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A Develop LEACH Protocol Based Queuing Theory to Improve the Wireless Sensor Network Performance

A Thesis
Submitted to the University of Babylon / College of information technology / Department of Information Networks in Partial Fulfilment of the Requirements of the Master's degree in Information Networks

By

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Dedication

This thesis is lovingly dedicated to my marvelous parents and to my wonderful family (My Brothers & my sisters).

Researcher
Salar Essa

Acknowledgments

First and foremost, my thanks are for God the Almighty who always gives me the strength and determination throughout my work on this thesis and all other times throughout my life.

*My sincere gratitude then goes to my supervisor, **Prof. Dr. Saad Talib Al-Jebori**, for his immense and unlimited support, help and invaluable guidance in every step of my research and the writing of this thesis.*

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Researcher

Salar Essa

Abstract

In embedded systems with latency and energy restrictions, such as wireless sensor networks (WSNs). Task allocation is a crucial problem in effective engineering for WSNs cooperative applications. Existing task allocation algorithms are prioritizing energy conservation with time restrictions. These allocation algorithms may increase the jobs completing time and increasing the likelihood of network failure.

In this thesis, a task allocation approach is proposed based on Queuing theory by considering both energy awareness and network performance in WSNs. Queuing theory fundamentals and Low-energy adaptive clustering hierarchy (LEACH) protocol can be utilized and modified to improve the power consumption and network performance of WSNs.

Network simulator (NS2.35) is utilized to implement LEACH protocol with four scenarios (different nodes number, clusters number, base station location, number of cluster heads). Drop Tail Queueing is also implemented with LEACH protocol to observe and evaluate the network performance and power consumption. An optimization technique for resources allocation is also utilized.

The results demonstrate that the performance of WSNs has improved and become more efficient with LEACH protocol. When the number of nodes increased from (100 to 200) nodes, the base station location is changed and the number of clusters increased from (5 to 9) the packet received is increased from (150 to 200), the drop packet decreased from (3.76% to 2.18%), packet deliver ratio increased from (0.21% to 0.47%) and the throughput increased (132.4%). This thesis approach improves the Quality of service by lowering packet loss while improving the network packet delivery ratio and throughput.

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List of abbreviations

N0.	Abbreviation	Definition
1.	ADV	Advertisement Message
2.	BS	Base Station
3.	CBR	Constant Bit Rate
4.	CH	Cluster Head
5.	CM	Cluster Member
6.	CSMA	Carrier Sensing Multiple Access
7.	DPDSN	Detection Of Packet Dropping Attacks For Wireless Sensor Networks
8.	EED	End To End Delay
9.	EIACO	Elite Immune Ant Colony Optimization
10.	GA	Genetic Algorithm
11.	GPS	Global Positioning System
12.	LEACH	Low-Energy Adaptive Clustering Hierarchy
13.	Leach.tr	Trace Leach File
14.	LEACH-C	Centralized Low Energy Adaptive Clustering Hierarchy

15.	NS-2	Network Simulator Version 2
16.	P	Percentage Of Cluster Nodes
17.	PB	Probability Of Blocking
18.	PDR	Packet Delivery Ratio
19.	PLR	Packet Loss Ratio
20.	QoS	Quality of Service
21.	R	Number Of Rounds
22.	SA	Simulated Annealing
23.	SNO	Social Network Optimization
24.	T	Threshold
25.	TASIM	Task Allocation Based On A Score Incentive Mechanism
26.	TDMA	Time Division Multiple Access
27.	TR	Throughput Ratio
28.	WSN	Wireless Sensor Network

CHAPTER ONE

OVERVIEW

1 Overview

1.1 Introduction

Effective Wireless sensor network design and implementation has evolved into Sensor networks applications and being a prominent research area in recent years. Wireless sensor network (WSN) composed of many low cost tiny sensor nodes with limited energy resource, so it is a tedious task to develop energy efficient routing schemes that enhances the network lifetime [1]. WSN usually composed of center node known as base stations and hundreds of other single distributed sensor nodes. Recently, WSNs extensively applied in various significant applications, including industrial, military, household, marine, medical field, and other areas. WSNs can be used in systems utilized for monitoring natural disaster, protecting, early alerts, and other emergency circumstances [2].

An extremely developed and especially superior communication protocols are essential to realize the available and prospective application for WSNs[3]. Some of the researches stated the energy efficient routing protocols. The taxonomy of routing protocols in WSN is important. In WSNs, the routing protocols can be classified as location based protocols, data centric protocols and hierarchical protocols [4] .

Sensors are principally significant to find a relevant task assignment methodology that can effectively apply large number complex tasks to different nodes for collaboration, to share processing [5] .If one of the sensor nodes fails, the job allocation process must be restarted from the beginning, which uses a lot of power and can't keep up with the application's real-time demands[6]. The WSN network's total performance influenced by the performance of each node. A wireless sensor network's structure and performance are influenced by the following factors [7]:

1. Characteristics of Wireless Radio Communication
2. Schemes of Medium Access
3. Localization
4. Deployment
5. A synchronicity
6. Quality of Service
7. Security

The focus of this thesis is to improvement QoS by implementing the Low Energy Adaptive Clustering Hierarch (LEACH) protocol.

1.2 Thesis aim

The main aim of this thesis is to improve the WSN Quality of Service.

This aim can be achieved by the following objectives:

1. Create and implement a wireless sensor network.
2. Implement a simulation approach to operate and evaluate the built WSN.
3. Analyze and evaluate the WSN overall performance to indicate the reduction in loss packets, the increasing in the network lifetime, reducing the energy consumption, and increasing throughput.
4. Improve QoS by implement the Low-energy adaptive clustering hierarchy (LEACH) protocol.

1.3 Problem statement

Due to the development of the WSN nowadays and engaged it into many life applications. Sensor nodes are limited in their power, data assortment, storage size, limited processing and computation capabilities which affect the network efficiency. A network with hundreds of jobs and a huge number of nodes requires an optimal approach to enhance the network performance. To manage these tasks among network nodes and ensure a reliable execution to all tasks in an acceptable manner, an optimal routing protocol is important. In this thesis, a developed LEACH protocol is implemented to improve the network performance and optimize the power consumption. A simulation approach is used in creating and operating the suggested WSN and its LEACH protocol based on queuing theory.

1.4 Literature review

The related work can be summarized as in Table 1-1:

Table 1-1 summarized the related works

No	Research Title	Citation	Author (s)	Focus Area
1	Queuing Management in Wireless Sensor Networks for QoS Measurement.	[8]	Agassi Melikov1, Anar Rustamov.	The simplest model of QoS model-buffer less system is provided. In order to improve QoS, the proposed model suggests measuring the chance of arriving packets being blocked using queueing theory. Given the

				probability of blocking (PB).
2	Natural disaster monitoring with wireless sensor networks: A case study of data-intensive applications upon low-cost scalable systems	[2]	Dan Chen, Zhixin Liu, Lizhe Wang , Ming gang Dou, Jingying Chen , Hui Li.	proposes a dynamic routing protocol, a method for network recovery, and a method for managing mobile nodes A distributed algorithm for joint optimal control of power and rate has been developed, which can improve utility of network (larger than 95 %) and to minimize the energy consumption (reduction by 20 % in comparison with LEACH).
3	Integrating Queueing Theory and Scheduling for Dynamic Scheduling Problems	[9]	Daria Terekhov, Tony T. Tran, Douglas G. Down, J. Christopher Beck	Considered the combination of long-run stochastic reasoning with short-term combinatorial reasoning to solve dynamic scheduling problems. More specially, investigated the integration of queueing theory and scheduling in two simple scheduling

				problems: a dynamic two-machine Flow shop and a flexible queueing network. Provided both analytical and empirical results. Then a combinatorial scheduling algorithm can do so.
4	Cooperative task allocation in heterogeneous wireless sensor networks	[5]	Xiang Yin, Weichao Dai, Bin Li, Liping Chang and Chunxiao Li	Study the issue of task allocation of collaborative applications in heterogeneous WSNs. That assume that a task may require distinct types of capacities, and accordingly, sensor nodes have various Capacities that can be exploited for task execution, A novel scheme is developed to deal with this problem.
5	Network coding based energy efficent LEACH protocol for WSN	[1]	G.M.Tamilselvana , K. Gandhimathib .	An energy efficient LEACH protocol with Network coding is proposed for WSN. The existing LEACH protocol is modified in the cluster head selection by

				involving two metrics such as residual energy and drain rate. Afterwards the network coding is applied at the cluster head level.
6	Elite Immune Ant Colony Optimization(EIACO) -Based Task Allocation for Maximizing Task Execution Efficiency in Agricultural Wireless Sensor Networks	[10]	execute, Mengying Xu and Jie Zhou	Execute an elite immune ant colony optimization (EIACO) method is to deal with the problem of task allocation optimization, which is motivated by immune theory and elite optimization theory. The EIACO uses ant colony optimization (ACO) to combine the clone operator and elite operator together for the optimization of task allocation.
7	Hierarchical Routing Protocols for Wireless Sensor Networks: Functional and Performance Analysis	[4]	Muhammad K. Khan, Muhammad Shiraz,Qaisar Shaheen ,Shariq Aziz Butt,Rizwan Akhtar, Muazzam	Proposes a taxonomy for the classification of existing hierarchical routing protocols for WSNs and analyzes the functionality and performance of existing hierarchical routing

			A. Khan, Wang Changda .	protocols and provides performance comparison for the selected LEACH based routing protocols.
8	Energy-Efficient Wireless Sensor Network with an Unequal Clustering Protocol Based on a Balanced Energy Method (EEUCB)	[3]	Ahmed A. Jasim ,Mohd Yamani Idna Idris ,Saaidal Razalli Bin Azzuhri ,Noor Riyadh Issa ,Muhammad Towfiqur Rahman ,Muhammad Farris b Khyasudeen	Proposes an energy-efficient unequal clustering scheme based on a balanced energy method (EEUCB) that utilizes minimum and maximum distance to reduce energy wastage.

1.5 Outline

Thesis outlined in the following way: In chapter two have theoretical Background, the study methodology is defined, a collaborative research model is set, and the research question is investigated. The third chapter discusses the issue description as well as the proposed solution, which includes block diagrams and algorithms. It going to present LEACH protocol, queueing theory and network enhancement metrics. Chapter four shows methods implementation steps, results and How the LEACH protocol improves network performance and compare the result with other researches proposed results. Chapter five includes the conclusion and future work proposed.

CHAPTER TWO

Theoretical Background

2 Theoretical Background

2.1 Introduction

In this chapter, the presentation of the theoretical aspect. It provide general overview of wireless sensor networks, queueing theory and LEACH protocol. It provides lists of example and diagrams to provide the reader with full understanding to thesis subject and practical.

2.2 Wireless Sensor Networks (WSN)

As depicted in Figure 2.1, a wireless sensor network (WSN) is a network of wirelessly networked devices that utilize sensors to monitor their environment [11][12]. WSNs are used in many different applications. Just a few examples are security surveillance, environmental monitoring, and target tracking[13]. Tracking, military defense, intrusion detection, and other services are available. Because most existing security solutions are inadequate due to the unique properties of WSNs, security in wireless sensor networks is becoming increasingly essential. That is, the nodes of WSNs have limited processing capacity and energy [14]. Although WSN sensor nodes can communicate with one another, their primary function is to detect, collect, and send data [15]. These files are transmitted to a sink, which can use them or distribute them to other networks, across many hops [16]. WSNs require efficient routing techniques to achieve successful communication [17]. They make it easier for WSNs to communicate by finding the optimal data transfer paths and ensuring that these pathways are maintained for future transmission [18].

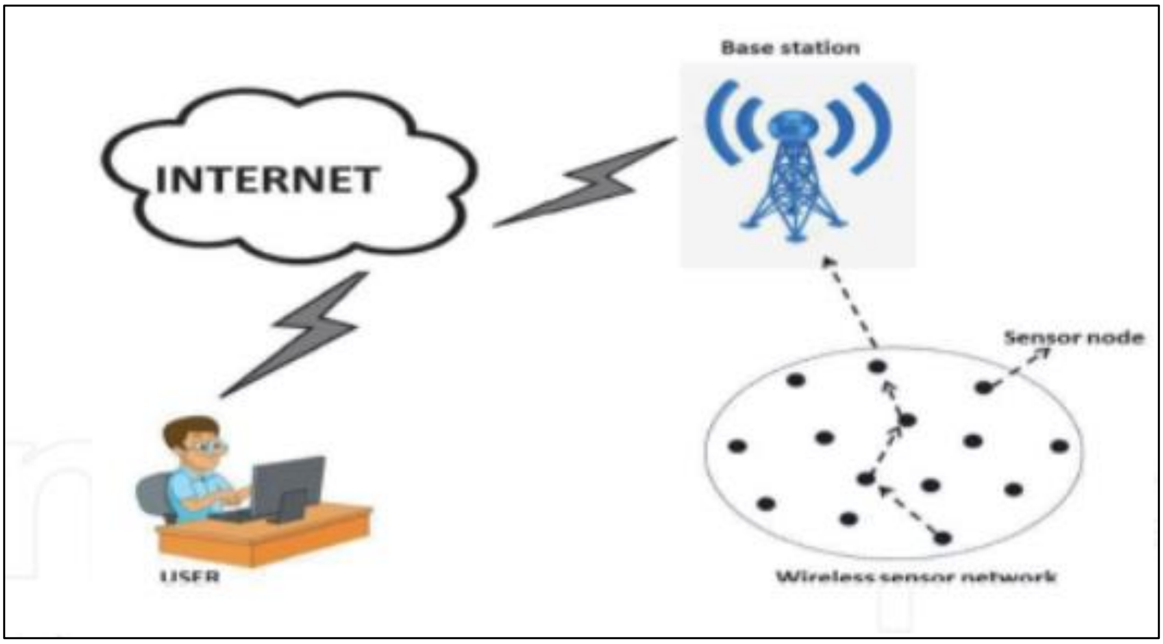


Fig 2:1 Wireless sensor network sample [18]

WSNs can be used on a worldwide scale for remote sensing and plant community’s study, on a field of battle for security monitoring and intelligence gathering, in emergency cases for the purpose of search and rescue, in industries for situation servicing, in building structures in the interest of infrastructure healthcare applications, in Homes for home automation, or even in bodies for the management of healthcare [19]. the inbuilt sensors collect sound data, earthquake, optical, or electromagnetic data from the surroundings in either continuously or event-driven modes [20]. Information on location and situating Local location algorithms or the Global Positioning System (GPS). This data can be acquired from all around the network and the data suitably to create a global picture of the monitored events or objects. WSNs are based on the idea that, while each sensor node's capability is limited, the network's overall power is enough for the job at hand. In a typical situation, A WSN can provide consumers with relevant information by sending queries to base stations and getting responses (or sink nodes), which act as a user-to-network interface. WSNs can be thought of as a distributed database in this sense.

Sensor networks are also expected to be connected to the Internet at some point in the future when global information sharing be possible. Figure 2.2 shows an scenario of accessing WSNs through internet [21].

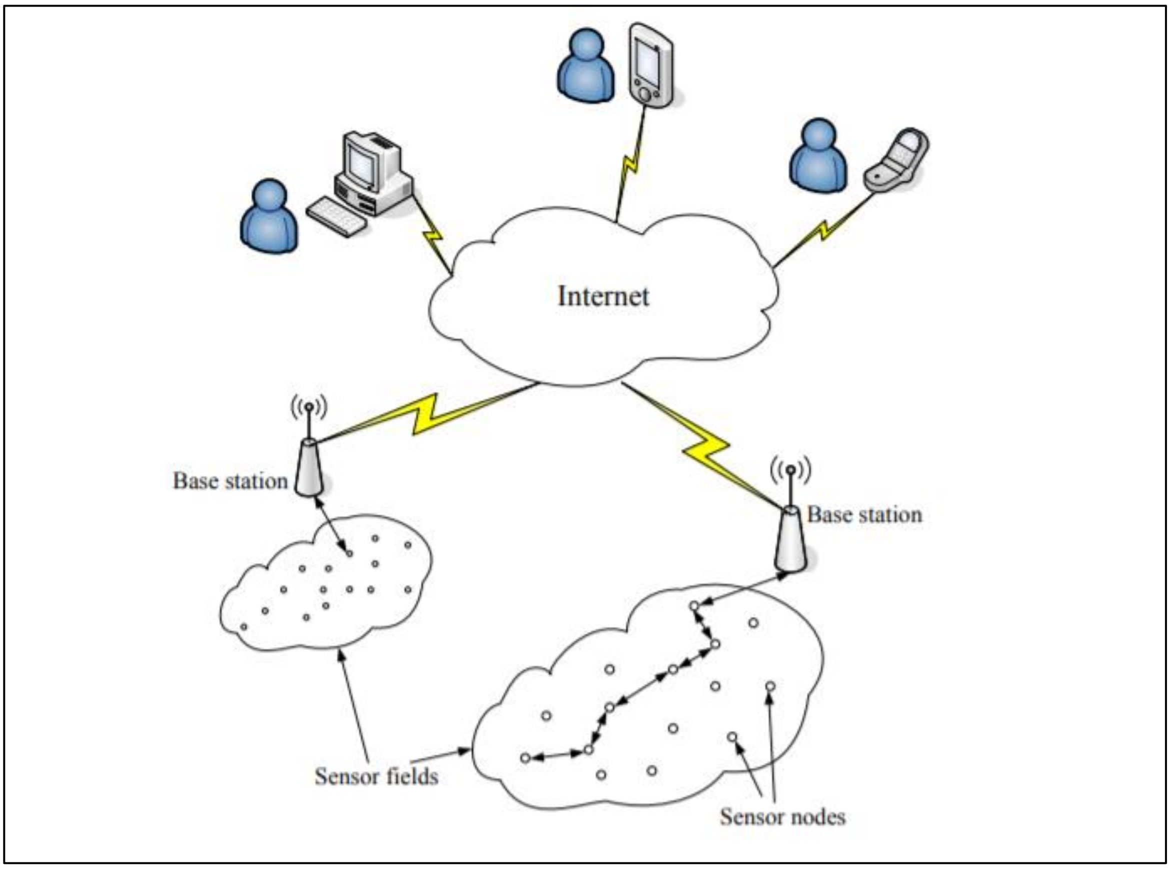


Fig. 2:2 Accessing WSNs through Internet [21].

2.3 Taxonomy of Sensor Networks

The number of applications that have been proposed to take advantage of this vast amount of data has grown in lockstep with sensor network research [22]. The underlying sensor network must fulfill a number of requirements as a result of the vast range of sensor network applications [23].

• Data sink(s): is used to collect data in wireless sensor network; data collection may one hop, multi- hop, all sensor collect data is send to the base station called sink node.

• Sensor mobility: is important. Sensor networks might be classified differently depending on the type of sensors utilized. Sensors are generally believed to be stationary, however recent sensor network studies have shown otherwise, Mobile sensor nodes have been included into projects like the Zebra Net project. Additional sensors may be added to soldiers or unmanned aerial aircraft during military operations to communicate with a sensor network that has been deployed. Sensor mobility can affect networking protocols as well as location service protocols.

• Sensory resources: The computer resources available to sensor nodes can vary substantially. Of course, at virtually every level, memory and processing restrictions should influence protocol design.

• Patterns of traffic: other thing to think about is how much the network generates traffic. Many event-driven systems' sensors may spend the bulk of their time in sentry mode, creating data flow only when a significant event is discovered. Data should be generated regularly in other applications, such as environmental monitoring.

As the preceding discussion shows, there are a variety of sensor, Protocol design should be influenced by network and application variables. As a result, a lot of work has gone into creating procedures for these different situations [24].

2.4 Communication Protocols for WSNs

The majority of WSN communication protocols employ the multilayer protocol architecture in its conventional form [14]. These procedures, however, may deliver outstanding results in terms of the metrics that each of these levels is linked with, they are not adjusted together to boost network performance in general while lowering energy consumption [25]. In light of

WSNs' limited energy and processing resources, cross-layer design (joint optimization and design of networking layers) appears to be the most viable Traditional tiered protocol designs are inefficient, therefore this is an alternative [26] [27]. Cross-layer design's fundamental notion is to improve information management and exchange across two or more layers in order leveraging relationships across several protocol levels to obtain substantial performance gains. The following section shows number of communication protocols [28].

2.4.1 LEACH Protocol

As a low-power WSN clustering routing mechanism, the Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is given [29]. Its clustering structure is extensible and is used and inherited by the majority of existing clustering routing protocols [30]. However, there are significant flaws with LEACH and some enhancement protocols, such as LEACH-C, because there is no guarantee of consumption balance between cluster nodes. This circumstance may cause some cluster nodes to expire sooner, reducing the network's lifespan. As a result, the “LEACH-A” Adaptive routing protocol is developed to balance the energy usage amongst cluster nodes [20]. LEACH is a sensor network that uses wireless technology. The main idea is to partition the network into multiple clusters, select a cluster head node at random, and then connect the cluster using the principle of proximity. Within the cluster, The cluster head node receives data from the nodes and compresses it before sending it to the Sink node [31]. LEACH uses the "round" approach to choose cluster heads. Its operation is split into two stages: the first is cluster formation, and the second is reliable data transfer [32]. Clusters can be formed from all of the nodes, with each cluster selecting a cluster head node at random. If the random number generated by each node is not as large as a specific threshold T (n), the node takes on the role of cluster head node. The T (n) threshold has the following definition:

$$T(n) = \begin{cases} \dfrac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.1)\ [31]$$

The percentage of cluster nodes in the network that account for the total number of nodes is denoted by p, and r denotes the number of performed rotations , the nodes of a gathering is the nodes whose previous r rounds do not act as nodes of cluster nodes [33].

LEACH has a decent energy consumption performance; however there are still some flaws:

- In the LEACH technique, random cluster head node selection cannot guarantee uniform space distribution, resulting in some cluster nodes being unable to join into any cluster member or members of the node, and cluster head nodes consuming too much energy during data transmission [34].
- Direct communication is used between the cluster head node and the sink node, resulting in increased energy consumption by sensors located further distant from the sink node.
- Cluster head selection ignores node residual energy, allowing nodes with lower residual energy to serve as cluster heads. This can hasten node mortality and shorten network longevity.

2.4.1.1 LEACH Protocol Phases

The LEACH procedure is divided into rounds. There are two phases to each round:

A. Setup-Phase

The setup process is separated into two parts: Cluster Setup Phase and Steady-Phase. In setup Phase, Cluster Heads (CHs) send an advertisement package to their neighbors informing them that they have become CHs. The setup process phase is summarized in a proposed diagram as illustrated in Figure 2.3. The advertisement packet with the highest received signal strength is chosen by non-CH nodes[35]. Every node chooses whether or not to become a CH independently of the others. This choice is based on when the node last functioned as a CH (In other words, nodes that haven't served as a CH in a Lengthy period of time are most likely to be chosen themselves compared to nodes that have lately been used as a CH). This is done in accordance with T, a threshold value (n). The threshold value is determined by the required proportion of nodes to become cluster heads (p), the most recent round (r), as well as the nodes that have not yet become cluster head in the past 1/p rounds (G). If this random integer is not as big as T (n), for the current round, the node is assigned as the cluster head. The newly selected CH then sends a message in an advertising to the public of the station's nodes, inviting them to establish their clusters. The strength of the advertising signal determines whether non-cluster head nodes join the clusters. The cluster head nodes are chosen at random from the sensor nodes during the setup phase, and multiple clusters are dynamically built.

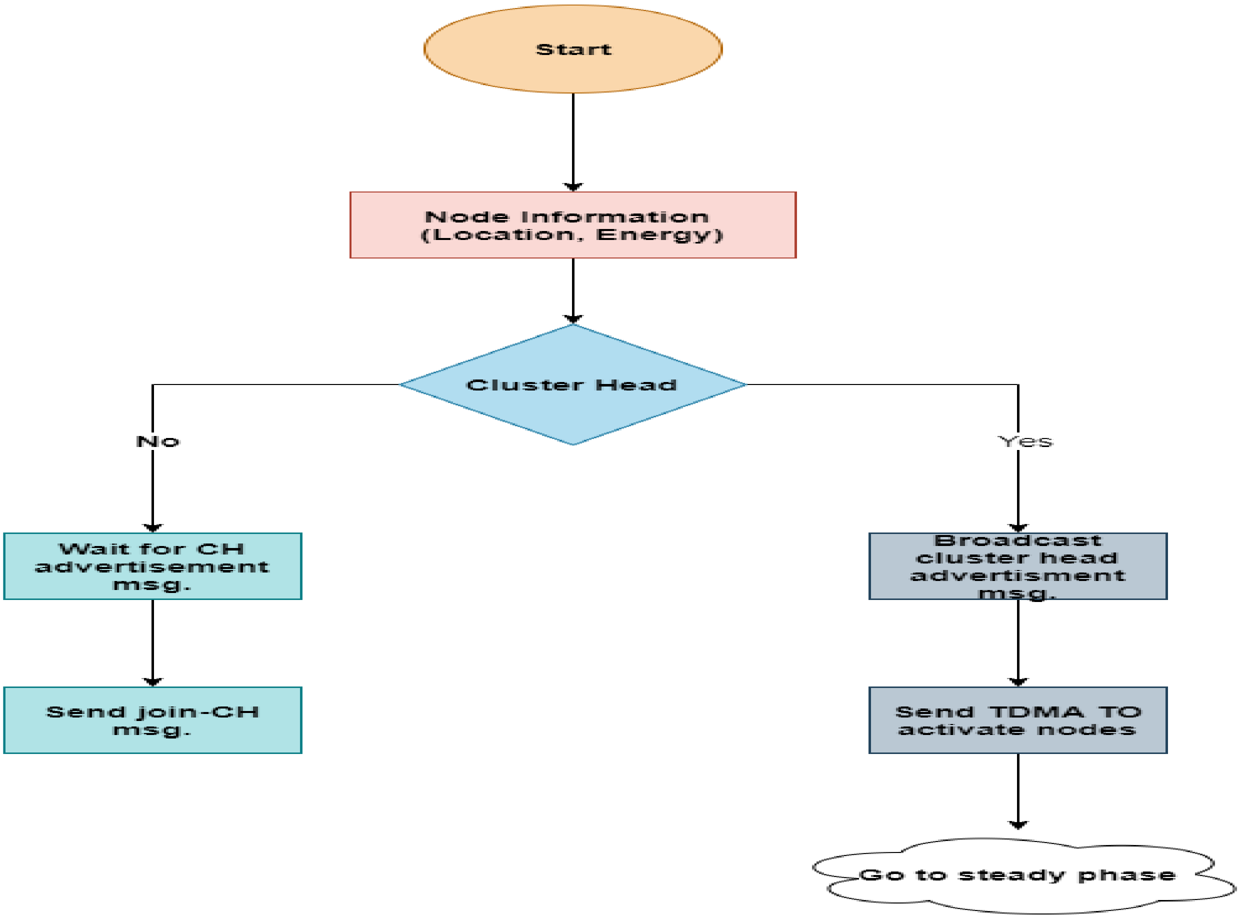


Fig. 2:3 LEACH protocol setup phase

B. Steady-Phase

The steady phase is separated into two parts:

- Make a schedule
- Transmission of Data

The steady phase is summarized as a flowchart as shown in Figure 2:4. Once the cluster head nodes have elected themselves as cluster leaders for the current round[36], it must tell all other nodes in the network about their decision. Each node in the cluster's head node sends out a broadcast an Advertising message (ADV) using a non-persistent Carrier Sensing Multiple Access (CSMA). This is a brief message that includes the node ID and identifies it as an announcement message in the header. After each node has decided which cluster to join, it must notify the cluster head node of its decision. Using a non-persistent CSMA, to the chosen cluster head, each node sends a join request message (Join REQ). The CH is aware of the total number of member nodes as well as their IDs after the schedule generation sub phase. Based on all of the messages When a Time Division Multiple Access (TDMA) schedule inside the cluster is received, the CH generates a TDMA schedule, selects a CSMA code at random, and The TDMA table is transmitted to cluster members. After that, the Data Transmission phase begins [37].

During their allotted TDMA slot, nodes submit their data to the CH This broadcast utilizes the radio's minimum the quantity of energy (determined depending on the received intensity of the CH advertising). Each non-CH node can be turned off until a TDMA slot is assigned to it. This will reduce energy dissipation in cluster nodes, with the CH aggregating the data and sending it to the BS. To minimize the quantity of data transferred to the base station, LEACH may conduct local aggregation of data in each cluster [38].

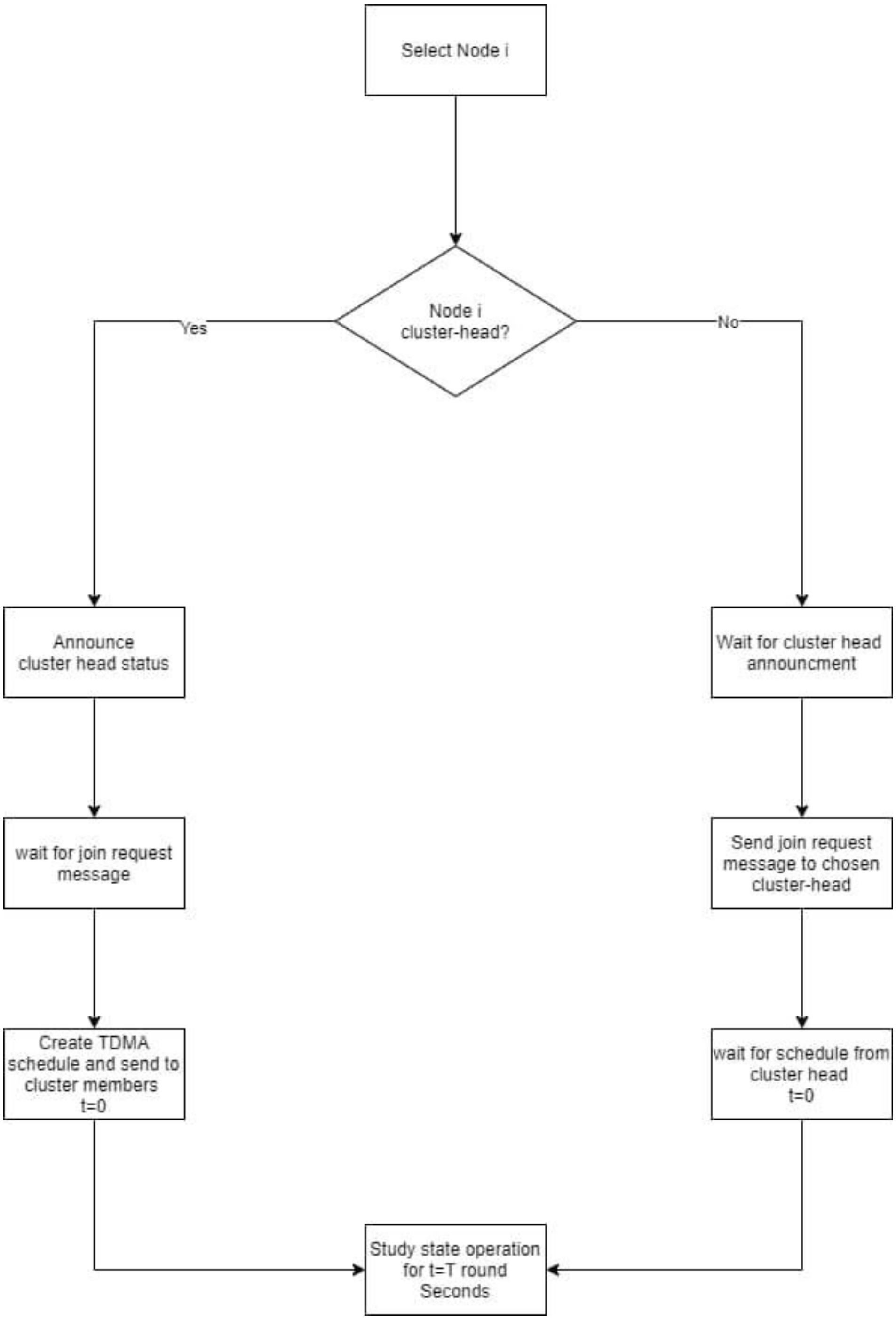


Fig. 2:4 LEACH Steady phase

2.4.2 Breath Protocol

It’s a cross-layer protocol that incorporates randomized routing, MAC, and duty cycling. According to Breath, a node in the network's direction toward the sink node transmits a data packet to another node in a forwarding area. This process is driven by messages exchanged between nodes in the forwarding zone that are accessible to accept data packets [37]. There is no acknowledgement or retransmission system in place, and the MAC is randomized [40]. Each node, whether transmitter or receiver, does not remain active but instead sleeps for a variable amount of time dependent on traffic conditions, resulting in a randomized duty cycling mechanism. Breath is meant to save network energy while preserving packet delivery reliability and end-to-end latency. The protocol's biggest flaw is its poor operative state, which includes a high wake-up rate [41].

2.4.3 SERAN Protocol

SERAN is a Semi-Random Clustering Algorithm with two layers. It defines the routing and MAC layer by combining randomized and deterministic components. SERAN, Unlike LEACH, it lacks cluster heads and the associated problems. The MAC protocol is a hybrid of TDMA and CSMA [42]. The TDMA technique reduces the wake-up rate and is implemented at the cluster level, While the CSMA method offers resilience across defective channels and an acknowledgement-based contention scheme lowers repeated packets, an acknowledgement-based contention scheme decreases repeated packets[43]. The routing algorithm has a similar dual character. The end result is a high level of reliability and energy efficiency. For these reasons, SERAN appears to be one of the best candidate protocols for WSNs [44].

2.5 Background of queuing theory

WSNs are made up of multiple sensor nodes that monitor the habitat, process data, and send it to a sink node or a base station. Typically, the sensor node perceives the environment at a capacity of packets with a Poisson distribution, and the node's control unit analyses these data at a rate of packets using an exponentially method[45]. This behavior is comparable to a queuing network structure with an outside queue length of packets and a utilization rate of packets. As a result, the queuing model is appropriate for WSNs to investigate performance metrics. In WSNs, the Poisson and exponential distributions are used to properly comply with the probability distribution of sensing data arrival rate and sensor node service rate. As a result, the M/M/1 queuing model can be used to assess WSN performance. WSN traffic is often divided into three categories: Data that perceives the habitat and is transferred to neighboring sensor nodes or the sink node is referred to as "originated traffic. “The data information traffic that is transported from neighbor nodes is known as forwarding traffic and finally, routing protocol introduces routing traffic. The data (originating and forwarding traffic) is represented by an open queuing network. Data packets might be either initiated packets containing sensor data or redirected packets from neighboring nodes. If the connection between the sensor as well as the sink is good, these packets can be sent straight to the sink; otherwise, they can be sent to a neighbor node as an intermediary node. Finally, the sink node transmits the collected data packets to the destination base station. Because data is collected by sensing applications from out of the network and finally leaves the system, the open queuing network paradigm is appropriate for this type of data communications system [46].

2.6 Queuing Systems

Queuing theory is a useful tool for modeling and analyzing the operation of a variety of complex systems, including computer networks, telecommunications systems, contact centers, industrial systems, and service systems [47]. Queuing theory, which includes queuing systems and networks, has piqued the interest of mathematicians, engineers, designers, and economists in recent years [48]. Many real-world systems, such as a bank's waiting line, a bus stop, an airport's waiting line, a factory's material flow, and a network's signal flow, may be described as a network of queues. As a result, each of these basic systems has three major components[49]:

• Entities: Something that alters the system's status. In many situations, especially when dealing with service systems, the entity is a person. Customers are the entities in the customer service center. Entities do not have to be humans; they can be objects as well. Loan applications are the entities that the mortgage loan officer works with. Similarly, the entities in the factory example are components that are ready to be machined. Entities can be signals waiting to be received in communication networks.

• Queues: Lines are referred to as queues in simulation. Entities usually queue until it is their turn to be processed.

• Resources: The resource is process that serves the entities that are waiting in line. Examples factory machines, computer processor, nodes in communication networks the relationships among these components are illustrated in figure 2.5.

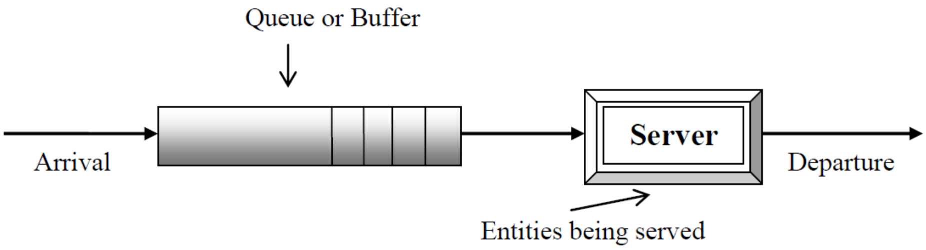


Fig. 2:5 Components relationship in queening system[49]

2.7 Queue strategy

The discipline for ordering things in a queue is determined by a queue strategy. It specifies the sequence in which they are supplied and how resources are distributed among consumers. Here are some of these strategies[50]:

- First In First out (FIFO): Entities are ordered according to their arrival times. The entity that has been waiting the longest is served first. This kind of queue is the most commonly used model because there is no differences between entities. It is a fair queuing strategy and low overhead. There is no Infinite postponement in such a queue. But long entities may let the short entities wait for a long time.
- Last in First out (LIFO): Sometimes, the entities are serviced in the reverse order of their entry so that the last entity join the queue serve first.
- Priority Queue: Priorities are a measure of urgency or importance. Each entity is assigned a priority and the entities are sorted in the queue by their priorities. Low values represent high priorities.

- The shortest is served first: So the waiting time of short entity is small. But the latent danger is that the longer service time entities may be infinitely postponed.
- Random Service: The entities in the queue are served in random order.
- Round Robin: Every entity gets a time slice .It will re-enter the queue, if its service not completed[51].

Network Congestion Management Techniques Congestion control keeps track of the methods for supervising the total input of data in order to maintain a suitable rate of movement. It's all about moving traffic away from congested areas and avoiding excessive subscription. Congestion control takes into account the network's size and use requirements. A variety of approaches were proposed to deal with these interactions[52]:

1- Drop Tail.
2- Additive Increase/Multiplicative-Decrease.
3- Partial Buffer Sharing.

2.8 Drop Tail Queue

LEACH protocol use the first Techniques that is a Drop Tail in Congestion Management Because of its simplicity, this method is frequently used in modern internet routers. It's a passive queue management (PQM) algorithm that uses a FIFO-based queue with a limited size that respectfully drops inbound data when the queue is full. Its implementation is stress-free due to its simple and decentralized character, and it is suited for heterogeneity. It has a higher link consumption rate. Transmission Control Protocol (TCP) Reno router on Drop tail method is now used on the internet. Its lockout behavior and full queue phenomenon are two major flaws, as detailed in [53]. Lock–out behavior refers to the use of available bandwidth by a single or restricted number of sources, with the goal of achieving global harmonization [9]. The term "full queue" refers to a queue that has reached capacity. This has a significant disadvantage, as it results in lengthy end-to-end delays. Although approaches such as drop front or indiscriminate drop alleviate the problem of lockout behavior, they are unable to solve the problem of overcrowding. To deal with these issues, early congestion detection is critical, as is accepting the reasons of congestion through a notification received sensor[54]. Because there is no separation of traffic from different sources, drop tail does not allocate buffer space evenly. Sources with a larger amount of traffic will require more buffer space. As a result, it is not suited for networks with many TCP connections since a buffer overflow causes TCP global synchronization, which drastically decreases network speed and utility.

2.9 Clustering Technique in Wireless Sensor Network

Data clustering is a descriptive and exploratory data analysis approach that has sparked a lot of attention, for example, pattern recognition, data mining, statistics, and other fields [55]. It is a method for investigating multivariate data sets that may comprise a variety of data types[56]. These data sets vary in size in terms of a variety of objects and sizes, or they include distinct data kinds, among other things. Without a doubt, data clustering is one of the most important data mining techniques, as it focuses on enormous data sets with unknown underlying structure.

Sensor nodes gather data in an environment and send it to a sink either directly or cooperatively through other nodes. To provide scalability, reliability, and decreased network traffic, many sensor applications cluster the sensor nodes. (Fig. 2:6) depicts an example clustering scenario. Cluster heads are installed on clusters, and these cluster heads provide the aggregated data to the base station or sink[57].

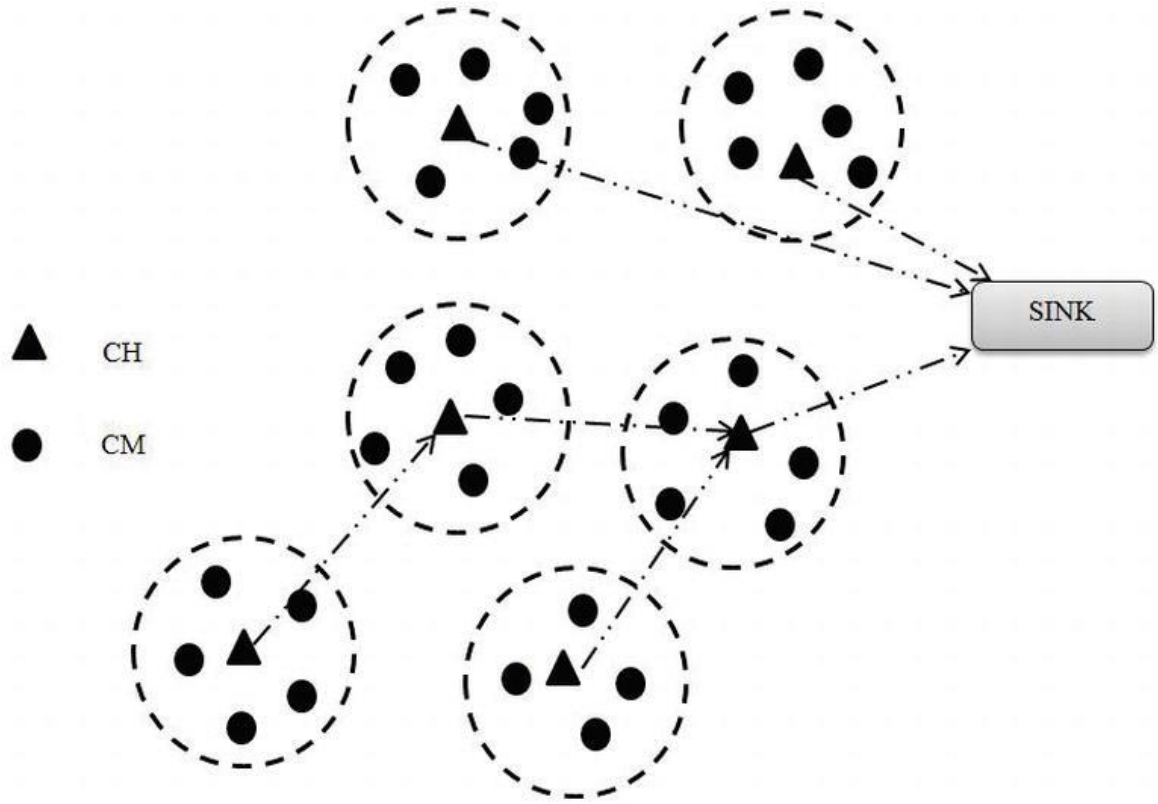


Fig. 2:6 Clustering technique in wireless sensor network [57]

The major benefit of clustering is performance scalability over growing sensor networks. Furthermore, the clustering technique has a slew of additional benefits. Because of its targeted solutions, it assures dependability and prevents one-point failure[58]. To efficiently minimize power consumption, a clustering solution might recommend a sleep/wakeup schedule for a WSN. Many sensor applications do not require all sensor nodes to be in a waking state and waste energy. Some sensor nodes can be placed into sleep mode, which consumes no energy, based on their temporal and geographical relationships. Through the sink or administrator, an effective schedule may be created and transmitted to these sensor nodes. Due to its semi-distributed nature, clustering also assures scalability of application performance. Clustering has several drawbacks in addition to its benefits[59]. There are a few sensor nodes known as "cluster heads" that monitor and manage data flow between clusters, which consumes a lot of energy. As a result, the procedure of re-clustering and reelection of cluster heads is necessary, resulting in sensor network lifespan being shortened. Low energy adaptive clustering hierarchy (LEACH) is a traditional clustering algorithm that solves cluster overloading by rotating the role of cluster leaders among the sensor nodes of a cluster.

2.10 Features of Cluster-Based WSN

Data fusion is a term used to describe the process of CHs acquire data from various nodes and deliver it to the base station during data fusion (BS). Data fusion also reduces duplicate data at the CH level, which relieves the sensor nodes of additional communication load. As a result, data fusion improves total network lifespan and conserves all network energy[60].

- **Data Load Management**: Clustering allows for effective data load control and a consistent network lifespan. In order to transmit data from upper levels, CHs closer to the BS incur increased data loads. To deal with this issue, CHs that are closer to the BS maintain fewer member nodes to reduce burden. As a result, the energy loss of all nodes is equal, and the network lifespan is uniform.
- **Efficient Energy Saving**: Data is sent by flooding in flat networks, whereas data is pooled on the CH level and sent to the BS via multihop

routing in cluster-based networks. In a cluster-based network, multihop routing reduces the number of transmission routes, saving energy exponentially[60].

- **Relay Node**: When nodes cease to communicate, the network is partitioned or disconnected. The relay node is used to reconnect the partitions and restart the route. The relay node might be either stationary or movable. A static node's first duty, on the other hand, is to locate the discontinuous section and then deploy a relay node there. Mobile relay nodes, on the other hand, are a unique sort of node that operates in a discontinuous part.
- **Robustness**: The second critical step after forming a cluster-based WSN is cluster maintenance. Cluster maintenance is necessary to keep the network running smoothly. It can manage a variety of situations, including network size changes, node relocation, and unforeseen operational flaws. Managing these differences throughout each cluster is all that clustering techniques require. As a result, cluster maintenance makes the network more resilient and convenient to manipulate topologically[61].
- **Collision Avoidance**: When a single channel is considered in a sensor network, it is shared among sensor nodes. As a result, when a large number of nodes send data at the same time, the network's performance suffers. This may be easily handled in a cluster-based WSN, where the CH uses scheduling to assign a unique time slot to each member node.
- **Latency Reduction**: The overall time it takes for a message to transit from source to destination node is referred to as latency. By keeping a routing table at the CH level to make optimal routing decisions, cluster-based WSN improves packet delivery performance. Furthermore,

cluster-based networks based on the linked dominant set (CDS) establish a predetermined communication channel known as the backbone tree, which allows for rapid and efficient multihop routing.

- **Secure Data Communication**: Malicious nodes may attempt to modify or hack data since CH does data aggregation. Strong authentication techniques are established in cluster-based WSNs to prevent malicious nodes from joining the network. These methods help to ensure data integrity and privacy.
- **Fault Tolerance**: Sensor nodes may be affected by hardware failure, delay, interference, energy exhaustion, and so forth. Due to such constraints, where the nodes are not replaceable in harsh atmosphere, cluster-based protocols are suitable. Therefore, WSNs must have the ability to reconfigure themselves without human intervention, particularly in harsh environments and inaccessible locations. In order to secure aggregated data, fault tolerance technique needs to be considered during protocol design stage. Cluster maintenance and CH backup are more feasible techniques to secure the entire network reconstruction when CH is malfunctioning[62].
- **Data Communication Assurance**: CH sends the aggregated data to the base station through single-hop or multihop routing. In mobile network, the probability of data loss takes keen interest in recent researches because of its high chance of occurrence. To handle such problems in mobile node, the node sends a joint request to its CH before the actual data communication takes place. If the sender receives the acknowledgement message, then it initiates data transmission; otherwise the sender node considers that it is no more a part of the network and that it needs to rejoin the network. When the node is

rejoined, the network then initiates data sending to parent node. Thus, connectivity assurance between member nodes and their CH is a crucial task for successful data delivery.

- **Deadlock Prevention**: Data is sent to the base station via intermediary nodes in multihop transmission. Different nodes relay data to the base station in this criteria. As a result, the node closest to the sink node is overburdened with more information than the nodes further away. As a result, nodes closer to the BS consume energy faster, resulting in stalemate near the BS. This may result in the network being divided into groups. As a result of the limited range, the distant nodes may not be able to approach BS. Other nodes, on the other hand, continue to have energy. To address these issues, load balanced clusters were studied, in which a cluster closer to the base station keeps a lesser number of MNs than a cluster further away[63].
- **Network Lifetime**: Because nodes have limited power, bandwidth, and computing capabilities, increasing network lifespan is a critical concern. Optimizing a few issues in WSNs, such as intracluster communication cost, redundant data collection, and uniform cluster loads, is usually a critical job. Such considerations are taken into account during CH election, extending the network's lifespan. Furthermore, higher energy routes are favored for data transmission, with this criterion resulting in consistent energy depletion in the network and extending network lifetime.
- **Efficient Quality of Services**: WSN's capabilities and network applications necessitate the requirement of service quality (QoS). End-to-end latency, dependability, throughput, jitter, and bandwidth are common effective QoS characteristics. In cluster-based protocols, it is

challenging to meet all of the requirements for QoS parameters. To evaluate one or more QoS factors based on application needs, a trade-off is necessary. The energy efficiency of state-of-the-art cluster-based protocols is prioritized above QoS. For real-time application domains such as healthcare, combat applications, and event observation, QoS problems are taken into account [64].

2.11 Performance metrics overview

In this part, a set of performance metrics are enumerated which can be used to evaluate the performance of cluster-based wireless sensor network:

2.11.1 Network lifetime

Perhaps the most significant measure for evaluating sensor networks is network lifespan. Of course, in a resource-constrained setting, the use of every finite resource must be addressed [65]. However, network lifespan as a measure of energy consumption holds the unique position of forming an upper constraint for the utility of the sensor network [65,66]. The network can only serve its function while it is considered "alive," and not beyond that. As a result, it is an indicator of the greatest usefulness that a sensor network can give. If the measure is utilized in a study before to a real-world deployment, the predicted network lifetime can also help to justify the deployment cost. It also regarded as an important characteristic in the context of network availability and security. The lifespan of the network is heavily dependent on the lives of the individual nodes that make up the network. This is independent of how the network lifespan is defined. When the individual nodes fail, each definition may eventually be reduced to a question. The most common definition found in the literature is n-of-n lifetime.

2.11.2 Packet delivery ratio

Packet delivery ratio (PDR) is defined as the ratio of the number of data packets successfully delivered to the destination to the number of packets transmitted by the source

$$PDR = \frac{P_{recieved}}{P_{sent}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

The entire number of packets received by the sink node is represented by $P_{recieved}$ the total number of packets created by the source nodes is P_{sent} .

2.11.3 Throughput

The throughput of a WSN is measured by the total traffic that reaches the sink per time unit. The throughput-delay connection is straightforward to determine since the TDMA frame length, which in turn defines the throughput, limits the end-to-end delay between a sensor and the sink. However, The TDMA frame duration will increase as more targets are monitored within the network, As a result, there may be longer delays, although overall throughput will stay steady. As a result, In this case, transmission ordering becomes critical, However, we are primarily concerned with concerned with maximizing total throughput, thus the end-to-end latency isn't expressly taken into account [68]. It calculate by equation:

$$\mathrm{Throughput(bit/s)} = \frac{\mathrm{output\ data\ [bit]}}{\mathrm{Time[s]}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

Where output data [bit] represent the amount of data send by sender and Time[s] refer to the time that data take it to arrive to destination.

2.11.4 Drop packets

Detection of Packet Dropping attacks for wireless Sensor Networks (DPDSN) monitors routes and identifies packet drops at any node along the path. When identify such an occurrence, switch to a different communication path.
By incorporating it in route discovery in source-initiated and receiver-initiated routing protocols, the cost of discovering an alternate path is lowered. To reduce the switching latency, always maintain an alternate path ready. It refers to a packet that has not been delivered and is calculated using an equation:

$$\text{Dropped Packet} = \text{sent Packets} - \text{received Packets} \ldots\ldots\ldots\ldots\ldots. \ (2.4)$$

2.11.5 Delay

End-to-end latency, which is defined as the average total of the differential delay of each data packet received by the sink node and the time a data packet is provided by sensor nodes, is another network performance measure.

$$\text{EED} = \text{Tr} - \text{Ts} \ldots\ldots\ldots\ldots\ldots.. \ (2.5)$$

Where EDD refer to end to end delay, Tr refer to time received of packet by node and Ts refer to time sent of packet by node.

Summary:

The theoretical aspect's presentation it covers wireless sensor networks in general, queueing theory, and the LEACH protocol in particular. It includes lists of examples and illustrations to provide the reader a thorough knowledge of the thesis topic and application.

CHAPTER THREE

The Proposed Approach

3 The Proposed Approach

3.1 Introduction

This chapter provides an overview of the research methodologies used in the thesis. The research design that was chosen is stated for the purposes of this research, as well as the rationale behind this decision. Additionally, the system functionality proposed in details with flowcharts and block diagrams.

3.2 Research Methodology

Network Simulator (Version 2), abbreviated as NS2, and is a straightforward event-driven simulation program suggested to be utilized in this project. It has shown to be effective beneficial in researching the dynamic communication networks' nature. NS2 can simulate both wired and wireless network operations and protocols. Due, choose it as a primary simulator to the proposed WSN. In general, NS2 allows users to select network protocols and mimic the behavior of those protocols. First, to achieve system objectives that enhance the overall WSN and eventually gives great productivity to users. To manage and implement the project passed through the following stages:

- **Stage 1:** Generate a Wireless sensors Network with different number of sensors nodes.
- **Stage 2:** Implement LEACH protocol
- **Stage 3** Evaluate the network via (throughput, network delay and packet delivery ratio).
- **Stage 4:** Increase network's capacity by adding extra nodes and recharge base station locations and clusters numbers. By default that will change the number of network cluster head (CH).
- **Stage 5:** Re-evaluate the network performance.

- **Stage 6:** Compare the results.

The following section shows detailed process steps of both design and implementation stages:

1-Design WSN using NS2 codes. The result shows 100 nodes as a first scenario.

2-Choose cluster and every 20 second change the current cluster.

3- Select cluster head node (CH) if a node is unable to reach the base station due to a lack of energy, it can route its data through other CH nodes and have it relayed to its eventual destination. Using several hops reduces energy usage since transmission distances are cut in half. Many CHs are necessary to provide energy expenditure consistency and homogeneity across the network. The disadvantage of having many hops is that it might influence the routing latency of information because it must transit several sections to reach. So, the goal is to identify the optimum options for transmitting data from one location to another by balancing many characteristics, including energy usage, signal strength, routing information end-to-end delays, and hop count.

4-Nodes sense data from around environment and then send it to the near cluster head (CH). Sending message from sender node to receiver node, which is CH take directed path if it close to it. Otherwise, it takes multi hops or clustering. Multi hops takes two different approaches:

a. Random Transmission approach

b. Guidance approach (The transmission will be guided toward the next node in the direction of the receiver)

5- Cluster head nodes will resend the received data to the base station (sink node) in order to be maintained.

6- The base station node process all received data from cluster head nodes. For example, it used the sense nodes to sense heating in a wide environment the heating reads will be pass from CH to base station in order to take an action.

7- The query pass to all connected nodes in order to run.

8- Previous are designing and implementation steps, next is an enhancement stages:

a. Evaluate WSN metrics: (network throughput, network lifetime, packet delay, dropped packet and packet delivery ration) before implementing LEACH protocol. The previous researches shows that WSN has a weak performance and packet loos [69][70] .

b.Initially, clusters are generated using the LEACH procedure, which selects cluster heads based on the residual energy measure and flow rate. Because network coding is an optimum approach for improving network performance by reducing the amount of transmissions, it has been included into the LEACH Protocol and is used at the cluster levels.

c. Additionally, the next level of network coding takes place at a node when one of the nodes is designated as a master node. The simulation results show that the proposed technique is effective Outperforms the EE-LEACH and LEACH protocols in terms of packet delivery ratio and network lifespan.

9- Evaluate network by comparing simulation results between proposed system and other similar projects and discussed the results. Three main metrics focused on this thesis are packet delivery ration, packet delay, network lifetime. The following flowchart in Fig.3.1 shows the suggested methodology.

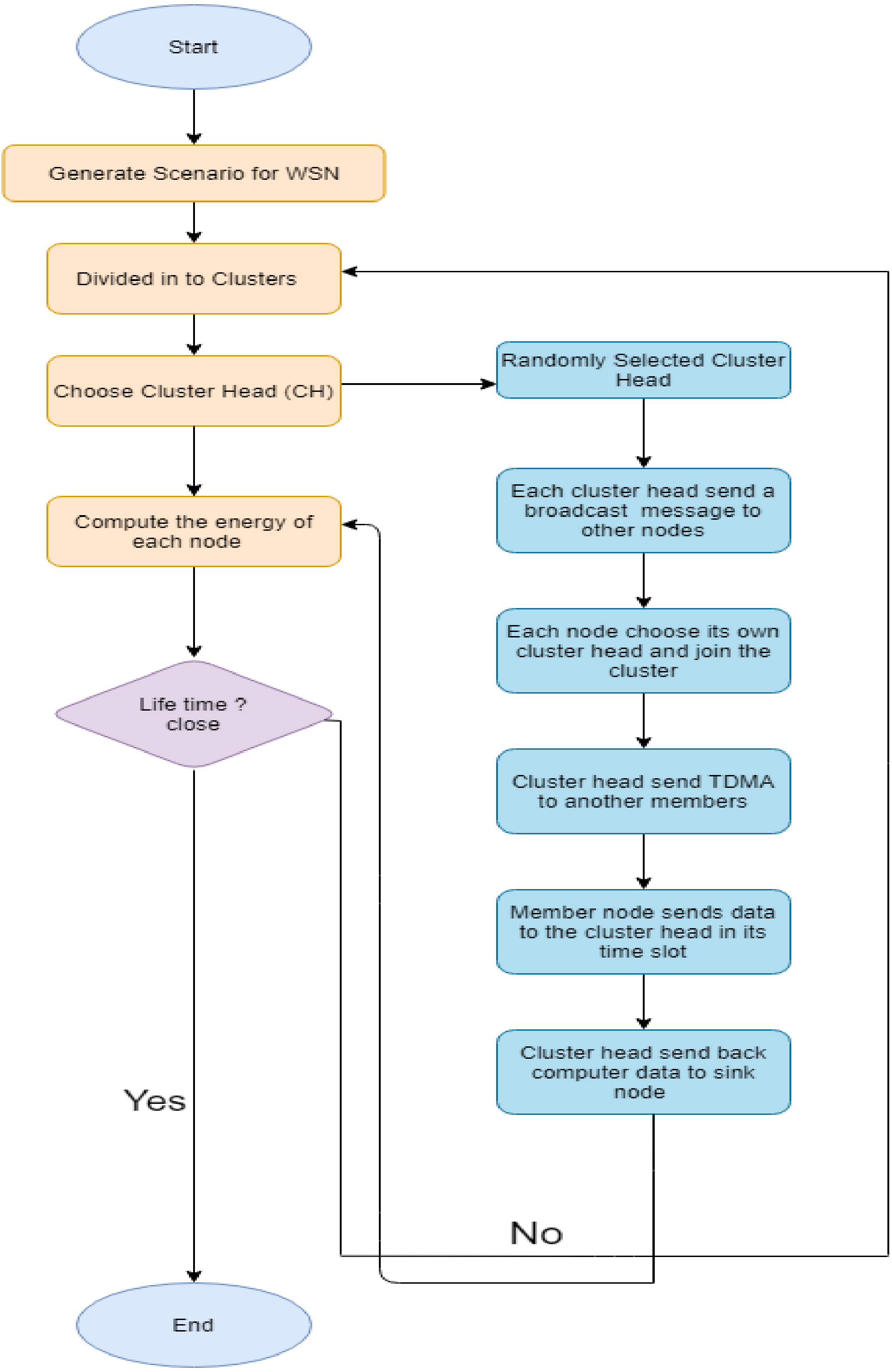


Fig. 3:1 System Methodology

3.3 System Setup and Functionality

Figure 3.2. Shows the main flowchart of implementing system and obtaining the result. The diagram divided into two main stages: implement and evaluate network.

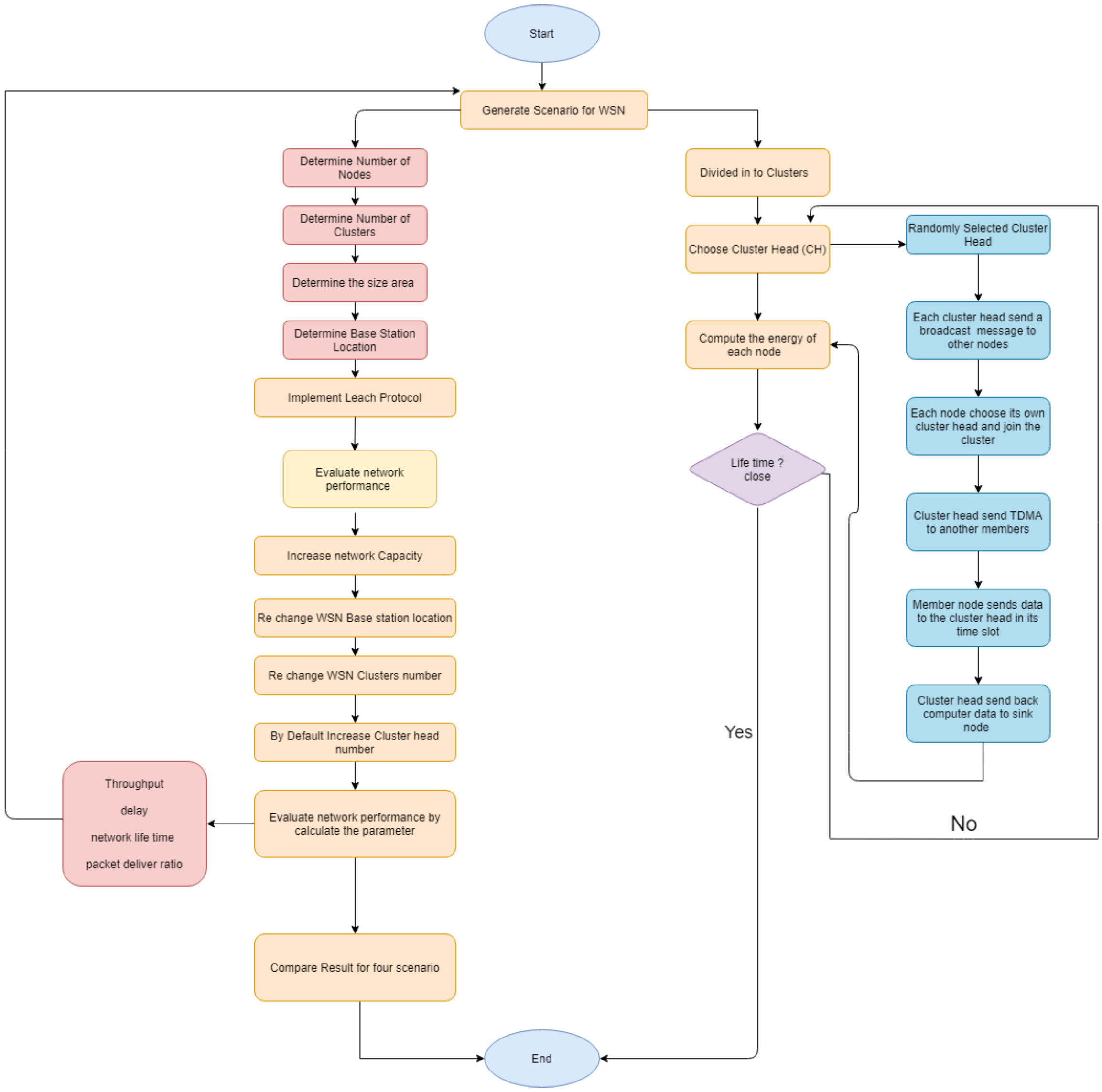


Fig. 3:2 Flowchart of the proposed system

Implementing the system include generate scenarios with different nodes number. After deciding number of nodes, it is necessary to choose a cluster head node to received data from other nodes and pass it to the base station.

Lastly, network enhancement stage after implementing LEACH protocol to make network performance better.

3.3.1 Generate WSN

The following step declared how to generate scenario for WSN and implement them with different number of node in four cases and evaluate performance of the network:

3.3.1.1 The First Case

In this case, Simulation steps for 100 nodes is implemented:

- Network generating phase illustrates as shown in algorithm (3.1). Algorithm (3.1) illustrates the steps to generate scenario for a WSN of 100 nodes.

Algorithm (3.1) : Generate WSN with 100 nodes	
Input	nodes number
Output	WSN with 100 nodes
Begin	
1	Open new file (name.txt)
2	Set nodes number to 100
3	Set Range
4	Set begin ← 0 Set end ← 100
5	For i = 1 i <= node number increment i set x position set y position generate output file with x,y position end

End

- The following command line runs inside NS2 platform **cd mit/uAMPS- ns genscen**
- Result contains network's nodes within positions of (x, y) for each node.

3.3.1.2 Implements Leach Protocol on (100 node) WSN

Algorithm (3.2) shows the steps to generate leach protocol into WSN.

Algorithm (3.2) : Leach protocol generation	
Input	nodes number
Output	WSN with 100 nodes
Begin	
1	Set algorithm = leach
2	Set out file name and directory
3	Set number of clusters c=n
4	Set n energy for each node
5	Set timer
6	Set field size x and y
	Set base station positions (x, y)
	Run
End	

- Run above algorithm using the following commands **cd mit/uAMPS- ns genscen**
- Network generated with 100 nodes.
- One further step utilized to check whether we successfully run the protocol. Run "**leach.err**" to shows errors if found.

- After implementing codes to generate WSN it's essential to evaluate its performance by adding "**all.pl**" file in ns2 that work on leach trace file "**leach.tr" to** see transmission data in network and make calculation by using the equations in 2-11 in chapter 2.

3.3.1.3 Simulation Steps For Second Use Case (150 node) WSN

- Network generating phase illustrates in algorithm (3.3).Algorithm (3.3) illustrates the steps to generate scenario of 150 nodes network.

Algorithm (3.3) : Generate WSN with 150 nodes	
Input	nodes number
Output	WSN with 150 nodes
Begin	
1	Open new file (name.txt)
2	Set nodes number to 150
3	Set Range
4	Set begin← 0 Set end ← 150
5	For i = 1 i <= node number increment i set x position set y position generate output file with x,y position end
End	

- The following commad line runs inside NS2 platform **cd mit/uAMPS- ns genscen**

- Result contains network's nodes within positions of (x, y) for each node

3.3.1.4 Implements Leach Protocol on (150 node) WSN

Algorithm (3.4) shows the steps to generate leach protocol into WSN.

Algorithm (3.4) : Leach protocol generation	
Input	nodes number
Output	WSN with 150 nodes
Begin	
1	Set algorithm = leach
2	Set out file name and directory
3	Set number of clusters c=n
4	Set n energy for each node
5	Set timer
6	Set field size x and y
	Set base station positions (x, y)
	Run
End	

- Run above algorithm using the following commands <u>**cd mit/uAMPS-ns genscen**</u>
- Network generated with 150 nodes.
- One further step utilized to check whether we successfully run the protocol" **leach.err"** shows errors if found.
- After implementing codes to generate WSN it's essential to evaluate its performance by adding "**all.pl**" file in ns2 that work on leach trace file "**leach.tr"** to see transmission data in network and make calculation on by using the equations in 2-11 in chapter 2.

3.3.1.5 Simulation Steps For Third Use Case (200 node) WSN

- Network generating phase illustrates in algorithm (3.5).Algorithm (3.5) illustrates the steps to generate scenario of 200 nodes network.

Algorithm (3.5) : Generate WSN with 200 nodes	
Input	nodes number
Output	WSN with 200 nodes
Begin	
1	Open new file (name.txt)
2	Set nodes number to 200
3	Set Range
4	Set begin← 0 Set end ← 200
5	For i = 1 i <= node number increment i set x position set y position generate output file with x,y position end
End	

The following comma line runs inside NS2 platform **<u>cd mit/uAMPS-ns genscen</u>**

Result contains network's nodes within positions of (x, y) for each node.

3.3.1.6 Implements Leach Protocol on (200 node) WSN

Algorithm (3.6) shows the steps to generate leach protocol into WSN.

Algorithm (3.6) : Leach protocol generation	
Input	nodes number

Output	WSN with 200 nodes
Begin	
1	Set algorithm = leach
2	Set out file name and directory
3	Set number of clusters c=n
4	Set n energy for each node
5	Set timer
6	Set field size x and y
	Set base station positions (x, y)
	Run
End	

- Run above algorithm using the following commands **cd mit/uAMPS-ns genscen**
- Network generated with 200 nodes.
- One further step utilized to check whether we successfully run the protocol. "**leach.err**" shows errors if found.
- After implementing codes to generate WSN it's essential to evaluate its performance by adding "**all.pl**" file in ns2.35 folder that work on leach trace file "**leach.tr"** to see transmission data in network and make calculation on by using the equations in 2-11 in chapter 2.

3.3.1.7 Simulation Steps For Fourth Use Case (250 node) WSN

- Network generating phase illustrates in algorithm (3.7).Algorithm (3.7) illustrates the steps to generate scenario of 250 nodes network.

Algorithm (3.7) : Generate WSN with 250 nodes	
Input	nodes number
Output	WSN with 250 nodes
Begin	
1	Open new file (name.txt)
2	Set nodes number to 250
3	Set Range
4	Set begin← 0 Set end ← 250
5	For i = 1 i <= node number increment i set x position set y position generate output file with x,y position end
End	

- The following comma line runs inside NS2 platform **cd mit/uAMPS- ns genscen**
- Result shows as below screenshot contains network's nodes within positions of (x, y) for each node

3.3.1.8 Implements Leach Protocol on (250 node) WSN

Algorithm (3.8) shows the steps to generate leach protocol into WSN.

Algorithm (3.8) : Leach protocol generation	
Input	nodes number

Output	WSN with 250 nodes
Begin	
1	Set algorithm = leach
2	Set out file name and directory
3	Set number of clusters c=n
4	Set n energy for each node
5	Set timer
6	Set field size x and y
	Set base station positions (x, y)
	Run
End	

- Run above algorithm using the following commands
- Network generated with 250 nodes
- One further step utilized to check whether we successfully run the protocol. "**leach.err**" shows errors if found.
- After implementing codes to generate WSN it's essential to evaluate its performance by adding "**all.pl**" file in ns2 that work on leach trace file "**leach.tr"** to see transmission data in network and make calculation on by using the equations in 2-11 in chapter 2.

Summary:

Gives an outline of the thesis's research methodology. For the goals of this study, the research design that was adopted as well as the reasoning behind it are described. In addition, flowcharts and block diagrams are used to illustrate the system's functioning.

CHAPTER FOUR

Implementation and Results

4 Implementation and Results

4.1 Introduction

In this chapter, the simulation results are given to demonstrate the WSN's performance with LEACH protocol, Packet-Loss, network Throughput, and End-to-End Delay are the QoS parameters that are computed, and Packet Delivery ratio.

4.2 Generate And Implement WSN and LEACH Protocol

Generate scenario for WSN in different number sensor node and implement leach protocol with make change on five filed that declared in table 4-1:

Table 4-1 WSN scenarios details

To	Number of nodes	Number of clusters	Number of cluster head	Size of scenario(space x,y)	location Base station (bs_x, bs_y)
1	100	5	5	1000px -1000px	50,175
2	150	8	16	1500px-1500px	75,200
3	200	9	19	2000px -2000px	100,350
4	250	11	26	2500px-2500px	125 , 375

Table 4-1 shows the details of four-use cases. Each case has a scenario of generating WSN with different nodes number, different base station location, different size of scenario and different number of cluster that change every 20 second.

4.2.1 Case1 100 Nodes Network

Generates WSN scenario with 100 nodes with positions of (x, y)for each sensor node like in first row the number(65.7459) represent the position X for first node and the second number in first row (92.5817) represent position Y for first node as it shows Fig. 4:1

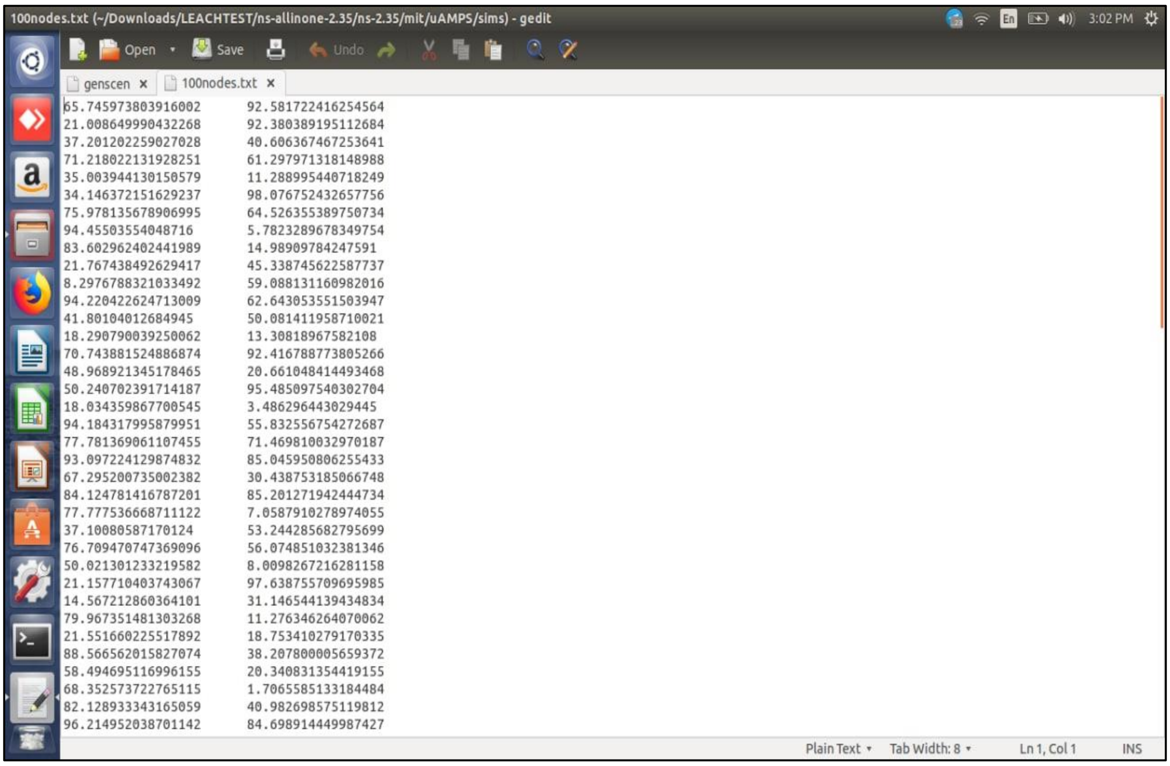


Fig. 4:2 positions(x,y) for 100 nodes WSN

1- Go to command terminal and write the command :"./leach_test"

To Impalement leach protocol as declared in Fig. 4:2.

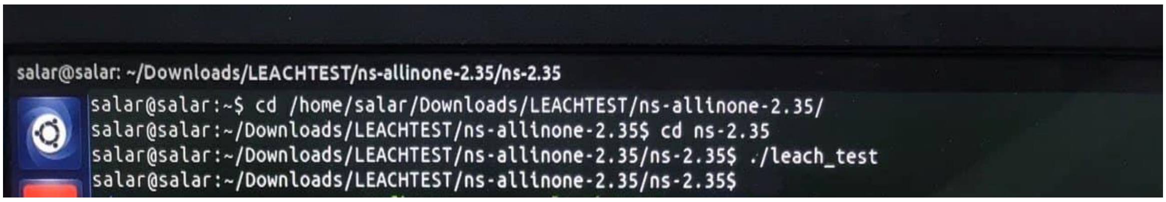


Fig. 4:2 Leach protocol implementation code for 100 nodes

The result shows WSN network information for 100 nodes that appear in second line in Fig. 4:3 represent number of node start from 0 to 99 and other line represent position for each node in (x,y) and send ADV message to declere which node is a cluster head node . Next screenshot illustrates that.

```
leach - Notepad
File Edit Format View Help
Creating sensor nodes...
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 6
*** NOTE: no connection pattern specified.
Loading scenario file...
Node 0: (65.745973803916002,92.581722416254564)
Node 1: (21.008649990432268,92.380389195112684)
Node 2: (37.201202259027028,40.606367467253641)
Node 3: (71.218022131928251,61.297971318148988)
Node 4: (35.003944130150579,11.288995440718249)
Node 5: (34.146372151629237,98.076752432657756)
Node 6: (75.978135678906995,64.526355389750734)
Node 7: (94.45503554048716,5.7823289678349754)
Node 8: (83.602962402441989,14.98909784247591)
Node 9: (21.767438492629417,45.338745622587737)
Node 10: (8.2976788321033492,59.088131160982016)
Node 11: (94.220422624713009,62.643053551503947)
Node 12: (41.80104012684945,50.081411958710021)
Node 13: (18.290790039250062,13.30818967582108)
Node 14: (70.743881524886874,92.416788773805266)
Node 15: (48.968921345178465,20.661048414493468)
Node 16: (50.240702391714187,95.485097540302704)
Node 17: (18.034359867700545,3.486296443029445)
Node 18: (94.184317995879951,55.832556754272687)
Node 19: (77.781369061107455,71.469810032970187)
Node 20: (93.097224129874832,85.045950806255433)
Node 21: (67.295200735002382,30.438753185066748)
Node 22: (84.124781416787201,85.201271942444734)
Node 23: (77.777536668711122,7.0587910278974055)
Node 24: (37.10080587170124,53.244285682795699)
Node 25: (76.709470747369096,56.074851032381346)
Node 26: (50.021301233219582,8.0098267216281158)
Node 27: (21.157710403743067,97.638755709695985)
Node 28: (14.567212860364101,31.146544139434834)
Node 29: (79.967351481303268,11.276346264070062)
Node 30: (21.551660225517892,18.753410279170335)
Node 31: (88.566562015827074,38.207800005659372)
Node 32: (58.494695116996155,20.340831354419155)
Node 33: (68.352573722765115,1.7065585133184484)
Node 34: (82.128933343165059,40.982698575119812)
Node 35: (96.214952038701142,84.698914449987427)
Node 36: (34.655160938694685,49.28989664152725)
Node 37: (15.292854148565258,26.999674936290681)
```

Fig. 4:3 100 nodes generated successfully

2- Check whether an errors happen when we run the protocol by running “**leach.err”** file that display message for error if anything of file not install correctly or not implemented in right way but if show the word “**SORTIND LISTS …DONE!”** That mean the installing and implement successful done.

```
leach - Notepad
File Edit Format View Help
INITIALIZE THE LIST xListHead
SORTING LISTS ...DONE!
```

3- Evaluate network performance metrics. It running by adding ”**all.pl**” file that contain the a Mathematical equations declare in chapter 2 in detail After that go to ns2 folder and open the command terminal to write the code

“`Perl all.pl leach.tr”

That when running make analyses on “**leach.tr”** file columns and display the result for analyses scenario of 100 node running the command to get the final results shows in Fig. 4:4.

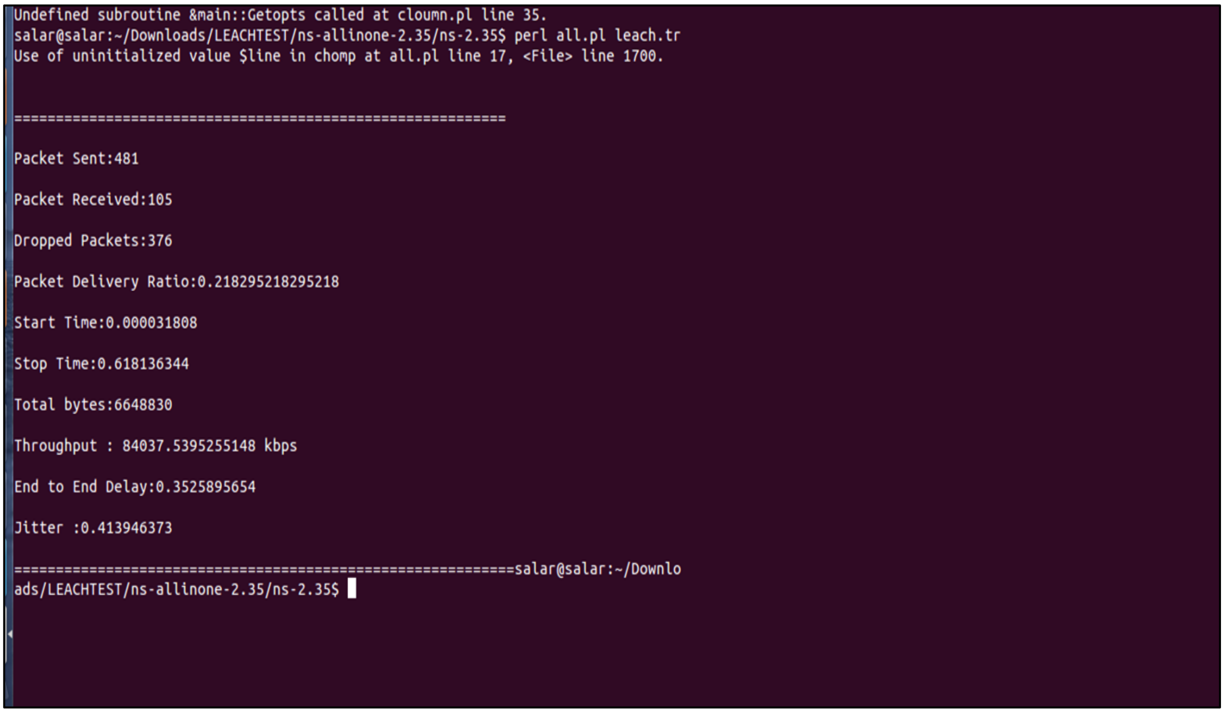


Fig. 4:4 100 nodes WSN performance metrics

As we see in Fig. 4:4 it display metric evaulation (packet sent,packet recived ,Dropped packet packet deliver ratio ,…..,Jitter).

4.2.2 Case2 ;150 Nodes Network

1. Generates WSN scenario with 150 nodes with positions of (x, y)for each sensor node like in first row the number(36.6823) represent the position X for first node and the second number in first row (92.2823) represent position Y for first node as it shows in Fig. 4:5:

new150nodes - Notepad

File Edit Format View Help

36.682324338090758	92.383235247052838
78.077857651784015	95.424098985001493
77.886572912282574	119.68124952152429
11.01581936749435	72.336289390146874
61.164379846846863	122.93086106559767
84.129887206540388	32.704025126390171
64.840718831327152	71.629981264299701
120.70774271651531	32.517116229290664
16.893065495832388	55.207286032478919
125.57434324434695	83.930583849516964
25.500320748193342	79.716593273783388
6.7775749167323003	97.727099595464352
12.408251647096245	23.213083354389799
142.91788413790889	14.245749644118245
109.05546113339042	135.59405095204434
121.18447889629029	44.0218527075005
80.362142799590771	92.689208170720008
72.478113776295501	49.212543293467043
115.75556854519786	123.15036676505132
116.00147933512994	94.745842434813198
118.54447185459756	111.09369781850543
10.174936642951769	89.744382253728986
43.62858177331676	143.46691646774622
3.9842217247859675	4.709123147050442
51.188332005957299	75.484616740366732
126.31033001295772	82.152257897962016
114.67832795562144	24.74035538022423
93.873204450995289	97.237933192978588
111.60016076713808	57.584716196909881
50.054722628581672	17.332501158738744
33.055785872533818	139.58117868266123
128.95560326471721	65.35219646308208
42.529759878539373	60.705432300784359
149.77175826196176	132.37385674490307
45.080731550734832	3.3237815384398126
93.764710632974612	43.821655210955839
114.24457780748818	143.31663851315
1.6783198582373184	129.25374602398546
143.40839108610916	64.085297572466217
142.70982916593078	119.45662520334898
126.77630669287232	133.12756627943719
112.77471518273219	131.92302148413054

Fig. 4:5 positions(x,y) for 150 nodes WSN

2. Go to command terminal and write the command:**”./leach_test”**

To Impalement leach protocol as declared in Fig. 4:6 :

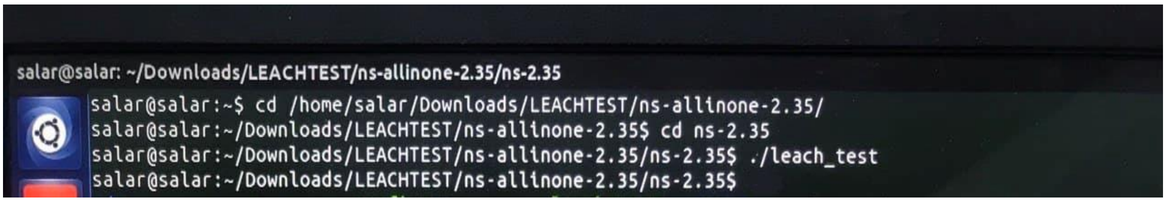


Fig. 4:6 Leach protocol implementing code for 150 nodes

The result shows WSN network information for 150 nodes that appear in second line in Fig.4:7 represent number of node start from 0 to 149 and other line represent position for each node in (x,y) and send ADV message to declere which node is a cluster head node. Next screenshot illustrates that.

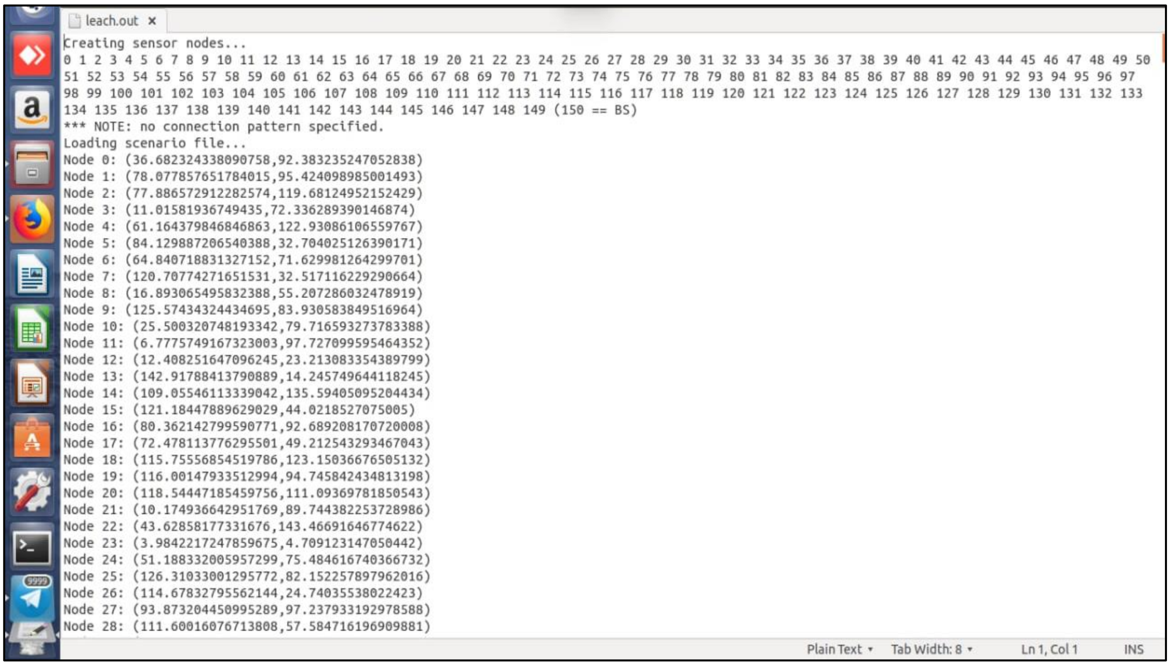


Fig. 4:7 150 nodes generated successfully

3.Check whether an errors happen when we run the protocol by running "**leach.err**" file that display message for error if anything of file not install correctly or not implemented in right way but if show the word "**SORTIND LISTS …DONE!**"

That mean the installing and implement successful done.

4. Evaluate network performance metrics. It running by adding "**all.pl**" file that contain the a Mathematical equations declare in chapter 2 in detail After that go to ns2 folder and open the command terminal to write the code

"Perl all.pl leach.tr"

That when running make analyses on "**leach.tr**" file columns and display the result for analyses scenario of 150 node running the command to get the final results shows in Fig. 4:8:

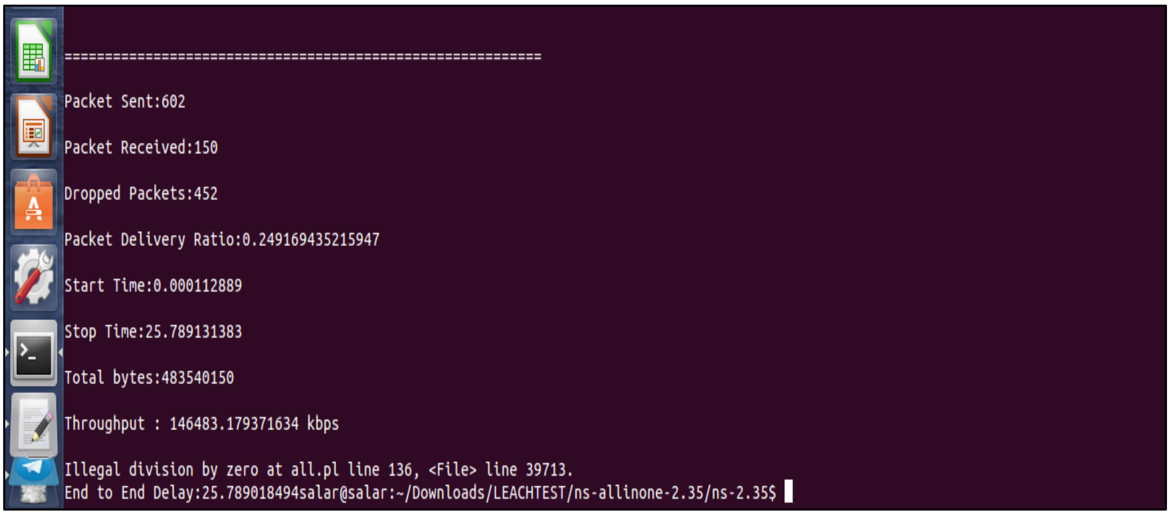


Fig. 4:8 150 nodes WSN performance metrics

4.2.3 Case3; 200 nodes network

1. Generates WSN scenario with 200 nodes with positions of (x, y)for each sensor node like in first row the number(49.7182) represent the position X for first node and the second number in first row (191.0253) represent position Y for first node as it shows in Fig. 4:9:

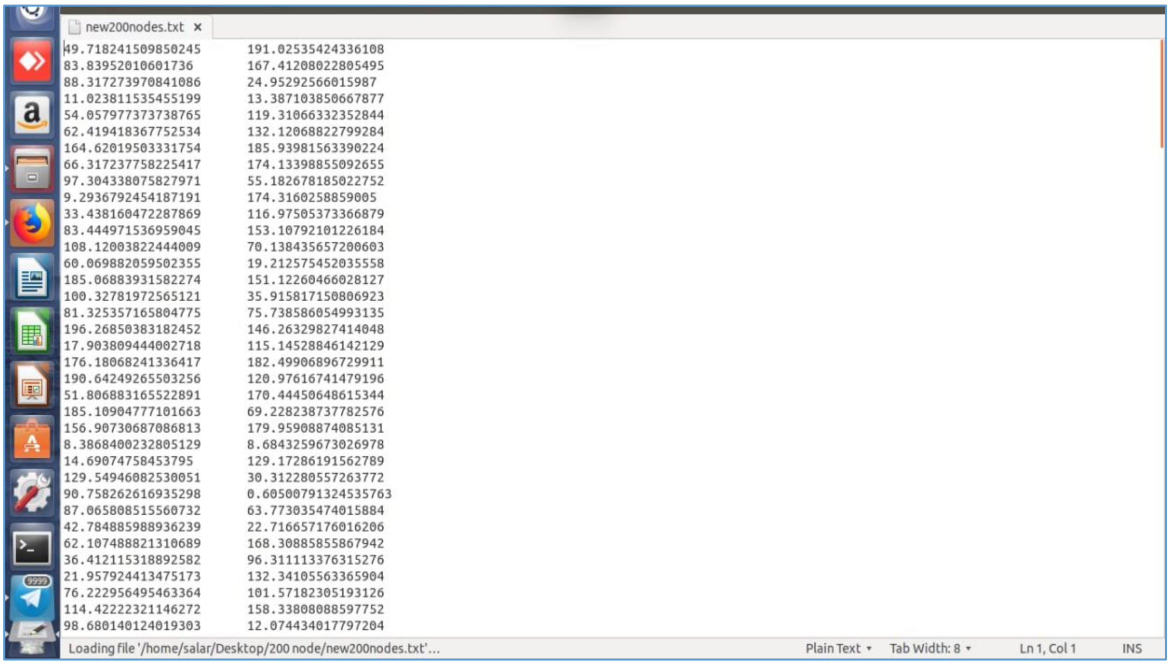


Fig. 4:9 positions(x,y) for 200 nodes WSN

2. Go to command terminal and write the command :**”./leach_test”**

To Impalement leach protocol as declared in Fig. 4:10 :

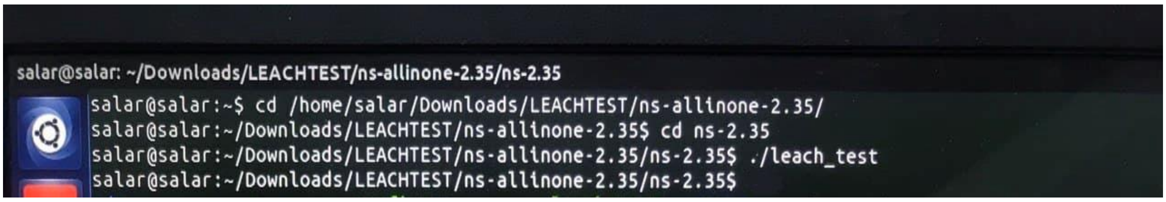


Fig. 4:10 Leach protocol implementing code for 200 nodes

The result shows WSN network information for 200 nodes that appear in second line in Fig. 4:11 represent number of node start from 0 to 199 and other line represent position for each node in (x,y) and send ADV message to declere which node is a cluster head node . Next screenshot illustrates that.

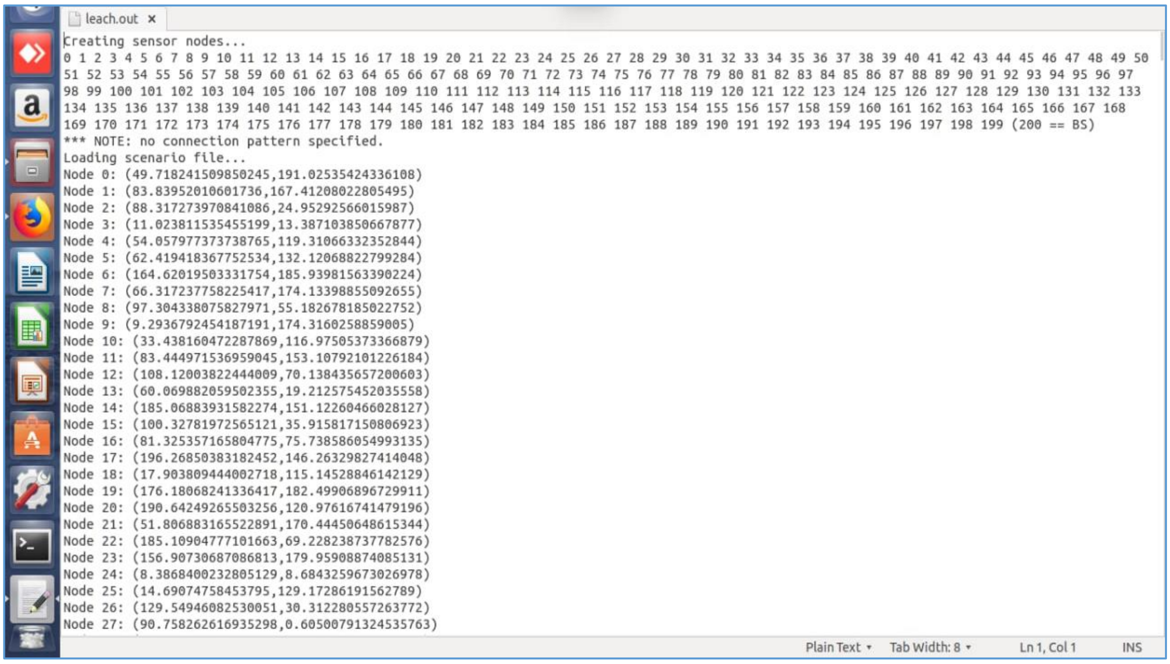


Fig. 4:11 200 nodes generated successfully

3. Check whether an errors happen when we run the protocol by running "**leach.err**" file that display message for error if anything of file not install correctly or not implemented in right way but if show the word "**SORTIND LISTS …DONE!**"

   That mean the installing and implement successful done.

4. Evaluate network performance metrics. It running by adding "**all.pl**" file that contain the a Mathematical equations declare in chapter 2 in detail After that go to ns2 folder and open the command terminal to write the code

   "Perl all.pl leach.tr"

That when running make analyses on “**leach.tr**” file columns and display the result for analyses scenario of 200 node running the command to get the final results shows in Fig. 4:12:

To run this equation we need to open command terminal and run the code to show the result for network simulation parameter :

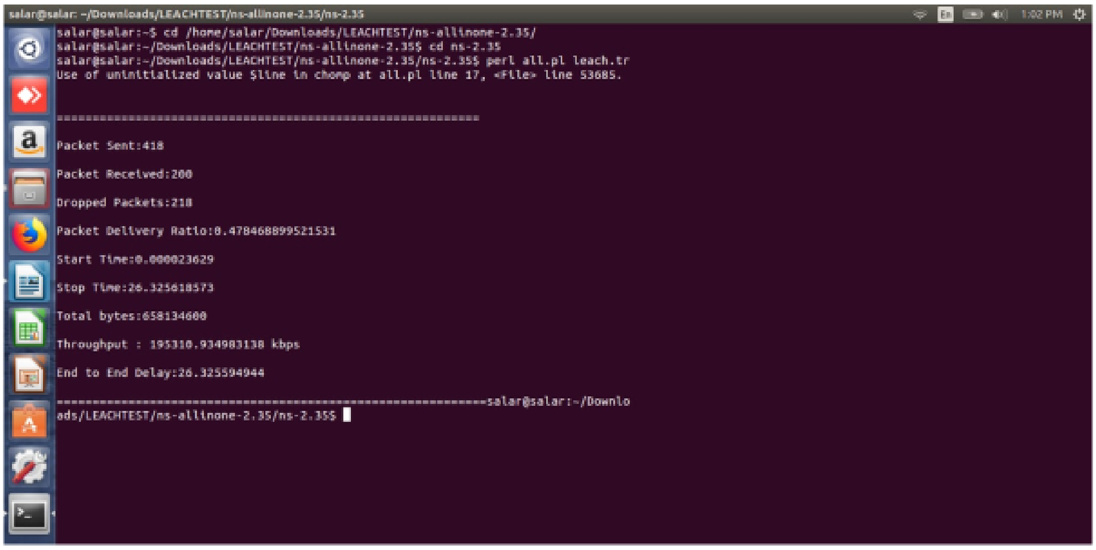


Fig. 4:6 200 nodes WSN performance metrics

4.2.4 Case4 ;250 nodes network

1. Generates WSN scenario with 250 nodes with positions of (x, y)for each sensor node like in first row the number(81.7091) represent the position X for first node and the second number in first row (194.6511) represent position Y for first node as it shows in Fig. 4:13:

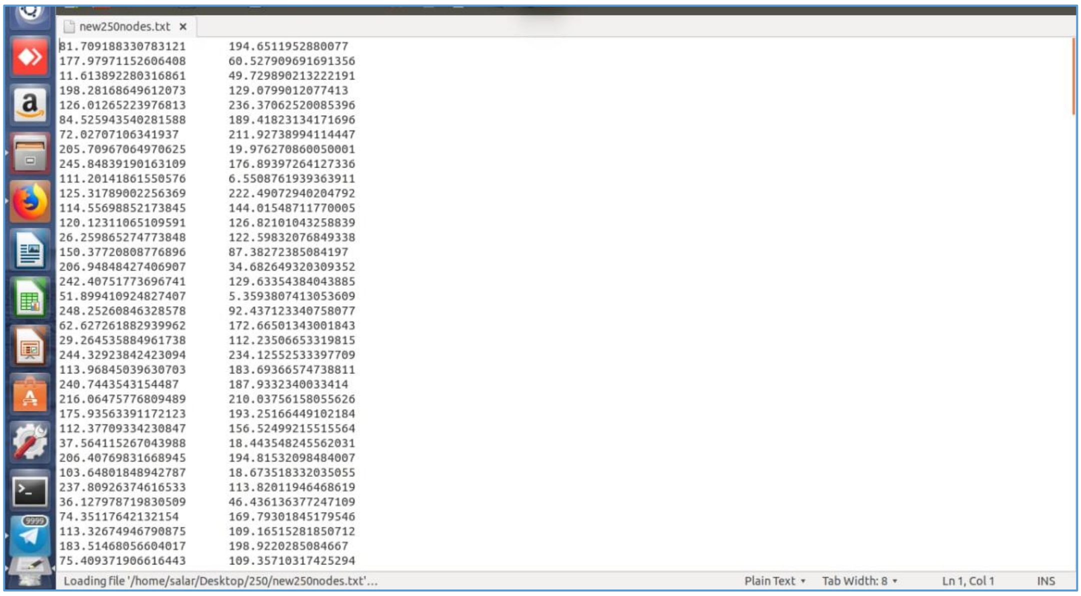


Fig. 4:7 positions(x,y) for 250 nodes WSN

2-Go to command terminal and write the command **"./leach_test"**

To Impalement leach protocol as declared in Fig. 4:14 :

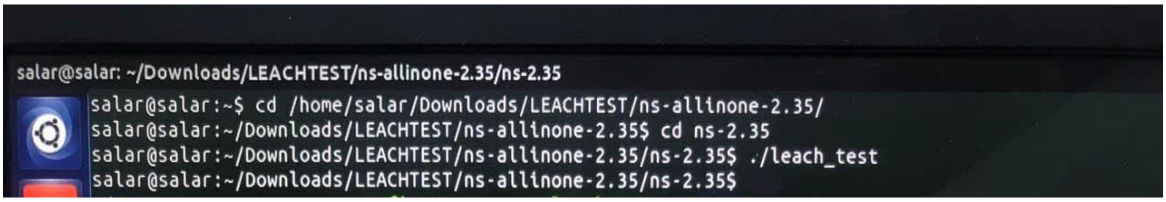


Fig. 4:8 Leach protocol implementing code for 250 nodes

The result shows WSN network information for 250 nodes that appear in second line in Fig. 4:15 represent number of node start from 0 to 249 and other line represent position for each node in (x,y) and send ADV message to declere which node is a cluster head node . Next screenshot illustrates that.

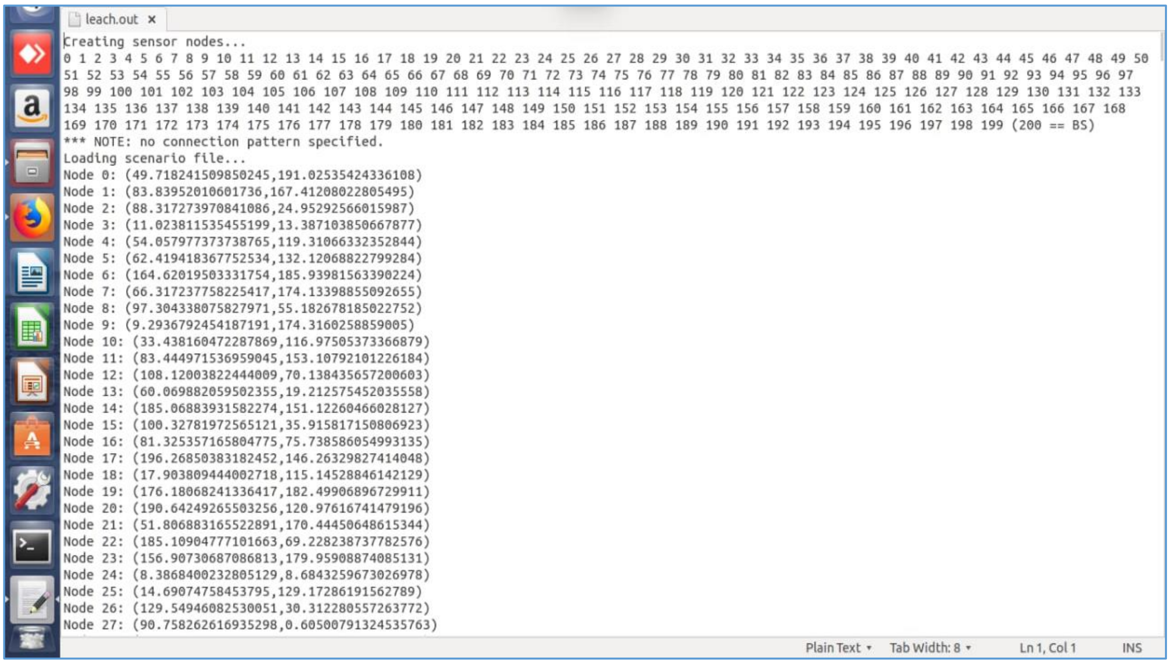
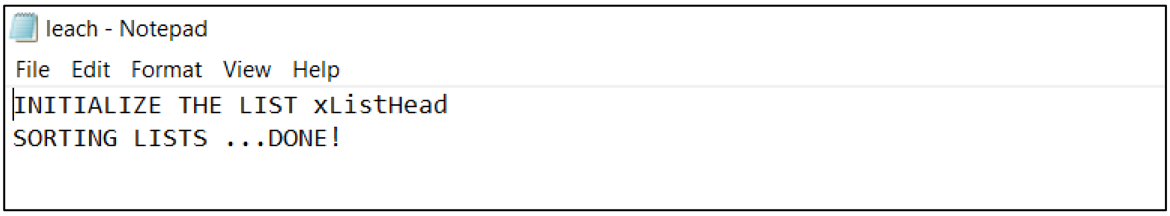


Fig. 4:9 250 nodes generated successfully

3-Check whether an errors happen when we run the protocol by running "**leach.err**" file that display message for error if anything of file not install correctly or not implemented in right way but if show the word

"**SORTIND LISTS …DONE!**"

That mean the installing and implement successful done.



4. Evaluate network performance metrics. It running by adding "**all.pl**" file that contain the a Mathematical equations declare in chapter 2 in detail After that go to ns2 folder and open the command terminal to write the code

"**Perl all.pl leach.tr**"

That when running make analyses on “**leach.tr**” file columns and display the result for analyses scenario of 250 node running the command to get the final results shows in Fig. 4:16:

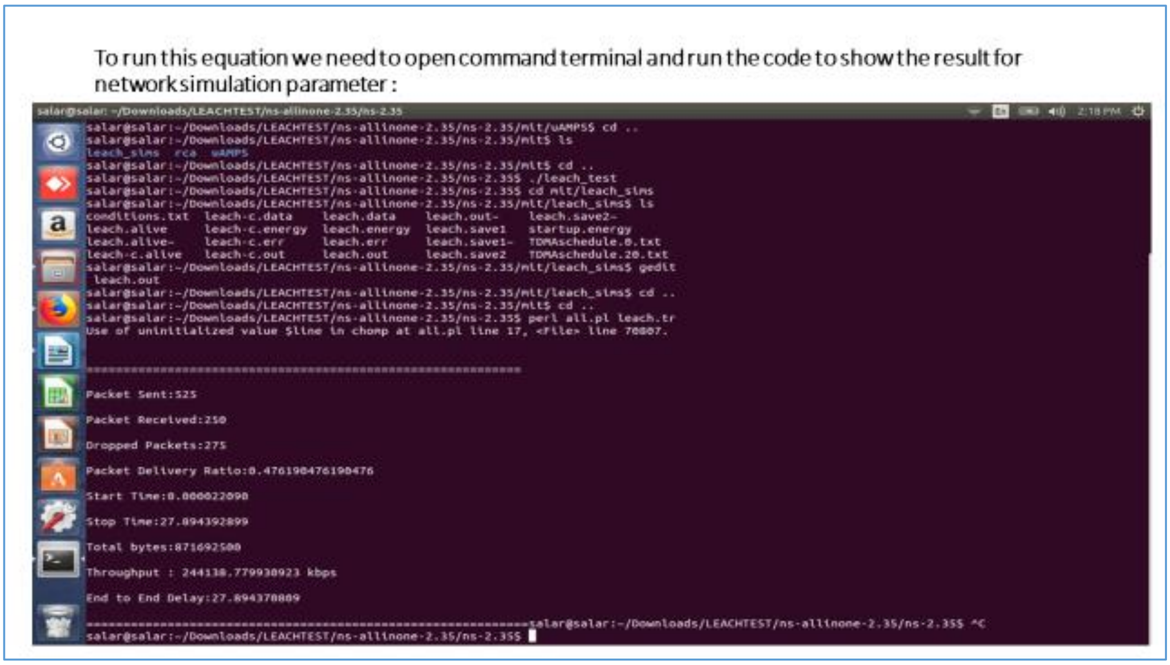


Fig. 4:10 250 nodes WSN performance metrics

4.3 Performance Metrics

In WSN implementation, an overview of QoS proposed. It includes End-to-End delay, Packet Delivery Ratio, Packet-Loss and packet Throughput, and The guarantee on packet loss and end-to-end delay is typically hoped to be decreased. The suggested traffic control method's result is evaluated to the method without the need for a congestion controller. The following measures are primarily used to assess performance:

- Throughput: the number of packets received throughout the simulation time is measured.
- End-to-End Delay: the time it takes for packets to go from the cluster head node to the sink node.

- Packet-Loss: the number of packets lost by a sink node in a network.
- Packet Delivery Ratio: This is the percentage of packets received to sink node to packets issued from cluster head nodes in the network.

4.4 Simulation Parameters

1- The parameter using in first case in scenario for100 node WSN to implement leach protocol declare in the following.

Table 4-2 simulation parameters for case 1

Parameters	Values
Simulations area	1000*1000px
Base station Location	50,175
Simulation time	3600 sec
Number of nodes	100
Number of cluster	5
Number of sinks	1
Routing protocol	leach
Channel Type	Wireless Channel
Traffic Type	CBR
Interface queue type	Queue/Drop Tail
sink speed	Random

As declared in table we make change on simulation area, base station location, number of node and number of cluster.

2-The parameter using in second case in scenario for150 node WSN to implement leach protocol declare in Table 4-3:

Table 4-3 simulation parameters for case 2

Parameters	Values
Simulations area	1500*1500px
Base station Location	75,200
Simulation time	3600 sec
Number of nodes	150
Number of clusters	8
Number of sinks	1
Routing protocol	leach
Channel Type	Wireless Channel
Traffic Type	CBR
Interface queue type	Queue/Drop Tail
sink speed	Random

As declared in table we make change on simulation area, base station location, number of node and number of cluster.

3-The parameter using in third case in scenario for200 node WSN to implement leach protocol declare in Table 4-4:

Table 4-4 simulation parameters for case 3

Parameters	Values
Simulations area	2000*2000px
Base station Location	100,350
Simulation time	3600 sec
Number of nodes	200
Number of cluster	9
Number of sinks	1
Routing protocol	leach
Channel Type	Wireless Channel
Traffic Type	CBR
Interface queue type	Queue/Drop Tail
sink speed	Random

As declared in table we make change on simulation area, base station location, number of node and number of cluster.

4- The parameter using in fourth case in scenario for 250 node WSN to implement leach protocol declare in Table 4-5:

Table 4-5 simulations parameters for case 4

Parameters	Values
Simulations area	2500*2500px
Base station Location	125,375
Simulation time	3600 sec
Number of nodes	250
Number of clusters	11
Number of sinks	1

Routing protocol	leach
Channel Type	Wireless Channel
Traffic Type	CBR
Interface queue type	Queue/Drop Tail
sink speed	Random

As declared in table we make change on simulation area, base station location, number of node and number of cluster.

4.5 Simulation Results

The simulation of LEACH protocol performed using NS2 simulation software under the environment of Linux Ubuntu, ns2.35, core i 7, RAM 4 G.

4.5.1 Cluster Numbers

Four WSN scenario are proposed with different numbers of nodes. Clusters heads are automatically changed when clusters number are changed as in Table 4-1.

The flow chart in Fig. 4:17 represent four cases scenario declared the number of cluster change in each case:

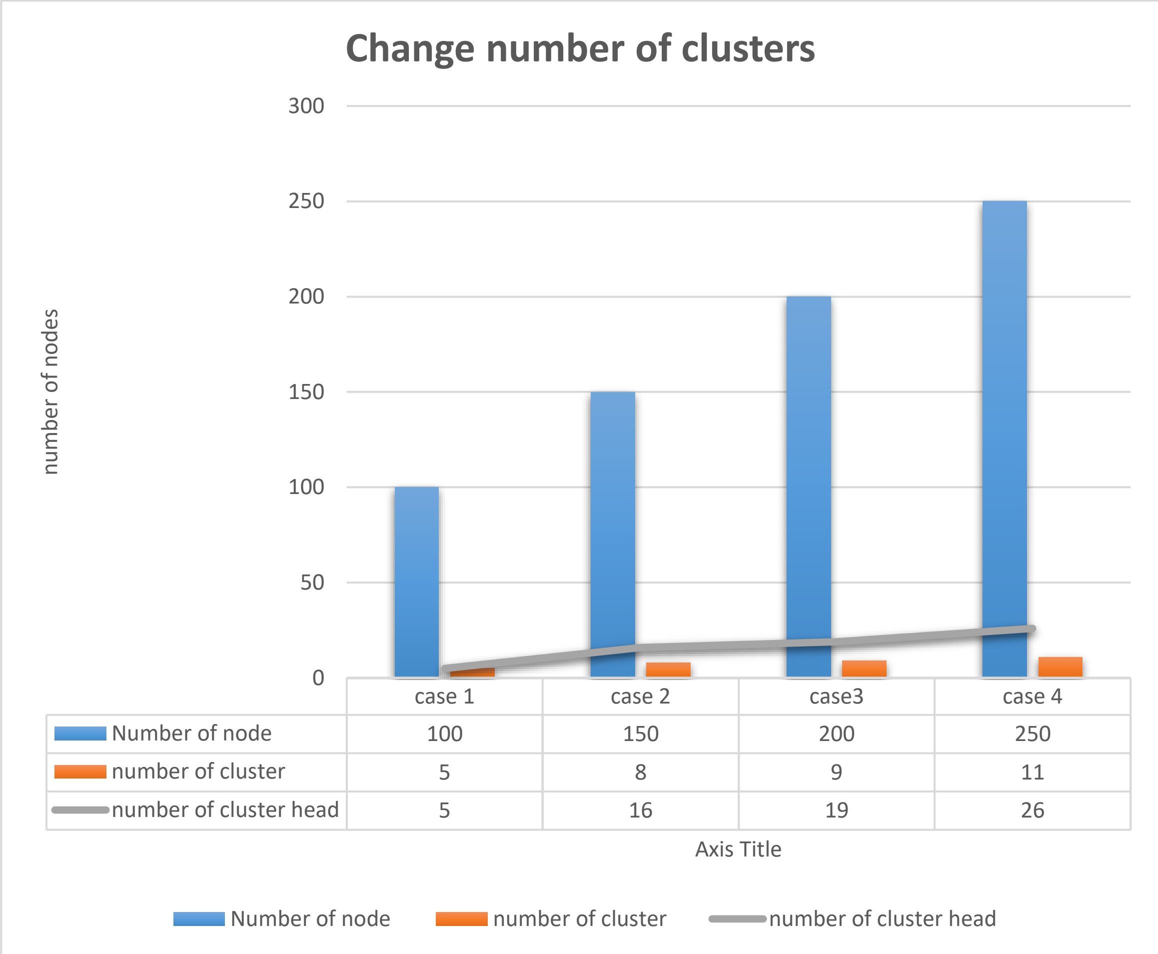


Fig. 4:11 Total number of cluster heads in different WSN scenarios

As see when increase the number of nodes and number of clusters the number of cluster head atomically increase to be appropriate to network size.

4.5.2 Packet Delivery Ratio

Table 4-7 shows the total number of Packet Delivery ratio in WSN with different nodes number in fourth cases (100,150,200,250):

Table 4-6 the total ratio of packet delivery in different WSN scenarios

NO.	Number of Node	Packet Delivery Ratio
1	100	21.829%
2	150	24.916%

3	200	47.846%
4	250	47.619%

As we seen in table the value of packet deliver ratio gradually increase by increasing number of node, change base station location, increase number of cluster and increase size of scenario and it’s an important factors make network performance more efficiencies and we declare that in a flow chart as show in Fig. 4:18:

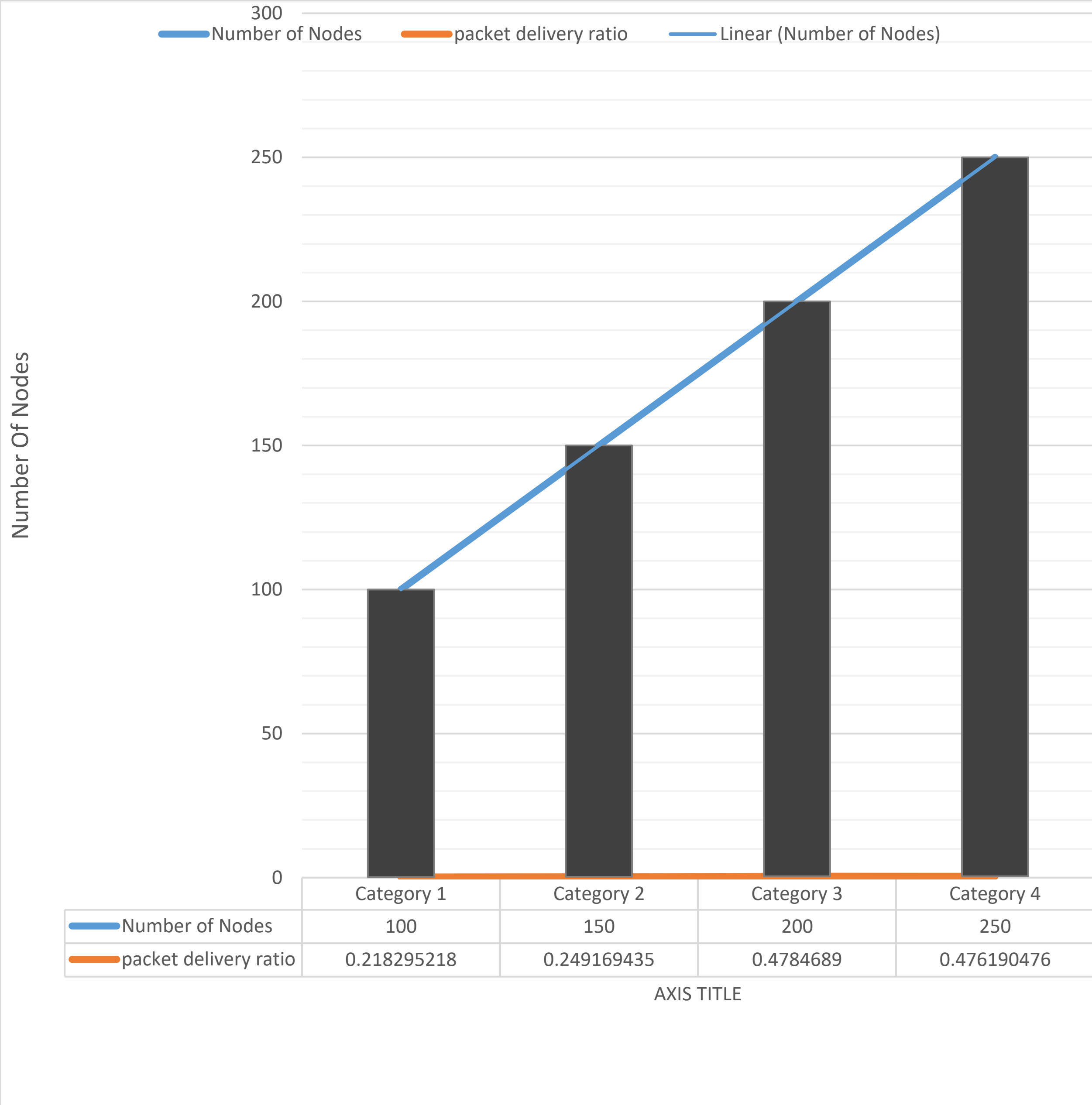


Fig. 4:12 illustrates packet delivery rations in different nodes WSN.

4.5.3 Network life time

Table 4-8 shows the network life time in WSN with different nodes number in fourth cases (100,150,200,250):

Table 4-7 Network over all Life time in WSN with different number of nodes.

NO.	Number of Node	Start Time	Stop Time

1	100	0.00003	0.61
2	150	0.00011	25.78
3	200	0.00002	26.32
4	250	0.00002	27.89

As seen in table the network life time gradually increase by increasing number of node we declare that in a flow chart as show in Fig. 4:19:

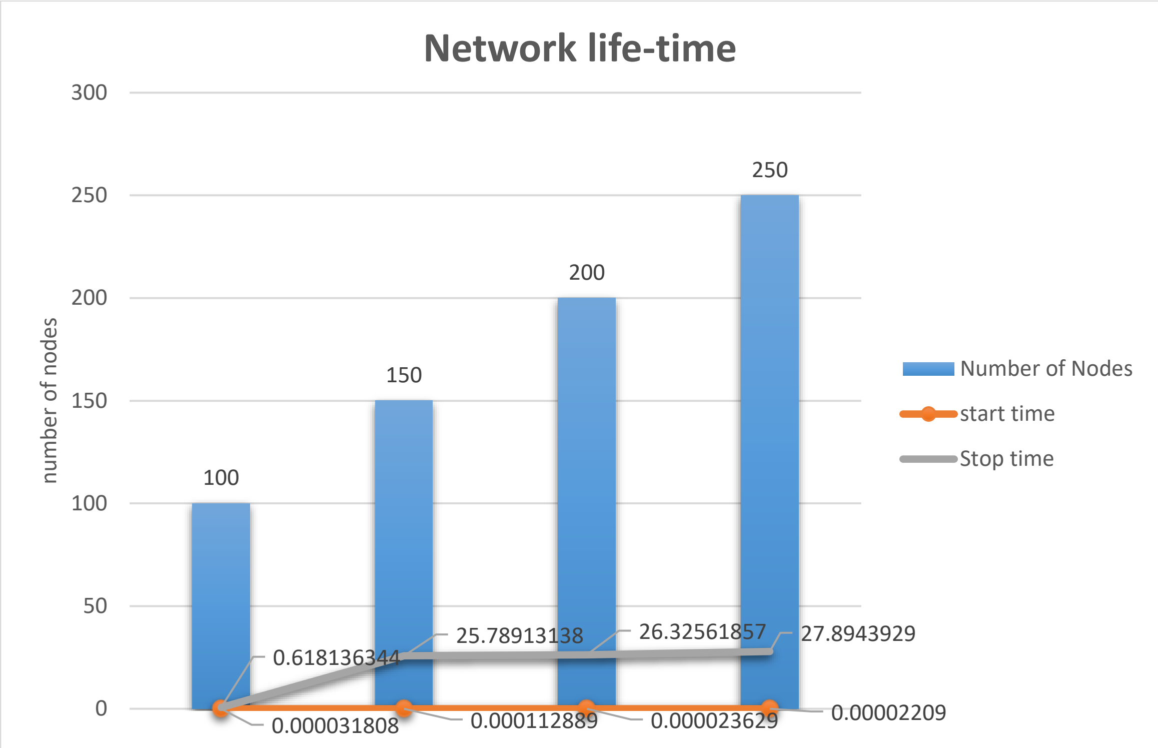


Fig. 4:13 Network life-time on different WSN node's number

4.5.4 Total bytes

Table 4-9 shows the total bytes of Packet in WSN with different nodes number in fourth cases (100,150,200,250) every packet hold an information to pass from node to another and the following table illustrates the total bytes for packets on each WSN.

Table 4-8 total bytes for each packet in each WSN

NO.	Number of Node	Total bytes
1	100	6648830
2	150	483540150
3	200	658134600
4	250	871692500

As seen in table the total byte gradually increase by increasing number of node declare that in a flow chart as show in Fig. 4:20:

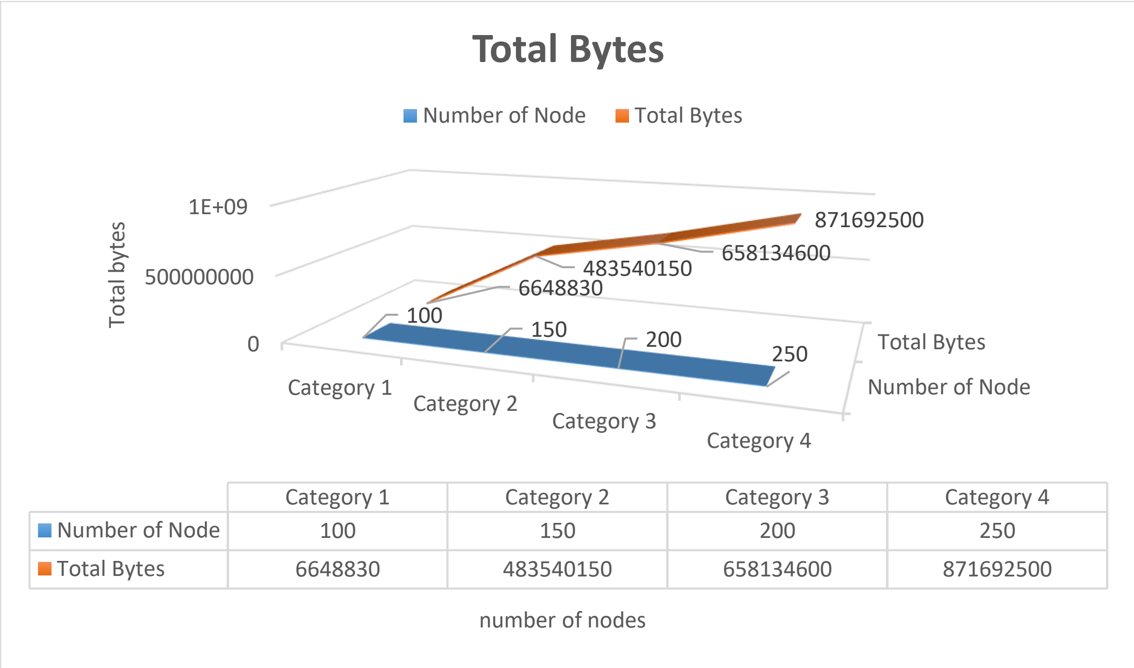


Fig. 4:20 Total Bytes for each packet in every WSN

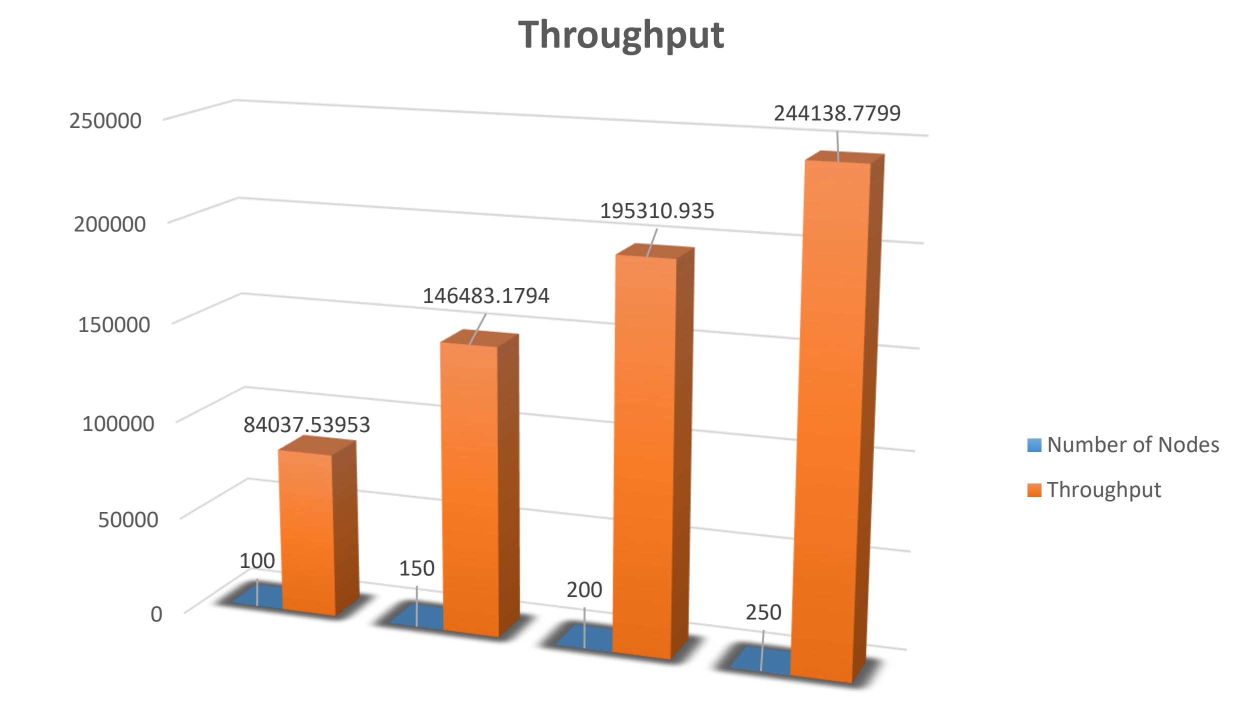
4.5.4 Throughput

Table 4-10 shows the throughput of WSN with different nodes number in fourth cases (100,150,200,250) that shows the simulation results of the average Throughput from the sink node after receive the data packet from the cluster head nodes for four WSN.

Table 4-9 throughput values

NO.	Number of Node	Throughput
1	100	84037.53 kbps
2	150	146483.17 kbps
3	200	195310.93 kbps
4	250	244138.77 kbps

As seen in table the value of the total average Throughput gradually increase by increasing number of node and it’s an important factor make network performance more efficiencies and declare that in a flow chart as show in Fig. 4:21:



	Category 1	Category 2	Category 3	Category 4
Number of Nodes	100	150	200	250
Throughput	84037.53953	146483.1794	195310.935	244138.7799

Fig. 4:21 The total average Throughput over number of nodes in many WSNs

4.5.5 End to End Delay

Delay is defined as the time it takes for a packet to go from the beginning node's queue to the terminating node's queue. The kind of delay determines the definition of beginning and ending nodes. The sort of delay utilized in theses is the End-to-End Delay. The End-to-End Delay is the amount of time It takes for the cluster head node to send data to the sink node. Table 4-11 represents the total number of end-to-end delay for all utilized WSNs.

Table 4-10 the total number of end to end delay

NO.	Number of Node	End to End Delay
1	100	0.352
2	150	25.789
3	200	26.325
4	250	27.894

As seen in the table the value of delay gradually increase by increasing number of node declare that in a flow chart as show in Fig. 4:22:

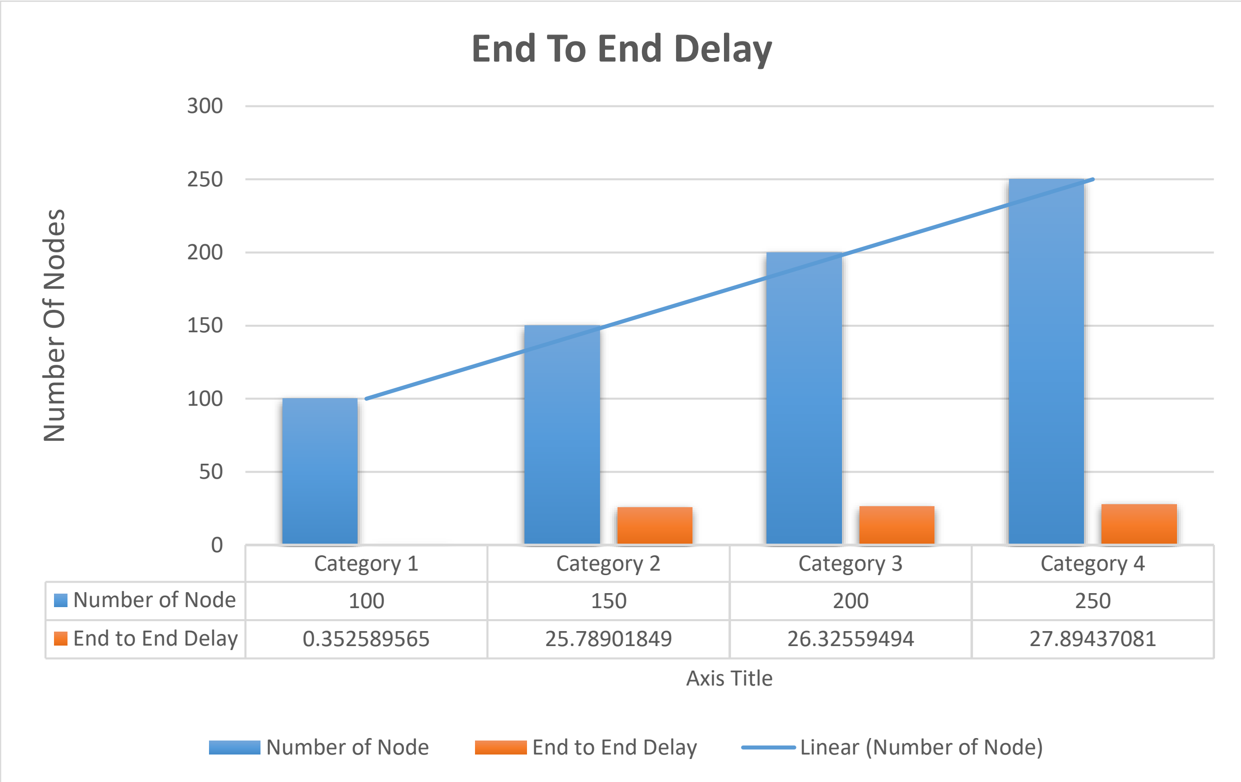


Fig. 4:14 overall End- to - end delay

Table 4:12 The following figure declared how to generate scenario for WSN and implement them with different number of node in four cases in each case change five filed of leach protocol parameter and evaluate performance of the network by calculate arrival packet, packet deliver ratio and throughput that overall show that the performance of the network become more efficient by implementing leach protocol.

Summary

The simulation results are shown in this chapter to demonstrate the WSN's performance using the LEACH protocol. Packet-Loss, network Throughput, and End-to-End Delay are the QoS parameters that are computed, and Packet Delivery Ratio is the QoS parameter that is computed

cases	Case 1	Case 2	Case 3	Case 4
End to End Delay	0.3	25.7	26.3	27.8
Throughput	84037.5 kbps	146483.1 kbps	195310.9 kbps	244138.7 kbps
Total bytes	6648830	483540150	658134600	871692500
Stop Time	0.6	25.7	26.3	27.8
Start Time	0.000031	0.000112	0.000023	0.000022
Packet Delivery	0.218	0.249	0.478	0.476
Dropped Packets	376	452	218	275
Packet Received	105	150	200	250
Packet Sent	481	602	418	525
location Base	50,175	75,200	100,350	125 ,375
Size of scenario	1000-1000	1500-1500	2000-2000	2500-2500
Number of	5	16	19	26
Number of	5	8	9	11
Number of nodes	100	150	200	250

Table 4-11 all changed parameter and performance metrics

CHAPTER FIVE

Conclusions and Future Works

Chapter five

Conclusions and Future Works

5.1 Conclusion

The optimization technique suggested in this thesis for the job allocation issue using LEACH protocol is implemented in WSN using the ns2 simulation program. To obtain a more accurate indication, the average of performance metrics is obtained. The following conclusions can be drawn as a result of the implementation:

1- The suggested technique improves the transmission rate and minimizes traffic, resulting in improved WSN overall performance.

2- The method enhances QoS by reducing Packet-Loss while also increasing the network's Throughput and Packet Delivery Ratio as in table 4-12.

3- When the number of nodes increased from (100 to 200), the number of clusters increased from (5 to 9) and the base station location is changed from (50,175 to 100,350) the packet received ratio is increased from (150 to 200).

4- When the number of nodes increased from (100 to 200), the number of clusters increased from (5 to 9) and the base station location is changed from (50,175 to 100,350) the ratio of dropped packet is decreased from (3.76% to 2.18%).

5-When the number of nodes increased from (100 to 200), the number of clusters increased from (5 to 9) and the base station location is changed from (50,175 to 100,350) the packet delivery ratio is increased from (0.21% to 0.47%).

6-When the number of nodes increased from (100 to 200), the number of clusters increased from (5 to 9) and the base station location is changed from (50,175 to 100,350) the throughput is increased to (132.4%).

5.2 Future Works

Some aspects may be considered for future there are several contributions to the research that may be considered to enhance the present system's performance. The following is a list of them:

1- Implement queuing theory with priority instead of drop tail.
2- Implement the same scenarios in other simulators such as Net logo.
3- Implement LEACH protocol with mobile sensor network.
4- Perform the effect of other performance metrics on LEACH protocol.

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الخلاصة

في الأنظمة المضمنة مع قيود التأخير والطاقة مثل شبكات الاستشعار اللاسلكية يعد تخصيص المهام مشكلة حاسمة في الهندسة الفعالة للتطبيقات التعاونية لشبكات الاستشعار اللاسلكية تعطي خوارزميات تخصيص المهام الحالية الأولوية للحفاظ على الطاقة مع قيود الوقت قد تؤدي خوارزميات التخصيص هذه إلى زيادة وقت إكمال الوظائف وزيادة احتمال فشل الشبكة في هذه الأطروحة ، تم اقتراح نهج تخصيص المهام بناءً على نظرية قائمة الانتظار من خلال النظر في كل من الوعي بالطاقة وأداء الشبكة في شبكات الاستشعار اللاسلكية يمكن استخدام أساسيات نظرية قائمة الانتظار وبروتوكول التسلسل الهرمي للتكيف منخفض الطاقة الليج بروتوكول وتعديله لتحسين استهلاك الطاقة وأداء الشبكة لشبكات الأستشعار اللاسلكية يتم استخدام محاكي الشبكة النسخة الثانية بأربعة سينوريوهات بحيث يختلف كل من عدد العقد ، وعدد المجموعات ، وموقع المحطة الأساسية ، وعدد رؤوس المجموعات يتم تطبيق دروب تيل كوينك أيضًا مع بروتوكول الليج لمراقبة وتقييم أداء الشبكة واستهلاك الطاقة. يتم أيضًا استخدام تقنية تحسين لتخصيص الموارد توضح النتائج أن أداء شبكة الاستشعار اللاسلكية قد تحسن وأصبح أكثر كفاءة مع بروتوكول الليج عندما زاد عدد العقد من (100 إلى 200) عقدة ، يتغير موقع المحطة الأساسية ويزداد عدد المجموعات من \ الحزمة المستلمة من (150 إلى 200) ، تنخفض الحزمة المسقطة من (376 إلى 218) ، زادت نسبة تسليم الحزمة من (0.21 إلى 0.47) وزادت الإنتاجية من (84037.5 إلى 195310.9). يعمل نهج الأطروحة هذا على تحسين جودة الخدمة عن طريق تقليل فقد الحزمة مع تحسين معدل تسليم حزم الشبكة والإنتاجية

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل
كلية تكنولوجيا المعلومات
قسم شبكات المعلومات

تطوير الليج بروتوكول بالأعتماد على نظرية الأنتظار لتحسين أداء شبكة المستشعر اللاسلكية

رسالة

مقدمة إلى مجلس كلية تكنولوجيا المعلومات في جامعة بابل والتي هي جزء من متطلبات الحصول على درجة الماجستير في تكنولوجيا المعلومات /شبكات المعلومات

أعداد الطالبة

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2021 A.D. **1443 A.H.**