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Energy Based Simulation and Performance Evaluation of Routing Protocols of Wireless Sensor Networks (WSN)

Mulugeta Adibaru

College of Engineering and Technology, Wollega University, Post Box No-395, Nekemte, Ethiopia

***Abstract*– In recent years many researchers demonstrate their great interest in energy efficient based hierarchical routing protocols in Wireless sensor networks (WSNs). Wireless sensor networks are networks of tiny sensor nodes intelligent to data processing, sensing, wireless communication proficiency, along with memory and energy limitations. In the existing era many energy efficient routing protocols for Wireless sensor networks have been proposed to prolong the network lifetime of the tiny sensor node however, because of their transformed behavior in altered scenarios performance superior or poorer cannot be observed without any doubt by conventional techniques. The main purpose of this project is to evaluate the performance among energy efficient hierarchical routing protocols in WSNs based on metrics Energy consumption, number of nodes alive, number of data received at the base station. In this project Simulations between LEACH,LEACH-C and STAT-CLUS hierarchical routing protocols in wireless sensor networks has be done and confirms their results in term of Energy consumption, number of data received , no of nodes alive when number of clusters, number of nodes and location of base stations are varied over a fixed topology of wireless sensor networks. The project is concluded by mentioning valuable observations made from analysis of results about several hierarchical routing protocols of wireless sensor networks.**

***Index Terms*– Wireless Sensor Network, Energy Efficient Routing Protocol, Cluster and NS-2**

I. INTRODUCTION

WIRELESS communication endowed with numerous advantages over traditional wired network and enables to develop small, low-cost, low power and multi-functional sensing devices. These small sensing devices have the capabilities of sensing, computation, self organizing and communication known as sensors. Sensor is a tiny device used to sense the ambient condition of its surroundings, gather data, and process it to draw some meaningful information which can be used to recognize the phenomena around its environment. These sensors can be grouped together using mesh networking protocols to form a network communicating wirelessly using radio frequency channel. The collection of these homogenous or heterogeneous sensor nodes called wireless sensor network (WSN). The ability of low cost, small size and easy deployment of the sensor nodes make it possible to deploy them in a large number in an area to be investigated. Interestingly, unlike other networks that performs poor with growth in their networks size, WSN get stronger and performs better as much as number of nodes exceeds.

In addition, without any complexity in configuration network size can be extended simply by adding additional number of nodes. Therefore, it is said that connectivity using mesh networking will occupy any possible communication path in search of destination using node to node hoping. Owing all these considerable advantages, application domain of WSNs varies from environmental monitoring, to health care applications, military operation, to transportation, to security applications, to weather forecasting, to real time tracking [3], [4]. WSN is the collection of hundreds or thousands of tiny sensor nodes having the abilities of sensing, computations and communication among each other or with the base station. The functional architecture of sensor nodes consists of four units which are sensor, CPU, radio and power. Among these four units, three units are responsible for accomplishing a task while power unit supplies energy to the overall operation. The function of sensing unit is to measure physical conditions of the environment like temperature, humidity and pressure [5], [6] the processing unit is mainly responsible for processing the data (signals) while communication unit transmit data from the sensor unit to the user through the base station (BS) [7]. These tiny sensor nodes are scattered throughout the investigation area to acquire information from the environment, process it and then transfers it to the base station [4].

By considering WSNs application domain one can presume it like a traditional wired or wireless network. But the reality is very different because traditional wired or wireless networks have enough resources like unlimited power, memory, fixed network topologies, enough communication range and computational capabilities. But on the other side, WSNs have a resource constrained nature with respect to energy, computational capabilities and memory resources [3]. Unfortunately despite these constrained resources we have the same expectation from the WSNs as that from the traditional computer networks.

The resource constrained nature of WSNs impels numerous challenges in its design and operations degrading its performance. These challenges include significantly communication management, unattended operational nature,

network lifetime and fault-tolerance. Therefore, on one side, to improve WSNs performance these challenges are subjected to be investigated. While on other side, the performance of WSN can be achieved significantly by efficient resource utilization. Resource utilization can be enhanced by focusing on factors involved in WSN operations. Communication in WSN has certainly influences on its resources. The communication pattern of WSNs involves node to node, note to BS and BS to node communication. This communication involves optimal route selection, route maintenance and other computations to compete with user expectation and ensure network performance [7].

According to [11] route selection of each message in communication pattern result in either network delay by choosing long routes consisting many sensor nodes or degrade network lifetime in terms of short routes resulting in depleted batteries. Besides, unnecessary load on a network and delay in operation not only degrades application quality but also wastes network resources. Furthermore, as WSNs deployment can be seen in critical applications so the demands for application vary according to its nature. Different applications have different demands from network which cannot be avoided. Therefore, there is a need of efficient routing protocol which should not only be appropriate for the application demands but also assist network with respect to its limited resources and performs well. To identify and select best routing protocol for an application, it is required to understand the strict demands of that application first and then to select the appropriate protocol to be implemented and simulated. There are several routing protocols developed for WSNs. All these routing protocols have different competing features and qualities. Therefore, the selection of correct routing protocol is vital.

II. STATEMENTS OF THE PROBLEM

Routing is a challenging task in WSNs because of their unique characteristics which makes it different from other wired and wireless networks like cellular or mobile ad hoc network (MANETs) [4], [7]. Due to its deployment nature (large scale deployment), the Internet Protocol (IP) based protocols may not be the better choice to be applied on.

- ✓ Mostly, the flow of sensed data is towards base station from all sources in all applications.
- ✓ Resource management is critical due to their resource constrained nature.
- ✓ Application-specific nature.
- ✓ Location based data collection needs nodes position awareness.
- ✓ Sensor nodes are energy-constrained. All of them are stationary and BS is the node with high energy.
- ✓ Each sensor node periodically senses the monitored environment and has a perpetual desire to send the sensed data to the BS.
- ✓ Energy is dissipated during transmission and reception only and nodes failure is attributed to energy drainage only.
- ✓ Data redundancy is another issue.

Therefore, it is required that routing protocols should have the capabilities to handle these characteristic for reliable and efficient communication. Different routing protocols must be measured and evaluated for addressing the above listed problems and an energy efficient wireless sensor networks routing protocols must be selected for different applications which uses WSN protocol.

III. WIRELESS SENSOR NETWORK ROUTING PROTOCOL

Routing is the process of moving information from a source node to a destination node through the help of intermediate nodes in an internetwork. It is commonly known as path from source to the destination. Different routing protocols are designed to fulfill the shortcomings of the recourse constraint nature of the WSNs. The deployed WSN can be differentiated according to the network structure or intended operations. Therefore, routing protocols for WSN needs to be categorized according to the nature of WSN operation and its network architecture.WSN routing protocols can be subdivided into two broad categories, network architecture based routing protocols and operation based routing protocols [4], [6].

A. Route Selection Base Classification of Routing Protocols

The WSN routing protocols can be further classified on the method used to acquire and maintain the information, and also on the basis of path computation on the acquired information. This classification of protocol is based on how the source node finds a route to a destination node [7].

Architecture Based Routing Protocols

Protocols are divided according to the structure of network which is very crucial for the required operation. The protocols included into this category are further divided into three subcategories according to their functionalities. These protocols are [4], [6].

- ✓ Flat-based routing
- ✓ Hierarchical-based routing
- ✓ Location-based routing
- ✓ Flat-Based Routing

When enormous amount of sensor nodes are required, flat-based routing is needed where every node plays the same role. Since the number of sensor nodes is very large therefore it is not possible to assign a particular Identifier (ID) to each and every node. This guides to data-centric routing approach in which Base station sends query to a group of particular nodes in a region and waits for response. Examples of Flat-based routing protocols are [4], [6].

- ✓ minimum transmission energy(MTE)
- ✓ Adhoc on demand distance vector(AODV)
- ✓ Destination Sequence Distance Vector(DSDV)
- ✓ Sensor Protocols for Information via Negotiation(SPIN)
- ✓ Direct Diffusion

Hierarchical-Based Routing

When network scalability and efficient communication is needed, hierarchical-based routing is the best match. It is also called cluster based routing. Hierarchical-based routing is energy efficient method in which high energy nodes are randomly selected for processing and sending data while low

energy nodes are used for sensing and send information to the cluster heads. This property of hierarchical-based routing contributes greatly to the network scalability, lifetime and minimum energy.
Examples of hierarchical-based routing protocols are [4], [6].

- ✓ Low energy adaptive clustering hierarchy(LEACH)
- ✓ Low energy adaptive clustering hierarchy-Centered(LEACH_C)
- ✓ Static Clustering(STAT_CLUS)
- ✓ The Power-Efficient Gathering in Sensor Information Systems(PEGASIS)
- ✓ Threshold sensitive Energy Efficient Sensor Network(TEEN)
- ✓ Adaptive Periodic Threshold-sensitive Energy Efficient Sensor Network(APTEEN)

Location-Based Routing

In this kind of network architecture, sensor nodes are scattered randomly in an area of interest and mostly known by the geographic position where they are deployed. They are located mostly by means of GPS. The distance between nodes is estimated by the signal strength received from those nodes and coordinates are calculated by exchanging information between neighboring nodes. Location-based routing networks are [4], [6].

- ✓ Geographic adaptive fidelity (GAF)
- ✓ Geographic and energy aware routing (GEAR)

B. Operation Based Routing Protocol Classification

WSNs applications are categorized according to their functionalities. Hence routing protocols are classified according to their operations to meet these functionalities. The rationale behind their classification is to achieve optimal performance and to save the scarce resources of the network. Protocols classified to their operations are:

- ✓ Multipath routing protocols
- ✓ Query based routing
- ✓ Negotiation based routing
- ✓ QoS based routing
- ✓ Coherent routing

C. Hybrid Protocols

This strategy is applied to large networks. Hybrid routing strategies contain both proactive and reactive routing strategies. It uses clustering technique which makes the network stable and scalable. The network cloud is divided into many clusters and these clusters are maintained dynamically if a node is added or leave a particular cluster. This strategy uses proactive technique when routing is needed within clusters and reactive technique when routing is needed across the clusters. Hybrid routing exhibit network overhead required maintaining clusters [4].

IV. RELATED WORK

Recently, several researchers show their enormous interest in hierarchical based energy efficient routing in Wireless sensor networks. A clustering scheme has been applied to sensor networks with hierarchical structures to improve the performance of the network along with minimizing the need for power consumption. Clustering is a cross- cut technique which is used in nearly all segments of the protocol stack. The basic idea behind clustering scheme is to make a group of nodes around a cluster head with the responsibility of up keeping state and inter cluster connectivity involved in data processing. Furthermore, this processed data sent to the base station (BS) via sink by deciding the least amount of route nodes over long distance to save node energy [8]. So far, based on clustering techniques many energy efficient routing protocols have been proposed such as, Mobile Clustering Routing Scheme (MMLC) [9], Partition-based Hybrid Clustering Routing protocol (PHCR) [7].

The primary aim of these energy efficient routing protocols is to prolong the network lifetime of the tiny sensor node. In hierarchical routing Low Energy Adaptive Clustering Hierarchy protocol (LEACH) is one of the most popular routing protocols. The primary aim to propose LEACH protocol was to balance energy utilization in Wireless sensor network by selecting a set of nodes among normal nodes to act as Cluster Heads (CHs) in the entire network. The basic LEACH algorithm divides the whole network life span into a number of rounds. For cluster head (CH) election each node selects a random number between 0 and 1. If the random number is greater than a specific threshold value then the node appointed as a CH. Cluster head is a liable to create a Time Division Multiple Access (TDMA) schedule and broadcasts it to all the member nodes. For communication to its CH, each node utilizes its time slot as per assigned in Time Division Multiple Access schedule. Cluster head is responsible to receive all data from its member nodes. After aggregating, it sends this data directly to the BS for further analysis, and then it changes its state to the sleep mode. This process is repeated until the end of the round. The nods again go into the setup phase to choose a new set of cluster heads for the next round. Where in equation (1), Ci represents the function has to be determined, ‘N’ represents the number of nodes, ‘r’ is the current round number and ‘k’ represents the number of clusters. If node i select a value between 0 and 1 based on this it will be elected as a cluster head in the current round(r mod (N/k)) [10].

In this project, the researcher examines energy aware hierarchical based routing protocols of wireless sensor networks. The researched also simulates and measures the energy consumption, number of data received and number of alive nodes when the number of nodes, location of base stations, number of clusters and simulation round time of three types of Hierarchical routing protocols of thus routing protocols with different environment/scenario and parameters which is totally different from the works done before.

V. EXPERIMENTAL MODEL AND INVESTIGATION

A. Simulation Tool (NS-2)

Wireless sensor networks are implemented(simulated) with varies simulators developed for different organizations like OPNET, Sensoria, Manassim, OMNET++ and some other simulators but in this project the researcher used ns-allinone-

2.34 with MIT μ-AMPS module extensions. The reason what the researcher choose ns-allinone-2.34 is that:

- ✓ The other tools are commercially available
- ✓ Ns-allinone-ns2.xx is free downloadable
- ✓ The researcher interest and knowledge of ns-2

B. Overview of an Ns Mobile Node

In NS the Application creates "data packets" that are sent to the Agent. The Agent performs the transport and network layer Functions of the protocol stack. The Agent sends packets of data to CMUTrace, which writes statistics about the packets to trace files. The packets are then sent to a Connector, which passes them to the Link Layer to the Queue, where they are queued if there are packets ahead that have not yet been transmitted. Once a packet is removed from the Queue, it is sent to the MAC, where media access protocols are run. Finally, the packet is sent to the Network interface, where the correct transmit power is added to the packet and it is sent through the Channel. The Channel sends a copy of the packet to each node connected to the channel. The packets are received by each node's Network Interface and then passed up through the MAC, Link Layer, Connector, CMUTrace, and Agent functions. The Agent depacketizes the data and sends notification of packet arrival to the Application.

C. The MIT μ-AMPS code extensions

Researchers at MIT have developed the μ-AMPS (Micro Adaptive Multi-domain Power aware Sensors) project as a framework for implementing adaptive energy aware distributed micro sensors.

The protocol architectures of the LEACH project are designed in the context of the μ-AMPS project. The MIT μ-AMPS extensions to ns add support for simulating large scale wireless sensor networks in ns2.1b5.

This is a very old version of ns (year 2000) and MIT has not actualized the code of the μAMPS extensions. Therefore, making them work in ns2.34 consumed more than 50% of the total time I have spent working on this research.

These extensions include models for node energy dissipation and node state, as well as several routing protocols like LEACH, LEACH_C, STAT_CLUS and other WSN routing protocols.

D. Selected Protocols for Evaluation

STAT-CLUS (Static Clustering)

The clusters routing protocol is chosen a-priori and fixed. It also incorporates scheduled data Transmissions from the cluster members to the cluster head and performs data aggregation at this cluster-head [4].

LEACH (Low Energy Adaptive Clustering Hierarch)

LEACH is a hierarchical cluster based routing protocol proposed by Heinzelman et. al. [8]. This protocol incorporates the formation of clusters and cluster heads (CHs) for the respective clusters in which all the other sensor nodes send the data to the cluster head (CH). The received data is then aggregated and is sent to the base-station (BS) periodically by the cluster head which reduces the amount of data that is to be transmitted to the base station.

The role of the cluster head (CH) is rotated among the other sensor nodes in the cluster so as to evenly distribute the power load between the sensor nodes in a particular cluster. A TDMA/CDMA MAC is used for avoiding the collisions among the clusters and within the clusters.

LEACH-C (Low Energy Adaptive Clustering Hierarch-Centralized)

Unlike LEACH where nodes self-organized themselves into clusters, LEACH-C uses the base station as a coordinator for cluster head selection and cluster formation. The operation of LEACH-C is the same as that of LEACH that divided into rounds and each round consists of a set-up phase and steady-state phase. During the set-up phase of LEACH-C, every node in the network sends its location information and energy level to the base station. Using this information, the base station selects set of optimal cluster head and configures the network into clusters. The cluster grouping the chosen to minimize the energy required for ordinary nodes to transmit data to their associated cluster heads.

E. Selected Performance Metrics for Evaluation

Energy efficiency: it is vital consideration in routing protocols of wireless sensor networks due to limited energy of sensor nodes.

Energy consumption: It is defined as the total energy consumed by sensor nodes for the period of communications. Number of Cluster, number of nodes, location of base station and round time are the most important factors which directly affect node energy.

Average energy vs. number of cluster:

Average energy: it is calculated by dividing the total energy consumed by both of receiving and sending of senor nodes with fixed base stations and varying number of clusters and number of nodes of the base station divided by number of rounds of the simulation time.

Location of base station vs. average energy:

Varying location of base station for both 50 and 100 nodes but number of cluster is constant i.e. 5.

Round Time vs. no data received at BS:

Calculating number of data received by the sensor nodes for both 50 and 100 nodes with constant number of clusters (i.e., 5) with varying number of rounds of the simulation time.

Round Time vs. number of node alive

Find the number of a live node for both 50 and 100 nodes with constant number of clusters (i.e., 5) with varying number of rounds of the simulation time.

Round Time vs. energy

Calculating the energy consumption of sensor nodes of both 50 and 100 nodes of wireless senor network routing protocols for each round time with fixed number of clusters i.e., 5 numbers of clusters.

VI. SIMULATION AND ANALYSIS OF THE RESULT

In this section the researcher discussed and analyzed the results of these simulations. The researcher had discussed the results according to the scenarios chosen in two different nodes 50 node scenarios and 100 node scenarios. For both 50 and 100 node Scenario case the researcher used the following parameters.

Table 1: Simulation Parameter

Simulation parameter	
Topology	fixed
Number of nodes	50,100(varied when required)
Area	1000*1000
Antenna	Omni-directional
Propagation model	Two Ray Ground
Simulation time	200
Base station location	(50,50),(75,75),(100,100),(125,125)
Number of cluster	5,10,15,20,25
Round Time	10 secs
Model	Energy Model
Routing protocols	LEACH,LEACH-C,STAT-CLUS
Initial energy	2J

A. Simulation Results by varying number of clusters

In this scenario the number of cluster for each routing protocol of wireless senor networks are varied (changed) while other parameters are constant like the location of base station is (50, 50), simulation time is 200 with 10 seconds or round time and the initial Energy of each protocol is 2J as well as the simulation area is 1000*1000 for both 50 and 100 nodes Scenario.

Average Energy Vs Number of Cluster

As we have shown in Fig. 1 and Fig. 2 for both 100 nodes Scenario and 50 nodes Scenarios the average energy consumption of LEACH and STAT-CLUS is high as compared to LEACH-C routing protocols of Wireless sensor networks.

For 50 node Scenarios

The Average Energy consumed by LEACH protocol is varied between 50J and 70J. When the number of cluster increases the Average Energy consumed by this routing protocol becomes constant that is around 60J. In the case of STAT-CLUS the average energy consumed is increased continuously when the number of cluster increases starting from 10J. but in the case or LEACH-C routing protocol initially it consumes high energy that is around 40J as compared to STAT-CLUS routing protocols but when the number of cluster increases the average energy consumed by this routing protocol decreases and at some point it becomes constant i.e., 20J.

For 100 node Scenarios

The average energy consumed by LEACH routing protocol is initially around 50J and continually increasing until it becomes 140J but when the number of cluster increases it becomes constant at some stage. Still it consumes higher energy than that of STAT-CLUST and LEACH protocols.

In General LEACH-C Routing protocol consumes minimum Energy than that of LEACH and STAT-CLUS in both 50 nodes and 100 nodes Scenarios when the number of cluster increases at the base station of wireless sensor networks.

B. Simulation Results by Varying the Location of Base Station

In this scenario the Location of Base Stations for each routing protocol of wireless senor networks are varied (changed) while other parameters like number of cluster of each routing protocol is 5% of the total, simulation time is 200 with 10 seconds or round time and the initial Energy of each protocol is 2J as well as the simulation area is 1000*1000 for both 50 nodes and 100 nodes Scenario are constant.

Location of base station vs. average energy

As we can observe in Fig. 3 and Fig. 4 for both 100 nodes and 50 nodes Scenarios the average energy consumption of LEACH and LEACH-C is high as compared to STAT-CLUS routing protocols of Wireless sensor networks.

For 50 node scenarios

The average energy consumed by LEACH and LEACH-C routing protocols of wireless sensor network varies between 40J and 60J but when the Location of base station increases (the distance from the base station) the average energy consumed by this routing protocol becomes constant that is 50J. But in STAT-CLUS routing protocol the average Energy consumption becomes constant that is 10J.

For 100 node scenario

Just like that of 50 node scenario the average energy consumed by LEACH and LEACH-C routing protocol is still higher than that of STAT-CLUS routing protocols of wireless sensor networks. So STAT-CLUS routing protocol consumes minimum energy when the location of base station far from the origin of the sensor nodes and the number of nodes increase.

C. Simulation Results by varying Round time of the simulation

In this scenario the Round Time for each routing protocol of wireless senor networks are varied (changed) while other parameters like number of cluster of each routing protocol is 5% of the total, simulation time is 200 and the initial Energy of each protocol is 2J as well as the simulation area is 1000*1000 for both 50 nodes and 100 nodes Scenario are constant.

Number of Alive Nodes vs. Round Time

As shown in the Fig. 5 and Fig. 6 in both 50 nodes and 100 node scenarios the number of alive nodes of LEACH-C routing protocol is constant that is 50 nodes is alive for 50 node Scenarios and 100 nodes are alive for 100 node Scenario

until the simulation time completes. But in the case of STAT-CLUS routing protocols all nodes are dead when the simulation time reaches around 50 seconds for both 50 nodes and 100 node Scenarios. Leach Routing protocol is better than STAT-CLUS routing protocols in terms of number of alive nodes when the Round time increases but still it is worst than LEACH-C routing protocols when the number of nodes are small because when the number of round time increases the number of alive nodes of LEACH protocol becomes dead and at the last it becomes zero, For example as we can see in Fig. 15 in case of 50 node Scenario both 50 nodes are alive until the simulation time reaches 100.but when the simulation time increases and greater than 100 number of alive nodes of this routing protocol are starting to dead and becomes zero when the simulation time completes. In the case of 100 nodes Scenario all nodes of LEACH and LEACH-C routing protocols are alive until the simulation time completes.

Number of Data Received Vs Round time

The numbers of data received at the base station for those of the three routing protocol increases continually when the simulation time (round time) increases in both 50 nodes and 100 nodes Scenarios as we can observed in Fig. 7 and Fig. 8. In the case of STAT-CLUS routing Protocol the number of

Data Received at the base station becomes zero when the number of round time of the simulation increases in both scenarios but when the simulation time reaches 50 seconds the data received by this routing protocol becomes zero in both scenarios due high energy requirements of these routing protocols. Still LEACH-C routing protocol is better in terms of receiving mach amount of data than that of STAT-CLUS and LEACH protocols in both 50 nodes and 100 nodes Scenarios.

Energy Vs Round time

As shown in Fig. 9 and Fig. 10, the energy consumed by both LEACHE, LEACH-C and STAT-CLUS Routing protocols of wireless sensor network increases as the simulation time (round time) increases in both 50 node Scenarios and 100 node Scenarios. In the case of STAT-CLUS routing protocols the simulation completed when it reaches round times of 50 due to energy constraints. In LEACH and LEACH-C routing protocols Energy consumption grows continually when the round time increases. Still LEACH-C routing protocol consumes minimum energy as compared to STAT-CLUS and LEACH routing protocols in both 50 node Scenarios and 100 node Scenarios.

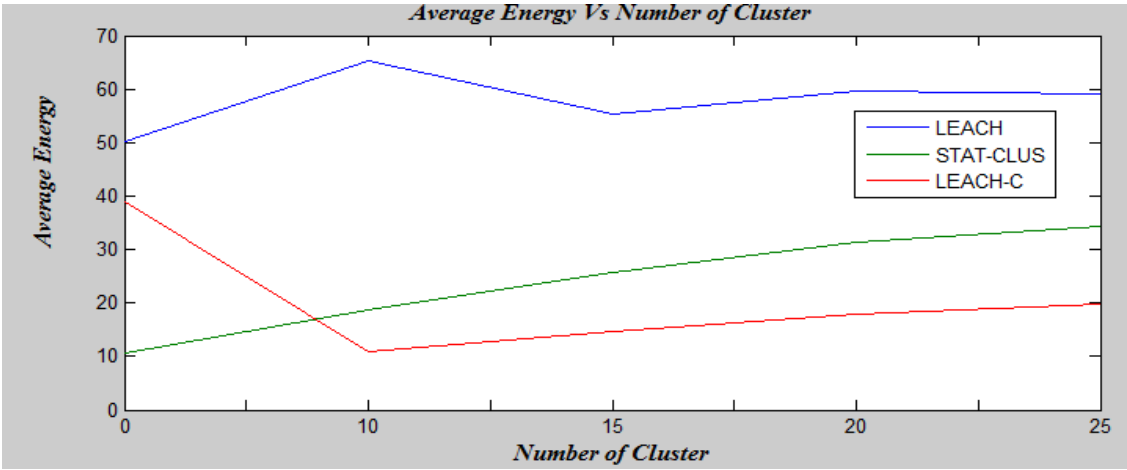

Fig. 1: 50 nodes scenarios of average Energy vs. number of cluster

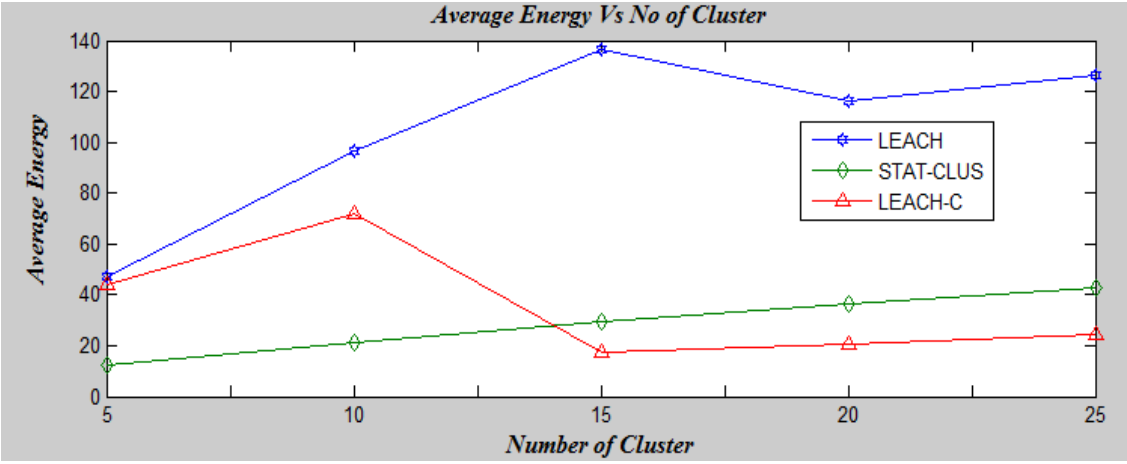

Fig. 2: 100 node scenarios of average Energy vs. number of cluster

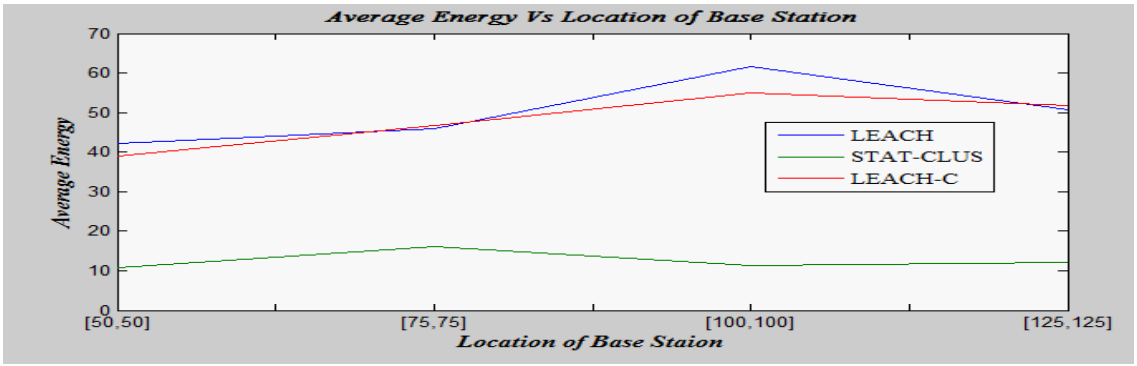

Fig. 3: 50 node scenario of average energy vs. change in base station

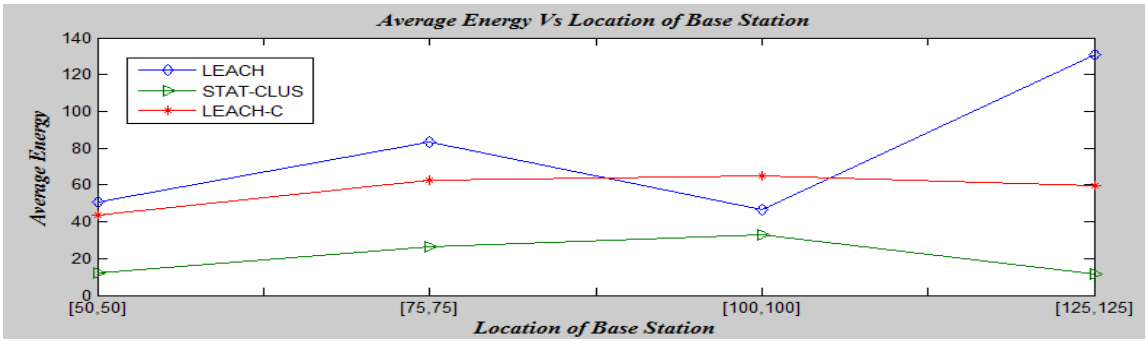

Fig. 4: 100 nodes Scenarios of average energy vs. Location of Base station

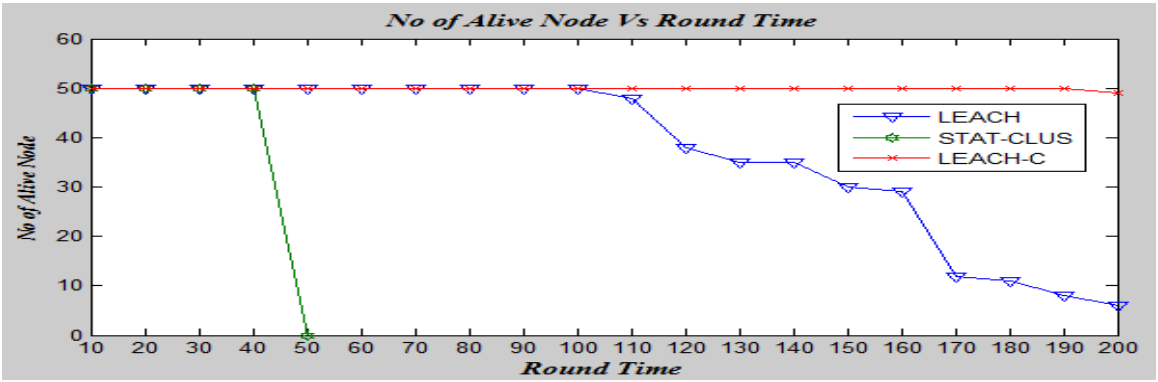

Fig. 5: 50 node Scenarios for No of Alive node vs. Round time

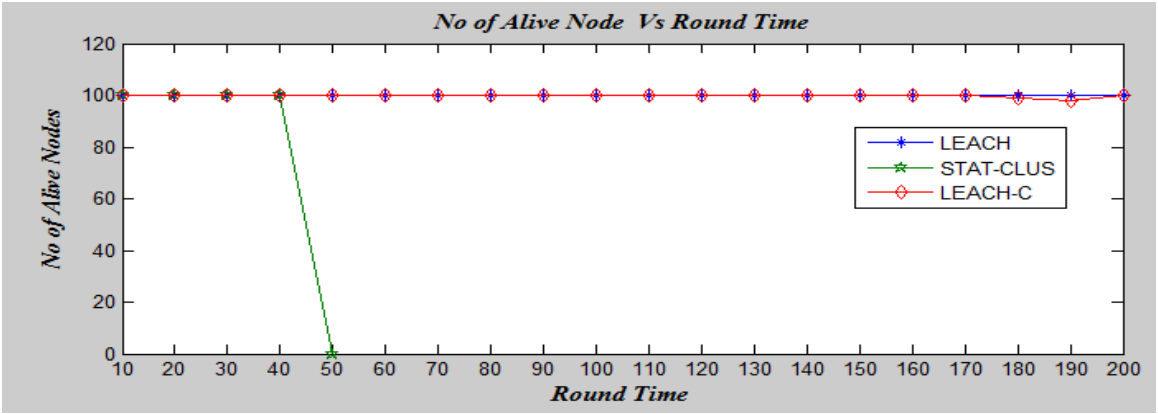

Fig. 6: 100 nodes Scenario for Number of alive nodes vs. round time

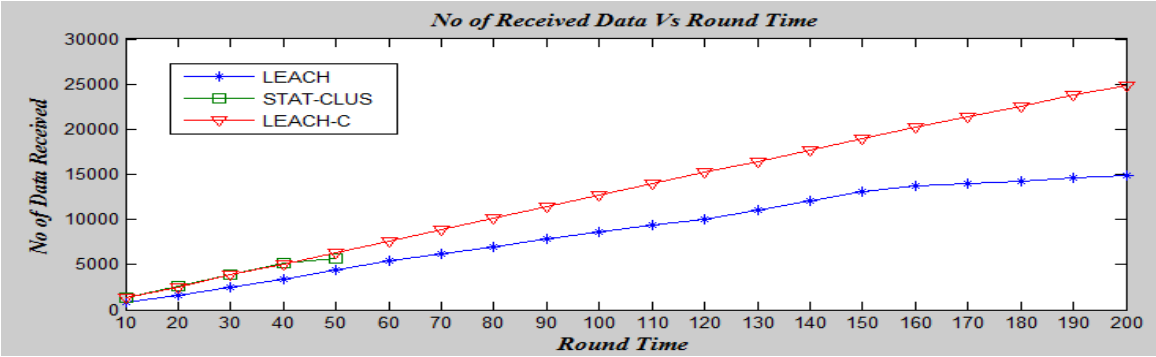

Fig. 7: 50 nodes Scenario for number of Received data at base station vs. Round time

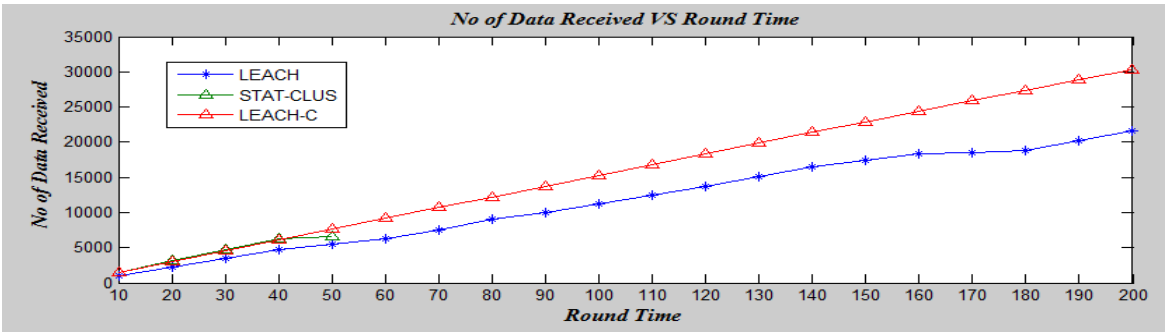

Fig. 8: 100 nodes Scenarios for number data received at BS vs. round time

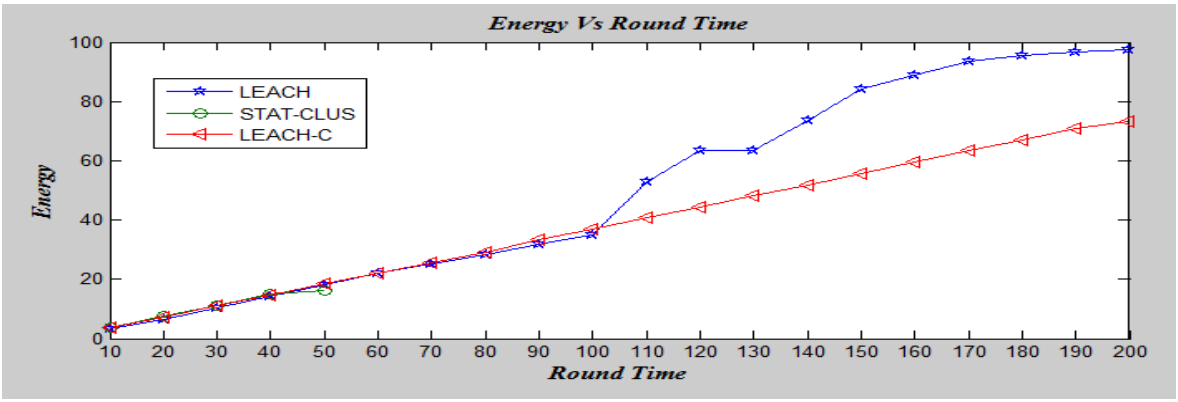

Fig. 9: 50 nodes Scenario for Energy vs. round time

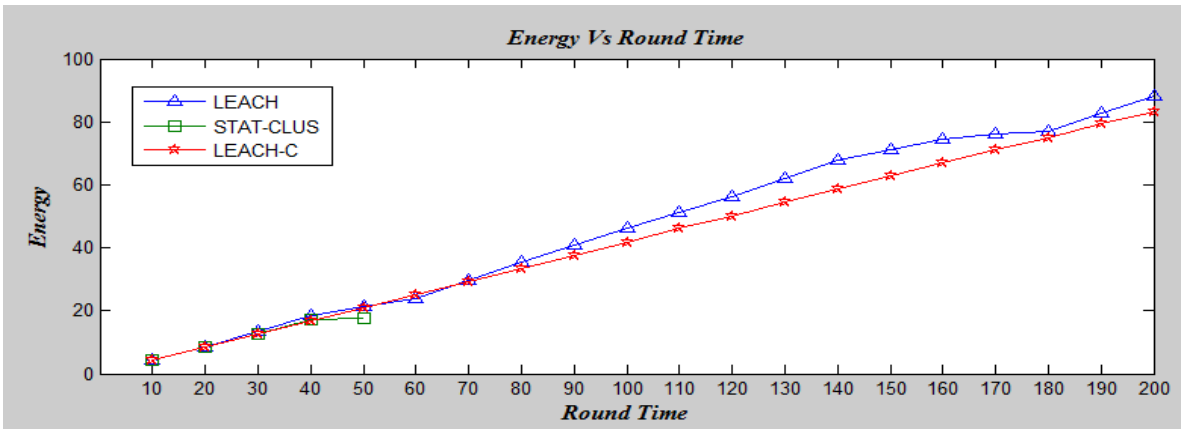

Fig. 10: 100 nodes Scenario for Energy vs. Round Time

VII. CONCLUSION AND RECOMMENDATION

This work compares the performance of hierarchical based routing protocols named as LEACH, LEACH-C and STAT-CLUS with respect to their different operations in Wireless sensor network. Here it has been mainly focused on the energy constraints of the miniature sensor node. The comparison simulation results illustrates that the number of cluster , number of nodes , round time and location of base station are the most important factor have an effect on the sensor lifetime and cause to increase the energy dissipation.

In conclusion, as referring to energy efficient routing protocol LEACH-C has a slower rate in decreasing energy that is much better than LEACH and STAT-CLUS in term of Energy consumption, number of data received and number of nodes alive. But in case of varying Location of Base stations and increasing number of nodes at the base station STAT-CLUS routing protocol is better than that of LEACH and LEACH-C routing protocols of wireless sensor networks.

In the estimated future, the factors in hierarchical routing protocol which affect the cluster building, communication of CHs and data fusion of clusters will be one of the research directions which can be more helpful to enhance a network lifetime of the WSN and other hierarchical routing protocols and parameters used measure the energy efficiency of thus routing protocols will be implemented and simulated. This also would be more energy efficient and improve the network lifetime.

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