Efficient data collection protocol for hybrid network structure for WSN

MS Thesis

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Final Approval

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Abstract

Wireless Sensor Network (WSN) consists of distributed nodes to cooperatively monitor physical or environmental conditions; these nodes are battery powered devices and have limited energy. We consider that if one node will become dead it will affect the life time of the whole network, so energy efficiency and load balancing is the most critical parts of this network. Many research works have been done for energy efficiency through different routing mechanism but mostly they ignored data collection efficiency. Our focus is on efficient topology creation mechanism to increase the network life time. With an efficient data collection mechanism energy resources can be saved and information is delivered more quickly and efficiently. We proposed a new data collection mechanism which can be implemented on heterogeneous network (in terms of energy) and this mechanism will work better than existing techniques, where sensor node have different characteristics and can be implemented of different type of topology. Efficient implementation of data decision/fusion technique is the characteristics of our proposed Algorithm. The solution is implemented through Castalia simulation Tool in OMNET++ environment.

DECLERATION

I hereby declare that this work, neither as a whole nor as a part has been copied out from any source. It is further declared that I have conducted this research and have accomplished this thesis entirely on the basis of our personal efforts and under the sincere guidance of my supervisor Prof. Dr. Muhammad Sheer. If any part of this project is proved to be copied out from any source or found to be reproduction of some other project, I shall stand by the consequences. No portion of the work presented in this dissertation has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning.

MUHAMMAD TAHIR

550-FBAS/MSCS/F09

A Dissertation submitted to the

Department of Computer Science

International Islamic University Islamabad

As a partial fulfillment of requirements for the award of

The degree of

MS in Computer Science

DEDICATION

I dedicate this research project to my beloved

PARENTS

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All praise to Almighty Allah who has all the names, and who needs no name the most generous, considerate, and compassionate who has blessed mankind with this verdict to think, explore, to learn and discover the hidden secrets of this universe and helped me to broaden the veils of my thought and enabling me to get through the difficulties indulged during this project. Also admiration to our beloved Prophet Muhammad (PBUH) who is always a great source of inspiration of divine devotion and dedication to me.

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Project In Brief

Project Title:	**Efficient data collection protocol for hybrid network structure for WSN**
Organization:	**International Islamic University, Islamabad (IIUI)**
Undertaken By:	**Muhammad Tahir (550-FBAS/MSCS/F09)**
Supervised By:	**Prof. Dr. Muhammad Sher** **Chairman, Department of Computer Science** **International Islamic University, Islamabad**
Start Date:	**November,2013**
Completion Date:	**October,2014**
Tools & Technologies:	**Castalia, Omnet++,MS Office 2013,**
Operating System:	**Windows 7,** **Ubunto**
System Used:	**Intel(R) Pentium(R) Dual Processor 1.6 GHz** **RAM 1 GB** **120 GB Hard Disk**

LIST OF FIGURES

LIST OF ABBREVIATIONS

WSN:	Wireless Sensor Network
LAN:	Local Area Network
MAN:	Metropolitan Area Network
WAN:	Wide Area Network
WLAN:	Wireless Local Area Network
TOSSIM:	TinyOS Simulator
NesC:	Network Embedded System C
OS:	Operating System
SOS:	Sensor Network Operating System
CH:	Cluster Head
BS:	Base Station
QoS:	Quality of Service
CPU:	Central Processing Unit
GHz:	Giga Hertz
ROM:	Read Only Memory
RAM:	Random Access Memory
EEPROM:	Electronically Erasable Programmable ROM
FPGA:	Field Programmable Gate Array
RSSI:	Received signal Strength Indicator
CRC:	Cyclic Redundancy Check
ADC:	Analog to Digital Converter
GUI:	Graphical User Interface
CLI:	Command Line Interface
IDE:	integrated Development Environment
LED:	Light Emitting Diode
RFM:	Radio Frequency Module
AM:	Active Messages
LASER:	Light Amplification by Stimulated Emission of Radiation
LEACH:	Low-Energy Adaptive Clustering Hierarchy
EYES:	Energy Efficient Networks
IEEE:	Institute of Electrical and Electronics Engineers

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CHAPTER 1

INTRODUCTION

1. Introduction

Wireless sensor networks (WSNs) have gained significant importance in the field of Computer Science and in communication technologies in the last few years. Wireless Sensor Network (WSN) are used for different application, typically involving some kind of monitoring, controlling, fire detection, land slide detection tracking, medical science, traffic monitoring. In a typical Small tinny node spread in selected area they sense the information and forward it towards a Base Station (BS) who performs the computing function on received information [1].

1.1 Wireless Sensor Network

Wireless networking comprised of number of numerous sensor nodes interlinked or connected with each other that performs the same function collectively or cooperatively for the sake of common task.

Sensor networks are used in application known as battle field surveillance which is completely a military application but now days it's also play an important part in civilian technologies like monitoring the physical conditions such as weather conditions, regularity of temperature controlling traffic etc.

1.2 Structural Design

WSN functions include sensing and computing:

- **Sensing portion** is a combination of small, cheap and efficient sensor nodes called motes. These tinny nodes collect required valuable information via sensing the area of interest while
- **Computing portion** called base station consists of a high profile system that has high processing capabilities.

Sensor nodes have very limited side of battery so the node having computing burden will become dead soon therefore routing in wireless sensor network is very complex task. As energy awareness is an important design issue so different routing model are develop to perform the routing task efficiently that uses low power recourses to save the energy and increase the life time of the WSN. [2]

Figure 1.2 describes the architecture of WSN sends data to remote station.

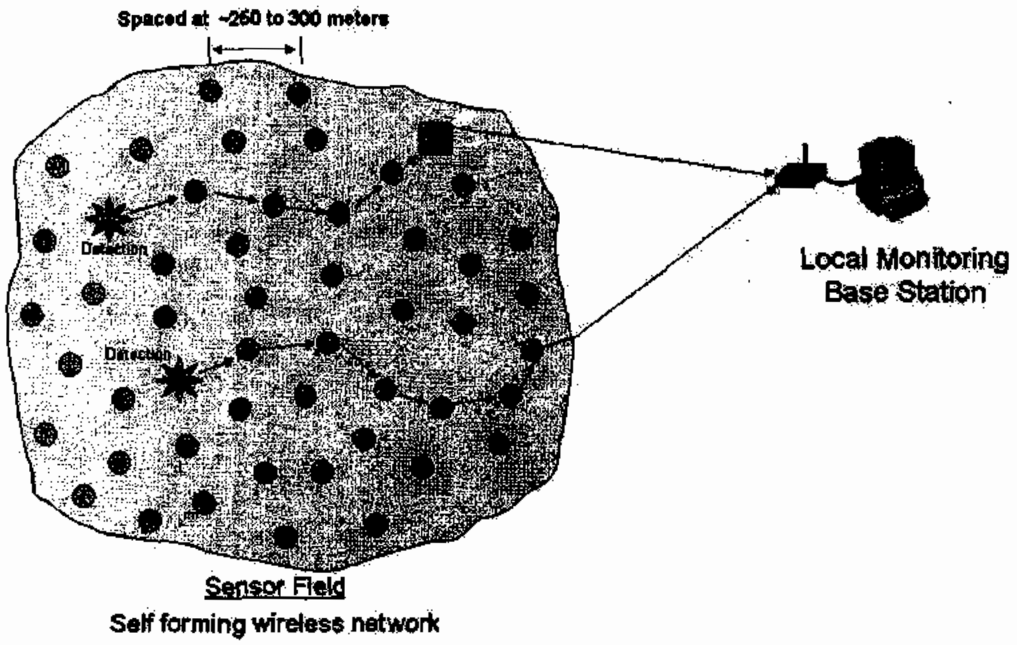

Figure 1.2 Architecture of a Wireless Sensor Network

1.3 WSNs Design Factors

These are the main factors on which the performance of the WSNs depends [1].

Radio Technologies: The flexibility and capacity are of the WSNs are very crucial. To enhance the performance of the WSNs different types of advanced radio technologies are used such as self-configuring radios, software base radios and the frequency agile radios.

Connectivity: The main advantage of the WSNs is connectivity. For the better connectivity the network must be self-configurable and optimized algorithms are required to control the topology.

Scalability: One of the major requirements of the WSNs is scalability. If the network is not scalable then the performance of the network significantly decreases as the size of network increase. For better performance all the protocols from data link layer to application layer must be scalable.

Broadband and QoS: Most of the WSNs systems use the broadband services which required heterogeneous type of Quality of Service (QoS) requirements as compared with the typical ad-hoc networks. The performance of the WSNs not only depends on the end-to-end delay and fair allocation of resources but some other factors such as aggregate throughput, ratio of the packets lost and per node throughput must be considered to enhance the QoS.

Security: There are number of security schemes for the ad-hoc networks which can be implemented on the WSNs but most of the schemes for ad-hoc networks are not too much mature for the practical implementation on the WSNs. The solutions of the typical ad-hoc networks are not much effective for the WSNs due to the internal architecture differences. That's why some optimized security schemes are required.

Ease of Use: The network should be self-configurable and autonomous as maximum as possible and design the protocol which ensure this property. There must be some network managements system for better performance measurement to manage the network operations and configure different properties and parameters of the WSNs. Combining optimized protocols and network management system enables rapid and secure deployment of the WSNs [3].

1.4 Hardware Architecture:

Hardware platform designed is an important part of wireless sensor networks. We already discussed that WSN consists of large number of small nodes with sensing, computation, and wireless communications capabilities. On the basis of capabilities a wireless sensor node is composed of four basic components which include a sensing unit, a processing unit (microcontroller), a transceiver unit and a power unit. [4]

A typical node with its components is presented in Fig 1.4.

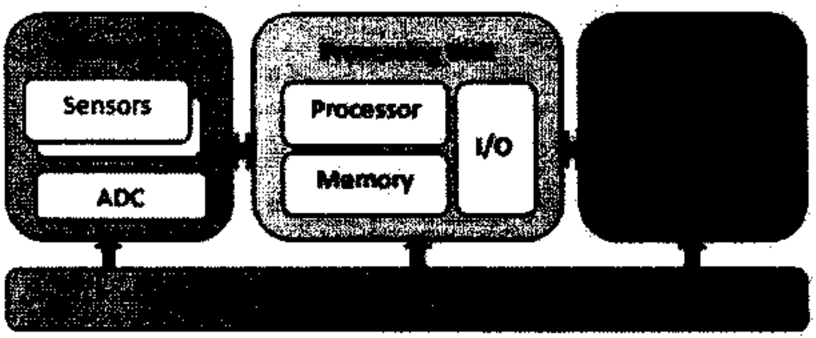

Figure 1.4 Architecture of a Wireless Sensor Node

A wireless sensor node may include multiple sensors providing complimentary data. A sensing unit is typically composed of a number of sensors and an analogue to digital convertor (ADC) which digitizes the signal. A Processing unit provides the processing power for sensor node and coordinates the activity. A microcontroller integrates processing with some memory provision and I/O peripherals.

A transceiver unit allows the transmission and reception of data to other devices connecting a wireless sensor node to a network. Wireless sensor nodes typically communicate using an RF (radio frequency) transceiver and communications tend to operate in the RF industrial, scientific and medical (ISM) bands which are designed for unlicensed operation. Wireless sensor nodes must be supported by a power unit which is typically some form of storage called battery. In wireless sensor node environments maintenance operations such as battery changing are impractical.

1.5 Software Architecture:

A critical step towards achieving the vision behind wireless sensor networks is the design of software architecture. Software of wireless sensor networks must be efficient in terms of real time sensor processing, time synchronization, maximizing battery life , managing data and events, and an easy to use user interface [5].

Different operating systems are available to implement and develop routing algorithms for WSNs like Contiki [6], EYES [7] and SOS [8] which are specifically designed to address the needs of wireless sensor networks.

A very renowned and Well-defined operating system TinyOS [9] which is a lightweight open source operating system for wireless embedded sensors. It is designed to use minimal resources and its configuration is defined at compile time by combining components from the TinyOS library and custom-developed components.

1.6 Wireless Sensor Networks applications

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate Magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of Ambient conditions that include the following [10]:

- Temperature,
- Humidity,
- Vehicular movement,
- Lightning condition,
- Pressure,
- Soil makeup,
- Noise levels,

1.7 Homogenous and Heterogeneous network:

In homogeneous networks all the sensor nodes with in a network are identical in terms of battery, energy, processing power, memory and other hardware complexity and operating system.

In a heterogeneous sensor network, two or more different types of nodes having different battery and energy sizes may be configured with more powerful process and more memory and also with different hardware complexity [11].

1.8 Data fusion technique:

"The integration of information from multiple sources to produce specific and comprehensive data is called data fusion".

Data fusion techniques are used to integrate information from multiple sensors and integration of these multiple information and knowledge into a comprehensive form, aiming towards into a consistent, accurate, and useful representation. Data Fusion Working Group, established in 1986, created a process model of data fusion by codify the terminology related to data fusion [12].

Many applications are widely used for multisensory data fusion. Military applications include: automated target recognition, guidance for autonomous vehicles, remote sensing, battlefield surveillance, and automated threat recognition systems, such as identification-friend foe-neutral (IFFN) systems. Nonmilitary applications include monitoring of manufacturing processes, condition based maintenance of complex machinery, robotics, and medical applications [13].

CHAPTER 2

LITERATURE REVIEW

2. Literature Review

Ideally, we would like the sensor network to perform as long as possible. Our focus is to save the energy through minimizing the delay in data collection process from sensor node toward cluster head or base station we have studied some of latest work done in this area.

B. Krishnamachari et al [1] proposed the idea to combine the data coming from different sources because of the limited energy resources of sensor nodes, data need to be delivered in the most energy-efficient manner without compromising the accuracy of the information content. Two Simple Models of Data routing schemes which use data aggregation for routing are data centric and address centric. Optimal and sub optimal data aggregation method are studied. The main factors that can affect the performance of data aggregation method are the position of the network, the number of sources, and the communication network topology. The simulation tells us that whether the sources are clustered near each other or located randomly, significant energy gains are possible with data aggregation but due to lack of proper network structuring the network has remains the problem of energy issues.

Jamil Ibriq and Imad Maghoub discussed and design the routing protocol for wireless sensor network. They grouped all routing model into three different categories. Following is the description of work done in each routing model [2].

2.1. One Hop Model:

This is simplest routing category of WSN which send data directly to base station, it does not depend on how far the node is from Base station if it is in the range of base station then it send the data to base station directly [14].

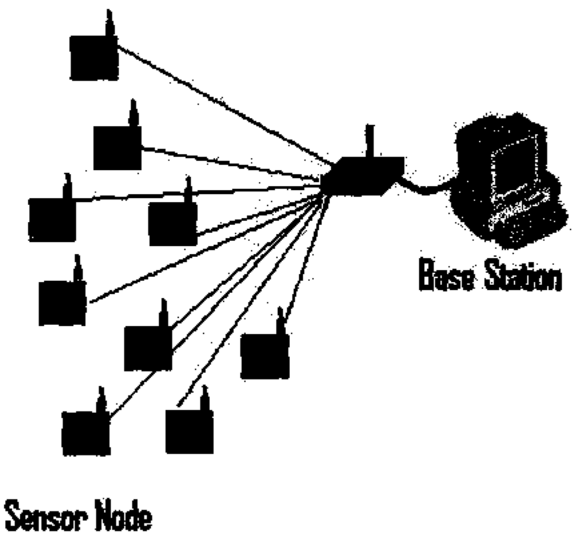

Figure 2.1

Limitations of One Hop Model

One hop model is not feasible because each node have limited transmission range and many time their transmission cannot reach to base station. If we use direct routing in large network then all nodes will send their data directly to Base Station. The node at maximum distance to BS will have to consume extra energy to send its data to BS. So after sending very small amount of data packets it utilize large amount of energy the death of that node will occur very soon which leads to small network lifetime. So adopting direct routing in large network size is not feasible.

2.2. Multi-Hop Model:

In Multi-hop model sensor nodes chose their neighbor node to forward data toward the base station instead of direct sending to base station. In this model less energy is utilized depending upon the topology of WSN [8].

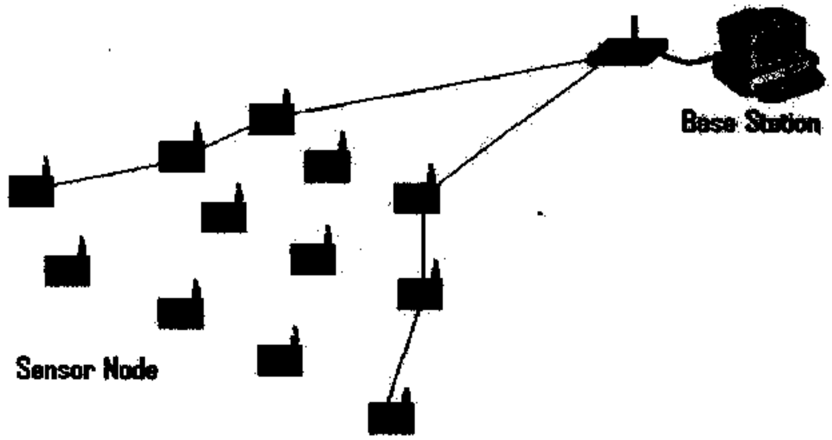

Figure 2.2 Limitations of Multi-hop Routing

If we use Multi-Hop routing In WSN then each node send its data packet to its neighbor so the nodes closer to the BS will get maximum load of the network because they have to send their own data as well as data from other nodes therefore the node closer to the BS will dead very soon. If this scenario is considered in large network size, then huge number of data packets will be routed through these closer nodes. This will drain the energy levels of the closer nodes very quickly. So Multi Hop routing in large network size is also not feasible.

2.3 Cluster-Based Model:

A cluster is a group of resources that act like a single system and enable high availability and, in some cases, load balancing and parallel processing. In WSNs whole network is grouped into clusters. Each cluster has one node that act as cluster head that gets the sensed data from cluster member nodes and then sends it to other cluster heads or direct to the base station [8].

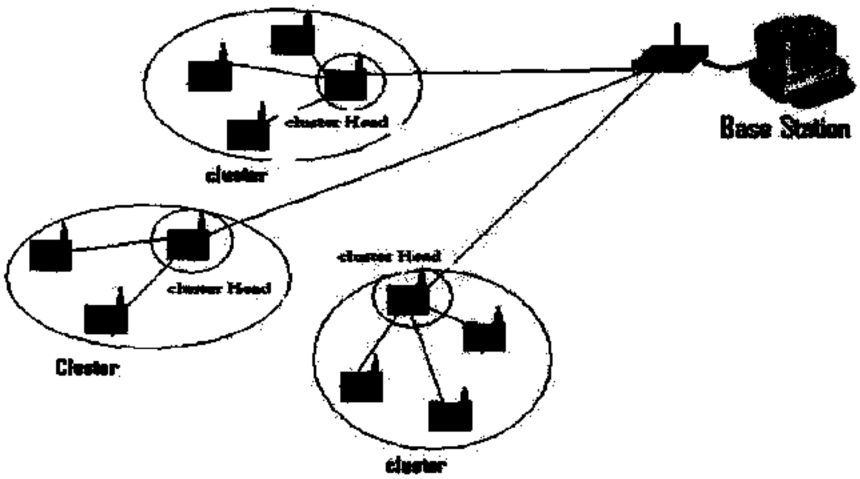

Figure.2.3 Limitations of Cluster Base Routing

In a cluster based model when a cluster is created then NO node can be added or removed at runtime, it remains as it is till the death of all the nodes. So this solution works only for static networks. And the network near to base station will carry out the information of the many nodes and overloaded which died quite early resulting in end of lifetime of network whereas some nodes remained with lot of energy.

I.Solis et al [3] discussed the impact of timing in data aggregation in WSNs that how much impact is occurred and the timing model defines when to "clock out" data as it is aggregated by nodes on its way to the information sink. The question is how long a node should wait to receive data from its children. If nodes wait too long, data produced in the next period will interfere with data from previous periods so three different timing models are compared [3]. In these three timing models the in-network data aggregation can achieve considerable energy savings.

WB. Heinzelman et al [4] proposed and analyzed LEACH architecture which. LEACH is based on the Clustering infrastructure. Since individual nodes data are highly correlated, so Cluster head are chosen to receive data from individual nodes (Cluster members) to process locally. And this transfused data are sent to base station by Cluster head. Therefore, being a cluster head node is much more energy intensive than being a non-cluster head node. So LEACH randomized the

Cluster Head Position. LEACH for this purpose use round technique for choosing cluster head. Since network life time is improved in this technique but if network structure remains constant than the cluster head loss energy in transmitting huge data of cluster members so changing of network structure is necessary for energy of cluster head.

Z.Chen et al [5] estimates the effects of variations of network structure and routing strategy by incorporating local traffic information into the basic shortest path routing policy on network capacity. It is also observed that the network capacity is greatly enhanced when the new traffic awareness routing strategy is adopted in each network structure.

H.Luo et al [6] proposed MFST, energy efficient data gathering with aggregation (fusion) routing protocol is for routing correlated data in sensor networks which not only optimizes over the data transmission cost, but also incorporates the cost for data fusion, which can be significant for emerging sensor networks with vectorial data and/or security requirements. Analytical and experimental results show that MFST adapts well to varying network conditions including network topology, fusion cost, and the degree of correlation.

Min Song, Bei He [7] analyzed the performance and the network capacity of two different architectures, named flat sensor network and clustered sensor network. It is found that there is a critical value of the number of cluster heads beyond which the network capacity of two clustered models approaches the same. Numerical results suggest that clustering can significantly improve the network capacity.

R.Saravanakumar et al [8] analyzed the basic LEACH protocol and proposed a new routing protocol and data aggregation method in which sensor nodes form the cluster and elects the cluster head based on the residual energy of the individual node calculation without re-clustering and the node scheduling scheme is adopted in each cluster of the WSNs .Energy efficiency is improved but network structure remains constant and distance among sensor nodes is also not considered so the distance and energy of cluster head is compromised in this protocol.

Hai Van Luu et al [9] proposed a generic scheduling algorithm for data collection through multi-path routing structures in wireless sensor networks. In this proposed protocol child nodes always make their schedules before their parents. Although running time and the message complexity of scheduling is reduced but if the cluster heads losses their energies than restructuring is necessary.

BS. Mathapati et al [10] developed data aggregation technique which considers energy and reliability .Cluster head is chosen on the basis of cost value, Neighbor information table (NIT) is maintained for sending it to cluster head which decides on the basis of loss ratio. This technique lacks network restructuring and choosing new cluster head so energy issue remains for cluster head and in other cluster nodes. Since this application work in those area where data reliability is main concern.

C T Cheng et al [11] proposed delay aware structure by organizing sensor nodes into clusters of different sizes such that each cluster can communicate with the fusion center in an interleaved manner and proposed a delay-aware data collection network structure to minimize delays in the data collection process of WSNs. Two network formation algorithms are designed to construct the proposed network structure in a centralized and a decentralized approach. Simulation shows that the proposed network structure is able to shorten the delays in the data collection process significantly. The Cluster members send fusible data to Cluster head which normally performs fusion process. Since clustering consumed extra energy consumption and delay in a data collection process so energy and network structure should consider to rebuild the network structure.

Israr [12] proposed a technique which base on cluster based routing which concern with Load balancing in WSN with efficiency in energy consumption. According to his proposed algorithm two layered communication is achieved by using temporary Cluster Head. Nodes at bottom layer send data to respective temporary CH and at top layer the temporary CHs adopt multi-hop routing to deliver the data to the Base station. Although author proves that his algorithm is energy efficient but selecting temporary CH phenomena required another algorithms for execution of some cluster head selection requiring more energy and have life time of the network will decrease.

Irfan Ahmed et al [13] presented algorithm for WSN in which he proposed adaptive cluster routing technique. He used Cluster ID based routing instead of CH-ID in routing table i.e., when a node sends data to a cluster then Cluster ID is used as a next hope which eliminate the cluster creation process for each round and hence increase energy efficiency and life time of the network.

Author only has considered adaptive feature in routing and hence cluster will remain static till the end of network i.e there is no addition or subtraction of node from that cluster.

Another adaptive intra cluster routing protocol presented by Raja Adeel Akhtar et al [14] in which direct and multi-hope model both are used. A close region is formed by the nodes near cluster head and the nodes related to close region will send data direct to the cluster head and the nodes outside of the closed region will send data to their neighbors. Author achieve energy efficiency and improve the life time of the network but the nodes near to close region and using multi-hope routing overloaded as sending the data of many node along with that by which results in an early death of that node.

Bashir Ahmed [15] presented an Hybrid Adaptive Intra Cluster Routing protocol for energy efficiency. He uses direct routing along with multi-hope routing. Nodes change their node of routing form direct to multi-hope on the basis of their current energy level, at the start of the network every node in the network send its data to base station after some time a close region is created for long distance node and three nodes start multi-hop routing and close region size will increase with the passage of time. Author has used this technique in expanded size of region on the basis of remaining energy of nodes and achieve the energy efficiency but he didn't describe that how many intermediate nodes will be used in multi-hope routing and which node will be used as intermediate node

Chi-Tsun Cheng et al [16] investigates the trade-offs among the data collection in a delay-aware data collection network structure using the concepts of Pareto optimality.

Chi-Tsun Cheng et al [17] proposed delay-aware data collection network structure for wireless sensor networks Two network formations algorithms were designed to construct the proposed network structure using centralized and a decentralized approaches. A network with clustering is divided into several clusters. Within each cluster, one of the sensor nodes is elected as a cluster head (CH) and with the rest being cluster members (CM). The cluster head will collect data from its cluster members directly or in a multihop manner and fusing the data by means of data/decision fusion techniques. This structure shortens the delay in the data collection process significantly. But network structure is fixed so the issue remains that as the network life time decreases as the cluster head losses energy.

LEACH (Low-Energy Adaptive Clustering Hierarchy), a well-known routing protocol, it is developed by Heinzelman et al [18] is a typical clustering protocol proposed for periodical data gathering applications in wireless sensor networks. In LEACH, each node independently elects itself as a cluster head with some probability. Cluster heads receive and aggregate data from cluster members and then send the aggregated data to the BS by single-hop communication. In order to balance energy dissipation, the role of cluster head is periodically rotated among the nodes. LEACH protocol is simple and does not require a large communication over-head. However, the performance in heterogeneous networks is not very well, because it does not elect cluster heads based on residual energy of nodes.

+/-: The main focus of the author is on the selection of the cluster head. This paper has nothing to do with the routing techniques used by the sensor nodes other than the cluster head. Moving the cluster head from one node to another again involves execution of cluster head selection algorithm, which in turn consumes energy. So reduces the network life time.

All algorithms that we have discussed above have emphasized on proper utilization of energy in the sensor node. But they ignore the fact how to transmit data faster. It is well known that efficient energy is most important factor to sensor node so we cannot also ignore it. So in our approach we try to give importance to both factors, that is to transmit data to base station faster as well as in an energy efficient way.

CHAPTER 3

PROBLEM IDENTIFICATION

3. Problem Identification

In the survey section we have thoroughly discussed the different models for data collation and network creation along with their limitations regarding to delay, energy efficiency and scalability of network. We found some problems in latest and currently the most efficient research published by Chi-Tsun Cheng et al [17] in 2011 in delay-aware data collection network structure for wireless sensor networks, which are discussed below.

3.1 It can only be implemented on homogenous WSNs

Researcher only work for homogenous network where the entire node have same characteristic like available energy, processing power, transmission unit etc. In heterogeneous network this technique will not work because all the node don't have same characteristic specially a network containing multivendor sensor where each sensor node has different characteristic. The author stated that only the distance parameter results in variable amount of energy consumption where all other energy cost are fixed so along with distance there are few more parameters need to consider i.e. remaining energy etc. so a modified efficient data collection protocol for hybrid network structure for WSN is required to achieve efficiency in heterogeneous network. The author of the base paper assumed that power and other characteristics of the sensor nodes are same throughout the network.

3.2 Algorithm is implemented only once (at the time of network creation)

The data that flows from nodes to BS via different other nodes depends upon the structure of the network created at the start. According to the authors it is the most efficient data collection mechanism compared to other latest available mechanisms. But with the passage of time the energy of all the nodes decreases at variable rates as each node has collected and forwarded different numbers of data packets from different distances. So implementing the solution only at network creation time results in more energy consumption and load unbalancing hence reduces the overall network lifetime.. Fig 3a shows the energy level of each node at start of the network T0, where every node has same energy level.

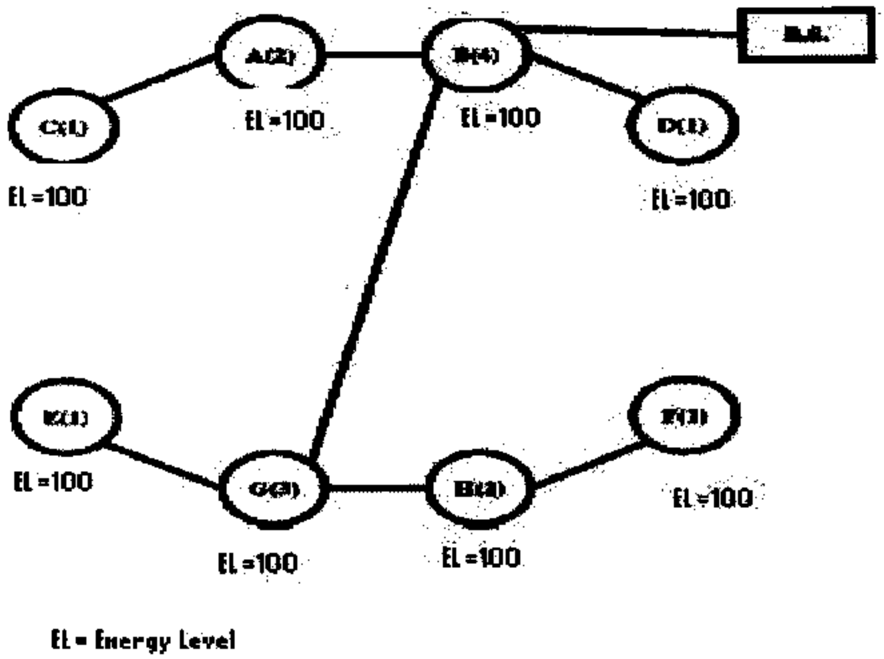

Figure 3a: Energy Level (EL) of nodes at time t_0

Fig 3b shows the diagram of the network after some time interval T1 where energy level of each node has changed as per utilization of node. The node at the edge only sensing and transmitting their own data to other node will utilize less energy than other node which have transmitting other node's data along with their own data.

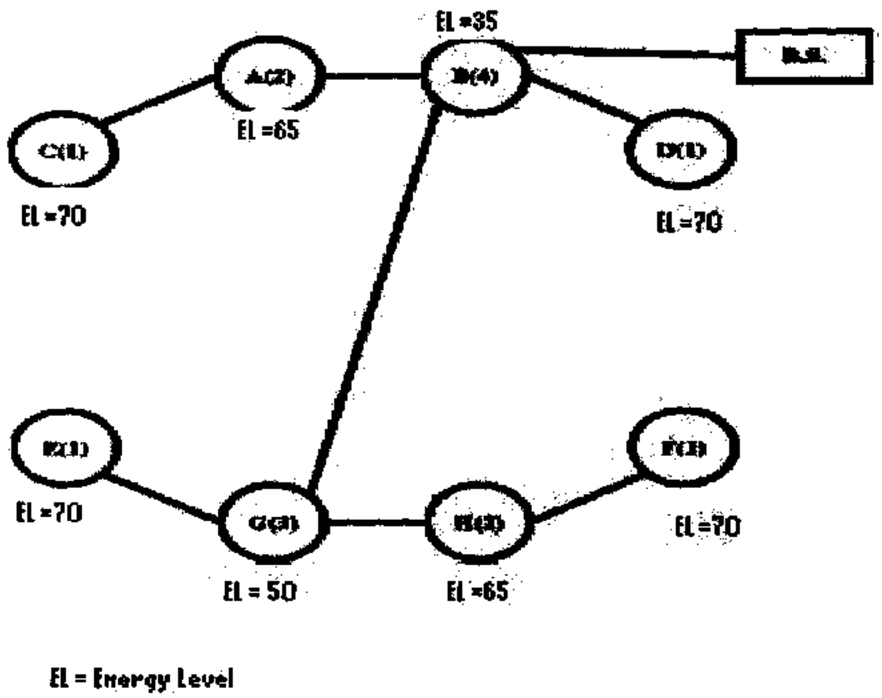

Figure 3b: Energy level of nodes at time t_1

Fig 3c shows the energy levels of the node after time interval T2 where node B (4) which have maximum load of the network nearly losing their battery life and other node still have enough energy level. So the other nodes will reconsider by restructuring of network.

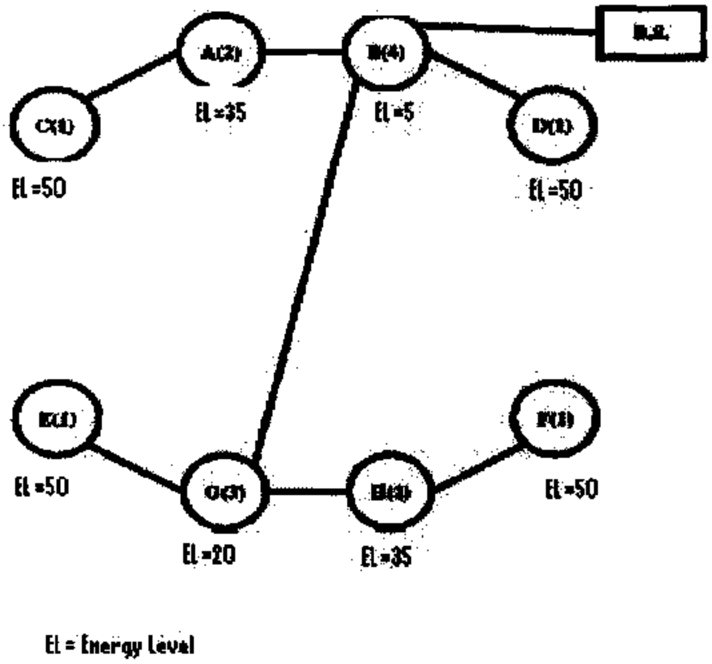

Figure 3c: energy level of nodes at ti

Now the problem is to find the Cluster Head which has remaining Energy which we have to choose on the basis of searching for node with more energy and new Cluster head thus selected will give us maximum network life time. So we will restructure our network according to maximum energy levels and nearest hop.

CHAPTER 4

PROPOSED SOLUTION & METHODOLOGY

4. Research Objectives

The Objectives of this Research are as follows:

- Efficient Topology creation mechanism to increase the network life time.

"An efficient data collection protocol for hybrid network structure for WSN" is efficient data collection technique which can be implemented on heterogeneous network where each node has different characteristics and different topologies i.e. Mesh, grid etc.

The major objectives for the development of our "An efficient data collection protocol for hybrid network structure for WSN" are:

- Must have support for large number of nodes.
- To take the benefits of both Direct and Multi Hop routing.
- Must be better than traditional routing techniques.
- Must have better data Collection Time
- Must have better data transmission time
- Must be energy efficient.
- Increased Network lifetime.
- Must have capacity of adding and flexibility of removing nodes

Our major research objectives are to minimize the delay in data collection from sensor node toward BS with efficient utilization of energy of each node within the WSN and to increase the overall life time of the network.We want to increase network life time and it will be achieved by reducing many costs such as routing delay. We will be developing a data collection protocol which will provide an efficient use of data fusion technique and network creation to achieve maximum life time of the network.

4.1 Proposed Solution

In this chapter we will discussed the proposed solution and methodology.

To meet the above mentioned problems we proposed a solution which is complete in every respect to solve the data collection routing and energy issue and shall increase network life time following this we will discuss efficient data collection mechanism.

4.1.1 Energy Efficient & Hybrid Adaptive Next Hop Routing

Routing is the key in wireless sensor network as it effects energy consumption of each node when it communicates with the other nodes in the network.Hence, non-efficient routing results in higher energy consumption thereby rendering the nodes "dead". It is because of this that researcher pay special emphasis on routing in WSN.

Adaptive routing mechanism for WSN is efficient energy utilization techniques which take the benefit of both direct and multi-hop model and change the routing model according to conditions.

Our major research objectives are to achieve efficient utilization of energy of each node with in the WSN. We will provide a routing protocol which provide load balancing for routing of nodes data to base station

4.1.2 Design Features

Our proposed routing protocol "Efficient data collection protocol for hybrid network structure for WSN " have following features

- Better Network Structure for data collection through efficient routing.
- Solution of Two problems " to find next hop with maximum energy and to find next Node"
- Energy Efficient routing Mechanism
- Routing Mechanism to change routing model from One hop to Multi Hop
- Increase lifetime of the network
- better than traditional routing techniques

In this section we shall discuss a new network formulation mechanism that can be applied on heterogeneous types (in terms of energy) of wireless sensor networks. Here the word heterogeneous means a network consists of sensor nodes designed by different manufacturers as well as that nodes also have different amount of battery levels. In this scenario situation becomes more complex and network formulation needs to consider more parameters including energy levels. Our main focus is on routing .We will shuffle the nodes position on basis of different parameters for better network life time. So in the proposed network formulation various number of parameters will be considered and a model will be designed for formulation of network.

In the 2nd module of this work deployment times of the proposed network formulation will be decided. In the existing available solutions network formulation mechanisms are deployed only once at the start of the network. But with the passage of time in heterogeneous networks it is required to reformulate the network structure. So the proposed network formulation will be deployed at different times those will be calculated on the basis of different network parameters.

4.2 Proposed Network Architecture

Since Our Proposed Network Structure is a tree structure. For delivery of maximum data collection efficiency, the number of nodes N in the proposed structure has to be restricted to $N = 2p$ where P =1,2,......It will be discussed in later part that such restrictions can be relaxed by giving up some performance. Each Cluster member has some connection degree for forwarding data to the base station and all the data are correlated so data fusion is still not necessary at node level.

By adopting the proposed network structure, the number of time slots t(N) required for the base station to collect the data from the whole network is given by

$$t(N) = \log_2 N + 1 \qquad (1)$$

so considering the network and by adopting the proposed network structure, the cluster head is the only node with the highest connection degree which is

$$kmax = \log_2 N + 1 \qquad (2)$$

From lemma 1,the number of time slots t(N) is required for a cluster head ,with conncetion degree Kmax,to collect data from its child nodes is

$$t(N)=k_{max}-1=\log_2 N \text{ ....(3)}$$

Thus the number of time slots t(N) require for the base station to collect data from the whole network is the timeslots required by the cluster head to collect all the data from its child nodes plus one i.e

$$t(N)=\log_2 N+1 \text{ ....(4)}$$

Now we proposed in our case that for Single hop Scenario and Multi Hop Scenario.

Let $t(N)=D_n+1$ ....(5)

where D_n=Connection Degree and t(N) is the time slots required for collecting all the data from all the member nodes. And

$k_{max}=D_n$

Where k_{max} is the maximum Rank and D_n is the conncetion degree.

Now according to the above proposed network structure we will build tables from the above equations.

$$E_{TOT}(N)=C1+C2+C3\sum_{i=1}^{N} d_i^2 \text{ .... (6)}$$

where C_2 and C_3 are constants. Here E_{TOT} shows that the total energy consumption of the network can be minimized by re- ducing $\sum_{i=1}^{N} d_i^2$. Thus, the objective of the proposed network formation algorithms is to construct the proposed network structure, while keeping $\sum_{i=1}^{N} d_i^2$ at low value. In this section, two network formation algorithms, namely the top-down and the bottom-up approaches, are proposed to achieve the objective mentioned above A node can transmit and receive at any time. In sensor network, a sensor node is always capable of fusing the all received data packets into a single packet. The size of aggregated packet is independent of number of data packets received.

Form the graph of Figure 4.1 it is clearly shown that our approach is best one as compare to DADCNS.As In previous work it proved that DADCNS approach is better than LEACH, PEDAP, and PEGASIS in case of faster data transmission. For example if N = 8, DADCN was taken 3 time slots where as our approach was taken only 1 time slot. So our approach is the best one in case of transmits the data to Cluster Head (CH) faster.

The proposed network structure is a tree structure. To deliver the maximum data collection efficiency, the number of nodes N in the proposed network structure has to be restricted to $N = 2^P$ where P=1,2,….It will be relaxed in later part for gaining up some performance. Each cluster member will be given a rank which is an integer between 1 and P.A node with rank k will form k-1 data links with k-1 nodes ,while these k-1 nodes are with different ranks starting from 1,2…up to k-1.All these nodes k-1 nodes will become the child nodes of the node with rank k. The node with rank k will form a data link with a node with a higher rank .This higher rank node will become the parent node of the node with rank k. The cluster head will be considered as a special case.The cluster head is the one with the highest rank in the network. The cluster will form only data link to base station.By following this logic the distribution of the rank will follow an in inverse exponential base-2 function, as shown in table 4.2

Rank	1	2	……	$\log_2 N - 1$	$\log_2 N$
No. of Nodes	$\frac{N}{2^1}$	$\frac{N}{2^2}$	……	$\frac{N}{2^{(\log_2 N-1)}}$	$\frac{N}{2^{(\log_2 N)}}$

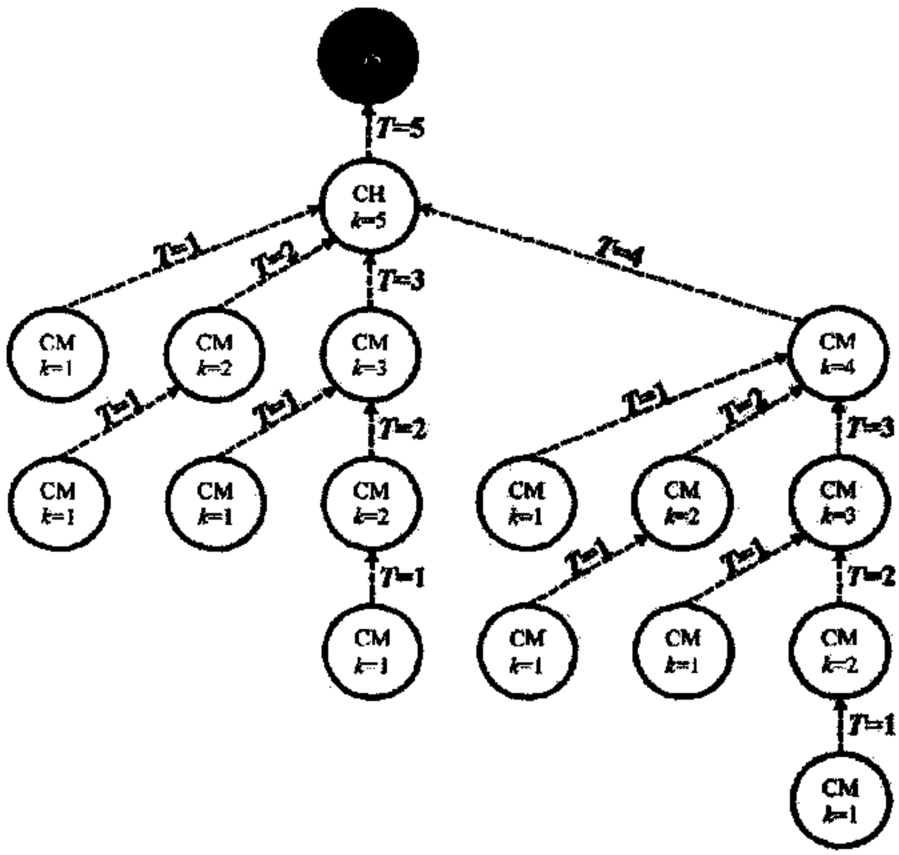

Fig 4.4 Proposed Network with Size *N=16*.Circles with CM represents Cluster Members Circles with CH represents Cluster Heads, Filled Circle represents with BS represents Base Station.*k* reprents the rank of each node. Dashed arrow represents the data link between two node.and the direction of the arrow shows the data flow.

An example of the the proposed network with N=16 is shown in Fig 4.2.In this example ,it takes 5 X T for the base station to collect all data from 16 nodes. By dividing the time domain in to time slots of durations *T*, the above process will last for five time slots.

4.3 Proposed Algorithm

The top down approach is basically a centralized control algorithm. In this technique the base station is assumed to have the coordinates of all sensor nodes in the network .The whole algorithm is going to be executed at the base station. At the end of optimization process, the base station and the child nodes to establish the essential data links and form the appropriate network structure. Now we will explains this algorithm step by step in Fig 4.5.1.

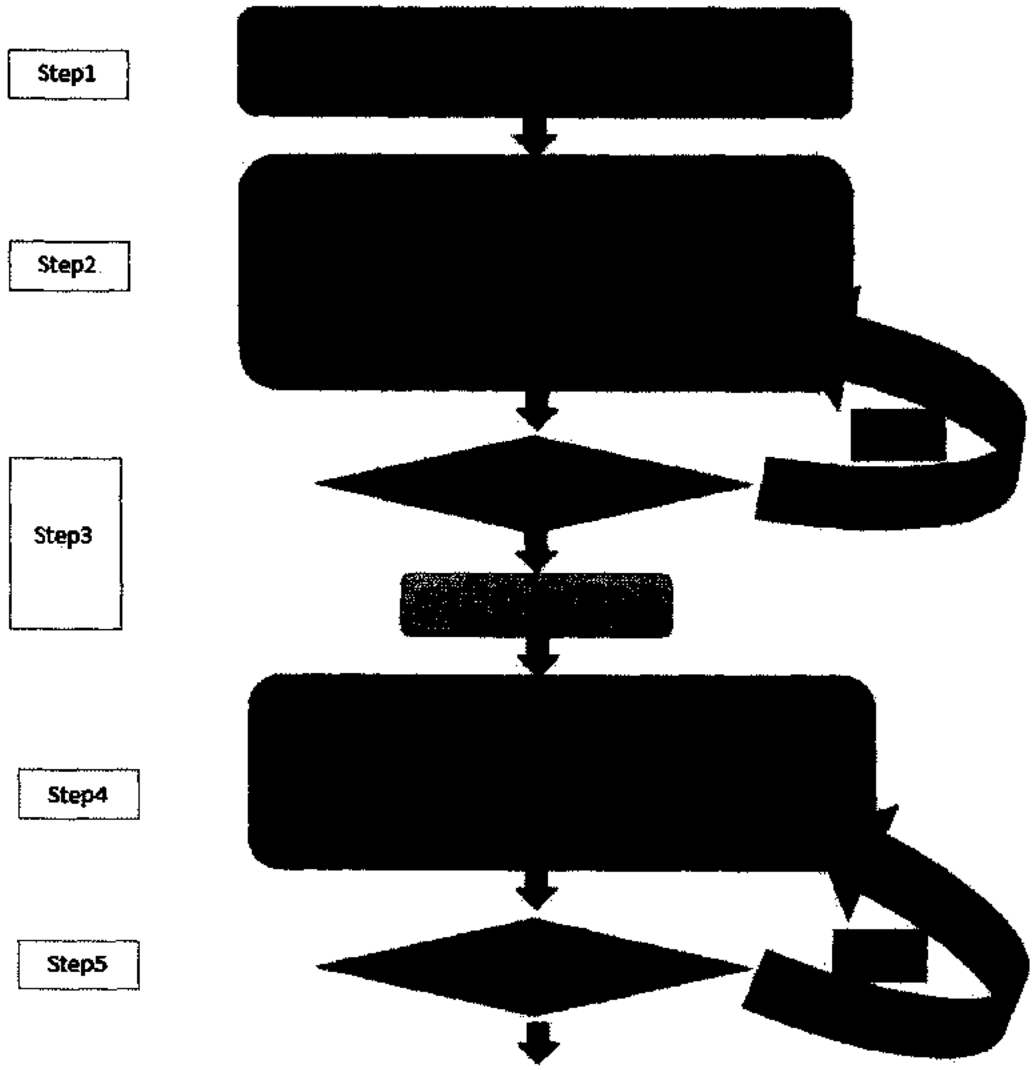

Fig 4.5.1 Network Formation Algorithm

The network constructions for $N = 2^0$ and $N = 2^1$ are trivial. For networks with $N = 2^p$ nodes, where p=2,3…, the proposed network structure can be constructed according to the following steps given in the above algorithm.

Step1. The algorithm starts with considering the whole network as a fully connected network. The term connected refers to the existence of a data link between two wireless nodes. And also two nodes are disconnected from each other if there does not exist any direct link between them. The connection degree of a wireless sensor node is telling the number of data links associated with a such node. A node with connection degree of 3 implies that such a node has formed three data links with other three nodes. For a network of $N = 2^p$nodes, where *p*=2,3,….each node will begin with degree equal to *N-1*.The nodes will form the set $H_{s=1}$..Set *b=N/2.*

Step 2. Select b nodes from set Hs to form set H_{s+1}.,such that$\sum_{i,i \in H_{s+1}} dij^2$ is maximized here.Here dij2 denotes the geographical distance between node I and node j.The rest of the nodes from Hs will form set H_{s+1}..The algorithm will than remove all connections (data links) among nodes withinH_{s+1}..The algorithm will then remove all connections (data links) among nodes within H S+1.Set iterators s←s+1 and b←b/2.

Step 3. Repeat step 2until b<2.set r=2.

Step 4. Nodes with degree *N-r* form set L.Nodes with degree greater than *N-r* form set U such that set *L* and set *U* are of the same number of nodes .Connections among nodes in the two set are reduced until each node in set Lis only connected to a single node in set *U*. Here, data links are removed according to their distance. After reducing the number of connections, set r←rX2.

Step 5. Repeat step 4 until *r=N.*

Notice that the connection degree of a node is in face denoting its rank. By substituting connection degree with rank, the proposed structure is formed.

Among these two nodes, the one node which is located near to the remotely base station will be selected as the cluster head CH and be connected directly to the base station.

Therefore, the cluster head will have a degree of which is the highest within the cluster.

Now in real scenario the fig 4.4 describes the algorithm in easy way.

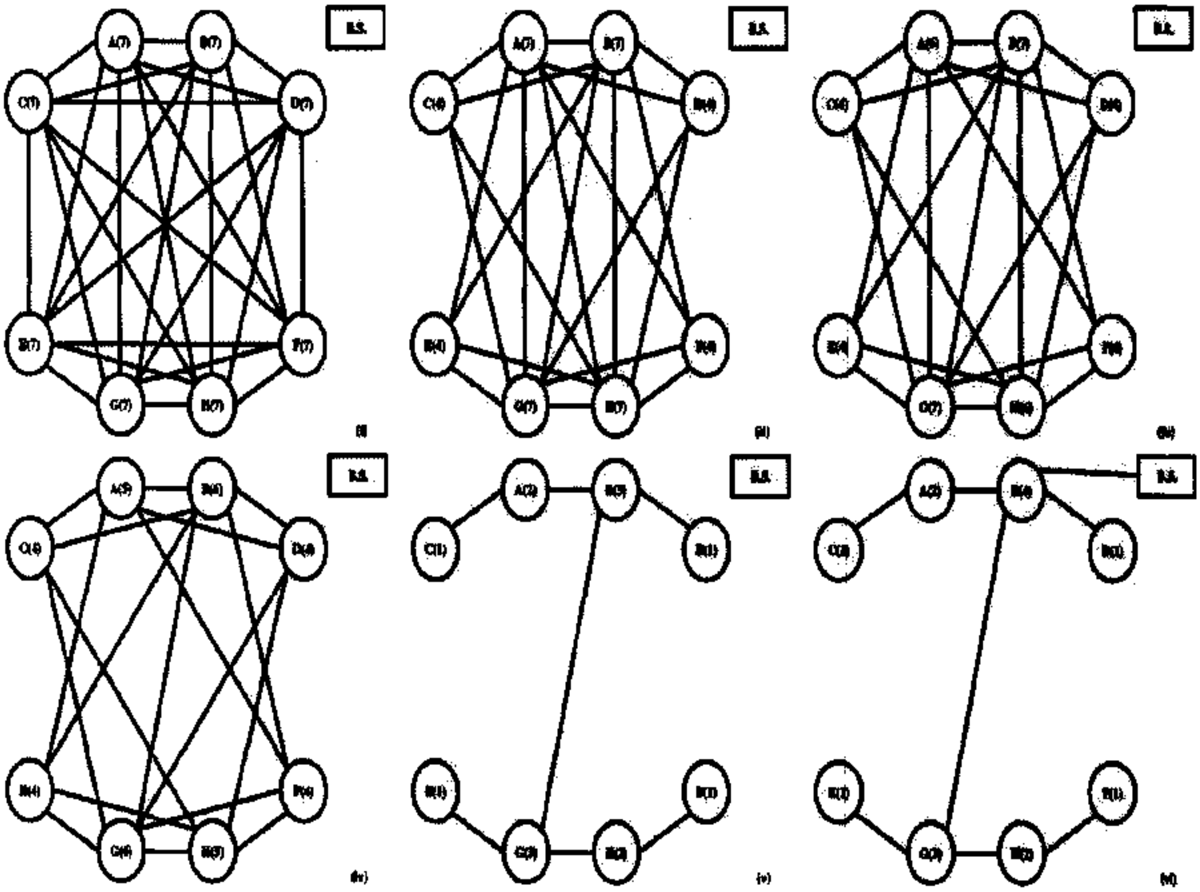

Fig 4.5.2 Network Formation at Top Down Approach with N=8

After making the network we shuffle the position of the cluster head for maximum energy purpose through the following pseudo code and algorithm at different time interval.

4.4 Pseudo Code

Initialization

Direct Routing = source node send data directly to Cluster Head

THV= Thrash hole value specified by the user

R.E= Remaining Energy

CH-1= all the nodes who are at the distance of one hop from cluster head

CH-2= all the nodes who are at the distance of two hops from cluster head

CH-3= all the nodes who are at the distance of three hops from cluster head

CH-4= all the nodes who are at the distance of four hops from cluster head

CH-n= all the nodes who are at the distance of n hops from cluster head

Dead node= the node with 0 % remaining energy

```
START
    1: Send Data Directly to Cluster Head
    2:  Calculate Remaining energy periodically
    3:  if the Remaining energy <TV0 then
            Start Multi-Hop Routing
    Else
            Continue Direct Routing
Multi-hop routing
                    Compare Remaining Energy with THVs
                    If (Next Hop = = Nodes hop+1)
                        Next hop will remain same
                    else
                        Select Next Hop on the basis of THV
                            If Number of node in Next Hop=1 then
                                Send Data
                            Else
```

Select Next Node

If Remaining Energy= 0 then

Node= Dead

End

Next Node Selection Process

Check the Next Node Calculation Method

If Method = MRE

Calculate the R.E of every node of the Next Hop

Select node with maximum energy

Send data to selected node

If Method = RR

Send data to the next hop nodes on round robin basis

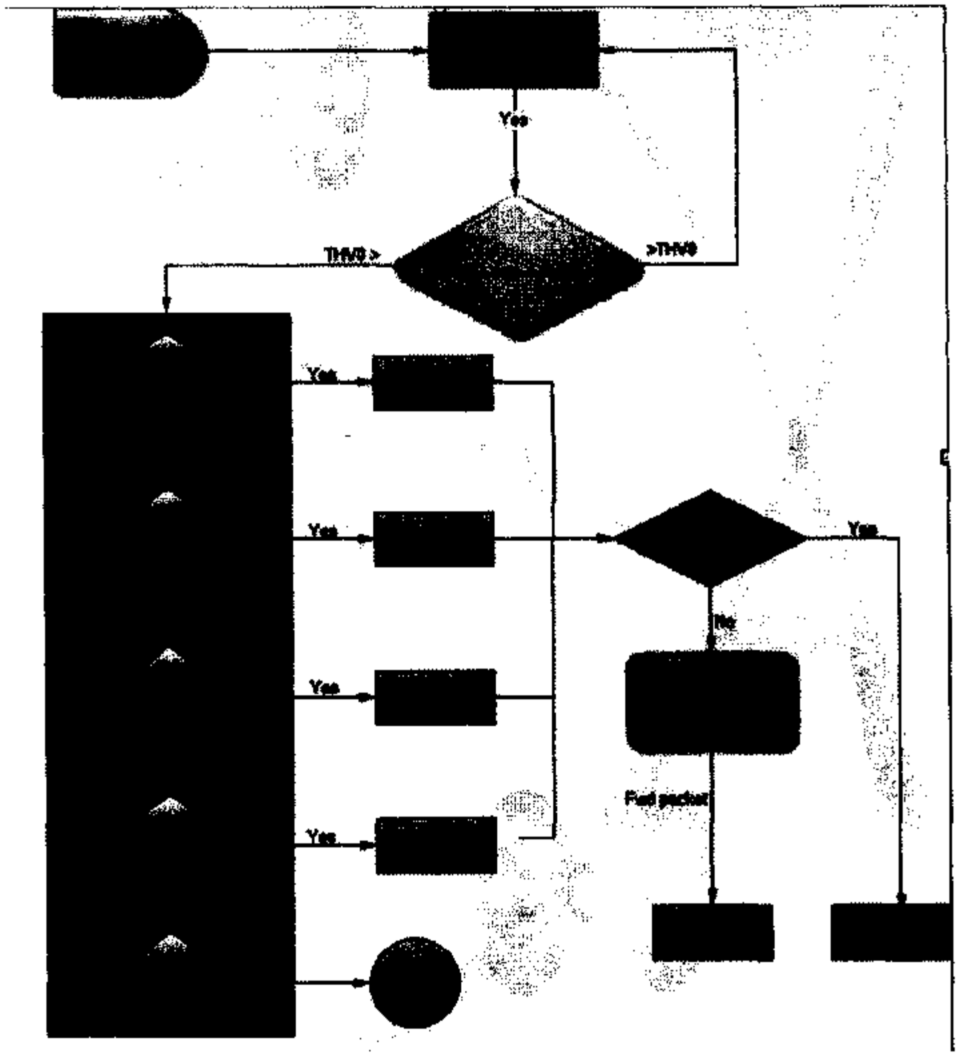

Fig 4.6 On the basis of maximum Remaining Energy

The above Flow diagram will illustrate the flow of data from source node to cluster head from the start of the network to death of first node

Before we study the flow diagram we must know the following terminologies

1: At the start of the network every node has 100 % energy

2: every node will share its remaining energy to each other node

3: Direct Routing = source node send data directly to Cluster Head

4: THV= Thrashold hole value specified at inintial stage

5: R.E= Remaining Energy

6: CH-1= all the nodes who are at the distance of one hop from cluster head at Netwok

7: CH-2= all the nodes who are at the distance of two hops from cluster head at Netwok

8: CH-3= all the nodes who are at the distance of three hops from cluster head at Netwok

9: CH-4= all the nodes who are at the distance of four hops from cluster head at Netwok

10: CH-n= all the nodes who are at the distance on hops from cluster head at Netwok

11: Dead node= the node with 0 % remaining energy at Netwok

CHAPTER 5

SIMULATION & RESULTS

5. Simulation

In this chapter we will discusses the simulation details, assumptions ,topology, implementation details and scenarios and obtain the results with two proposed methods and further discuss the comparison of results with traditional algorithms then explain the results and comparisons by graphs.

Simulation is the process to check and verify the proposed application in artificial environment so before real implementation the error and flaw can be checked. Wireless sensor network contain costly hardware and it's not commonly available for research purpose. So researcher prefers simulator to check and verify the proposed algorithm for WSN.

5.1 Simulation Environment

For simulation, we have selected Castalia simulator. Castalia is a simulator for Wireless Sensor Networks (WSN), Body Area Networks (BAN) and generally networks of low-power embedded devices. Castalia is meant to provide a generic reliable and realistic framework for the first order validation of an algorithm before moving to implementation on a specific sensor platform Castalia can also be used to evaluate different platform characteristics for specific applications, since it is highly parametric, and can simulate a wide range of platforms. It is based on the OMNeT++ platform and can be used by researchers and developers who want to test their distributed algorithms and/or protocols in realistic wireless channel.

5.2 Results and Analysis

In this section the proposed network structure is compared with LEACH, PEDAP, PEGASIS and Top-down approach. Networks having N nodes and N vary from 4 to 64. The sensor nodes are distributed randomly across the sensor field of 50X 50 m2. A node can transmit and receive data at any time. In sensor network, a sensor node is always capable of fusing the all received data packets into a single packet. The size of aggregated packet is independent of number of data packets received.

5.2.1 Test Case 1(Average data collection time)

In First Experiment, for simulation, initially each node is given energy of 50 J. The network performs the data collection periodically.

Parameters	Value
Packet Size	12 bytes
Transmission Radius	60 m
Data Collection	Periodically
Simulation Time	20 min
Maximum Energy level	50 J
Initial Energy	300 mJ
Cluster Size (Nodes)	4 to 64
Sensor Field	50X 50 m2

Table 0.2: Simulation Parameters - Experiment no 1

The lifetime of a network is defined as the number data collection processes (in terms of rounds) that a network can accomplish before
any of its nodes runs out of energy. Control packet size is very less as compare to
Data packet. In the simulation, some assumption are taken,

1. All sensor nodes are static in nature.
2. All Sensor node know its location (dx, dy).
3. All Sensor nodes have the information about the total number of nodes in the sensor field.

In the simulation, we have two approaches, In the first one, we try to find how many time slots are required for the sensor nodes to transmit data to Base station. It varies the total number of nodes from 4 to 64. We compare our approach with LEACH, PEDAP, PEGASIS, Top-down approach used in DADCNS. We plot the graph for it. In the graph X-axis indicates number of sensor nodes (N) and Y-axis indicates number of slot required to transmit data to base station.

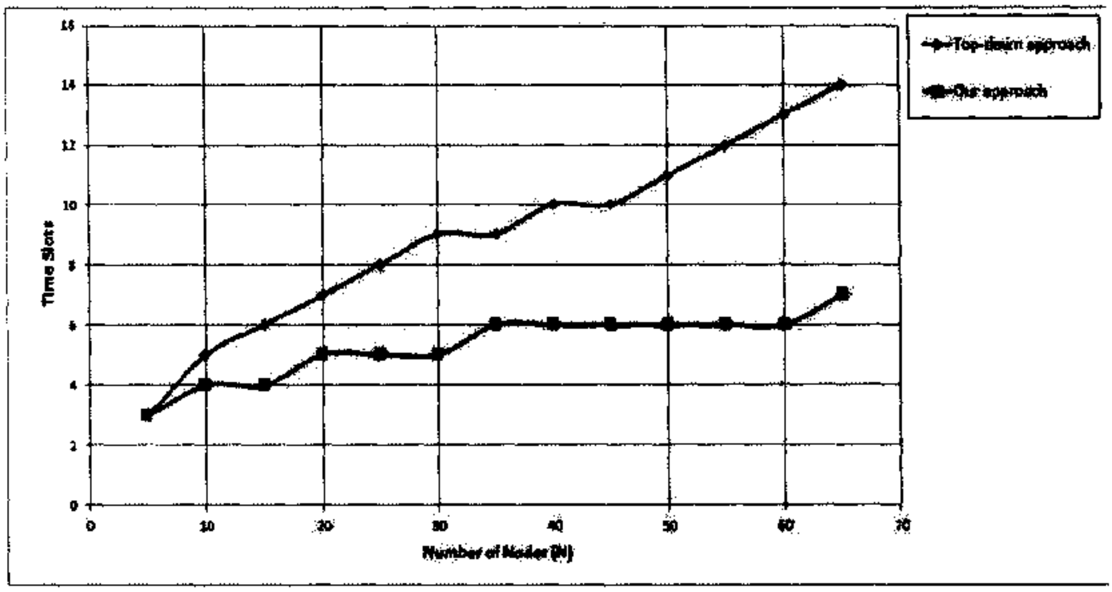

Figure 5.2.1: Average data collection time (Lower is Better)

Form the graph it is clearly shown that our approach is best one as compare to top-down approach used in DADCNS. In previous work it proved that top-down approach is better than LEACH, PEDAP, and PEGASIS in case of faster data transmission.

For example if $N = 60$, Top-down approach was taken 12 time slots where as our approach was taken only 6 time slot. As the proposed system can finished more data collection processes with in the desired time without any losses on the duration of the same time. So our approach is the best one in case of transmits the data to base station faster.

lifetime of the network. We find that our solution gives the better results as compared to other solutions. 1440 packets are sent by deploying PEDAP routing, 1229 packets are sent through LEACH routing, PEGASIS solution sent 2070 packets and DADCNS results in transmission of 2520 packets. When we test our proposed mechanism EDCNS we find that total 2730 packets are sent in the network. So our solution is transferring 210 more packets as compared to latest available technique. The reason of this increase is efficient use nodes shuffling according to the requirements and energy of the sending node.

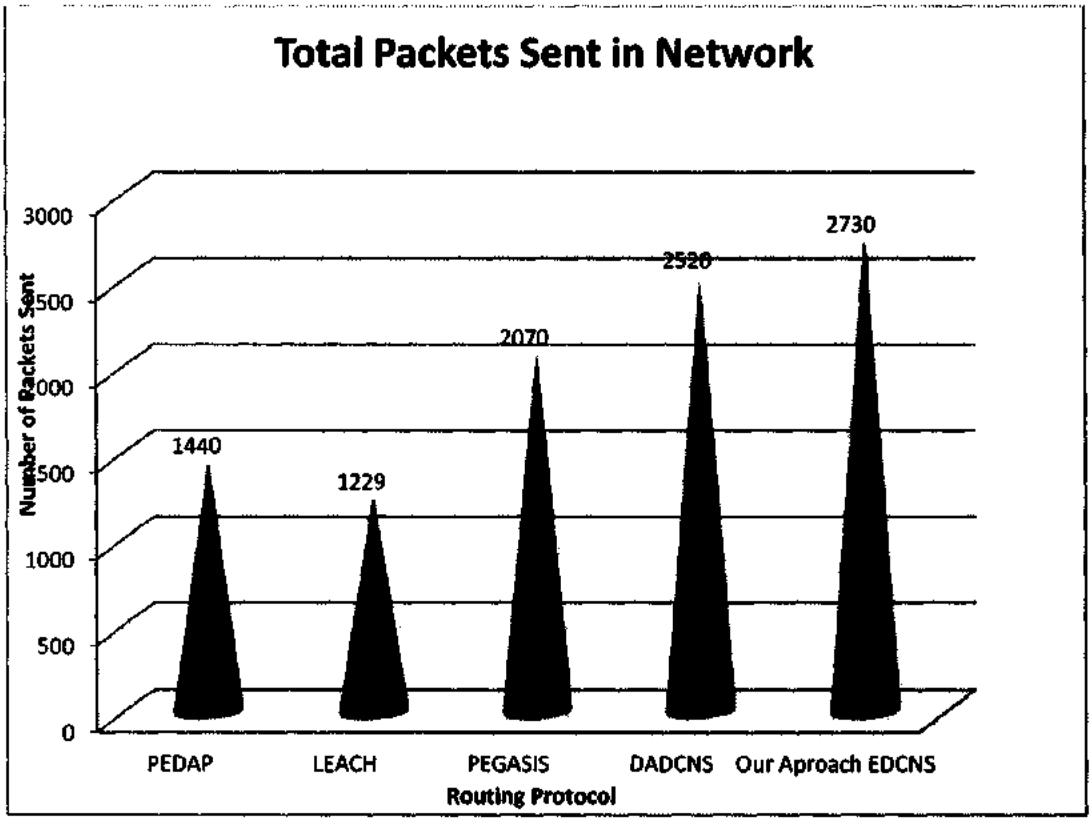

Figure 5.2.3: Total Packet Sent in the Network With EDCNS(Our Approach)

5.2.4 Test Case 4 (Network Life Time with Max Remaining Energy)

In the 4th Experiment ,As we discussed earlier that lifetime of the network mean the death of any node in the network and the any network which have more lifetime is consider an efficient network. We measure the life time of the network by simulating with different parameter and found that next hop routing protocol's results are much better then other routing techniques. Fig 5.3 show a graphical presentation of all routing techniques in terms of network life time

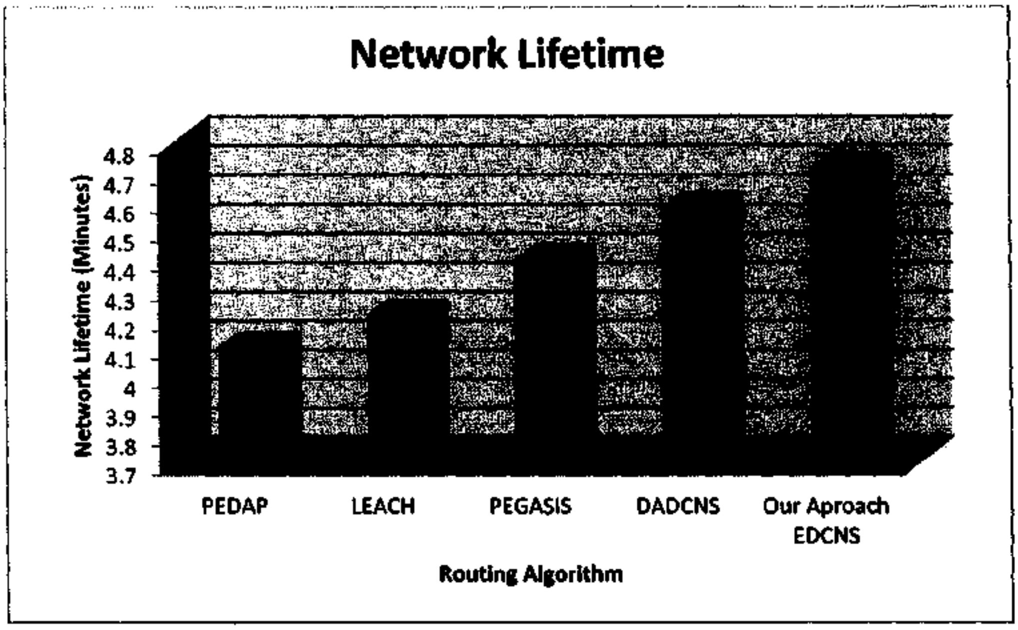

Figure 5.2.4: Network lifetime with maximum remaining energy

We set parameters as 300mJ energy level of each node and start the network so the first node becomes dead after 4.71 minutes which is the better lifetime then all other routing techniques. Simulation graph shows the output for reduce energy consumption of the whole network. This proposed system is suitable for various applications for the data collection processes.

5.3 Advantages

Using our approach, we are able to transmit and collect data faster as compared to other protocols/schemes and simultaneously, we give emphasize to energy constraint of sensor network. We try to make proper balance between two factors. In case of energy saving or data collection process (rounds) and also our approach out paly others approaches except Minimum spanning tree (PEGASIS).But In case of faster data collection (slots) our approach is the best one as compare to all other approaches.

CHAPTER 6

CONCLUSION & FUTURE WORK

6. Conclusion and Future Work

6.1 Conclusion

Wireless Sensor Network (WSN) are used for different application, typically involving some kind of monitoring, controlling, tracking, fire detection, land slide detection and traffic monitoring. In recent years Wireless Sensor Networks (WSNs) have become an established technology for a large number of applications, ranging from monitoring (e.g., pollution prevention, precision agriculture, structures and buildings health), to event detection (e.g., intrusions, fire/flood emergencies) and target tracking (e.g., surveillance). WSNs usually consist of a large number of sensor nodes, which are battery-powered tiny devices. Although many protocols and algorithms have been developed for traditional wireless ad hoc networks, they are not well suited for the unique features and application requirements of sensor networks.

Many algorithms are proposed to handle energy saving problem in wireless sensor network. The main aim is to save energy so that entire life time of the network can be increased. But these algorithms ignore the efficient data collection in wireless sensor network. So in our work we have tried to develop an algorithm which will form a network structure in wireless sensor network, through which data can be transmitted faster to base station without disturbing life time of network. Performances of the proposed network structure are evaluated using computer simulations. Simulation results show that, when comparing with other common network structures in wireless sensor networks, the proposed network structure is able to shorten the delay in the data collection process significantly.

In our research we tried to from a network structure so data can be collected as fast as possible and it should be in energy easy way. In many applications of sensor network, data has high importance and it should reach to base station as fast as possible. Also we cannot ignore the fact that sensor nodes are tiny battery powered devices having limited power. So we tried to balance both the factors. The proposed network structure is shown to be easy and efficient in terms of data collection time among all the existing network structures. The proposed network structure can greatly reduce the data collection time while keeping the total communication distance and the network lifetime at acceptable values.

6.2 Future Work

Our proposed research work may further be extended in varied dimensions as follows:

6.2.1 Experimenting with other Topologies

We test our proposed solution by deploying node in Grid topology. The work can be extended by implementing the same solution on different other topologies, specifically the irregular topology because if the nodes are thrown from a plan or from a Helicopter then the resulting topology will be irregular.

6.2.2 Mobility

To test our proposed solution we use the wireless sensor network where nodes are static and don't move their positions. But since mobility is becoming the demand of modern age so this solution can also be tested over mobile sensor network. Results of our proposed solution may vary in case of adding mobility.

6.2.3 Use of Mobility Models

The proposed model is able to collect data quickly and is also energy efficient. But there is always a room for improvement. It can be done in more energy efficient way. In our model we consider all the nodes as static in nature but in future, mobility of nodes can be considered.

There exist different mobility models. Results of one mobility model can be different as compared to other mobility models. So if mobility is added in wireless sensor network to use our proposed solution then the role of different mobility models can also be analyzed.

6.2.4 Testing with Different Parameters

We obtain the results by configuring the same parameters those were configured by the researchers who worked earlier on this topic. The reason of using the same parameters is to compare the results efficiently. However at different other parameters, for example in very dense network or in wide spread network the results can be different.

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