Yes
11	ZBRP	Multi-Hop	No	Homogeneous	Hybrid Clustering	Residual Energy	Yes
12	EEUGCR	Multi-Hop	No	Homogeneous	Unequal Clustering	Centrality factor	Yes
13	EUCA	Multi-Hop	No	Homogeneous	Unequal Clustering	Residual Energy	Yes
14	MRPUC	Multi-Hop	No	Homogeneous	Unequal Clustering	Deterministic	Yes

15	EDDUCA	Multi-Hop	No	Homogeneous	Unequal Clustering	Compound	Yes
16	EC	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
17	EDUC	Multi-Hop	No	Heterogeneous	Unequal Clustering	Random	Yes
18	EBUC	Multi-Hop	No	Homogeneous	Unequal Clustering	Heuristic	Yes
19	UCS	Multi-Hop	No	Homogeneous and Heterogeneous	Unequal Clustering	Preset	Yes
20	EUCS	Multi-Hop	No	Homogeneous	Unequal Clustering	High Residual Energy	Yes
21	HEED	Multi-Hop	No	Homogeneous	Static and Equal Clustering	Hybrid	Yes
22	UHEED	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
23	RUHEED	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
24	UCF	Multi-Hop	No	Homogeneous	Unequal Clustering	Fuzzy	Yes
26	COCA	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
27	Improved LEACH	Single-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
28	ACT	Multi-Hop	No	Homogeneous	Unequal Clustering	Deterministic	Yes
29	EEDUC	Multi-Hop	No	Homogeneous	Unequal Clustering	Hybrid	Yes
30	Hotspot-aware energy efficient Clustering Protocol	Multi-Hop	No	Homogeneous	Unequal Clustering	Residual Energy	Yes
31	UCAPN	Multi-Hop	No	Homogeneous	Unequal Clustering	Residual Energy	Yes
32	MHRP	Multi-Hop	No	Homogeneous	Optimal and Equal Clustering	Residual Energy	Yes
33	LEACH	Single-Hop	No	Homogeneous	Dynamic Clustering	Random	Yes
34	ERA	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes
35	ZEEHC	Multi-Hop	No	Homogeneous	Static and Equal Clustering	Residual Energy	Yes
36	EZ-LEACH	Multi-Hop	No	Homogeneous	Static and Equal Clustering	Hybrid	Yes
37	HEEC	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes
38	EADC	Multi-Hop	No	Heterogeneous	Dynamic Clustering	Hybrid	Yes
39	DHCS	Multi-Hop	No	Homogeneous	Dynamic Clustering	Hybrid	Yes

40	ESDCH	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes
41	DHCM	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes
42	DCH-NPSO	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes
43	PSO-DH	Multi-Hop	No	Homogeneous	Optimal Clustering	Hybrid	Yes

CHAPTER 3

PROBLEM STATEMENT

In WSNs clustering techniques are most efficient mechanism which has the ability to enhance the lifespan of the network by gathering the SNs together in a systematic way. Clustering technique has the ability to minimizing the central organization need and focus on localized decisions. Clustering techniques are categorized as dynamic clustering and static clustering or equal clustering and unequal clustering.

In clustering environment data engaged from one node to another node causes hot spots or energy-hole problem. Hot spots are caused by the node closest to base station and energy of these types of nodes are drain out due to lot of packets travel from it and due to excess of communication these nodes not only send their own data but also transmit the data from other sources due to which early death of nodes causes hot spot issues.

In order to alleviate the hot spot issues many of the researcher has proposed the dynamic and unequal clustering techniques which are effective for removing the hot-spot or energy-hole issues, but these techniques have a lot of different critical issues which are connectivity of the network, reliability factor, network traffic overhead and un-balanced energy utilization among the SNs and the CHs. So static and equal clustering technique is something effective for alleviating hot spot problem because it has less issues of network connectivity and coverage overhead. But in some extent static clustering also have hot spot issues due to the number of clusters in a zone and hence it decreases the lifetime of the network and its stability.

In a static and equal cluster environment if we use the number of clusters fewer than nine clusters then intra-cluster communication cost is increases and in other case if we use the number of clusters more than sixteen clusters then the cluster heads (CHs) which are closest to the BS get burden with heavy relay traffic and causes the hot spot problem [61].

So, there is a room for improvement in static and equal clustering technique while avoiding hot spot issues and enhancing life span and network stability. We have proposed a protocol called Improved Zone Based Divisional Hierarchical Routing Protocol (IZDHRP) for WSNs. This protocol alleviates the hot-spot or energy-hole issues in static and equal cluster environment by using efficiently multi-hopping technique to enhance the network lifespan, network stability and network throughput.

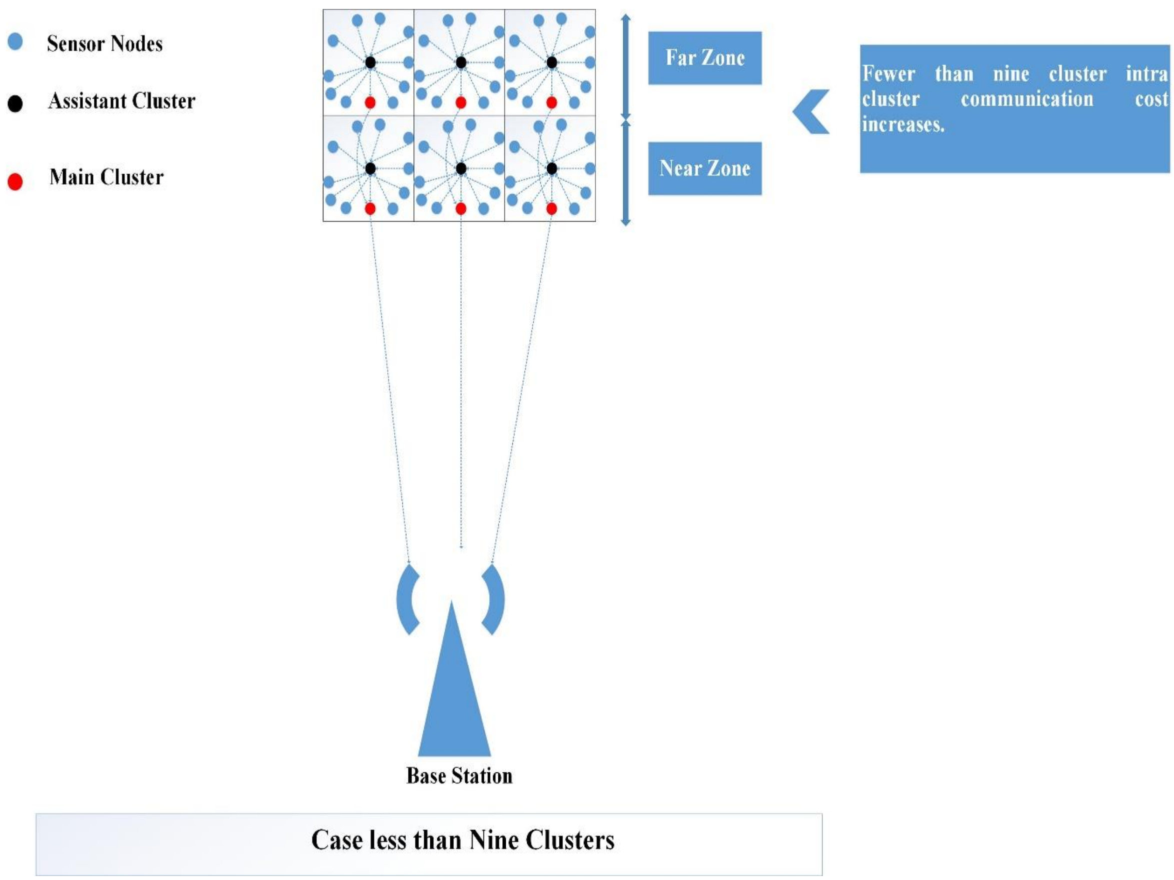

Fig 3.1: Problem Statement (Case Less than nine Clusters)

In above figure fig (3.1) in the first case we can see that the less than nine clusters in a network system increases the intra-cluster communication cost because due to the dual cluster head mechanism. Both cluster heads have the ability to maintain the other SNs records and their location information and all. Due to the fact of less than nine cluster case there is a lesser number of clusters in a zone. Like above case there is two zones one is far zone and other is near zone. In above case far zone consists of three clusters and the near zone also consists of three clusters. In each cluster there is a dual cluster head mechanism and each cluster has set of two clusters for aggregation mechanism and sending the data to the neighbor nodes or BS. Due to this dual CH mechanism in first case the intra-cluster communication cost within zone is increases and nodes dies due to the excess of communication and hence produces hot spot issues.

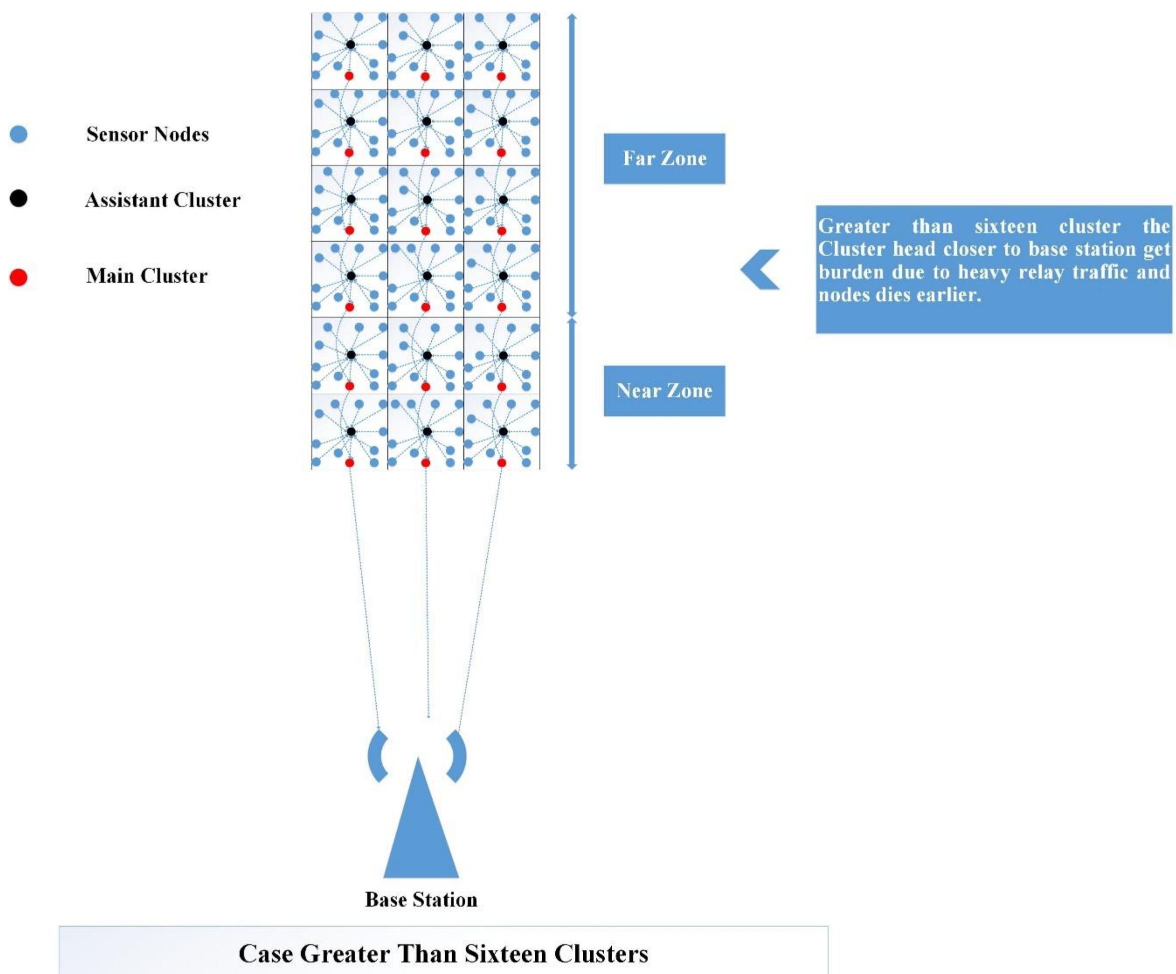

Fig 3.2: Problem Statement (Case greater than sixteen Clusters)

In second scenario as describes in the fig (3.2) above greater than sixteen clusters the cluster heads closer to the BS get burden due to the heavy relay traffic and nodes dies earlier and produces hot-spot issues. In above case while using clusters more than sixteen clusters as we have consider eighteen clusters, we can see that nodes closest to the BS has to forward the data passing from it and also its own data and when the clusters increases then there is extra burden on the closest cluster heads of the sink-node. So hot-spot or energy hole is a factor while increasing clusters more than sixteen clusters.

CHAPTER 4

SYSTEM DESCRIPTION

This section provides the extensive study of the functional capabilities of WSNs. These functional capabilities describe what are the main functions of WSNs. The factors influence the architecture and design of the WSNs is also discusses in this section which further include fault tolerance in WSNs, scalable behavior in WSNs, specific cost in WSNs and the topology in WSNs. This section also describes the hardware capabilities of the WSNs and broadly explain the set of hardware components requisite for the development of the WSNs. Power consumption mechanism is the most important and the vital part in the sensor network system. Power consumption is also extensively discussing in this section and provide a systematic way in which power consumption mechanism consider in communication mechanism and data processing. Our proposed network topology is also explained in this section and also provide a N-tier hierarchy of the network system.

4.1 Functional Capabilities of WSNs

In WSNs the sensor nodes have the ability to send the data to the BS periodically. The BS received these sensed data from the SNs and do some computation mechanism and evaluate this data periodically. These evaluations done by base station is intermittent and the evaluation mechanism is completed by the BS is depends upon at which rate the data from the SNs are captured. There is a lot of collection techniques in which data is collected at a systematic manner one of them is round robin technique in which data is forward from SNs to the BS in a direct manner. The data is forward to the BS in a manner that it received at the BS one after the other. In this round robin technique, the BS has the ability to capture the data one after the other so at one time it can process and evaluate just one sensor node data for N number of node and thus in this case the rate which is achieved by the round robin mechanism is 1/N.

4.2 Factors Influences the Architecture and Design of the WSNs

WSNs architecture and design is influenced by a lot of factors as fault-tolerance, scalable behavior of WSNs, specific cost, network topology, hardware capabilities and power consumptions [62]. These types of factors are the building blocks in wireless sensor networks (WSNs) and provide benchmarks for developing algorithms and protocols. Following are the factors which are discussing in this section below.

4.2.1 Fault Tolerance in WSNs

In WSNs due to some type of power failure, network congestion, energy hole or some type of environmental intrusion the SNs stops there working and makes there working temporarily blocked. This type of node failure cannot halt or disturbed the whole network system, but the network functionality is disturbed due to temporarily blockage of nodes. Fault tolerance is the mechanism in which functional behavior of the sensor network is maintained systematically. Fault tolerance lower the impact of the failure of sensor nodes (SNs) in the network system so that the network system functionalities is not disturbed. In [63] a set of network reliability model for SNs are describes the main purpose of this model is to maintaining the functionality of the network system in a node failure mechanism.

Following is the equation of the network reliability model:

$$R_k(t) = \exp(-\lambda_k t) \qquad 4.1$$

Here R_k in this equation describes the network reliability and (λ_k) and (t) are the values which explains the phenomena of sensor nodes (SNs) failure rate capacity and time period.

In some of the cases if the set of sensor nodes (SNs) are installed in critical environment like combat zone or other crucial surveillance purpose the fault tolerance mechanism has to be kept high because in this scenario the possibility of node failure is high due to critical situation. In other words, sensor nodes, which are installed in less critical environment liked agriculture monitoring or home surveillance purpose the node failure possibility is less and that's why the fault tolerance has to be kept lower. So, in overall context the fault tolerance mechanism depends upon the nature of WSNs applications.

4.2.2 Scalable behavior in WSNs

In wireless sensor networks (WSNs) on the basis of application mechanism the density of the set of SNs which are installed has a scope from set of small number of SNs to a thousands of SNs in a specified location, this location in which SNs are installed is no more than 10 meter in d (diameter). The set of protocols which we will developed must have great harmony with the set of density of the SNs distributed in the specified location. The set of density evaluated and proposed in [64] and the following equation describes the set of density of the SNs.

$$\mu(R) = (N\pi R2)/A \qquad \textbf{4.2}$$

In this density equation above N is the number of SNs installed in the specified location whose area is A. R is the specified transmission range and μ(R) is the set of SNs which are installed in the specified transmission range systematically.

4.2.3 Specific Cost in WSNs

In WSNs there is numerous sensor nodes and each sensor node has its own importance in the network system and each sensor node is consider in the network system and then whole sensor node cost is calculated systematically. Each sensor node cost is considered when we are estimating the overall aggregated cost in the network system. Bluetooth devices consists of sensor nodes which has cost estimated to US $10 and the Pico Node has estimated cost lower than US $1. So, the normal sensor nodes cost must be estimated to US $1 which is feasible. Bluetooth is a very much low cost estimated device and Bluetooth device cost is about to 10 times higher than the normal sensor nodes. So, the cost adjustment with desired functional capacities is very critical and challenging task in the network system.

4.2.4 Topology in Wireless Sensor Networks (WSNs)

In WSNs network topological maintenance is a crucial and challenging task because the SNs have very less energy and hence therefore, they are susceptible to frequent failure. Topological maintenance is necessary for the long lasting of the network system and also for increasing the efficiency of the network system. In some types of applications, the set of sensor nodes are installed in a randomized manner in an area of about 10 meter. In this case there is a need of topological maintenance in a network system for making the network system more efficient.

4.3 Hardware Component Requisite for the development of WSNs

In WSNs sensor nodes consists of four type of systematic components as discussed in [62]. The diagrammatic explanation is described in fig (4.1) below and the components are explained as follow:

4.3.1 Sensing Component

This hardware component is further partitioned into two types of components. First type of component name as sensors and the other type of component name as analog to digital converter (ADC). Sensor component has the ability to sense the information from the surrounding environment and produced the analog signals and these types of analog signals sensed from the surrounding environment convert into the digital signals through the component ADC. This type of signal or data is sent to the processing component.

4.3.2 Processor Component

This hardware component has the ability of processing the data and saved the data for other scenarios. This type of component is further divided into two components, one is called the processing and the other is called the storage component. Processing component has the ability that it can process the data coming from the SNs and evaluate this type of data in a systematic way. In storage component it has the ability to preserve the data for next scenario. It means that it can saved the data and this saved data is used in transmission mechanism like from one SN to the other SN or to the BS.

4.3.3 Transceiver Component

Transceiver has the ability that it can connects one SN to another SN using some communication medium. Transceiver can do both of task like it can transmit and received set of communication packets. It connects one sensor node to other sensor nodes and then finally to the sink node. Most of the SNs uses the ISM bands for communication purpose which has ability to provide the efficient spectrum access worldwide. In addition to ISM bands sensor nodes uses a lot of other transmission mechanism such as infrared transmission, optical fiber transmission mechanism (laser) and radio frequency transmission mechanism.

4.3.4 Power Component

The power component is the most vital component of the sensor nodes (SNs). Power component is the major and very crucial part of the sensor node (SN). Power component consists of a battery or cells or sometime an integrated power reservoir such as solar cells. These power components in sensor nodes (SNs) is most critical and the efficiency of the node is depending upon this power component. In some of the sensor nodes the power component is rechargeable depends upon the application mechanism.

In contrast to these basic hardware components some of the sensor nodes consists of other type of hardware functionalities which are GPS, power reservoir, external storage and mobility factor.

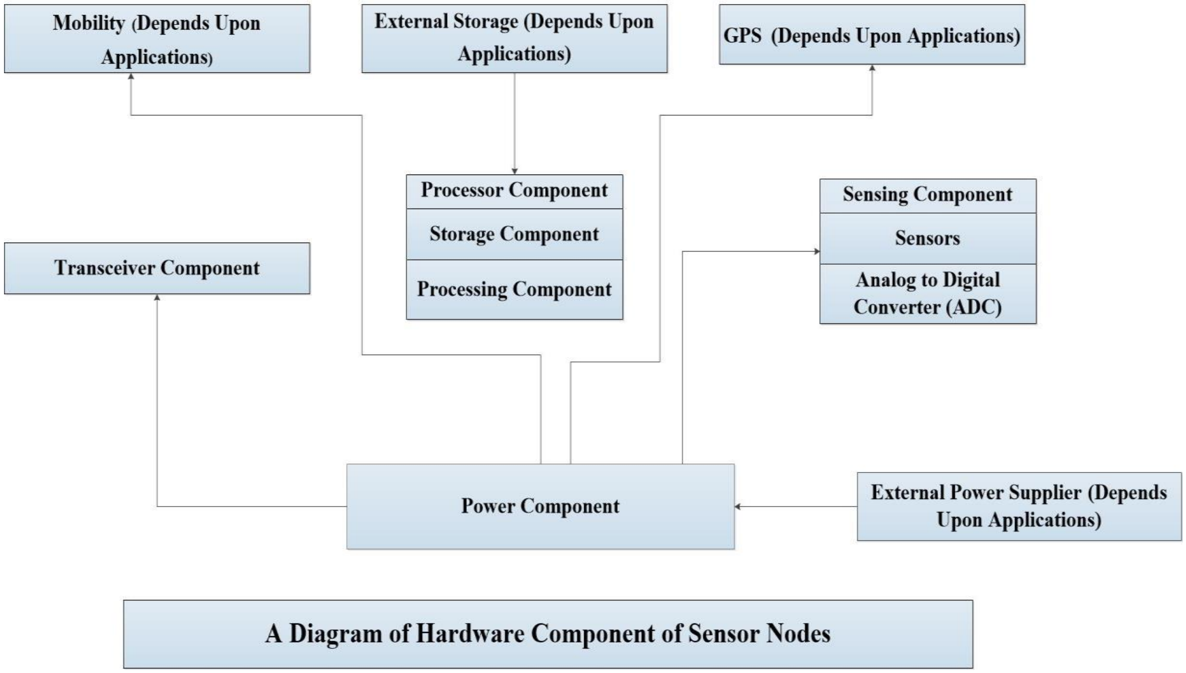

Fig 4.1: A Diagram of Hardware Component of Sensor Node

4.4 Environmental Scenario in WSNs

In WSNs the set of sensor nodes which are distributed and deployed in a location which is sometime easily locatable and sometime SNs are deployed in very intense and critical areas. All these types of scenarios depend upon the application mechanism it means that each type of application has its own environmental scenario. Some of the SNs deployed in intense environment and cannot be recharged or replaced. Following are some vital applications in WSNs in these types of applications, SNs are deployed in different environmental scenarios.

- Agriculture field application of sensor nodes in which sensor nodes are deployed for surveillance and monitoring of the growth of the plants and trees.
- Warzone based monitoring applications in which sensor nodes are deployed for surveillance purpose and this is the most critical and intense environment in which sensor nodes are deployed.
- Underwater surveillance purpose in which sensor nodes are deployed for monitoring and data collection such as location information of enemy submarine and cruises.

- Animal habitat monitoring and surveillance purpose in biological research perspectives.
- Home surveillance and monitoring purpose such as sensor nodes are deployed for improving the security of the home and surroundings.
- Surveillance and monitoring of a volcano surface after the earthquake happen.
- Home appliances surveillance and monitoring such as home automation system.

The above applications describe the phenomena how the SNs are deployed in physical world. These type of SNs are installed in intense conditions such as heat environment, warzone and other critical situations.

4.5 Power Consumption Mechanism in WSNs

In WSNs sensor nodes consists of finite battery power and these nodes have to process a lot of data and hence due to this fact the set of energy of the SNs get lower and hence they die. There is a lot of critical applications where the battery of sensor nodes cannot be recharged or replace. In this phenomenon the proper lifespan of the SNs in WSNs rely on the initial battery conditions or other power reservoir if this is applicable. It is very difficult and very crucial task to properly preserved and organized the battery power of each type of SN in a system.

In most of the other type of network system such as ad-hoc and mobile-networks the power consumption mechanism is not much important as it is in WSNs. In WSNs the SNs has the ability to sense the data from the surrounding environment and power is consumed in this first step and then send this data to the base station with the help of other type of nodes or send own its own and in this case, power is consumed a lot. So, in a wireless network system power utilization take place in three process which are sensing process, communication process and data aggregating processing. These three-power consumption processes are explained below in a broader way.

4.5.1 Sensing Process

In WSNs sensor nodes while sensing the data from surroundings consume a lot of energy because they have to sense continuously, and these sensing capacities depends upon the type of application mechanism. It means that for different type of applications the sensing power is different and power utilization is also different for these types of applications. This sensing capacity of sensor nodes consumed a lot of energy in a network system.

4.5.2 Communication Process

In WSNs the communication process utilizes a lot of energy in the SNs. This communication process is the key process of the whole network system that consists of transmission and the reception mechanism. This transmission of information from one SN to the other SN required a lot of energy and there is energy utilization while transferring packets from one node to other node and then to the base station. In most of the applications the startup span is minimal. It is just few micro-seconds. The startup span is both for transmitter and the receiver and in this span the utilization of energy is very small and after this startup span the energy utilization process increases systematically. The radio power utilization mechanism is represented in [65] as below:

$$P_c = N_t \left[P_t (T_{on} + T_{st}) + P_{out} (T_{on}) \right] + N_r \left[P_r (R_{on} + R_{st}) \right] \qquad \textbf{4.3}$$

In this formulation Pout is the output data scenario of the transmitter process and Ron scenario is the time in which receiver is in its on condition. Ton scenario is the time in which transmitter is in its on condition. Pt is the utilized power scenario and this power is utilized by transmitter. Pr is the utilized power scenario and this power is utilized by receiver. Tst is the startup span scenario and this startup span is by transmitter. Rst is the startup span scenario and this startup span is by receiver. Nt is the specified No. of transmitter switching in a unit of time. Nr is the specified number of receiver switching in a unit time.

4.5.3 Data Aggregating and Processing

In WSNs the power utilization in data aggregation and processing is lesser as compared to the communication process. It means that data aggregation cost is lower as compared to the communication process. In data aggregation and processing SNs just process the information coming from the other sensor nodes (SNs) and in this scenario the power utilization is lesser because SNs do not have to forward the data just to process and aggregate the data. This power utilization differentiation is systematically explain in [66]. In wireless sensor networks (WSNs) while considering multi-hop communication mechanism the data aggregation and processing is totally dependent on the localized sensor nodes which has the ability to lessen the power utilization mechanism. The set of power utilization in aggregation of data and processing is followed as:

$$P = ACV^2 f + V_{leak} \quad \textbf{4.4}$$

In the above equation of data aggregation and processing V is the voltage swing mechanism. Voltage swing is the average voltage between the maximum and minimum output voltage. In the above equation A is the fractioning of logical gates switching in an active manner. f is the operational frequency and C is the capacitance of logical gates which are switching in an active manner. In the above equation the most important part describes the current leakage and this leakage is due to power dissipation mechanism [67].

4.6 Proposed Network Topology

In our proposed network system in order to efficiently enhance the network lifespan and stability an N-Tier hierarchy of network topology is proposed. This N-tier network topology is shown in fig (4.2) below. This divides the whole network system into set of levels and each level in the network system has its own capabilities and responsibilities. The set of rules and responsibilities of each level is defined in a systematic manner. In our proposed network topology, the set of nodes are depending on the wireless network coverage area. There are four levels in our proposed network topology. These are level 0, level 1, level 2 and level 3 respectively and each level has its own set of rules and functionalities. Level 0 describes the base station (BS), Level 1 describes the zone controller (ZC), level 2 describes the cluster heads (CHs). In our proposed protocol we are using the dual cluster head mechanism and level 3 describes the normal sensor nodes (SNs). In our proposed protocol the set of nodes can be classified into different types of roles. These levels in our proposed network topology is explained below in a systematic way:

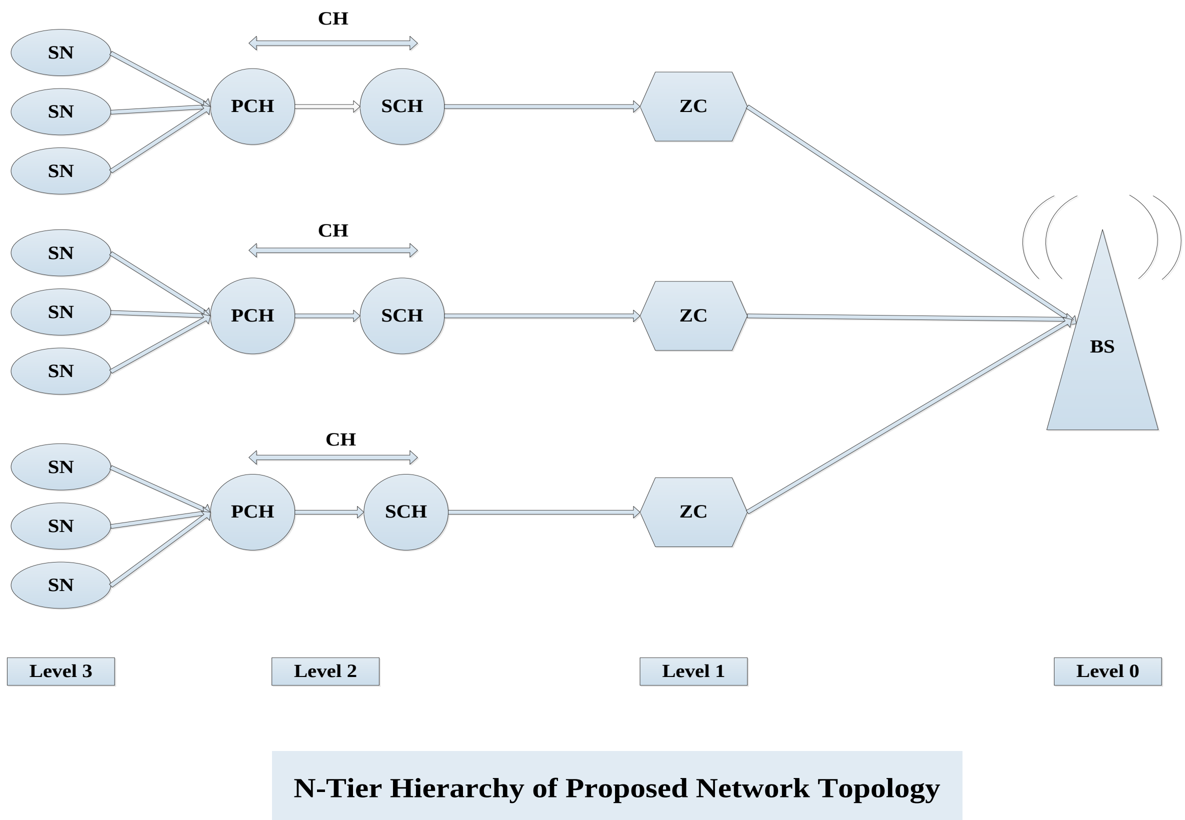

Fig 4.2: N-Tier Hierarchy of Proposed Network Topology

4.6.1 Base Station (BS)

In our proposed network topology, the top-most hierarchical node is the BS. The BS is the power full node in the proposed network system, and it act as central administrating node. The BS is responsible for the data processing, data aggregation and also set of other requests generating from the BS which has responsibility of other management tasks systematically. BS act as a central hub in our proposed network topology and it has the ability to manage the tasks of zone controller (ZC), cluster heads (CHs) and other normal nodes. The base station (BS) has ability of evaluating the data coming from different sensor nodes through cluster heads (CHs) and Zone controller (ZC) and these evaluations depends upon different types of parameters.

4.6.2 Zone Controller (ZC)

In our proposed protocol the zone controller (ZC) act as an intermediate node between the CHs and the BS. It has the second level in our proposed network topology, and it is the second highest node in the proposed network topology. Zone controller (ZC) has energy more than the cluster heads (CHs) in our proposed network model and each zone has its own efficient zone controller node. Zone controller (ZC) in a zone has the ability of managing and organizing the task. These tasks consist of data processing, data aggregation, data evaluation mechanism and also data relaying towards the base station (BS). This zone controller (ZC) node also act as a relay node in our proposed protocol and balance the loads in a network system.

4.6.3 Cluster Head (CH)

Cluster head (CH) has third level in our proposed network topology and it is the localized leader in a particular cluster. The CH is the efficient node in a cluster and its energy is more than other SNs in a cluster and act as leader of other SNs. CH in cluster has a lot of SNs which act as CM and CH has the ability that it responsible for gathering the data from the CM and provide data aggregation mechanism and send this data to the respective zone controller (ZC). In our proposed protocol we are introducing a dual cluster head (CH) mechanism. Each set of cluster has two cluster heads (CHs) which are PCH and SCH. These dual cluster head mechanisms have the ability to balance the load in the network system systematically.

4.6.4 Sensor Node (SN)

The lowest level of our proposed network topology is sensor nodes (SNs). Sensor nodes has the ability to sense the information from the surrounding environment and forward this sensed data to the CH. SNs has the ability that they are totally independent from each other. In our proposed method we are deploying homogeneous type sensor nodes in our network system.

CHAPTER 5

NETWORK MODEL AND PROPOSED SCHEME

This section extensively elaborates the proposed network model of our protocol and efficiently describes the proposed scheme and Network Architecture. This network architecture and proposed scheme efficiently describe the architecture of our proposed network and also the set of operations in the overall network system. This section also provides an extensive mechanism on proposed N-Tier network hierarchical topology. This N-Tier network topological model describes the overall network system into set of levels. Communication hierarchy of our proposed network system is also described systematically. In the last, Assumptions of network system and example of assumptions in our network system is describe in a broader way.

5.1 Network Model

The following fig (5.1) describes the network model of 16 cluster case in our proposed protocol IZDHRP. In which cluster heads CHs, cluster members CMs, Zone Controller (ZC) and base station BS role and responsibilities are describes systematically. The figure elaborates the working behavior of our proposed protocol IZDHRP in an efficient way. Dual CH mechanism is developed in each set of clusters and this dual CH mechanism has the ability to balance the load and energy utilization among the SNs. A resource rich node called zone controller (ZC) is deployed and it has the ability to manage the tasks in a respective zone. This Zone Controller also act as a relay node in the proposed network system. The addition of this Zone controller (ZC) in proposed network system is to lower the burden on cluster heads (CHs) and balanced the energy utilization in a systematic way. The BS is kept at the center of the rectangular observing area and has the ability to manage all the tasks in a network system. The location of the BS is fixed and consists of adequate amount of energy and other set of resources for routing mechanism.

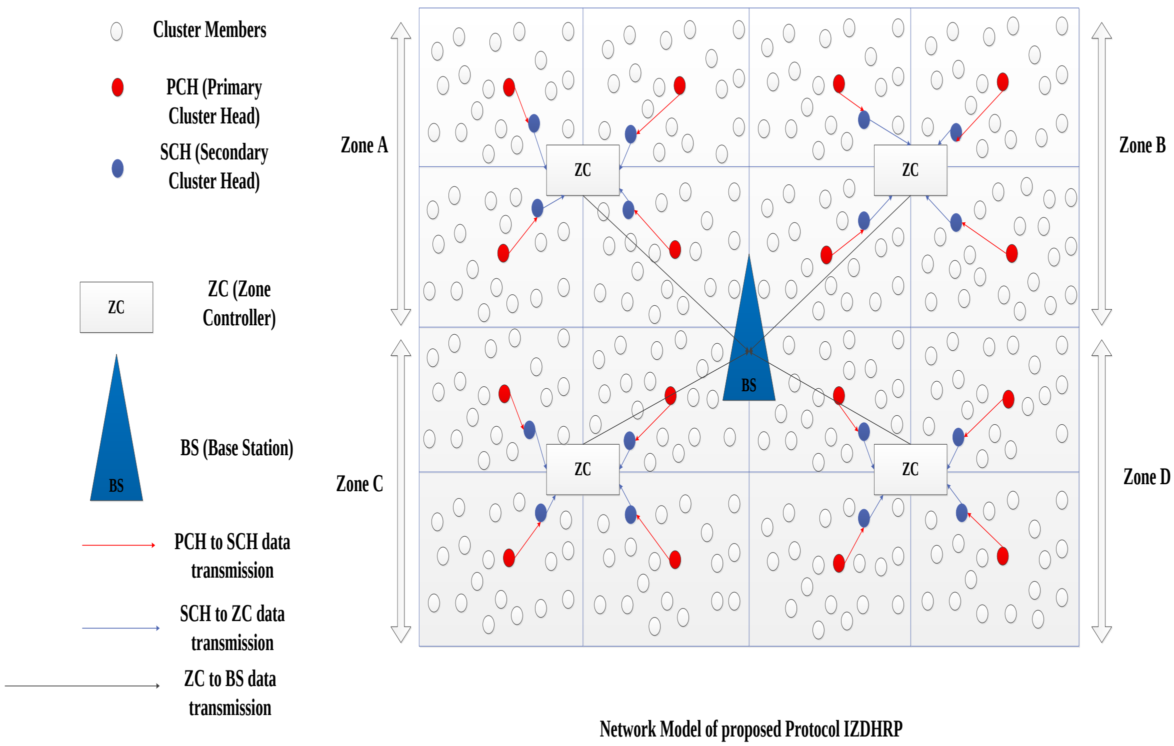

Fig 5.1: Network Model of Proposed Protocol IZDHRP

5.2 Proposed Scheme

5.2.1 Network Architecture

In our proposed protocol Improved zone based divisional hierarchical routing protocol (IZDHRP) we are considering 100 homogeneous type of sensor nodes (SNs) that are distributed in a random mechanism in an area of 100 m x 100 m. The BS in our proposed protocol is supposed to be positioned at (50, 50) m (meter) coordinates during simulation process. A powerful BS is installed in the network system which has the ability of transmitting, evaluating, aggregating and set of receiving data from zone controller to CH and CH to the other set of CMs. A zone controller node (ZC) is also deployed in each zone which is the second highest powerful node in our proposed network system and this zone controller node (ZC) has the ability that it can relay the data from SCH to the BS and BS to the SCH of respective zone.

5.2.2 Network phases in proposed scheme

Our proposed protocol Improved zone based divisional hierarchical routing protocol (IZDHRP) has set of functions in rounds and each set of round has ability that it can be divided into two systematic phases.

First phase: First phase of our proposed protocol is set to be named as the **set-up** phase. This set-up phase involves the deployment of sensor nodes (SNs) and also zone division and rectangular Clusters formation. After that formation of zones and rectangular clusters in the first round; selection of PCH and SCH for data forwarding in all the rounds.

Second phase: Second Phase of our proposed protocol is set to be named as the **steady-state phase.** This phase consists of the transmission of the data in all respective zones in a proficient way with the help of PCH and SCH nodes.

5.2.3 Formation of Equal Sized Static Rectangular Clusters

In the first round of our proposed scheme, the BS initiate a command and partitioned the total network area into set of fixed number of same sized static and rectangular shaped clusters which depends on area. Our proposed protocol consists of three models for implementation in which there is 8 clusters, 16 clusters and 24 clusters. We are considering these three models for simulation process.

In ZDHRP protocol by using clusters more than sixteen and less than nine makes the network system unstable due to hot-spot or energy hole issues but our proposed mechanism overcome this issue by using scenario of PCH and SCH. PCH and SCH are dual cluster heads node and each cluster are using this dual CH mechanism in our proposed protocol. This addition of dual cluster head mechanism has the ability that it can balance the energy utilization among the clusters in our proposed protocol and overcome the issues of hot-spot or energy hole. Moreover, to dual cluster head mechanism our proposed protocol also using a zone controller (ZC) node which act as a resource rich node. Each zone has a zone controller (ZC) which act as a relay node (RN) and balanced the load of the cluster heads. Zone controller is the second powerful node in our proposed protocol.

Our proposed protocol Improved zone based divisional hierarchical routing protocol (IZDHRP) has the ability of removing the hot-spot or energy hole issues which is in ZDHRP protocol and makes the network system energy efficient by increasing lifetime and stability. Since all the clusters are of equal size in the proposed network system so in this scenario there is a balanced energy utilization among the clusters of each zone. In our proposed protocol (IZDHRP) the cluster formation mechanism is governed by base station (BS) and due to this base station (BS) involvement it has the ability of making the network system more energy efficient. Cluster formation process governed by base station (BS) is just required in the set-up phase and it does not need to carry out again in further rounds except the first round of it.

5.2.4 Division into Zones

In our proposed protocol IZDHRP 4 equal sized zones are established. These zones are zone (A), zone (B), zone (C) and zone (D) respectively. Each set of zone has clusters and each cluster has CHs and CMs in it. This zone division is governed by BS in a systematic way.

5.2.5 PCH selection criteria

In our proposed protocol IZDHRP since we have considered that clusters are geographically static, so in this case their centurion are known. Every sensor node (SN) in a cluster calculate the distance of it from centroid. A centroid is a central point which is achieved by joining al the median of a geometrical shape. In our scenario the clusters are of rectangular shaped, so a centroid is achieved in our rectangular shaped cluster by joining all the sides of the rectangular cluster.

$$\text{Threshold} = \text{R.E/Distance} \quad \textbf{5.1}$$

So, threshold is equal to residual energy (R.E) of SNs over distance of SNs from its centroid. A node with greater T (Threshold) value is selected as primary cluster head (PCH).

5.2.6 SCH selection criteria

In our proposed protocol IZDHRP as position of zone controllers (ZCs) are known which indicate the desired area for the upcoming SCH. SCH should be in between the neighboring PCHs and zone controller (ZC). Nodes resides in this area competes for SCH on the basis of R.E. The nodes which have more R.E in this area should be selected as a SCH. Following fig (5.2) describes the selection criteria of the SCH.

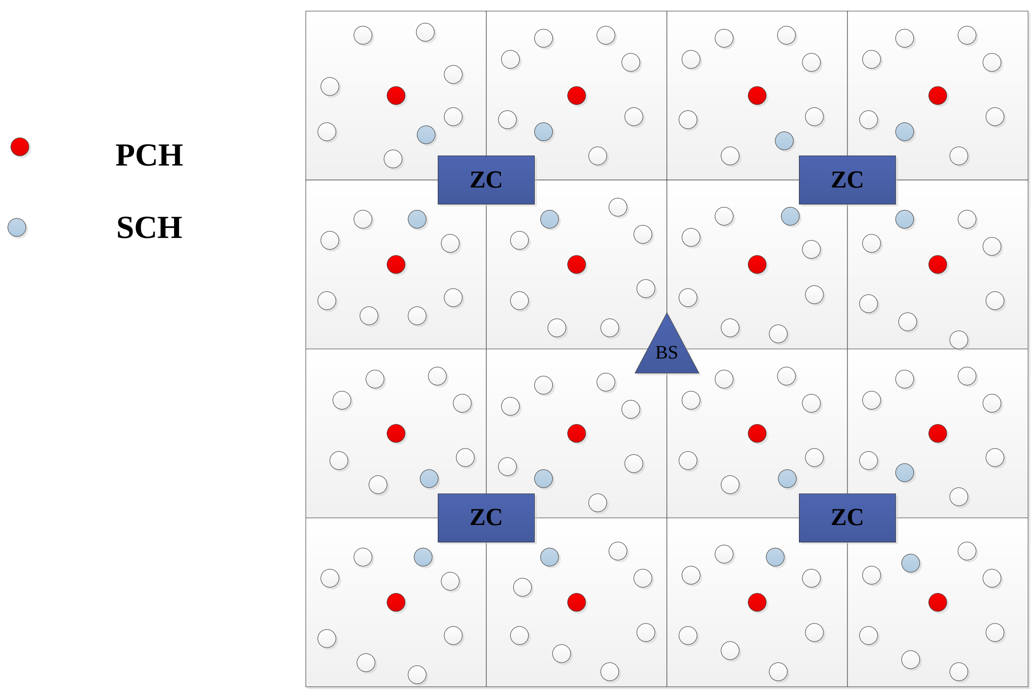

Fig 5.2: SCH Selection criteria

5.3 N-Tier Proposed Network Hierarchical Topology

In our proposed protocol in order to makes the network system energy-efficient and removing the hot spot or energy hole issues a network N-Tier hierarchical model is proposed as shown in fig (5.3). This model is based upon set of levels and each level has its own functionalities and capabilities. This network model provides a building block of our proposed protocol IZDHRP. Each level describes a set of system in our proposed network model. There are four levels in our proposed network model level 0, level 1, level 2 and level 3. The topmost and powerful level is level 0, and it describes the BS. The base station in our proposed network model is a resource rich node which has the ability of analyzing and evaluating the data coming from other set of nodes and provide a systematic mechanism of managing and organizing the tasks. The BS act as a central hub in our proposed network system. All the information of SNs are reside in the base station and it has the ability of formation of zone and clusters in our proposed network system.

Level 1 is the second most powerful level in our proposed network model, and it describes the Zone Controller (ZC). Zone controller (ZC) is the resource rich node in the respective zone and it act as a relay node between the CH and the BS. Zone controller (ZC) manage and organize the task in a zone and these tasks consists of data processing, data aggregation, data evaluation mechanism and also data relaying towards the base station (BS). The position of the zone controller in a zone is set to be known.

Level 2 describes the CH in our proposed network model. We are considering dual CH mechanism in our proposed network model. PCH and SCH are cluster head which are selected in each cluster and this type of dual cluster head mechanism has the ability that it can stabilize the energy utilization between the clusters. The PCH has the ability that it collects the data from the cluster members and forward this data to the SCH. SCH provide some aggregation and forward this data to the respective Zone Controller (ZC).

Level 3 describes SNs which is the lowest level in the proposed network model. Sensor nodes (SNs) has the ability of sense the useful information from the surrounding environment and send this sensed information to the CH of its respective cluster. SNs has the ability that they are independent from each other.

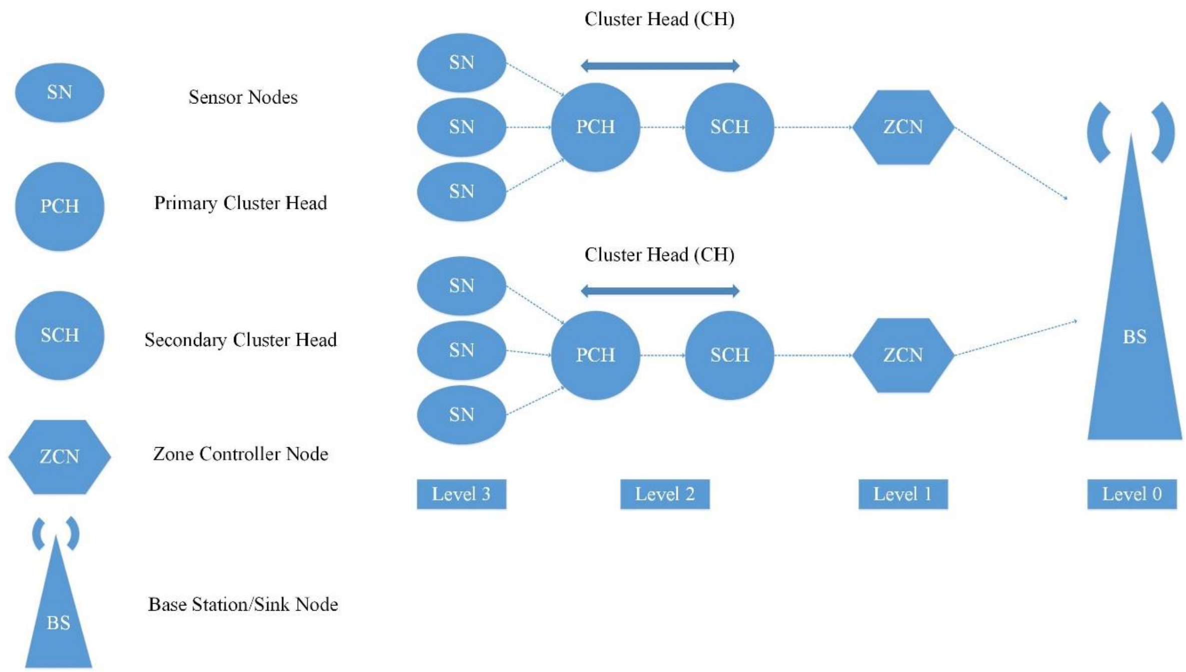

Fig 5.3: N-tier hierarchy of the Network

5.4 Communication Hierarchy

This section describes the communication hierarchy of our proposed scheme in a systematic way. The set of SNs sensed the data from the surrounding environment and forward this sensed data towards PCH of its respective cluster. PCH collects all the data of the respective cluster and send it to the SCH. SCH aggregate this data received from the PCH and forward it towards zone controller (ZC) of its respective zone.

Each zone controller (ZC) has the ability that it can received data from all secondary cluster heads (SCHs) of its respective zone and provide some aggregation method and forward it to the BS. This whole communication process carried out with the help of dual CH mechanism in a systematic way. PCH and SCH are the building blocks in our protocol for relaying the data from clusters to zone controller and then zone controller has the ability of relaying the data to the BS in a systematic way. The whole communication process of our network system is describes in the Following fig (5.4). the flow chart diagram describes each step involves in the communication hierarchy of our proposed network system.

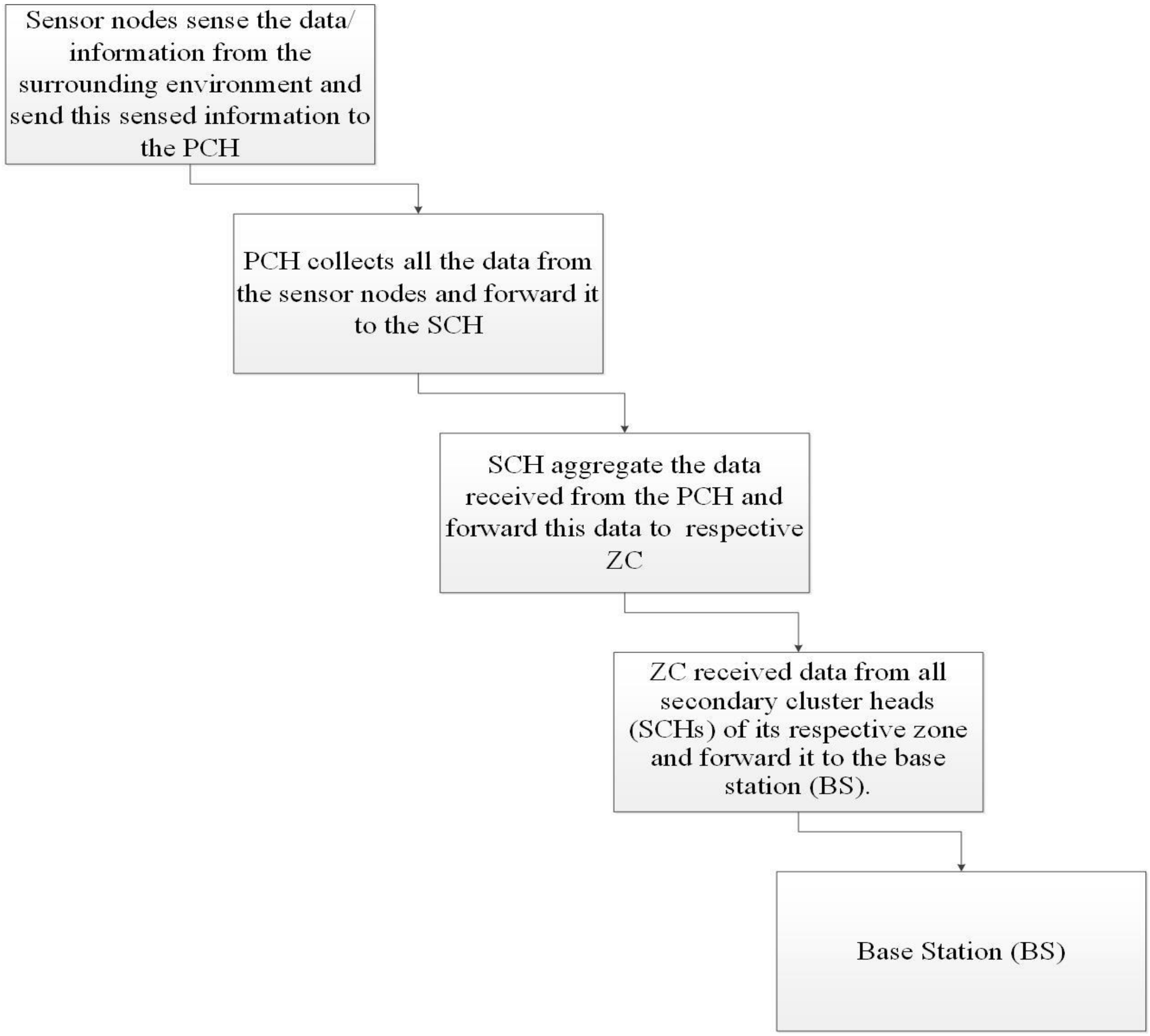

Fig 5.4: Communication Hierarchy

5.5 Assumptions of Network system

A number of assumptions are depending upon set of presentation and analytical behavior of the proposed protocol. Many of these assumptions are related to the set of systematic rules and configuration parameters and these relied on set of heuristic approach or optimization mechanism. This research study is anchored on the assumptions which are following:

- The base station (BS) has the capability that it can be reached by all the sensor nodes (SNs).

- The base station (BS) is in fixed location and it must be placed at the center of the rectangular observing area.
- The base station (BS) in the proposed method consist of adequate amount of energy and other resources for efficient routing of data.
- The sensor nodes (SNs) and the base station (BS) are stationary after the deployment process.
- The base station (BS) can send and receive the continuous data in a systematic way.
- The base station (BS) kept all the information about each sensor node (SN) and its energy status in our proposed network system.
- Clusters are geographically static in network system.
- The set of nodes are homogeneous in nature and it consists of unique set of ID and the initial energy is same for all the sensor nodes (SNs).
- A resource rich node called zone controller (ZC) consists of energy more than the normal nodes in a network system.
- Network system is divided into four equal sized zones.
- Each zone consists of resource rich node call the Zone Controller (ZC).
- Position of Zone Controller (ZC) in a network system is known.

5.6 Example of Assumptions in our proposed Network System

In our network system example, 100 homogeneous SNs are installed in an area of 100 m X 100 m. Network system is partitioned into four equal sized zones which are Zone A, Zone B, Zone C and Zone D respectively. Sensor nodes are deployed in a randomized manner. The partitioned is carried out by the base station and equal number of zone is established. In each zone there is equal number of rectangular shaped clusters in it. Clusters are geographically static in the proposed network system. If we consider the 16 clusters case then Zone A consists of 4 equal size rectangular cluster, Zone B consists of 4 equal size rectangular cluster, Zone C consists of 4 equal size rectangular cluster and Zone D also consists of 4 equal size rectangular clusters. We are using dual CH mechanism so in this case each cluster has two CHs and each zone has 8 CHs and overall network consist of 32 CHs in it. Each zone is assigned with a zone controller (ZC). So, in sixteen cluster case there is four zone controller (ZC) in the whole network system. Zone controller (ZC) is the resource rich node and it has the second level in our proposed network system. Its energy is greater than the normal sensor nodes.

CHAPTER 6

PROPOSED ALGORITHM (IZDHRP)

This chapter describes and elaborate the network model of our proposed protocol in a systematic way. All three models of our proposed protocol discussed here in an extensive way. These three models consist of 8-clusters case, 16-clusters case and 24-clusters case. A detail explanation of our proposed model is discussed in this chapter. The second part of this chapter describes the working of our proposed protocol with the help of algorithm and explain the steps involves in our protocol in an efficient way.

6.1 Network Model of Proposed Protocol (IZDHRP)

Following figure (6.1) describes the network model of 8-clusters case after the deployment of the SNs in the network field. BS is installed at the center position in the network-field and which act as a most powerful node in the network system. Network area is partitioned into four types of zones and each zone has a zone controller (ZC). This zone controller is the second most powerful node in our proposed network model. SNs are deployed in the network system in a randomized manner and these SNs are static after the deployment. In the following figure different color of nodes describes the different clusters in a zone and each color describe one cluster. SNs which are deployed are assumed to be the homogeneous type of nodes. It is set to be assumed that the position of the BS is known and also the position of zone controller (ZC) is known.

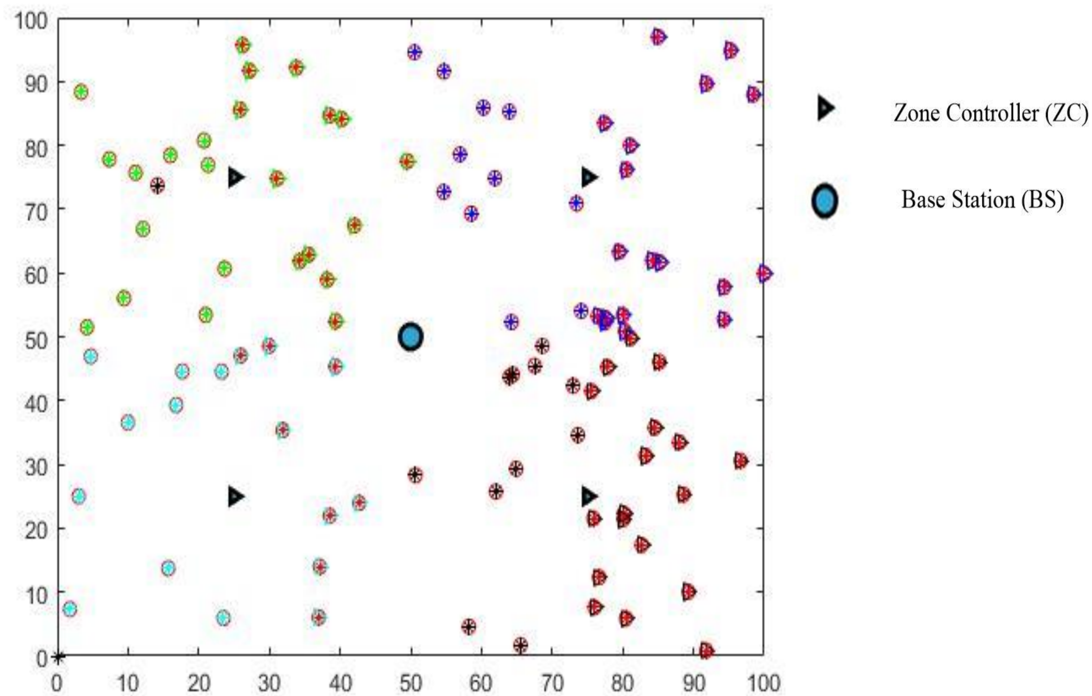

Fig 6.1: Network model of 8-clusters case (IZDHRP)

Following figure (6.2) describes the network model of 16-clusters case after the deployment of the SNs in the network. The network field is partitioned into four types of zones and each type of zone in this 16-clusters model consists of the 4 cluster. In the following figure each sensor node color represents the cluster in a zone. The BS is installed at the center of the network field and this BS is the most powerful node in the network system. The BS is located at the center and in this case the network system is set to be efficient. Each zone in the network system consists of zone controller (ZC) and this zone controller is the second most powerful in the proposed network model. SNs are deployed in the network system in a randomized manner and these SNs are static after the deployment. The SNs in our proposed protocol are homogeneous in nature. Each set of cluster has dual CH mechanism and this dual CH has the ability of balance the energy utilization among the nodes. It is set to be assumed that the position of the BS is known and also the position of zone controller (ZC) is known.

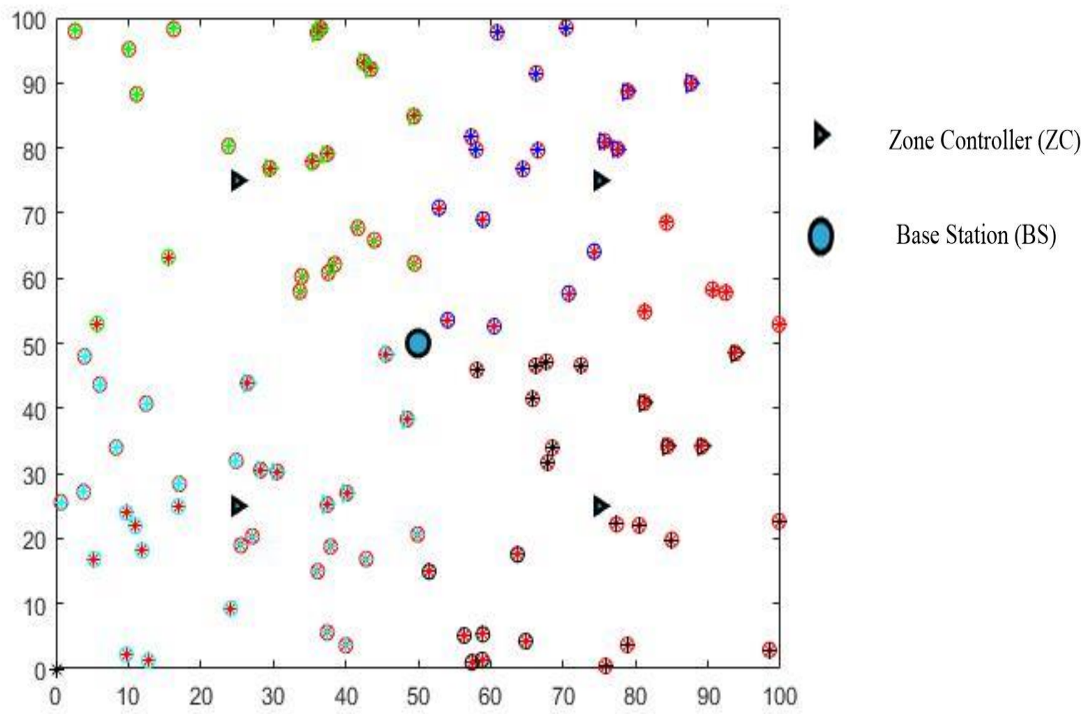

Fig 6.2: Network model of 16-clusters case (IZDHRP)

Following figure (6.3) describes the network model of 24-clusters case after the deployment of the SNs in the network field. Our proposed network is divided into four equal sized zone and each zone consists of equal number of clusters in it. In 24-clusters case each zone consists of six clusters and the size of each rectangular cluster is similar. A BS is installed at the center of the network field and this BS is the most powerful node in the network system. The main reason of this BS installation at the center is to make the network system energy efficient. Each zone in the proposed network system is assumed to be a zone controller (ZC) and this zone controller (ZC) is the second most powerful node in the proposed protocol. SNs deployment in the network system is randomized and each SN is static after the placement. The SNs in our proposed protocol are homogeneous in nature. In following figure, the different number of colored SNs describes the number of clusters in it. Each color represents a different cluster in our proposed network system. Our proposed protocol has dual CH mechanism and this dual CH has the responsibility of balance the energy utilization among the nodes. It is set to be assumed that the position of the BS is known and also the position of zone controller (ZC) is known.

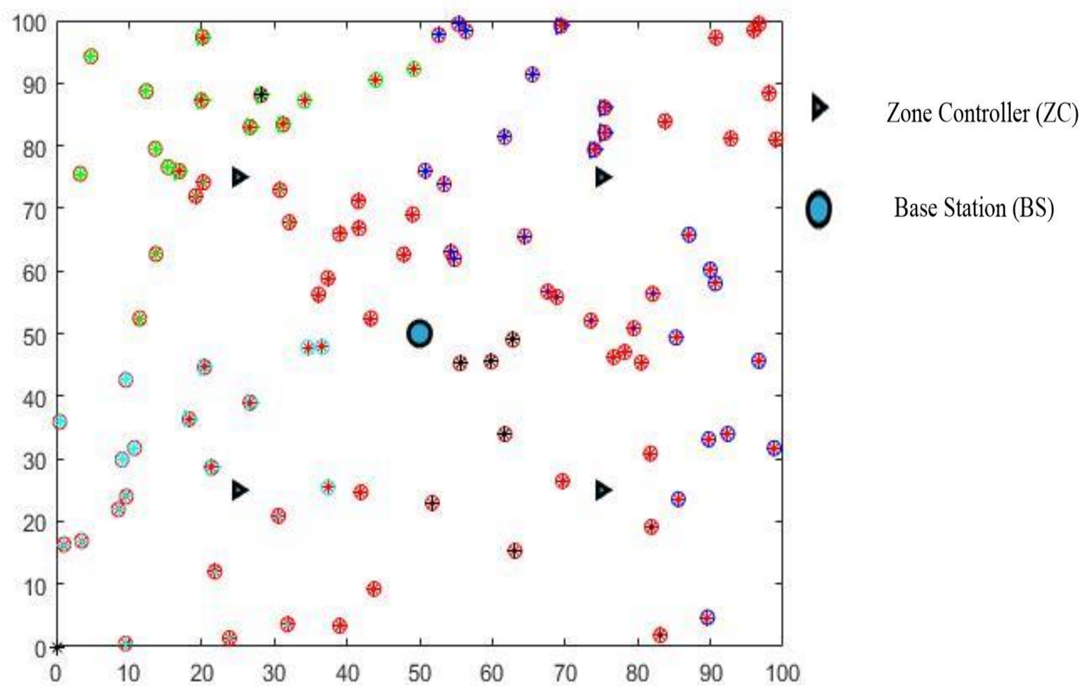

Fig 6.3: Network model of 24-clusters case (IZDHRP)

6.2 Detailed overview of our proposed Algorithm

This part of our chapter elaborates the pseudocode of the proposed scheme called improved zone based divisional hierarchical routing protocol (IZDHRP). Network field is partitioned into four equal sized zone and the SNs which are deployed in the network has the same set of energy and are homogeneous type of nodes. SNs are deployed in the network field in a randomized manner. Each set of zone has equal size of rectangular shaped clusters and we are considering three case here which are 8-clusters case, 16-clusters case and 24-clusters case. In 8-clusters case each zone has set of two clusters in it. It means that in four zones each zone consists of 2 cluster in 8-clusters case. In 16-clusters case each set of zone consists of 4 clusters in it and in 24-clusters case each set of zones consist of 6 clusters in it. BS is placed at the center of the network field and this BS is the most powerful node in our protocol and BS initialize a request and partitioned the network area into zones and then each zone is divided into set of clusters. This partition governed by base station is energy efficient and makes the network system more stable.

Dual CH is selected in a cluster and the purpose of this dual CH mechanism is to balance the energy utilization among the nodes. PCH and SCH are two nodes which are selected in each cluster. Each zone has resource rich node called the zone controller (ZC) and this zone controller node act as a RN and transmit the data from CH to the BS. The position of the zone controller is set to be known in the proposed network system and its coordinates are geographically known. PCH collects the data from the CMs and send this data to the SCH. SCH provide some aggregation mechanism and transmit this data to the respective zone controller. Zone controller (ZC) received the data from all the clusters of the respective zone and provides some aggregation and transmit this data to the BS.

ETx -- Transmitter energy Pernode
ERx -- Receiver energy Pernode
Eda -- Data Aggregation
E_0 -- Initial Energy of Sensor nodes
Efs -- Free Space Channel Parameter
Emp -- Multi-path Channel Parameter
d_0 -- Distance threshold

6.2.1 Set-up Network of our proposed Algorithm

1 - Diameter of a sensor network is defined 100m*100m
2 - Sink node is deployed at location (50,50)
3 - Zone controller nodes are deployed, and the location is fixed
4 - Energy is supplies to each zone controller (ZC)
5 - Ezc=10J => ZC. E=Ezc
6 - Sensor nodes are deployed // n=100
7 - E_0 = 0.5J // energy supplied to each SN
8 - *for* (i = 1 to n)
9 - Node(i).E = E_0
10 - *end for*

- *end*

6.2.2 Network Initialization phase in our proposed Algorithm

6.2.2.1 Zone Division

Our proposed algorithm is set to be divided into four equal sized zone. The following algorithm describes the division of zone in the network system. This division is of equal sized four zone in our network area.

- *for* i=1 to n
- *if* (node(i).xd = assigning set of position
  && node(i).yd = assigning set of position) then
- Assign values to zones
- Assigning set of area to zone
- *end if*
- *end for*
- *end*

6.2.2.2 Division of cluster

We are implementing three cases in our proposed algorithm which are 8-cluster, 16-cluster and 24-cluster. In 8-cluster each zone is set to be contain 2 clusters in it. In 16-cluster each zone consists of 4 clusters in it. In 24-cluster each zone consists of 6 clusters in it. The following is the algorithm of the division of cluster in a zone.

- *for* i = 1 to n
- *If* (node(i).xd = assigning set of position
  && node(i).yd = assigning set of position) then
- Assigning values to clusters
- Assigning the area allotted to the clusters
- *end if*

```
end for
end
```

6.2.2.3 Election of Cluster heads (CHs)

CHs which are elected are of two types PCH and SCH. This dual CH selection has the ability of balance the energy utilization among the nodes. Following is the CH election algorithm.

A Election of CH

```
Probability for election of cluster heads in a cluster is 0.1
p=0.1
for (r = 1 to rmax) // rmax = 5000
if (1<= (p/(1-p*mod(r,(1/p)))))   then
cluster heads are counted
packets sends to the base station
end if
end for
end
```

B For PCH selection

```
Nodes calculate distance from the centroid
for i = 1 to n
if node (i).E > T  // Where T = R.E / distance from centroid
Primary cluster head is selected
else cluster head not selected
endif
end for
end
```

C For SCH selection

Nodes reside in the area between primary cluster head and zone controller
for i = 1 to n
if node (i).E > T (T is the threshold value) // Where T = R.E
SCH is selected
else SCH is not selected
endif
end for
end

6.2.3 Transmission phase in our Proposed Algorithm

6.2.3.1 Transmission of data in 1st Zone with the help of ZC

The following algorithm describes the flow of data from CH to zone controller 1 and zone controller 1 to the BS and the overall algorithm describe the set of data transmission in a zone.

for i = 1 to n
if (node.(i) = set of time slots)
if node(i) has the ability that it can keep the sensed values then
data sensed by the cluster members are set to be received by the PCH
PCH gathers the set of data and forward it to the SCH
Aggregation is applied at SCH
Transmission of data from SCH to zc1
packets_TO_ZC1 = packets_TO_ZC1 + 1;
aggregation at zc1 node
transmission from zc1 to base station
packets_TO_BS1=packets_TO_BS1 + 1;
else
no data is transmitted
end if

else
no communication in the network
end if
end for
end

6.2.3.2 Transmission of data in 2nd Zone with the help of ZC

The following algorithm describes the flow of data from CH to the zone controller 2 and zone controller 2 to the BS and the complete algorithm describe the set of data transmission in a zone.

for i = 1 to n
If (node.(i) = set of time slots)
if node.(i) has the ability that it can keep the sensed values then
data sensed by the cluster members are set to be received by the PCH
PCH gathers the set of data and forward it to the SCH
Aggregation is applied at SCH
Transmission of data from SCH to zc2
packets_TO_ZC2=packets_TO_ZC2 + 1;
aggregation at zc2 node
transmission from zc2 to base station
packets_TO_BS1=packets_TO_BS1 + 1;
else
no data is transmitted
end if
else
no communication in the network
end if
end for
end

6.2.3.3 Transmission of data in 3rd Zone with the help of ZC

The following algorithm describes the flow of data from cluster heads to zone controller 3 and zone controller 3 to the BS and the complete algorithm describe the data transmission in a zone.

```
for i = 1 to n
If (node.(i) = set of time slots)
if node.(i) has the ability that it can keep the sensed values    then
data sensed by the cluster members are set to be received by the PCH
PCH gathers the data and forward it to the SCH
Aggregation is applied at SCH
Transmission of data from SCH to zc3
packets_TO_ZC3=packets_TO_ZC3 + 1;
aggregation at zc3 node
transmission from zc3 to base station
packets_TO_BS1=packets_TO_BS1 + 1;
else
no data is transmitted
end if
else
no communication in the network
end if
end for
end
```

6.2.3.4 Transmission of data in 4th zone with the help of ZC

The following algorithm describes the flow of data from CH to the zone controller 4 and zone controller 4 to the BS and the complete algorithm describe the set of data transmission in a zone.

for i = 1 to n
if (node.(i) = set of time slots)
if node.(i) has the ability that it can keep the sensed values then
data sensed by the cluster members are set to be received by the PCH
PCH gathers the data and forward it to the SCH
Aggregation is applied at SCH
Transmission of data from SCH to zc4
packets_TO_ZC4=packets_TO_ZC4 + 1;
aggregation at zc4 node
transmission from zc4 to base station
packets_TO_BS1=packets_TO_BS1 + 1;
else
no data is transmitted
end if
else
no communication in the network
end if
end for
end

6.2.3.5 Transmission phase when SCH node is Down

The following algorithm describes the flow of data from PCH to the zone controller and zone controller to the BS and the complete algorithm describe the set of data transmission in a zone.

for i = 1 to n

```
if (node.(i) = set of time slots)
if node.(i) has the ability that it can keep the sensed values    then
data sensed by the cluster members are set to be received by the PCH
PCH gathers the data and send it to the zone controller
packets_TO_ZC = packets_TO_ZC + 1;
aggregation at zc node
transmission from zc node to base station
packets_TO_BS1=packets_TO_BS1 + 1;
else
no data is transmitted
end if
else
no communication in the network
end if
end for
end
```

6.3 Proposed Algorithm Phases

This section provides the extensive study of the set of phases of our proposed Algorithm (IZDHRP) in an efficient way. Our proposed scheme is set to be partitioned into two phases. First type of phase is called the **setup phase** and the second type of phase is called the **steady state phase**.

6.3.1 Set Up phase in our Proposed Algorithm (IZDHRP)

The setup phase in our proposed algorithm is divided into following steps which are explained below.

Step 1: Deployment of SNs in a randomized manner in our network field.

Step 2: Partitioned the whole network system into set of zones and this partitioned is governed by the base station.

Step 3: Each zone is then partitioned into rectangular cluster of equal sized. Clusters are geographically static.

Step 4: Two types of CHs are selected which are PCH and SCH. Selection of CH is based upon set of criteria involved in it.

Step 5: After the cluster head selection the actual transmission governed by these two cluster head is started.

The following Fig (6.4) describes the flowchart of the setup phase of our proposed protocol.

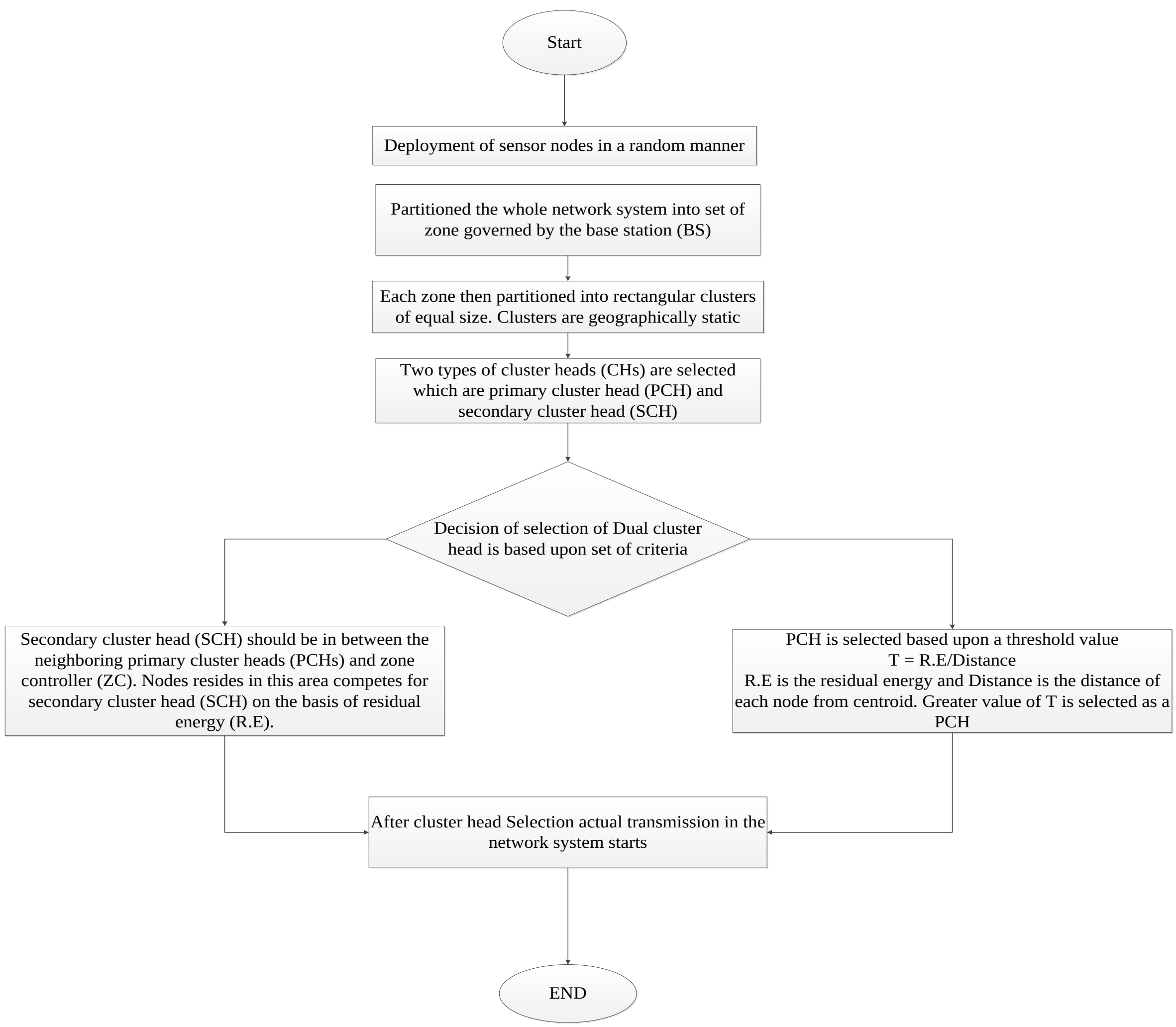

Fig 6.4: Flow chart diagram of the Setup Phase in our Proposed Protocol

6.3.2 Steady state phase in our proposed Algorithm

In steady state phase actual transmission is done after the cluster formation and zone division process. This transmission is carried out with the help of dual cluster head mechanism. This phase involves the following steps.

Step 1: after the cluster formation and zone division cluster members has the ability that they sensed the data from the surroundings and send this sensed data to the PCH of its respective cluster.

Step 2: PCH collects all the data from the CMs and send the data to the SCH.

Step 3: SCH received the data from the PCH and provide some type of aggregation mechanism send this data to the respective zone controller of its zone.

Step 4: zone controller collects all the data from the SCHs provide some aggregation and send this data to the BS.

Steady-state phase is the transmission phase in our proposed algorithm and the network communication mechanism is involved in the transmission of data from CMs to PCH, PCH to SCH, SCH to ZC and ZC to BS. This process is shown in the following fig (6.5).

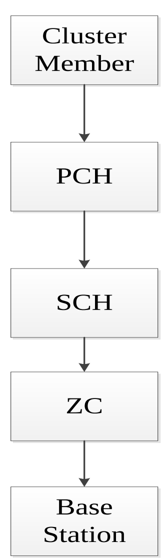

Fig 6.5: Network Communication Mechanism

The following fig (6.6) describes the flow chart diagram of our steady state phase and elaborates each step involves in this process. Our network area is divided into four types of zones which are Zone A, Zone B, Zone C and Zone D. The flow chart diagram describes the transmission of data in each zone in a systematic way. In each zone cluster members sensed the data and forward this sensed data to the PCH of its respective cluster. PCH gathers all the sensed data from the cluster members and send it to the SCH. SCH collects the data from PCH provides some aggregation mechanism and send this data to the respective zone controller. Zone controller receive the data from all the SCHs of the respective zone and provide some aggregation mechanism and send this data to the base station. Steady state phase is the complete transmission phase and this transmission is carried out with the help of PCH and SCH and Zone controller is act as a relay node.

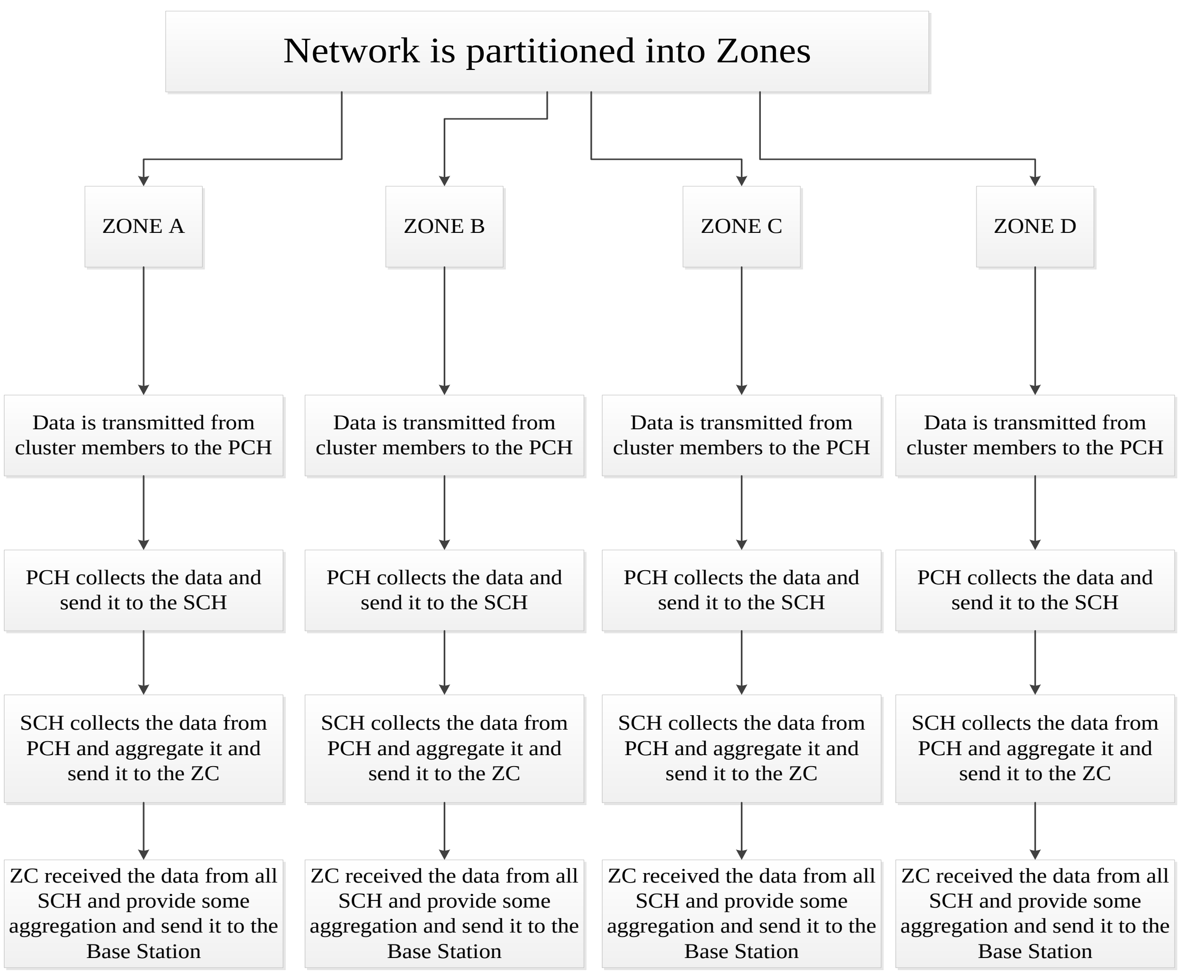

Fig 6.6: Flow chart diagram of steady state phase in our proposed protocol

CHAPTER 7

PERFORMANCE EVALUATION AND RESULTS

This chapter extensively elaborate the performance of our proposed scheme and comparison of it with other benchmark protocols. This section explains the parameter involves in the simulation and also set of performance metrices on which experiments, and results are discussed and compared. This section also describes the extensive explanation of results of our proposed protocol and makes comparison of these results to the benchmark protocols.

7.1 Experimental Set-Up

Simulations of our proposed protocol has been carried out by using the most efficient tool called MATLAB. MATLAB is an efficient and high-performance technical programming tool that govern through data visualization, simulation of the data and plotting the mathematical data in a systematic way. MATLAB simulations provide a systematic way of comparing the performance and results of our proposed scheme improved zone based divisional hierarchical routing protocol (IZDHRP) to the ZDHRP, LEACH, EADUC and HUCL protocol which are benchmark protocol. We are using these benchmark protocols because these protocols have criteria of removing the hot spot or energy hole issues. These protocols have same set of simulation parameters involves in it.

We are providing comparison of our results and performance with these four protocols and the simulation results of our proposed scheme shows that our proposed protocol is better than these four protocols which are LEACH, EADUC, HUCL and ZDHRP. The following fig (7.1) describes the network model of ZDHRP protocol and this shows that there is no zone controller placed in it and the BS is set to be placed at the outside of the field.

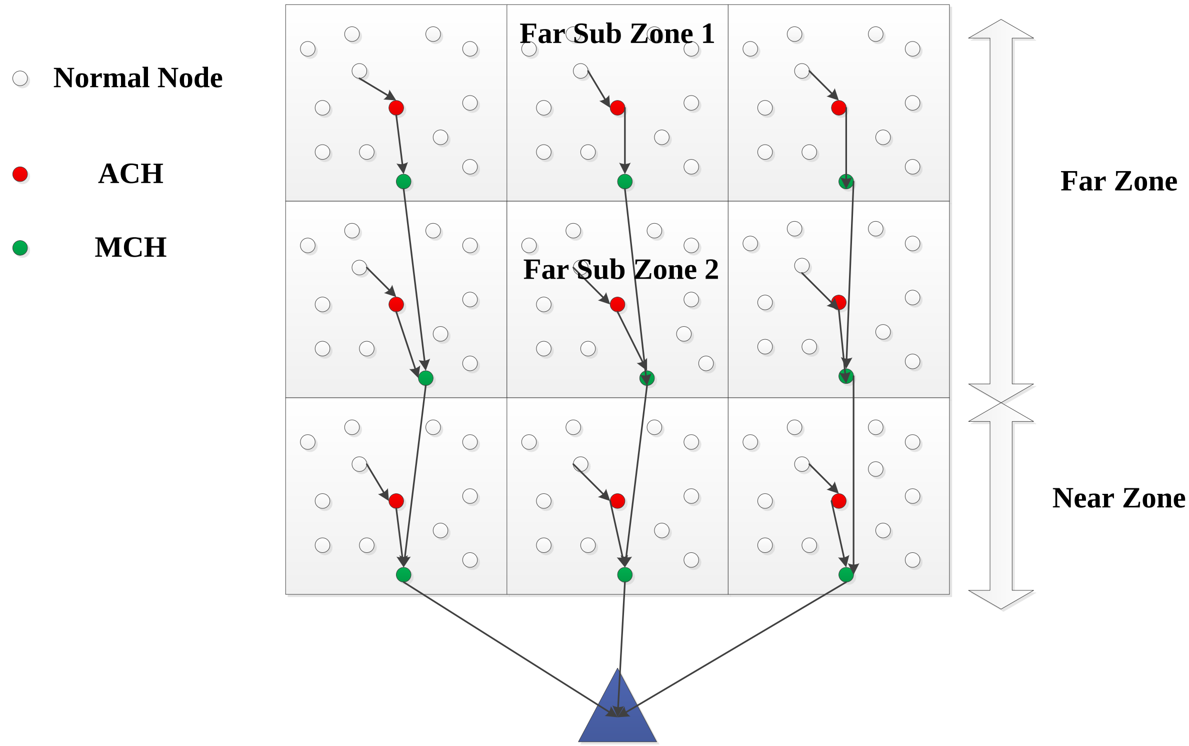

Fig 7.1: Network Model of ZDHRP (Benchmark scheme)

7.2 Simulation Parameters

Following table (7.1) describes the simulation parameters and with the help of these parameters we are simulating our proposed protocol IZDHRP. Our benchmark protocols ZDHRP, EADUC, HUCL and LEACH has similar type of simulation parameters. These parameters are such as network area which describes 100 m x100 m and the zone area which is 50 m x 50 m. Also describes that there are 4 zones and each zone have zone controller in it. So, 4 zone controllers are deployed. Homogeneous type of nodes are deployed in the network system. Simulation parameters describes the initial energy of the zone controller, which is 10j, transmitter energy 50nj/b, Receiver energy 50nj/b and also the aggregation energy of the nodes which is 5nj/b. Multi-path and free space channel space which are 0.0013pj/b and 10pj/b respectively. Following are some set of terminologies which are explained.

Eda – Data aggregation

Eamp – Multi-path channel parameter

E_{fs} – Free space channel parameter

ETx – Transmitter Energy

ERx – Receiver Energy

Table 7.1: Simulation Parameter

Parameters	Values
Network Area	100m * 100m
Zone area	50m * 50m
No. of zones	4
No of ZC	4
No. of sensor nodes	100
Sensor node type	Homogenous
Initial energy of sensor node	0.5J
Initial energy of ZC	10J
Packet size	400 byte
E_{fs}	10 pJ/bit/m^2
E_{amp}	0.0013 pJ/bit/m^2
E_{da}	5 nJ/bit
ETx	50 nj/bit
ERx	50 nj/bit
d_0	Sqrt (Efs/Eamp) m

7.3 Performance Metrics

In our proposed protocol IZDHRP following performance metrices are consider for the evaluation of the performance and results. These performance metrices are similar with our comparison schemes. These performance metrices are used for evaluating the results with benchmark protocols.

7.3.1 Network stability period

Network stability is the period in a network system in which from start of the network operations like data forwarding from cluster member to cluster head, cluster head to zone controller (ZC) and zone controller (ZC) to base station in this process when a first node die (FND) and this whole time period is called the network stability period. It means that from start of the operation till the first node die (FND) this time is called the network stability period. Increasing in the network stability period makes the network more efficient and reliable. Our proposed scheme IZDHRP has the ability that it can increases the network stability period in three of our proposed scenarios.

7.3.2 Lifetime of Network System

Lifetime of the network system is the process in which overall energy efficiency of the network system is maintained. Lifetime is considered to be three types of parameters and these parameters are discussed below:

7.3.2.1 Last Node Dead (LND) in the Network System

It is the set of time period in term of systematic rounds in which communication of nodes is carried out in the whole network system and at the end when last node in the network system is died. This whole time period is called the last node dead (LND) process. Our proposed scheme IZDHRP has the ability that by using efficient mechanism the LND time period is increases.

7.3.2.2 Alive Node vs Number of Rounds

This describes the set of alive nodes in the network system when a round is completed. It means that in each round this process describes the number of alive nodes in it.

In our proposed scheme IZDHRP by introducing an efficient mechanism the rate of alive node is increases in each round.

7.3.2.3 Percentage Node Alive (PNA) in the Network System

This describes the scenario in which network communication is started, cluster members forward the data to the cluster head and cluster head forward the data to the base station and a complete round is ended. In this scenario if 90 percent of the SNs are alive in the network system after the rounds are completed then this case is called PNA. In our proposed scheme IZDHRP by introducing new mechanism it takes greater rounds while achieving the scenario of the 90 percent case.

7.3.3 Remaining Energy

This phenomenon elaborates the remaining energy in the network system as set of rounds are completed. This describes the total amount of energy after rounds in the network system completed. Our proposed scheme IZDHRP shows that by using efficient mechanism the energy of the networks decreases after larger rounds as comparison with the benchmark scheme.

7.3.4 Dead Nodes per round in the Network System

This phenomenon describes the set of dead nodes in the network system when a round is completed. It means that in each set of rounds it describes the number of dead nodes. In IZDHRP by introducing the efficient mechanism the rate of dead nodes are reduced in each set of round.

7.4 Explanation of Results and Discussion

This section elaborates the set of results which we have got from our simulation and discussed the results of our simulation with the benchmark protocols. The results which we have obtained describes that our proposed mechanism is more effective and reliable as comparison with previous scheme. Following are the results obtained from our simulation and these results are compared with benchmark protocols.

7.4.1 Effects on Network Lifetime in the Network System

Network lifetime scenario describes, how much alive nodes are remains while we are considering each set of rounds. This effect is the most crucial effects on the performance of the scheme. We have three cases implementing in this simulation which are 8 clusters, 16 clusters and 24 clusters of our proposed scheme. We are comparing our network lifetime results with benchmark protocol ZDHRP, LEACH, EADUC and HUCL. The following figures describes the network lifetime results of our IZDHRP and comparison of it with 16-clusters case of ZDHRP and HUCL, LEACH and EADUC. Our proposed scheme's all three cases which are 8 clusters, 16 clusters and 24 clusters are better than that of the benchmark protocols.

While analyzing the performance and results of our benchmark protocol ZDHRP, the ZDHRP protocol consider 16 clusters implementation case and we can see that ZDHRP simulation results which shows that at almost 3500 rounds all the nodes are died. It means that at 3500 rounds the energy of all the nodes are set to be zero and no nodes are alive at this stage. Considering other benchmark protocols LEACH, EADUC and HUCL we can see that in these three protocols respectively LEACH protocol set of nodes are died at approximately 1000 rounds and in EADUC protocols nodes are died about 1000 rounds and in HUCL protocol all nodes are died at about 1500 rounds.

While considering our proposed protocol IZDHRP there is three case which are 8 clusters, 16 clusters and 24 clusters. Analyzing the case of 8 clusters as shown in fig (7.2) we can see that at about 7500 rounds all the nodes are died, and which is the greatest in all cases and while comparison of 8 clusters case with 16-clusters case of ZDHRP, HUCL, EADUC and LEACH we can see that our proposed IZDHRP scheme is effective. Now analyzing 16-clusters case as shown in fig (7.3) in our proposed protocol IZDHRP we can see that at about 7000 rounds all nodes are died and which is greater as compared to the 16-clusters case of our ZDHRP and also LEACH, EADUC and HUCL.

Considering the 24-clusters case as shown in fig (7.4) we can see that all the nodes are died at about 6500 rounds and which is greater as compared to 16-clusters case of our ZDHRP and also LEACH, EADUC and HUCL. In this case the network lifetime while considering 24-clusters in our proposed protocol is increases as compared to the benchmark protocols ZDHRP, LEACH, EADUC and HUCL.

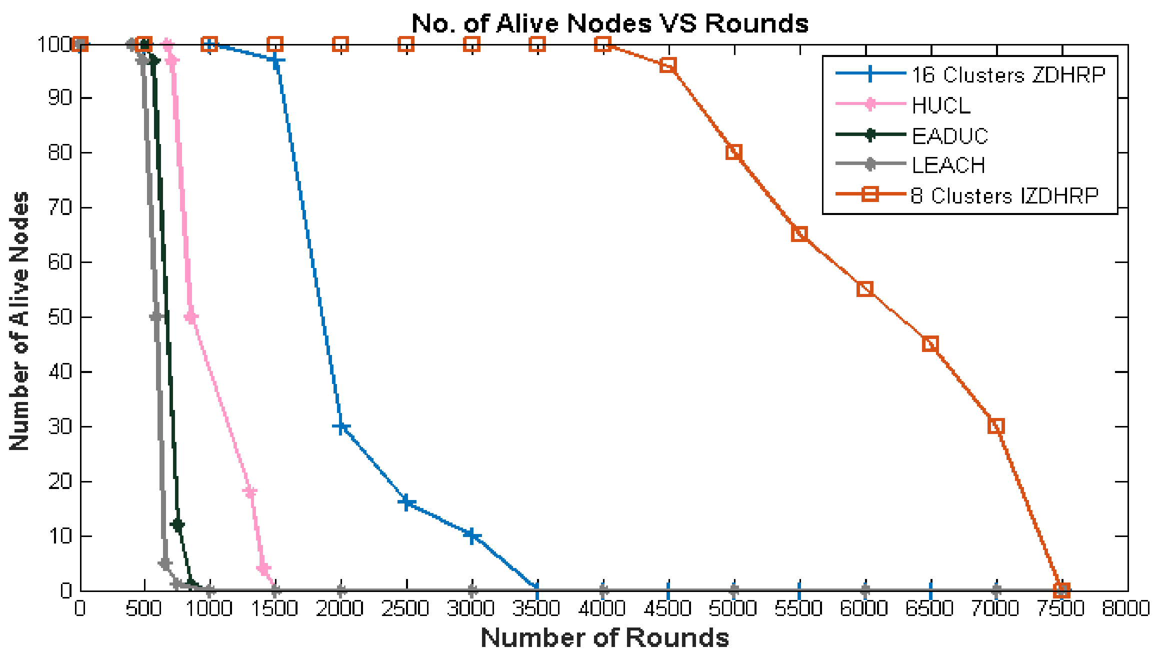

Fig 7.2: Network lifetime in 8 clusters case

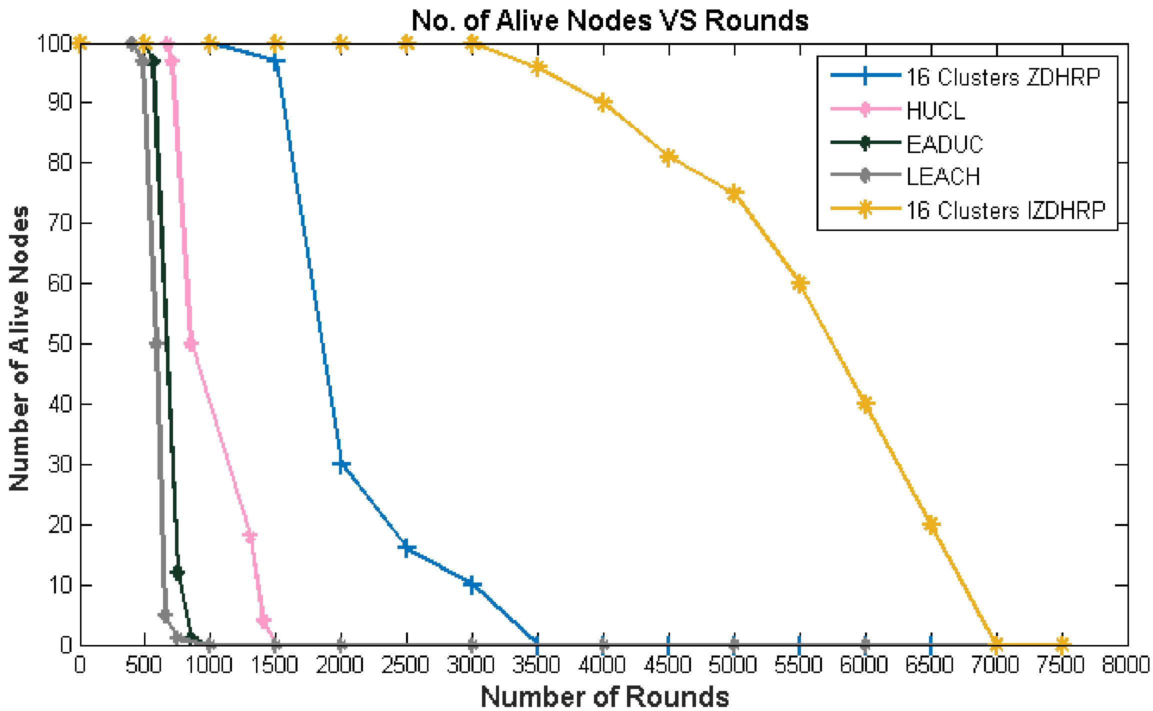

Fig 7.3: Network lifetime in 16 clusters case

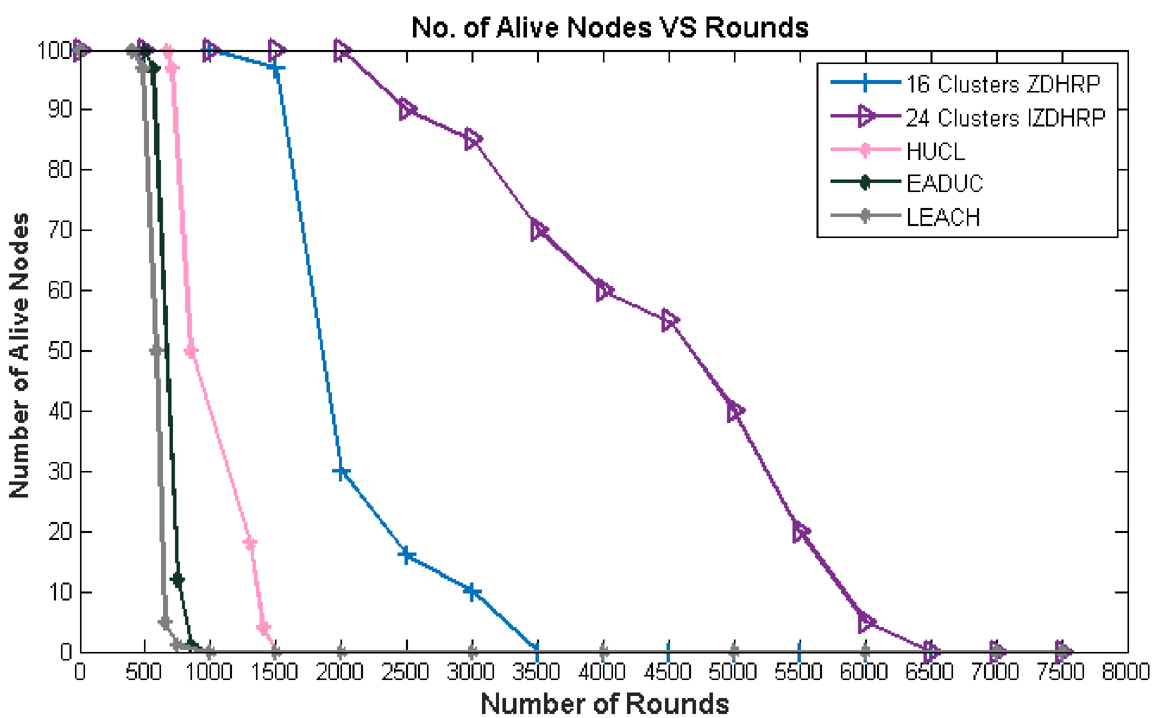

Fig 7.4: Network lifetime in 24 clusters case

7.4.2 Effects on No. of Dead Nodes in Network System

This scenario describes the set of dead SNs when a round is completed. The results of our proposed scheme IZDHRP is set to be compared with benchmark scheme ZDHRP, LEACH, HUCL and EADUC. Following figures elaborates the simulation results of IZDHRP and the results are set to be compared with ZDHRP, LEACH, HUCL and EADUC protocol. Our protocol IZDHRP simulation results consists of three cases which are 8 clusters case, 16 clusters case and 24 clusters case. Three cases are implemented, and the results are better than the comparison schemes. While analyzing the benchmark protocol ZDHRP results we can examine that number of nodes are dead at approximately 1000 rounds. It means that all the nodes are dead while we are considering 1000 rounds in the simulation process.

Considering other benchmark protocols which are LEACH, EADUC and HUCL we can see that in LEACH about 400 rounds all the SNs are dead approximately. In EADUC about 500 rounds all the SNs are dead and in HUCL about 670 rounds all the SNs are dead approximately.

While considering the 8-clusters case as shown in fig (7.5) we can see that all the nodes are dead about 4000 rounds and this case is the efficient most case. While comparing it with benchmark protocol ZDHRP, LEACH, EADUC and HUCL we can see that our 8-clusters case is the efficient most. While examining 16 clusters simulation results as shown in fig (7.6) we can see that all the nodes are dead approximately 3000 rounds. Comparing these results with benchmark protocol ZDHRP, LEACH, EADUC and HUCL we can see that our proposed protocol is efficient in 16 clusters case and the number of rounds are increases as compared to the benchmark schemes.

While analyzing the 24 clusters simulation as shown in fig (7.7) we can examine that all the nodes are died at 2000 rounds and comparison of it with benchmark protocol we can see that our 24 clusters case is efficient than that of 16 clusters case of our benchmark protocol ZDHRP, LEACH, EADUC and HUCL.

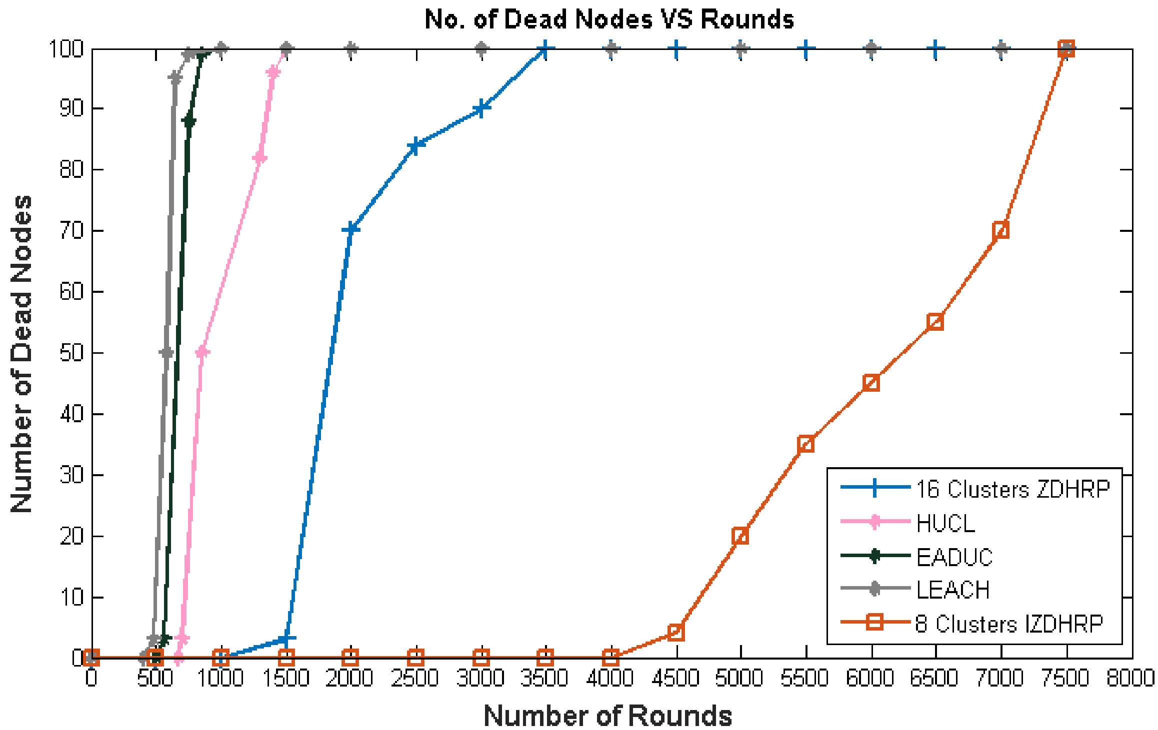

Fig 7.5: No. of dead nodes vs rounds for 8 clusters case

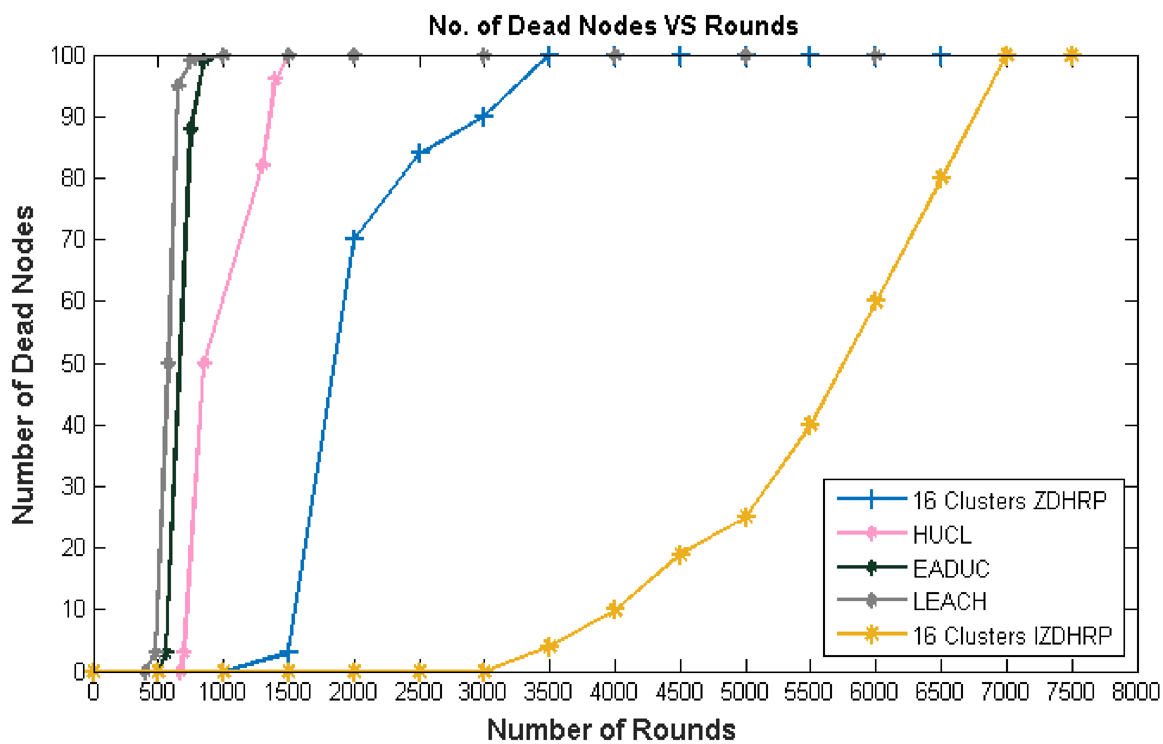

Fig 7.6: No. of dead nodes Vs Rounds for 16 clusters case

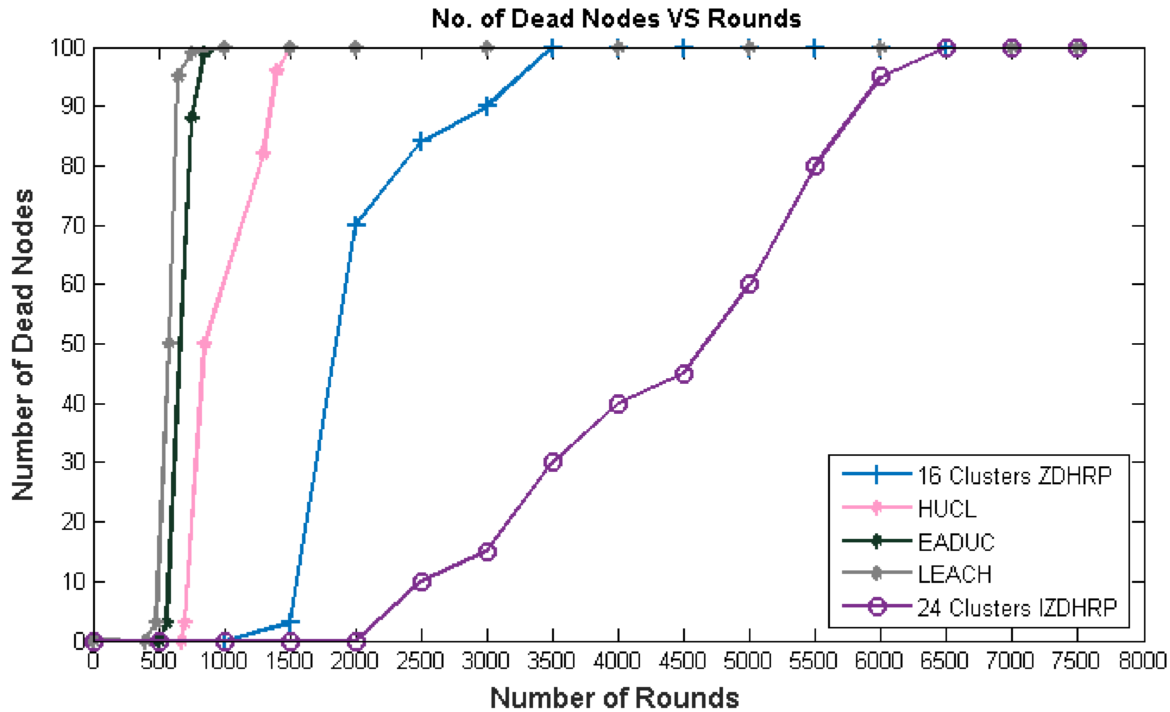

Fig 7.7: No. of dead nodes Vs Rounds for 24 clusters case

7.4.3 Remaining Energy

This phenomenon describes the energy after the set of rounds completed systematically. This method describes the overall energy in the system after the set of rounds are completed. Our proposed protocol IZDHRP consists of three cases and these three cases are 8 clusters case, 16 clusters case and 24 clusters case. The simulation of these three cluster cases are compared with the benchmark protocols ZDHRP, LEACH, EADUC and HUCL. While considering the case of our benchmark protocol ZDHRP the energy of all the nodes are drained out at approximately 4000 rounds of it. It means that all the SNs are dead at 4000 rounds.

Considering other three benchmark protocols LEACH, EADUC and HUCL we can examine that in LEACH energy of all the nodes are drained out at 800 rounds approximately. In EADUC all the nodes energy drained out at approximately 900 rounds and in HUCL energy drained out about 1300 rounds approximately.

Analyzing the simulation results of 8-clusters case as elaborates in fig (7.8), we can see that the simulation results of the 8-clusters case is most efficient while comparing it to the benchmark protocols. We can see that all the nodes drain out their energy at approximately 7000 rounds in the network system. Analyzing the simulation results of 16 clusters case as shown in fig (7.9) we can examine that all the nodes drained out their energy at approximately 6000 rounds in the network system. While compare it with the benchmark protocol ZDHRP, LEACH, EADUC and HUCL we can see that our proposed protocol results are better than the benchmark protocol.

While considering the case of 24 clusters as elaborates in fig (7.10) all the energy of the sensor nodes are drained out at 5000 rounds. Comparing this result with ZDHRP, LEACH, EADUC and HUCL protocol we can see that our 24-clusters case is better than that of all the benchmark protocols. In overall our proposed protocol IZDHRP is better than the benchmark protocols.

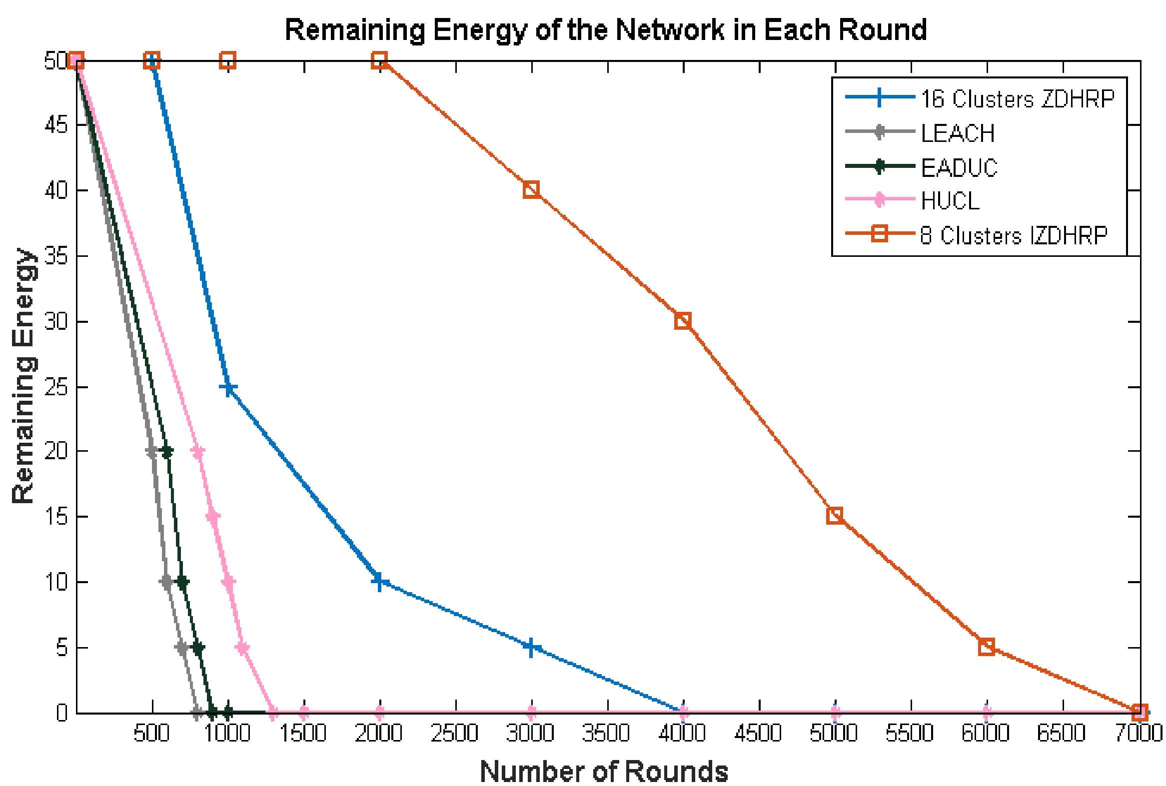

Fig 7.8: Remaining energy of the network in 8 clusters case

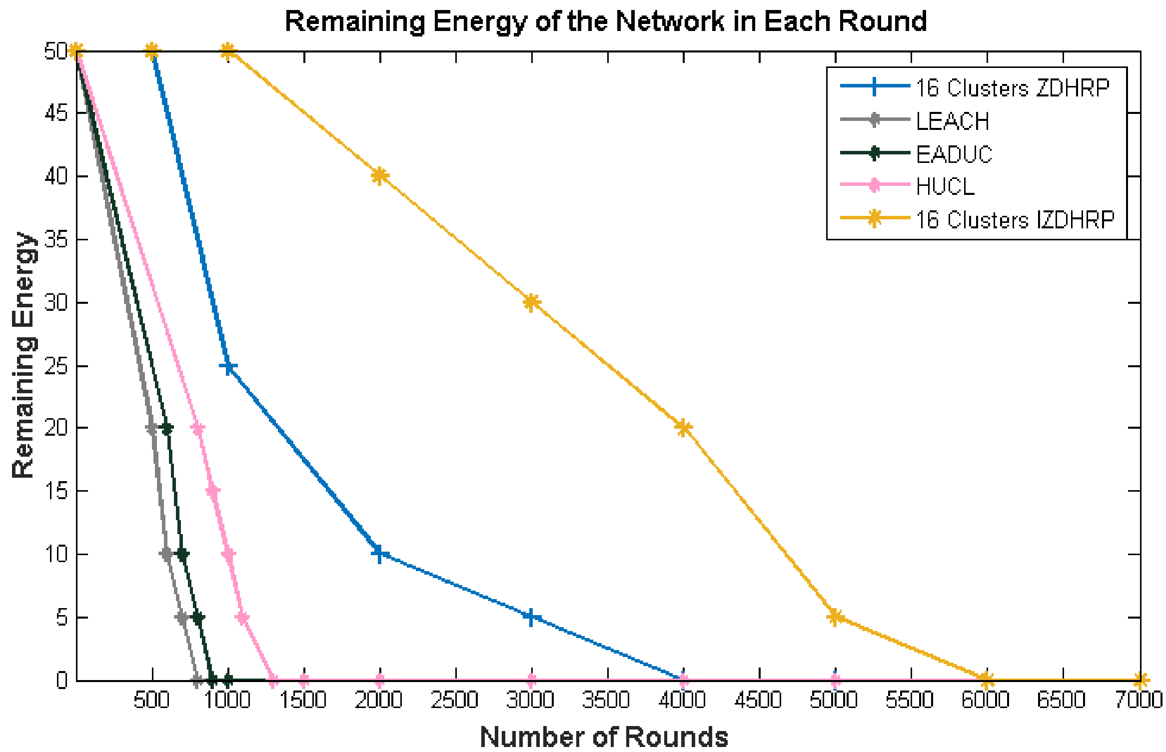

Fig 7.9: Remaining energy of the network in 16 clusters case

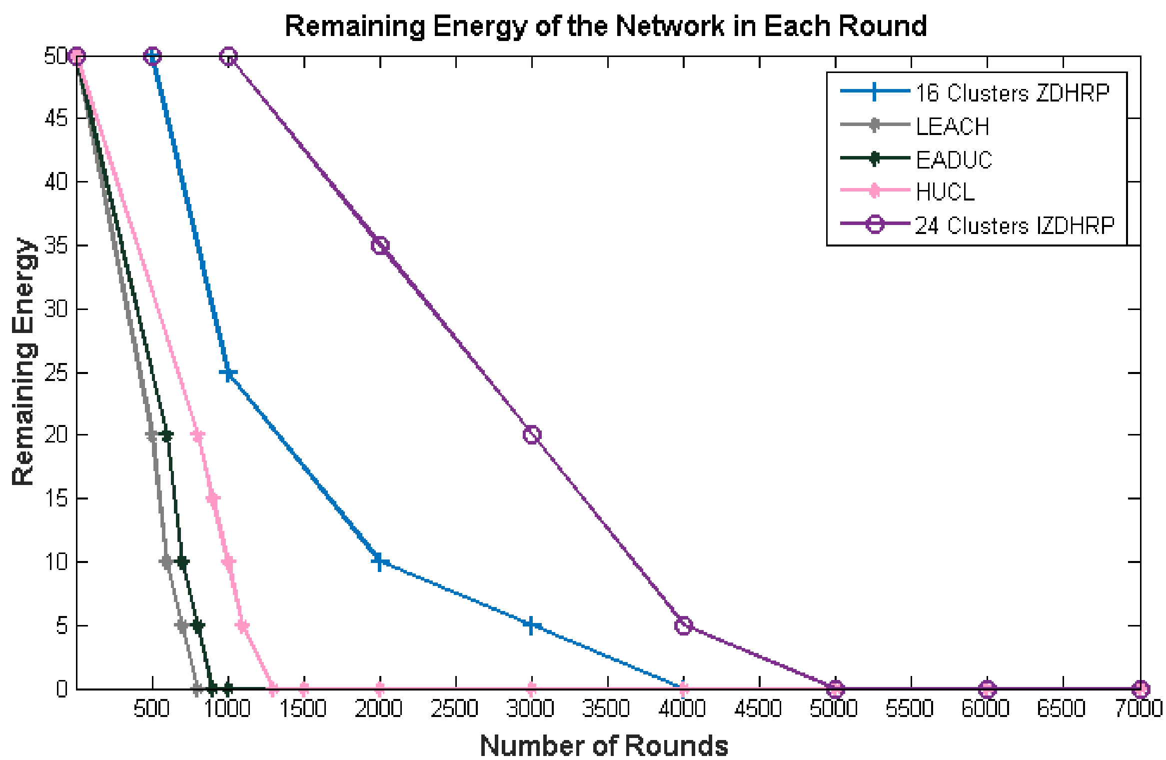

Fig 7.10: Remaining energy of the network in 24 clusters case

7.4.4 Remaining Energy of the network when SCH node is Down

Remaining energy in a network system describes how much energy is remaining after the set of rounds are completed systematically. This phenomenon describes the overall energy consumption in a network system after the set of rounds are completed. Our proposed protocol consists of three cases which are 8 clusters, 16 clusters and 24 clusters. The following figures describes the remaining energy phenomena in three cases when the secondary cluster head (SCH) node is down. The three cases in which SCH is down is compared with three cases of IZDHRP protocol and other benchmark protocols which are ZDHRP, LEACH, EADUC and HUCL. The implementation of these three cases is to consider the energy consumption rate when the secondary cluster head (SCH) node is die and also examine the effects on the whole network system. The following figures describes that when secondary cluster head (SCH) node is dies out then in three of the cases the remaining energy of the network is lower down as compared to when we have both PCH and SCH nodes. The simulation of our results is compare with the three cases of our proposed scheme IZDHRP and also benchmark protocols which are ZDHRP, LEACH, EADUC and HUCL. The simulation results show that when SCH node dies out then its energy is lower down as compared to the proposed scheme IZDHRP.

While considering the case of our benchmark protocol ZDHRP the energy of all the nodes are drained out at approximately 4000 rounds of it. It means that all the SNs are dead at 4000 rounds.

Considering other three benchmark protocols LEACH, EADUC and HUCL we can examine that in LEACH energy of all the nodes are drained out at 800 rounds approximately. In EADUC all the nodes energy drained out at approximately 900 rounds and in HUCL energy drained out about 1300 rounds approximately.

While analyzing the 8 clusters case as shown in fig (7.11) we can see that all the nodes drain out their energy at approximately 6000 rounds in the network system when SCH node is Down and in other case of it the network system drain out their energy at 7000 rounds approximately. So, we can see that when SCH node is down then in 8 clusters case the remaining energy of the network is lesser as compared to the 8 clusters IZDHRP protocol.

While analyzing the 16 clusters case as shown in fig (7.12) we can examine that all the nodes drained out their energy at approximately 5000 rounds in the network system and in other case of it network system drain out their energy at approximately 6000 rounds. So, we can clearly examine that when SCH node is down then in 16 clusters case the remaining energy of the network system is down as compared to the 16 clusters IZDHRP protocol.

While analyzing the 24 clusters case as shown in fig (7.13) we can see that all the energy of the nodes are drained out at approximately 4000 rounds and in other case of it the network system drain out their energy approximately 5000 rounds approximately. We can clearly examine that when SCH node is down then the energy of the network system is lower down as compared to the 24 clusters of IZDHRP protocol. In all three cases in which SCH node is down the remaining energy of the network system is drop down as compared to the three cases of IZDHRP protocol in which SCH node and PCH node are used.

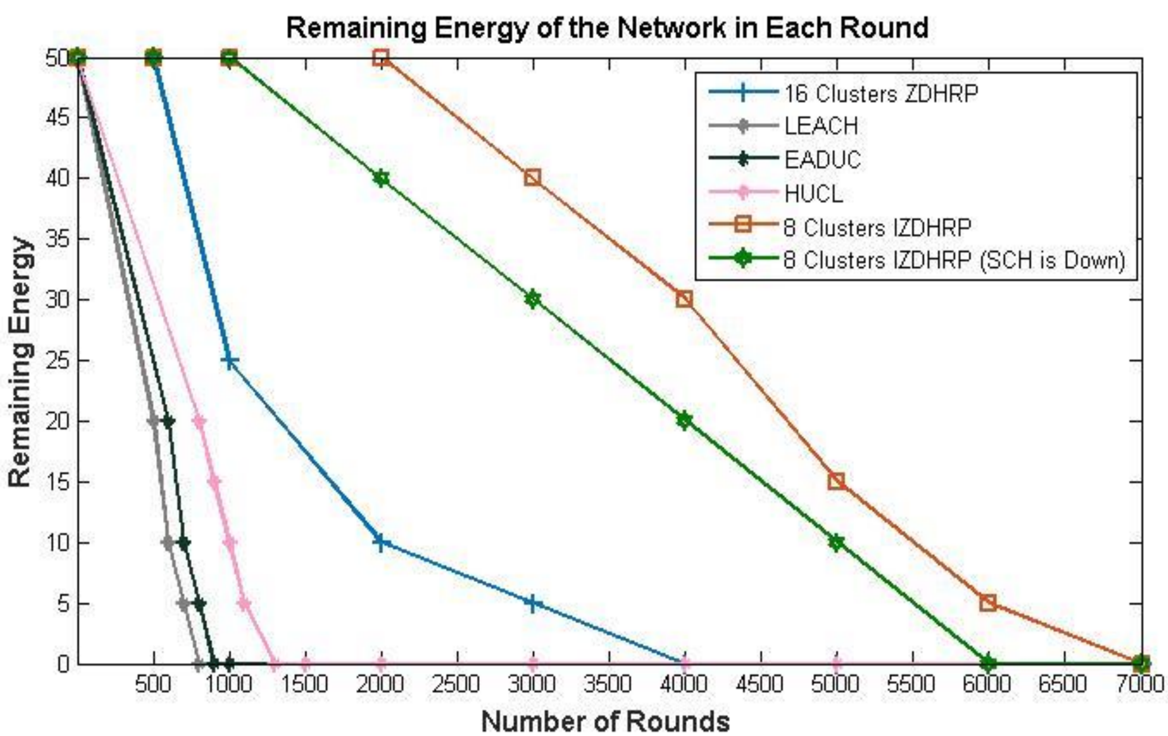

Fig 7.11: Remaining energy of the network in 8 clusters case when SCH is Down

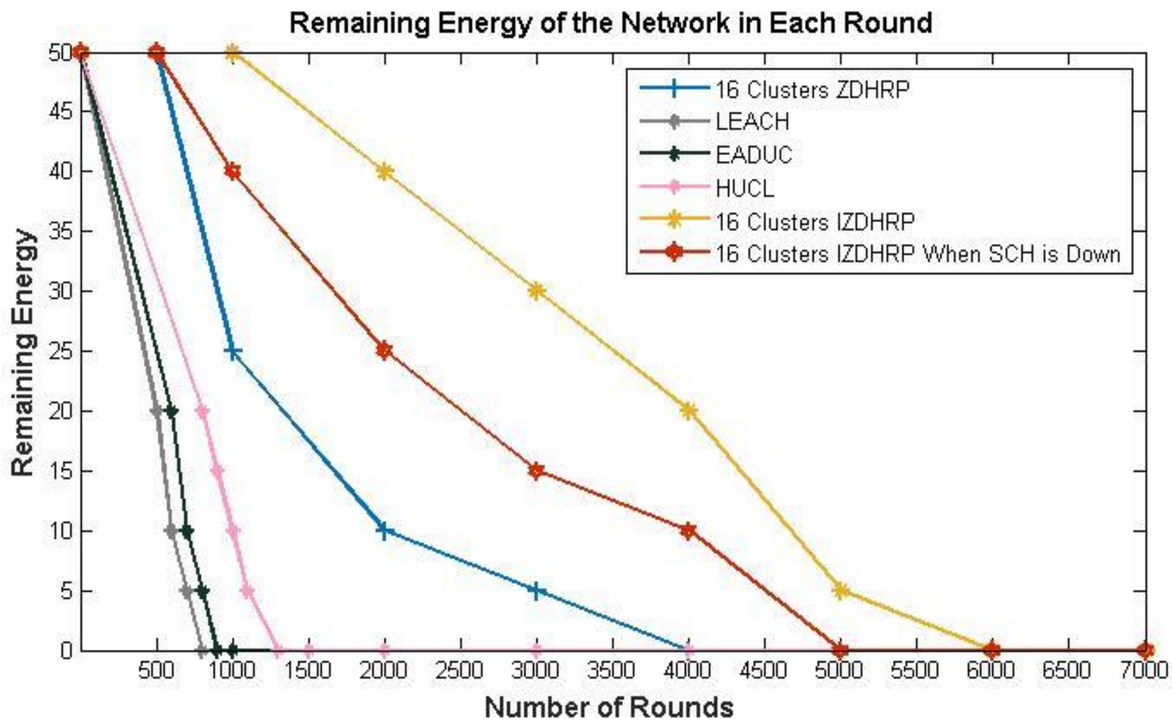

Fig 7.12: Remaining energy of the network in 16 clusters case when SCH is Down

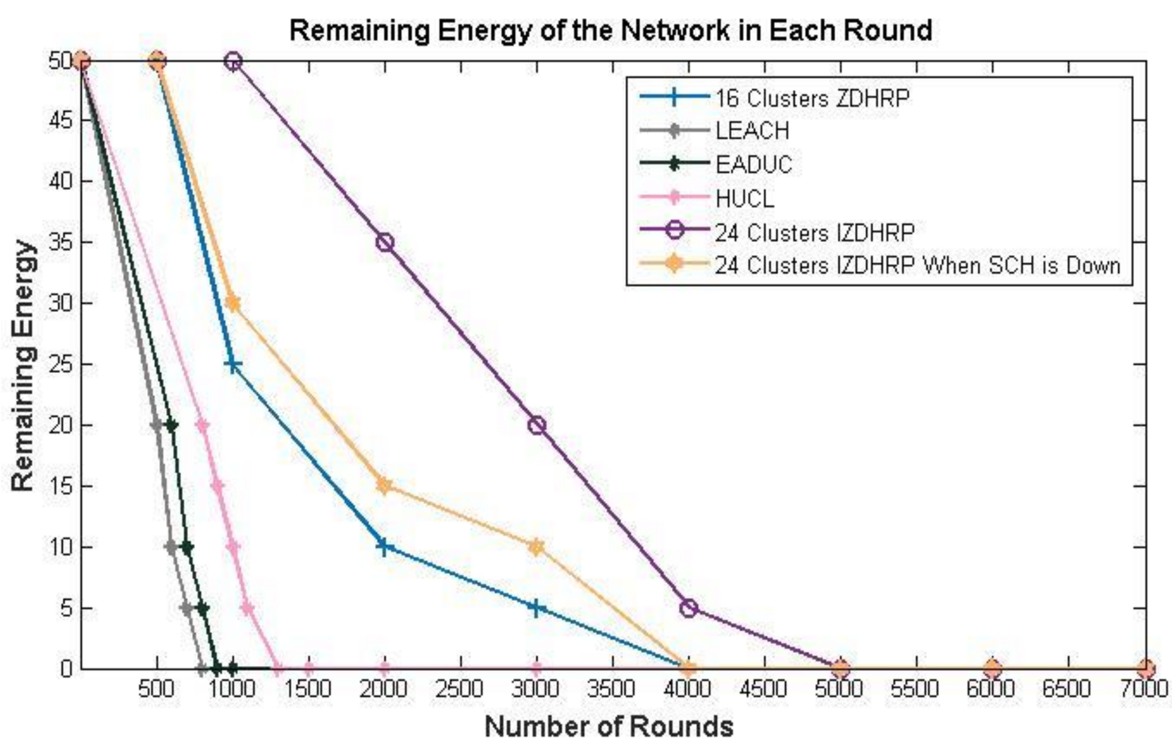

Fig 7.13: Remaining energy of the network in 24 clusters case when SCH is Down

7.5 Simulation results of IZDHRP & comparison with benchmark schemes

The following table (7.2) describes the simulation results of our proposed protocol IZDHRP and comparison of it with benchmark protocols which are LEACH, EADUC, HUCL and ZDHRP. In our proposed protocol IZDHRP simulation is implemented in three cases which are 8 clusters, 16 clusters and 24 clusters. The following table elaborates the results and performance of the protocols while considering the factors involved in it.

The factors are FND, HND, PNA and LND. Each protocol describes its set of rounds in which these factors involves. The simulation results of our three cases is compared with the ZDHRP, LEACH, EADUC and HUCL protocols and we can see that our all three cases have efficient results as compared to the benchmark protocols.

In 24 clusters case while comparison of it with benchmark protocols the set of rounds in all factors describes that it is efficient as compared to all the benchmark schemes and it placed in third number in our simulation results. In 16 clusters case while we are considering set of rounds in all factors, we can see that our 16 clusters case is efficient as compared to the benchmark schemes ZDHRP, LEACH, EADUC and HUCL. This 16 clusters case is placed in second number in our simulation results. 8 clusters case is the most efficient case in our proposed scheme and the results shows that number of rounds with respect to the factors are more as compared to the other cases. So, the following table of simulation results shows that our proposed scheme in all three cases has efficient results as compared to the benchmark protocols ZDHRP, LEACH, HUCL and EADUC.

Table 7.2: Simulation Results comparison in benchmark Protocols

Factors	**Number of Rounds**						
	LEACH	**EADUC**	**HUCL**	**ZDHRP (16 Clusters)**	**IZDHRP (8 Clusters)**	**IZDHRP (16 Clusters)**	**IZDHRP (24 Clusters)**
FND	440	540	690	1659	4330	3500	3059
HND	574	660	840	1785	6200	5517	4530
PNA	487	600	750	1705	5088	4073	3132
LND	650	750	1100	2450	7320	6584	6040

CHAPTER 8

CONCLUSION AND FUTURE WORK

In WSNs hot spot issues are still an open challenge. Hot-spot or energy hole issues makes the network system halt, partitioned the network system, coverage area get disappears, reduces the efficiency of the system and in addition to decreases the network lifetime. Many clustering protocols in past like dynamic and unequal clustering technique had try to overcome this issue but they have a lot of other issues while mitigating this problem which are overhead and connectivity issues. So static and equal clustering technique is something efficient for avoiding hot spot or energy-hole problem. But in some extent static clustering technique also have hot-spot or energy-hole issues while we are considering the number of clusters in a zone and hence it decreases the lifetime of the network system and its stability. We have developed an efficient static and equal clustering technique called IZDHRP which mitigate and overcome the hot-spot or energy hole issues faces in ZDHRP protocol. We are using dual cluster head mechanism in our proposed scheme and due to this there is balanced energy consumption among the clusters. Moreover, we are considering Zone controller node and the purpose of it to overcome the load on the cluster heads. We have implemented three cases in our proposed algorithm which are 8 clusters, 16 clusters and 24 clusters. The simulations of our proposed scheme IZDHRP is done using MATLAB tool. The results show that our proposed algorithm IZDHRP outperforms better performance as comparison with other schemes. IZDHRP algorithm has the ability that it increases the network lifetime and stability in all three cases which are 8 clusters, 16 clusters and 24 clusters.

In our proposed protocol the network lifetime of the 24-clusters case is less than that of 16 clusters and 8 clusters case. In future work we will emphasis on enhancing and improving the scheme of 24 clusters case in such a way that its network lifetime will be increases more than 16 clusters case and 8 clusters case. To overcome this issue different efficient clustering technique can be investigated.

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