PROJECT

REPORT ON

ROUTING PROTOCOLS IN

INTERNET OF THINGS

USING FUZZY LOGIC

BY CUP CARBON

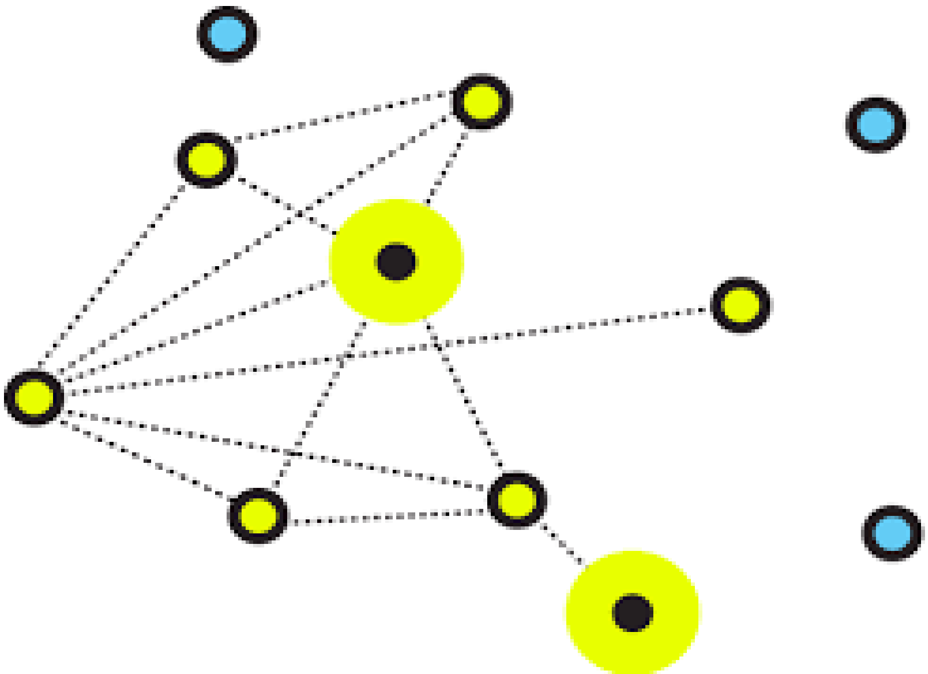

TABLE OF CONTENTS

1.	Introduction	
	1.1 Problem Statement	9
	1.2 Introduction of IoT	10
	1.3 Advantage of IoT	11
	1.4 IoT in various domains	12
	1.5 Challenges in IoT	13
2.	Routing in IoT	
	2.1 Routing	15
	2.2 Factors Affecting Routing Process	16
3.	Cupcarbon	
	3.1 Introduction of CupCarbon	17
	3.2 Features of CupCarbon	18
	3.3 CupCarbon environment	18
	3.4 Flow diagram of Cupcarbon	20
	3.5 comparison of WNS simulators	22
4.	Fuzzy logic	
	4.1 Introduction of fuzzy logic	
	4.2 Difference between fuzzy logic and classical set	
	4.3 Advantages of fuzzy logic	
	4.4 Application of fuzzy logic	
5.	Literature survey	25
6.	System Requirement	
	6.1 Hardware Requirement	30
	6.2 Software Requirement	30
7.	Methodology adopted	31
8.	Algorithm formulated	33
9.	Simulation done	37
10.	Result obtained	40
11.	Reports	43
12.	Conclusion and future work	46
13.	Bibliography	
14.	Paper Publish	49

LIST OF FIGURES

1. Layers of IoT	11
2. Application of WNS(wireless sensor network)	13
3. Routing of packet	15
4. Cupcarbon Environment	19
5. Flowchart of Cupcarbon	20
6. Modules of Cupcarbon	21
7. Cupcarbon Main components	21
8. Flow diagram of fuzzy logic	24
9. Example of fuzzy logic	
10.flowchart of Implemented fuzzy logic	32
11. Snapshot of D-LPCN implementation of 100 sensors	37
12. Snapshot of boundary node identification of 100 sensors	37
13. Snapshot of fuzzy logic implementation of 100 sensors	38
14.Snapshot of D-LPCN implementation of 10 sensors	38
15.Snapshot of fuzzy logic implementation of 10 sensors	39
16.Snapshot of Energy consumption of 10 sensors	40
17.Snapshot of battery level of 10 sensors	40
18.Snapshot of Energy consumption of fuzzy selected sensor(S1)	41
19.Snapshot of the battery level of the fuzzy selected sensor(S1)	41
20.Snapshot of Energy consumption of fuzzy selected sensor(S4)	42
21.Snapshot of the battery level of the fuzzy selected sensor(S4)	42

LIST OF TABLES

1. Factors affecting the routing process 16
2. Comparison of WNS simulators
3. Fuzzy set vs. classical set
4. Application of fuzzy logic
5. Hardware requirement 30
6. Software requirement 30

ABSTRACT

The Internet of Things (IoT) is the future of the coming generation due to the real-time communication and decision-making capabilities of sensors integrated into everyday objects. IoT is capturing its domain in almost every field, from healthcare to education. Routing plays a vital role in IoT, as sensors are mobile in nature, and these mobile sensors communicate. Thus there is a need for analyzing and developing routing protocols in IoT networks too. In this work, we studied the routing protocols developed so far, and we developed new routing protocols that are easy to implement and efficient. As these sensors are mobile in nature, therefore, the topology of the network changes frequently, so a fuzzy logic concept will work better in this case fuzzy logic is expanding its domain from artificial intelligence to other fields as well, so we would research its use in this domain as well. We used the CupCarbon simulator for routing in IoT for our work.

1.1 PROBLEM STATEMENT

With the evolution of technology devices and items such as home appliances, and vehicles are now embedded with sensors and Wi-Fi to decrease human labor, and these Sensors share information in a standard network that defines the future of our internet, this is known as the internet of things. Wireless Sensor Networks (WSNs) play an important role in IoT because sensors can be controlled by end-users and data can be transmitted to different sites on the Internet. These many devices and sensors create a more significant challenge in the routing of networks therefore routing plays a significant role in IoT. Most existing routing protocols designed so far do not consider the dense architecture of IoT; therefore it is a great challenge to provide these algorithms according to the changing requirements of sensor-based IoT applications. Therefore, these devices are not energy-efficient and they don't have fault-tolerant capabilities for such mobile IoT later on, using the fuzzy logic concept to make routing algorithms more efficient in this project, we have provided a brief introduction to IoT with the current related work in routing in IoT using the CupCarbon simulator and fuzzy logic concept.

1.2 INTRODUCTION

Birth of IoT

Kevin Ashton coined the term "The Internet of Things" (IoT) in a 1999 speech to Procter & Gamble. He is a co-founder of the Auto-ID Lab at MIT
Kevin Aston said
“If we had computers that knew everything there was to know about things—using data they gathered without any help from us—we would be able to track and count everything, and greatly reduce waste, loss, and cost. We would know when things needed replacing, repairing, or recalling and whether they were fresh or past their best.
We need to empower computers with their own means of gathering information, so they can see, hear, and smell the world for themselves, in all its random glory.”

1.2 Introduction of IoT

In IoT, ' Thing ' can be any device with any sort of built-in sensor aware of gathering and converting data without manual intervention over a network. The embedded software in the object allows them to communicate with internal conditions and the external environment tends to make choices. IoT is an internet connection term for all devices and enables them to communicate on the internet. IoT is a giant network of connected devices – all of which obtain and share data on our work conditions and how they are used.
By doing so, as humans do, each one of the systems can learn from this experience of other devices. IoT aims to increase user interdependence, i.e. to interact, participate, and cooperate on problems.

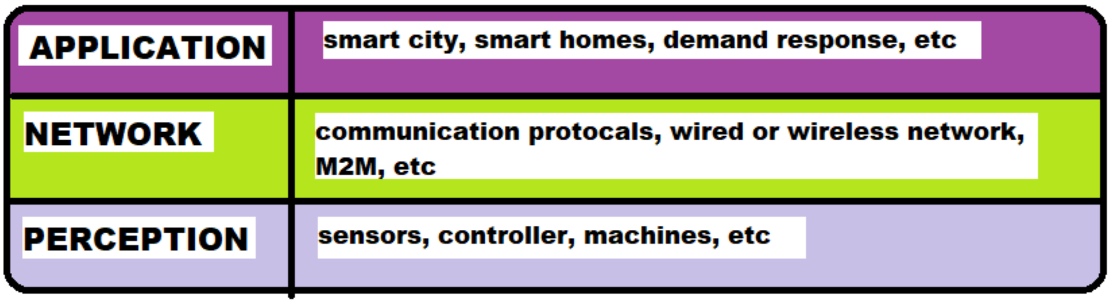

Fig.1: IoT layers

1.3 Advantages of using IoT

Because IoT enables devices to be remotely regulated It created the opportunity to connect and link the material world specifically via computer-based systems through sensors and the internet. These multiple embedded devices will be interlinked, resulting in almost every area of automation and activating advanced applications. With reduced human intervention, this helps in improved accuracy, efficiency, and economic advantage. This includes innovations like intelligent networks, intelligent houses, smart transport, and smart cities. IoT's main areas are:

- Enhanced customer satisfaction–By automating the operation, IoT improves customer experience. For instance, the sensors will automatically detect any problems in the vehicle. The driver will be notified, as well as the manufacturer. The supplier must ensure that the faulty component is accessible at the service station until the driver enters the service station.
- Digital Optimisation – IoT has greatly contributed to improving and enhancing Innovations. The supplier will analyze the data from different car sensors and store the data to improve their design and make them more effective.
- Minimizes waste- the existing perspectives are overshadowed, but IoT offers information in everything in real-time that contributes to efficient resource management and decision-making. For instance, if a manufacturer finds fault in multiple engines, he can track those engines ' manufacturing plants and with manufacturing, the belt can rectify the problem.

1.4 IoT across various domains

1.4.2. Energy usage: The graph of energy has risen to a great extent. Personal and organizations are looking for new ways to decrease consumption and control it. IoT provides a means of tracking the use of power not only at the level of the appliance but also at the level of the home, grid, and distribution system. To track energy consumption, smart meters and smart grids are used. It also detects device quality and reliability threats that protect appliances against downtime and damage.

1.4.2. Healthcare usage: Intelligent watches and health equipment have modified the health monitoring wavelength. A person can regularly go through their own health. Also, now that a patient arrives at the hospital by ambulance, his health report is treated by physicians when he or she arrives at the hospital and the clinic begins the treatment quickly. Data collected There are now a range of medical solutions Used for evaluating and discovering medicine for various diseases.

1.4.3. Education: IoT provides educational support to help fill the gaps in the education sector. Not only does it improve performance by taking into consideration the quality of learning, but it also does cost optimization and enhances management by taking into account the response and success of the student.

1.4.4. Government: Governments are attempting to use IoT technologies to create smart cities. IoT strengthens the structures and equipment of the armed forces. It provides enhanced border security through low-cost & high-performance tools. IoT helps the government to go through real-time information and better services such as health care, transportation, education, and so on.

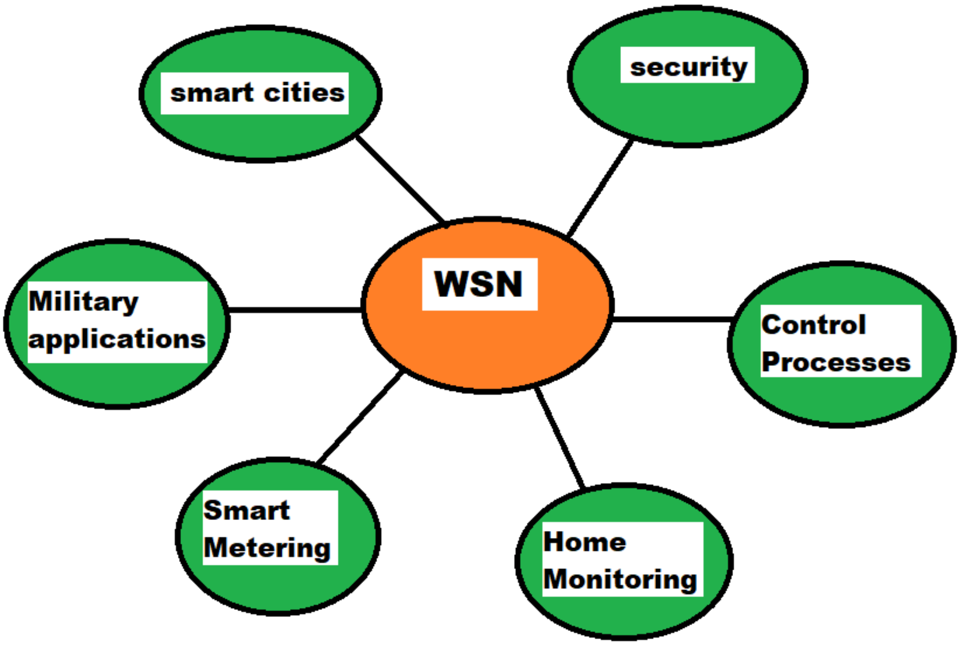

Fig.2: applications of wireless sensor network.

1.5 Challenges of IoT:

1.5.1 Security

IoT's main purpose is to connect devices over the Internet to each other. Digital burglar, malware acquisition, and data breaches face potential risks with more devices acquiring connectivity. IoT security breach reports and surveys are adequate to remove the uncertainty about security risks. The appetite of a hacker for user data will not stop, and businesses can take advantage of this.

1.5.2. Confidentiality

Another urgent problem with IoT is consumer security. A recent study at Glasgow University showed that Consumers are largely unhappy with the IoT's lack of privacy. As users have become more aware of the extent of cyber-surveillance, they have begun to take their privacy more seriously and demand that their data be ultimately controlled by them. To ensure that user data is not vulnerable to others, greater corporate transparency is required.

1.5.3. Walls of the Internet

The possibility of significant data loss through the attacks is not only a risky idea for businesses but for countries as well through threats across boundaries. These threats were expected by the World Economic Forum which enables countries to build walls of the internet that will restrict IoT access to specific regions. In addition, countries will be compelled to safeguard their financial interests, as governments cannot process open services within the leading online network businesses. This ultimately jeopardizes preventing the very concept of the Internet of Things as obstacles to data sharing demanded by every company. Such a rule will also serve as a barrier to technological progress by significantly slowing it down.

2. ROUTING IN IoT

IoT devices communicate with each other in a multi-hop way to collect, share, and forward information. IoT generates massive amounts of data on an ongoing basis, so the data collected must be turned into smartness to create an intelligent environment. This smart architecture will be vital to the network's data routing. Many nodes in IoT are constantly moving, which can lead to intermittent interconnectivity between devices that frequently change topology. Because of these repeated changes in topology and few resources on the Internet of Things software, the routing of data is now a major issue. IoT will offer a huge number of applications to enhance the quality of our lives in different environments.

These technologies are going to generate huge amounts of information. One of the key features of this growing field is the creation and storage of an enormous amount of data, control, protection, expiration, and its routing in the actual location to generate little information that can be further used to create a smart environment from it. With less power and loss of Station connections, multi-hop mesh topology, nodes supplied by the battery, and often modified network topology, routing problems are becoming increasingly difficult.

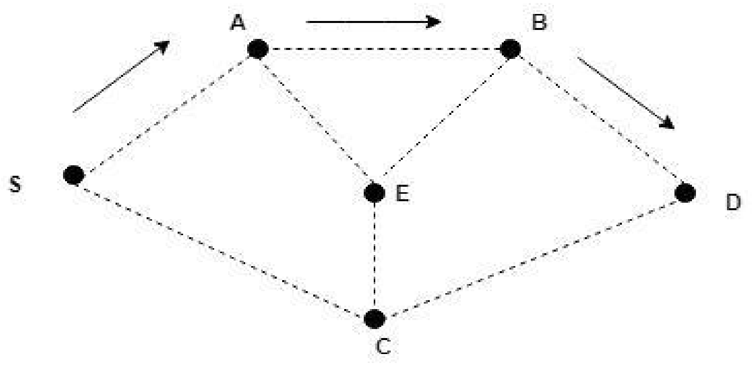

Fig 3: routing from source(s) to destination(d)

2.1 Factors affecting the routing process

Devices	Some of the same kind or of different types
Manufactures	Such products can be produced in the same or separate networks.
network	On the same or different network, the origin and the destination can exist
Connectivity	Connectivity can be permanent or irregular between any two devices.
Resources	Lack of resources
Assistance in data replaying	Due to resource limitations, system non-cooperation.
Communication process	Changes in interaction mode, e.g., multihop and single-hop
Network Topology	Portable devices and resource limitations frequently change the configuration of the network
Communication range	Wide range of contact ranges between systems provided by various suppliers
Tough climatic conditions	Tough climatic conditions such as heavy rain, high temperature of the equipment, or may die.
Addressing mechanism	The D2D interaction failure should be resolved by a universally understood and special method.

Table 1

3. **CUPCARBON SIMULATOR**

The number of connected devices is increasing, and it is expected to become extremely large in urban areas shortly. Therefore it is of great importance to use simulators to test and plan a project of installing new networks before their actual deployment. It helps determine relevant information, such as signal overload or implementation flexibility regarding area, interruption, communication, and expense. We, therefore, are using the Cupcarbon simulator for our work.

CupCarbon is an Intelligent Cities and Internet of things (IoT) Wireless Sensor Network (SCI-WSN) simulator. It aims at Layout, visualization, testing, and verification of decentralized control algorithms, data gathering, etc., and creating environment scenarios such as gas, fires, mobile devices, and in particular, in research and academic programs. Not only can this help to clarify visually the fundamental concepts of sensor networks and how they operate; but Scientists can also test their wireless topologies, protocols, etc. Two simulation environments are available at CupCarbon. The very first simulation environment allows the layout of mobility scenarios and natural processes such as fire and gas as well as the simulation of mobile devices such as automobiles and flying debris (e.g., UAVs, butterflies, etc.). The next simulation model describes a separate wireless sensor network event simulation that takes the first environment-based scenario into account.

3.1 Features of CupCarbon

- CupCarbon offers a multi-agent simulation framework.
- It enables us to run simulations and monitor different events and changes over time.
- It provides environment integration of OpenStreetMap, which offers a digitized interface and repository of geo-location data such as streets, housing positions, etc.
- CupCarbon enables us to configure any virtual system agent without using low-level programming. System agents for scripting their interactions can be connected to script files.

3.2 CupCarbon Environment

CupCarbon (GUI) is composed of the following five parts:

1. Map

2. Menu Bar

3. Toolbar

4. Parameter Menu

5. State Bar

6. Console

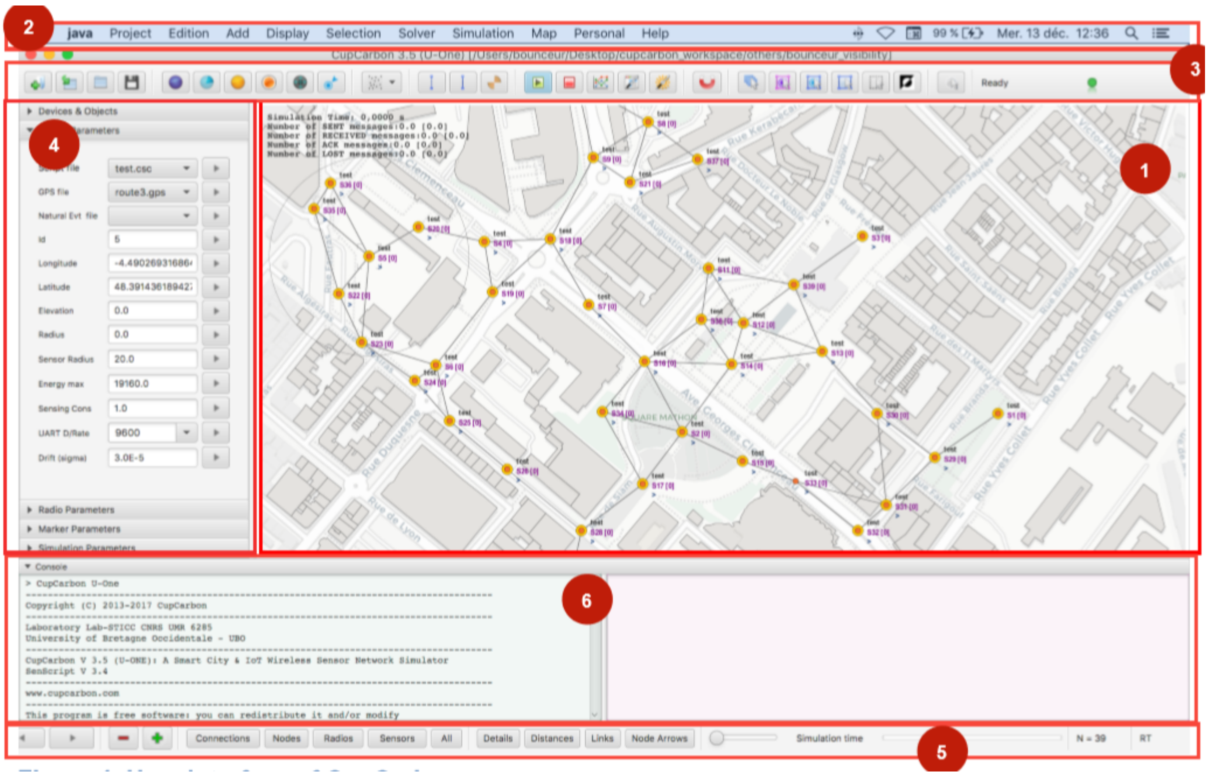

Fig 4: environment of CupCarbon

3.4 Flow Diagram of CupCarbon

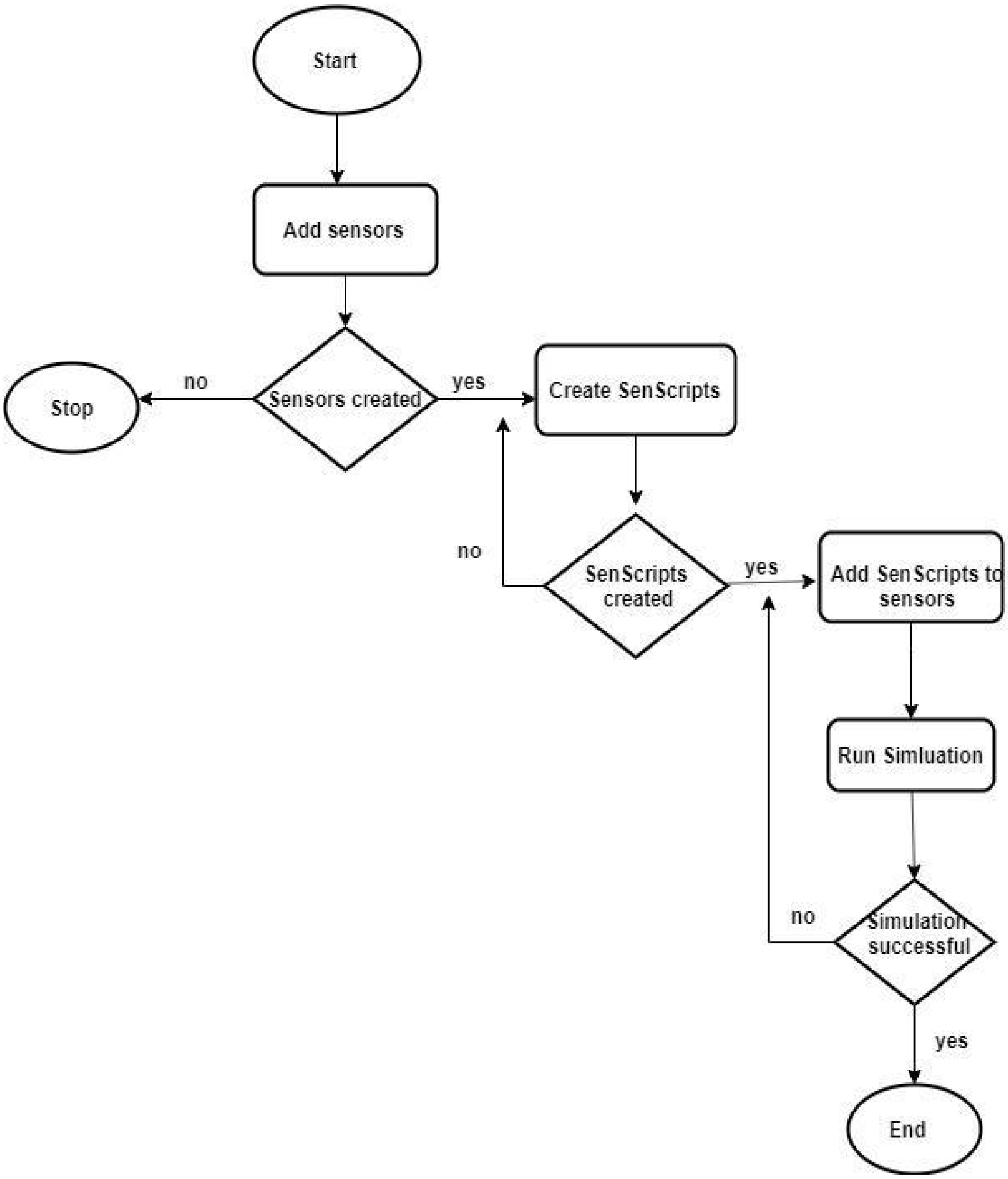

Fig 5: Flowchart of cup carbon

3.5 CupCarbon Modules

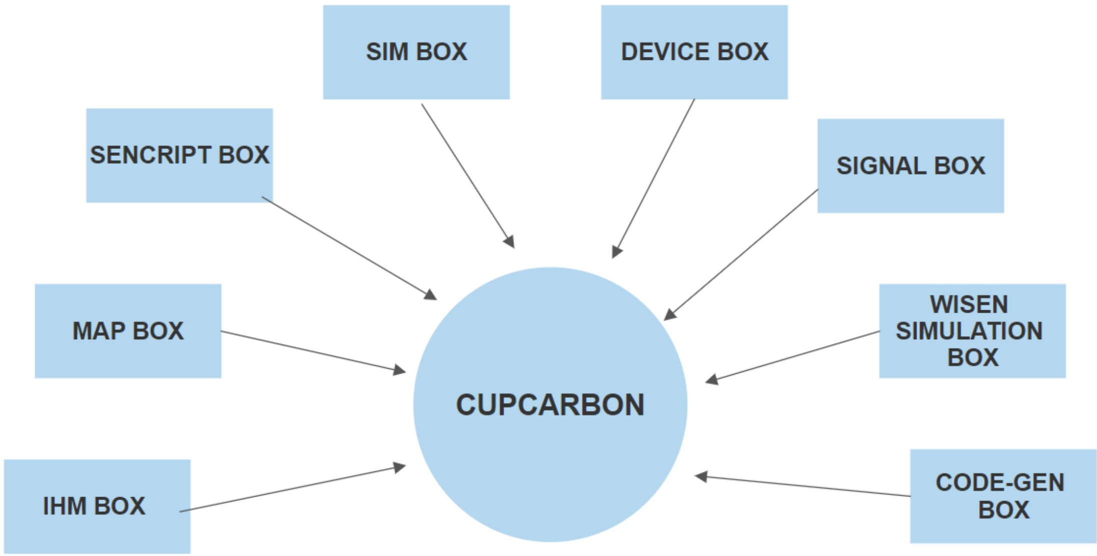

Fig. 6: modules of cup carbon.

3.6 MAIN COMPONENTS OF CUPCARBON

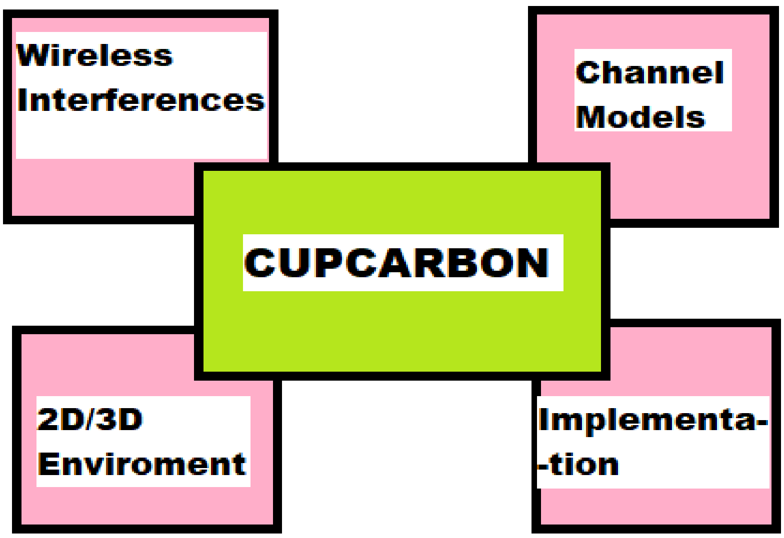

Fig 7: Cupcarbon main component

3.7 COMPARISON OF WNS (WIRELESS SENSOR NETWORK) SIMULATOR

Parameters	**OMNet++**	**NS_2**	**Cupcarbon**
used for research work	high	high	low
Platform used	Linux, Windows	FreeBSD, Linux, SunOs, Solaris, Windows, Mac OS X	Windows, Linux, Mac
GUI	medium	low	high
Energy modeling	no	yes	yes
Programing language used	c/c++, octl	Ned	java, senscript
Traffic modeling	medium	high	-

Table 2

4. FUZZY LOGIC

4.1 INTRODUCTION

Lofti Zadeh introduced the term fuzzy logic in 1965; he wrote a paper defining and creating this new concept. Fuzzy logic is used to represent uncertain things that are neither true nor false but in between true and false. Fuzzy Logic is determined as a set of mathematical principles for knowledge representation based on the degree of membership rather than on crisp membership of classical binary logic. Fuzzy logic is multivalve compared to Boolean logic, which accepts only two values; in fuzzy logic, you can select any number of different scales. For example, water in class can not only be possible to select between full or empty, but you can also select completely full, medium, medium empty, etc.

A fuzzy System can be divided into four steps:

1. Fuzzification: we convert the given inputs into fuzzy sets. Like the values, the sensors detected are passed to make a fuzzy set for the given system.
2. Fuzzy Rules: here, we create rules for the system. Like if-then rules.
3. Inference Engine: It determines which rules must be applied according to the inputs.
4. Defuzzification: It basically finds output, that is it converts the fuzzy sets that we get from the inference engine to a crisp value as output.

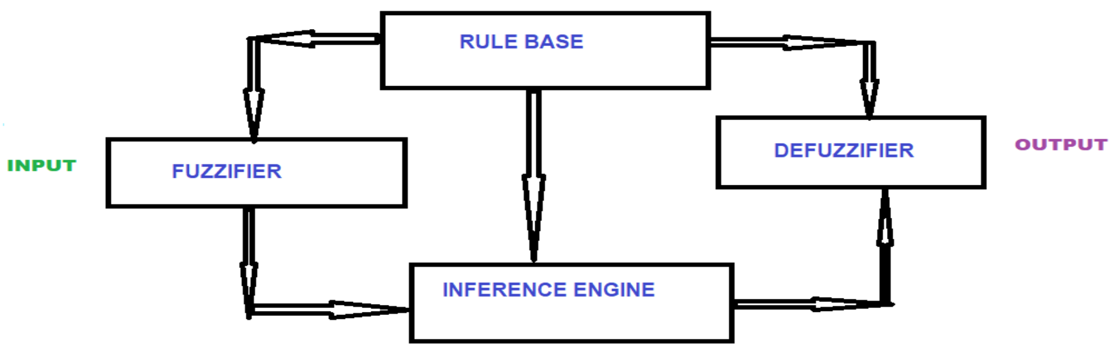

Fig.8: flow diagram of fuzzy logic

4.2 DIFFERENCE BETWEEN CLASSICAL SET/BOOLEAN LOGIC AND FUZZY SET THEORY

FUZZY SET	CLASSICAL SET
They have sharp boundaries in classes of objects.	They don't have sharp edges in classes of objects.
Crip boundaries define them.	Uncertain boundaries define them.
The location of the set of boundaries is precise.	The location of the set of boundaries is ambiguous.
It is mainly used in digital systems.	It is only used in fuzzy controller systems.

Table 3

4.3 SIMPLE EXAMPLE OF FUZZY LOGIC

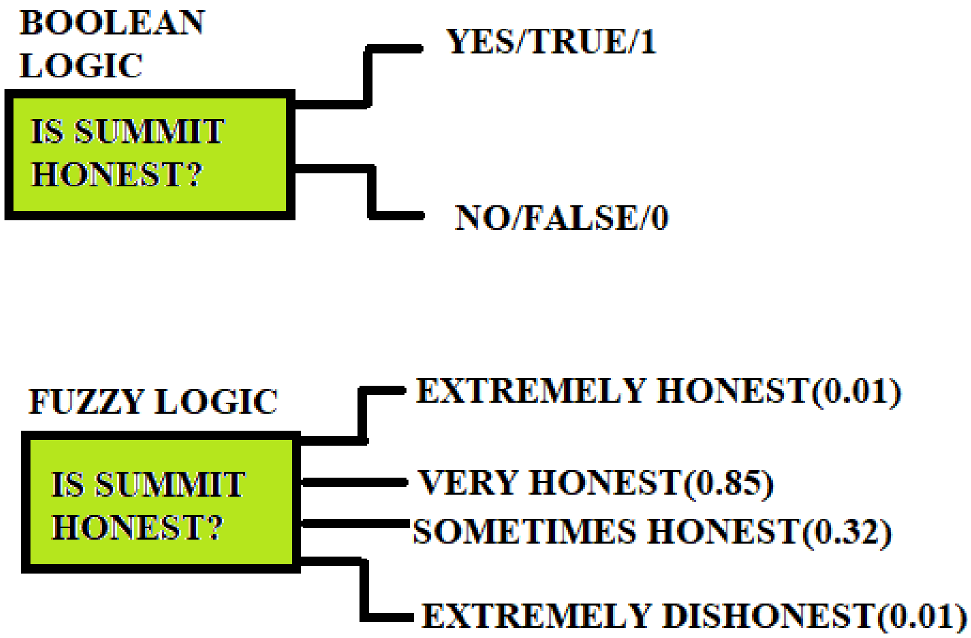

Fig.9: fuzzy logic example

4.4 ADVANTAGES OF FUZZY LOGIC

- Fuzzy Logic systems structure is essential and understandable.
- Fuzzy logic is commonly used commercially and in reality.
- It helps power machines and consumer goods.
- It does not have correct reasoning but is the only reasoning that is reasonable.
- It enables you to tackle engineering uncertainty.
- Mostly robust since no exact inputs are needed.
- When the feedback sensor stops working, it can be programmed to.
- This can easily be changed to boost or change system performance.
- Cheap sensors that will help to keep the total cost and complexity of the device small.
- It gives the best possible solution to complex problems.

4.5 APPLICATION OF FUZZY LOGIC

FUZZY LOGIC	COMPANY	PRODUCT
In hazardous situations, using fuzzy logic to control braking depends on car speed, acceleration, wheel speed, and acceleration, which are uncertain	Nissan	Anti-lock brakes
Using it to reduce waiting times based on passenger traffic	Toshiba, Fujitec, Mitsubishi Electric,	Elevator control
They suggested fuzzy rules for testing the health of their employees.	Omron	Fitness management
To adjust the cleaning cycle, strategies for rinsing and washing depend on the number of dishes and the amount of food served on the dishes.	Matsushita	Dishwasher
Fuzzy logic is used to monitor direct injection and activation based on the throttle position, temperature of the cooling water, RPM, etc.	NOK/Nissan	Auto transmission

Table 4

5. LITERATURE SURVEY

Many researchers have taken place about improving the routing in IoT. All these researchers aim to improve the existing routing protocols to ensure that they will carry the future IoT-based network demand.

In [1], the author studied the first version of CupCarbon. The study focused on the wireless sensor network and WSN simulator. A WNS (wireless sensor network) is an ad-hoc network consisting of many sensor nodes capable of collecting, sending, and receiving environmental data autonomously through wireless communication. Simulators like NRL Sensors are based on modules, and RTNS is used for real-time distributed systems. Simulators based on the OMNET++ simulator like Castalia, for the development of protocols and distributed algorithms; MIXIM, an inter-level platform, NesCT which allows running TinyOS applications, Pawis with its modular design, allows simulating different types of nodes; and Sensim, which allows the development of new protocols and test their scalability are discussed.

Cupcarbon mobility and communication script architecture are discussed in detail. This enables networks to be built using the framework of OpenStreetMap. Networks can have sensors and components like mobile phones, fire, gas, etc. The tool represented can run in two simulation types. To make it independent, the analysis of large single agents has been used to parallel the behavior of each sensor. The discrete simulation of events is used to model interagent interaction, and in general,

In[4], the author presented smart accident management in Jordan using Cup Carbon Simulation. The main aim of the researchers was to enhance rescue operations when accidents occur, to reduce response time for accident management, to avoid Emergency Room occupancy, and to select the optimal route from the accident to the available hospital to enhance preparation for expected accidents. When accidents occur, the sensors in an ambulance or vehicle will sense it and send the accident information to the nearest control station. After connection with the rescue, the vehicle control station will send a message to the nearest hospital to check the availability of the hospital and after finding the hospital. The control station finds the optimal route using two equations.

Determining the Distance and Availability of Hospital to Find Optimal Route

F(n) = D(n)+ availability (n) (1) Where n is a specific route from accident to hospital, D(n) is the distance from the accident to the hospital, and availability (n) is a Boolean function that has true and false values. The scenario tested using CupCarbon

Determining the Optimal Route to Available Hospital with Respect to Traffic Congestion

F(n) = Traffic(n)+ availability(n)

Where n is a specific route from accident to hospital, T(n) is the traffic congestion from accident place to the hospital in route n, and availability (n) is a Boolean function that has true and false values.

In [2], the author proposed a Content-centred routing protocol in the IoT network and their implementation in low-power and lossy networks where content decides routing routes. A greater information collection can be accomplished by routing the associated information to intermediate relay nodes for storage, thereby effectively reducing network traffic. Here, the information is distinguished by its value during information processing, and the associated data is called the very same content information. A content-centered routing protocol is a decentralized system when a request enters the gateway where it is routed by default. The structure is first used to initiate data collection. The focus of the subsequent phases is to optimize this routing structure design so far. The operation includes three major functions: 1. trigger function, 2. the objective function, 3. routing updates with loop detection function, and system architecture. CCR is a decentralized idea that considers the reduction in traffic achieved by aggregating CC (content-centered) data while routing traffic over authenticated communications. Depending on the message's content, each node creates a Separate routing entrance by working for each content type the suggested novel objective function; the key concept is to route heterogeneous content types through chosen accurate interaction links to nodes that can aggregate and process data before the overview information is forwarded.

In [5], the author presented an evaluation of secure MANET routing characteristics to keep IoT routing closely guarded and complete. They analyzed the secure MANET protocols and used them to develop secure IoT dynamic routing. This paper focuses on confidentiality and integrity in keeping safe routes within the IoT network. Confidentiality ensures that information is not diverted to the wrong source. The integrity that guarantees the information received by the final node in transit has not been modified. The architecture of IoT is divided into the layer of perception, the network layer, and the layer of an application. IoT routing protocols 6LoWPAN, Low Power, and Loss Networks (LPL) routing protocol (CoAP) were discussed.

In [3], the author proposed Dynamic RPL for Multi-hop Routing in IoT Applications, studied RPL, and paper explored the use and implementation of RPL in complex networks, and improved RPL for different dynamic mobility usage and various requirements in the network. It is a tree-based distance-vector protocol; the routing tree is constructed as a collection of DODAG (Destination-Oriented Directed Acyclic Graphs) routed to the DODAG center. -DODAG is generated by the specified Objective Function (OF) to decide the routing metrics used to select the parent of choice.RPL was designed to handle low-power and lossy networks. DRPL is Suitable for networks where nodes can be mounted connected to individuals or objects creating a scenario for flexible mobility where multiple mobile nodes can be included in the DODAG formation. A real-time Internet of Things program with complex flexibility scenarios involving multi-hop routing across mobile nodes to the root or gateway is presented in this paper. The D-RPL design involves a change in the RPL tickle timer a new objective function, and these two variables interact with each other in managing mobile network nodes.

In[6]The author presented Routing in the Internet of Things network for dynamic service discovery, a semiconductor routing protocol for Internet of Things service discovery; most of the semiconductor routing protocols that have been exited so far are designed for one-to-one systems so that they can have higher memory demand because they use keywords, semiconductor routing to discover the Internet of Things capabilities in the Internet of Things network, Therefore, for dynamically occurring tasks, the routing table is indexed by the ability to reduce the space required for routing, each node is considered to have a telescopic view routing table, which means more information about the neighboring node and less information about additional nodes. An ontology coding scheme is used to realize the node's telescopic view.

In [7] presented the routing protocols for underwater wireless sensor networks, the network underwater goes through many problems, such as high path loss, few available bandwidth, restricted battery Power, and high attenuation needed to maintain an underwater network with a balanced and efficient energy consumption network. This protocol works in 1. initialization 2 in three parts. Building the tree 3. Data transmission. All nodes are to share data about their residual energy level and position in the initialization stage. The protocol utilizes information about the location in the tree construction part to select neighboring nodes and select the successor and facilitation of cost-functional nodes. The protocol selects remaining energy nodes significantly higher than the average remaining energy to regulate the energy usage of the network between the successors and the mediator nodes.

In [8], the authors presented an analytical model of a naive flooding-based routing protocol using Markov chains, showing the significance of routing protocols in the IoT network. The routing protocol developed was generic; that is, it can be applied to routing protocols in various domains.

In [9], the authors presented the importance of IoT in our daily lives and various other fields. The paper presented how life can become easy using IoT. They did a case study of HMIS (Health care Management system), and the result was analyzed later.

In [10], the author proposed applications of IoT and a literature survey was done systematically to know in detail the concepts of IoT. According to a literature survey, it was revealed that till now, less effort has been given to understanding the concepts of IoT.

In [11], they address the issue of context-awareness in routing protocols. The simulation was performed in Contiki os in the Cooja network simulator. As RPL does not meet all the requirements of the IoT network it was needed to introduce more effective routing protocols. They introduce an objective function that selects routes based on the fuzzy logic concept. The new routing metrics were introduced: queue fluctuations that indicate how much traffic the network is (how congested are the nodes) and the residue energy index, which gives the energy metric that will help in better understanding of the network. Fuzzy logic is used to find the best parent from a candidate parent set efficiently.

In [12], the authors introduce routing for dense wireless networks using fuzzy logic. First, they presented NORA (network role-based routing algorithm), and then they presented the evolution of NORA. NORIA(network role-based routing intelligent algorithm) combines different best methods to decrease the energy spent and make efficient data routes. That's why it is one of the novel routing protocols for wireless sensor networks. The fuzzy logic concept is used for comparing node conditions, which makes the decision-making effective.

In [13], the authors used the concept of reinforcement learning and fuzzy logic to find a new method for a highly reliable route in IoT. The main aim is to enhance the network lifetime for which energy-efficient algorithms are needed. Both concepts depend on the energy remains of the nodes in the path. They have also compared their proposed work with the IEEE 802.254 protocol. Simulation is performed on OPNET (optimum network performance). The result showed that in terms of consumption of power and lifetime of the network, their proposed algorithm performed better than other protocols.

In [14], the authors proposed the energy-efficient routing protocol using the fuzzy logic concept in IoT networks. They address issues like low power disconnection in between communication, which is the result of limited memory, less power, and processing capabilities. Their proposed algorithm reduces the loss of packets and raises the network's lifetime. The fuzzy logic concept is used to optimize the performance of a network by accepting input descriptors in the routing metrics form.

In [15], IoT has made machine-to-machine (M2M) communication more prominent. They coined the term opportunistic network, which is defined as the other variant of DTNs(delay tolerant networks). There may never exit end-to-end communication between the starting node and the final node They divided the IoT architecture into five layers that are perception layer, network layer, middleware layer, application layer, and business layer. Opportunistic network architecture is divided into the application layer, opportunistic service layer, opportunistic pervasive networks layer, resources layer, and human social layer. Later, fuzzy logic and genetic algorithms are used to optimize the protocol.

In [16], the authors optimized the IEEE802.15.4 protocol for IoTs in a hospital using fuzzy logic. simulation is performed in Castalia3.2 with OMNet++ platform. The protocol includes four steps: 1. Find a suitable IEEE802.15.4 protocol according to the hospital environment. 2. Giving information and analyzing concerning link quality protocol. 3. now implement this in real-time to find actual versus analyzed data. 4. design a fuzzy logic system that will map the experiment to the proposed fuzzy logic system for optimizing the results.

In [17], this research aims to increase the lifetime of the IoT network. They used MatLab for simulation. The paper provides the design and implementation of the routing protocol proposed. Routing metrics of the node are used for optimizing the network's performance. The protocol uses the fuzzy inference system to choose the desired path to extend the network lifetime. The performance comes out to be 63.4% for the given proposed system.

In [18], The researchers discuss the importance of energy requirements in the IoT sensor network; it is crucial for decreasing the number of lost packets, depletion of energy, and fast delivery of packets. The key concept is to increase the lifetime of IoT networks; it combines the concept of deep learning with NTFS(Neuro-fuzzy Inference System). The neuro-fuzzy inference system is used for making decisions. It takes multiple inputs and gives out a single output.

In [19], the paper gives an IoT route-selecting protocol using fuzzy logic to make it dynamic to be applied to real-life systems.

Four objective functions(OFs) are made for this protocol. These functions are selected dynamically based on the context information. The objective functions are generated by combining the expected transmission count(ETX), energy consumed, and the number of hops. The lifetime of the network is increased due to this protocol, and it keeps the device alive for a long period.

In [20], The researchers proposed two fuzzy logic protocols for determining and monitoring the confidence of fire, which is used to optimize and decrease the number of rules to be explored while making a decision making. This protocol will reduce the number of sensors' activities and increase the sensors' battery life. Representational state transfer (RESTful) services are used to get real-time verification of the proposed work.

In[21], The researchers showed the importance of WNS(wireless sensor network) which has various applications for security, tracking, and health monitoring. Every sensor acts as a routing element for the other sensor at the time of packet transmission, this process can impact the increase of energy consumption of sensors. They propose a routing protocol for improving the lifetime and performance of the IoT network. The protocol proposed uses the concept of type-2 fuzzy logic to decrease the effects of uncertainty produced by the noise of the environment.

In [22], they consider the network reliability, energy efficiency, and transport delay. According to these factors, a fuzzy logic
system is designed that is reliable, and a novel adaptive green is proposed. The renewed packet copies are generated in different numbers by applying certain steps in the fuzzy inference system. The fuzzy logic is used to make decisions. This proposed protocol gives data transmission a low latency and high energy efficiency.

6. SYSTEM SPECIFICATION

6.1 Hardware requirement

HARDWARE	SPECIFICATION
CPU	Intel Pentium4 or above
CLOCK SPEED	1GHz or above
RAM	1 GB or above
HARD DISK	10GB or more

Table 5

6.2 Software Requirement

SOFTWARE	MODULE	VERSION
OPERATING SYSTEM	Microsoft Windows	7 or above
Cup carbon		4.1
ECLIPSE		4.13 or above
JDK		8 or above
BROWSER	Mozilla Firefox, Google Chrome	Latest recommended

Table 6

7. METHODOLOGY ADOPTED

The key concept is to optimize the D-LPCN(Distributed Least Polar-angle Connected Node) algorithm using fuzzy logic. D-LPCN algorithms find all the boundary nodes in a network. when all the boundary nodes are marked a fuzzy logic concept is implemented to optimize the boundary nodes found. After fuzzy logic implementation, a few nodes are selected, which will broadcast the message. As in an IoT network, sensor nodes are moving continuously, which leads to changes in topology, and fuzzy logic deals with uncertainty; therefore, fuzzy logic concepts fit in our routing protocol. The fuzzy value lies between 0 and 1, so in this project, ten random sensor nodes are placed, and all are assigned a random value between 0 and 1 that is a fuzzy value The sensor node with the maximum value will be marked, and only that node will broadcast the message to all other nodes.

7.1 FLOWCHART OF IMPLEMENTED PROTOCAL

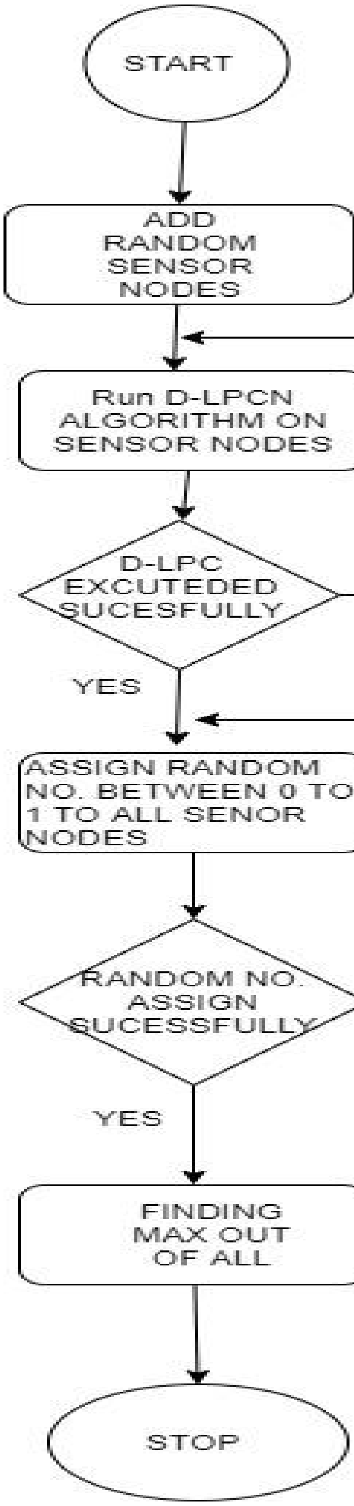

Fig.10: flowchart of the implemented algorithm

8. ALGORITHM FORMULATED

1. Primitive Definition
AC: ask for coordinates
CS: send coordinates
SN: select a node
2. Functions used
getId(): returns the node identifier
getCoord(): returns the node coordinates (x, y)
getNumberOfNeighbors(): returns the number of neighbors of the node
send(a, b): sends the message a to the sensor node having the identifier b, or in a broadcast (b = ∗)
read(): waiting for receipt of messages.

Algorithm 1 MinFind: The pseudo-code of determining the starting node

Input: tmax

1) first node = TRUE;

2) tb = getCurrentTime();

3) xmin = getX();

4) send(xmin, *);

5) repeat

6) x = read();

7) if (x < xmin) then

8) first node = FALSE;

9) xmin = x;

10) send(xmin, *);

*11)*end if

12) ta = getCurrentTime();

13) until (ta − tb > tmax);

Algorithm 2: D_LPCN

```
boundary = false; s = 10;
c id = getId(); c coord = getCoord();
boundary set = ∅;
n = getNFN(); i=0;
Run Algorithm 1 to determine the value of first node;
if (first node) then
boundary = true;
p coord = (c coord.x−1, c coord.y);
send(c id+”|”+”AC”, *);
end if
repeat
id = read();
type = read();
if (i==n) then
boundary set = boundary set ∪ {c id};
send(c id+”|”+”SN”+”|”+c coord+”|”+boundary set, n id);
end if
if (type==”AC”) then
send(c id+”|”+”CS”+”|”+c coord, id);
end if
if (type==”CS”) then
n coord = read(); i=i+1;
s- = angleWI(p coord, c coord, n coord, boundary set);
if (s<s  min) then
s min = s; n id = id;
end if
end if
if (type==”SN”) then
boundary = true; s min = 10; i=0;
p coord = read();
boundary set = read();
send(c id+”|”+”AC”, *);
```

33) end if

34) until false

Algorithm 3: fuzzy implementation

AS: Add SenScript

AM: Add markers

NP: New project

CG: CupCarbon GUI

SW: SenScript window

RS: Run simulation

ARS: Add random sensors

RDS: Add 10 random sensors

Triggers: when a user makes a new project and runs

---

1) Click NP from the project menu

2) Give the name of the project as fuzzy

3) Click AM

4) Click ARS from the add menu

5) Click RDS

6) Click SW from simulation menu and add Senscript

7) Run algorithm no. 2

8) Assign the random value to variable *x*

9) Print the value of *x*

10) Mark node as 1

11) Set the value of maximum as *x*

12) Send the maximum value to all other nodes

13) Loop

14) Wait

15) Read the value of other sensors

16) If (sensor node value >maximum)

17) Mark node as 0

18) Set maximum as the value of node discover

19) Send the value of that node to other nodes

20) End

9. SIMULATION DONE

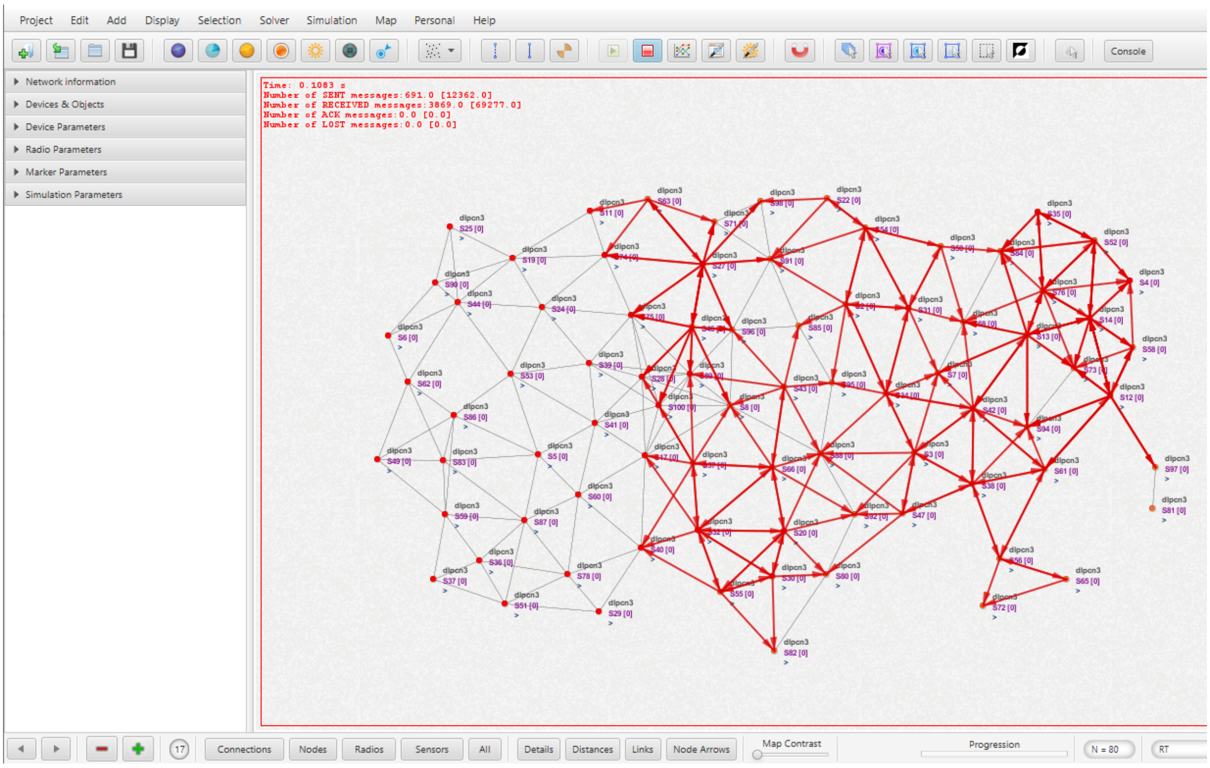

Fig.11: implementing D-LPCN for 100 sensors

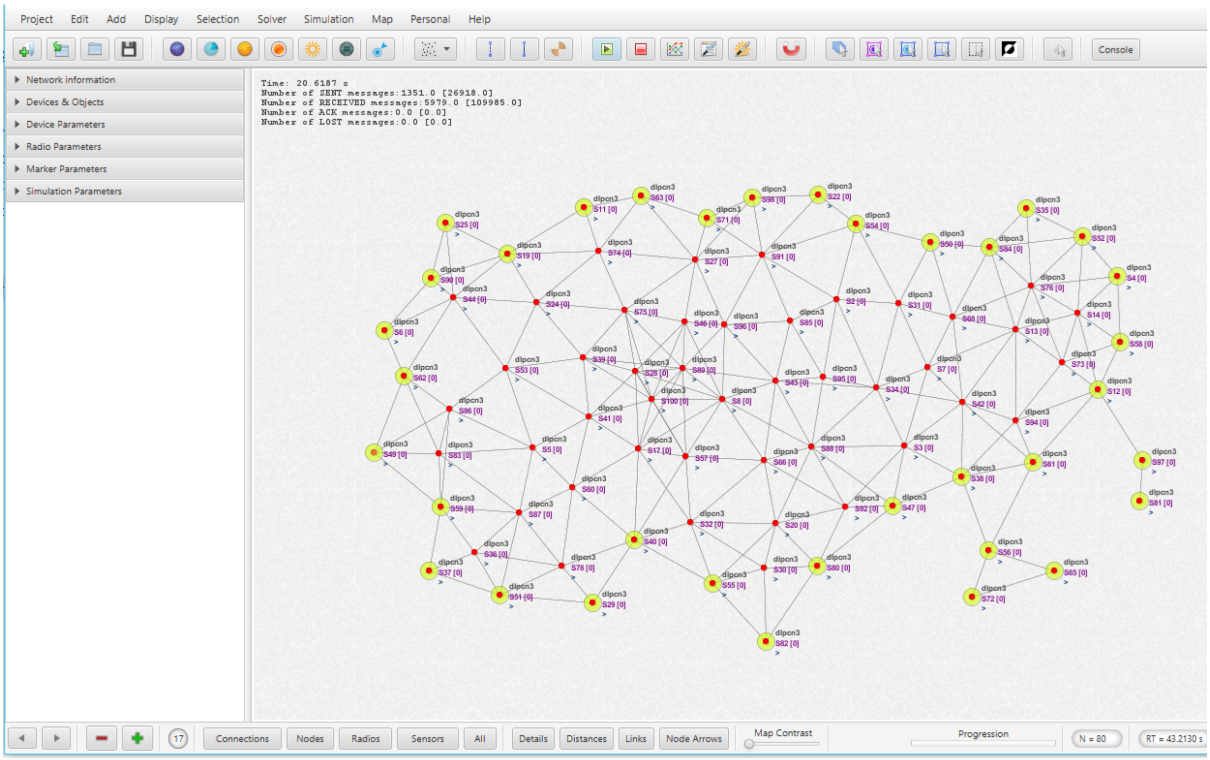

Fig.12: finding boundary nodes for 100 sensors

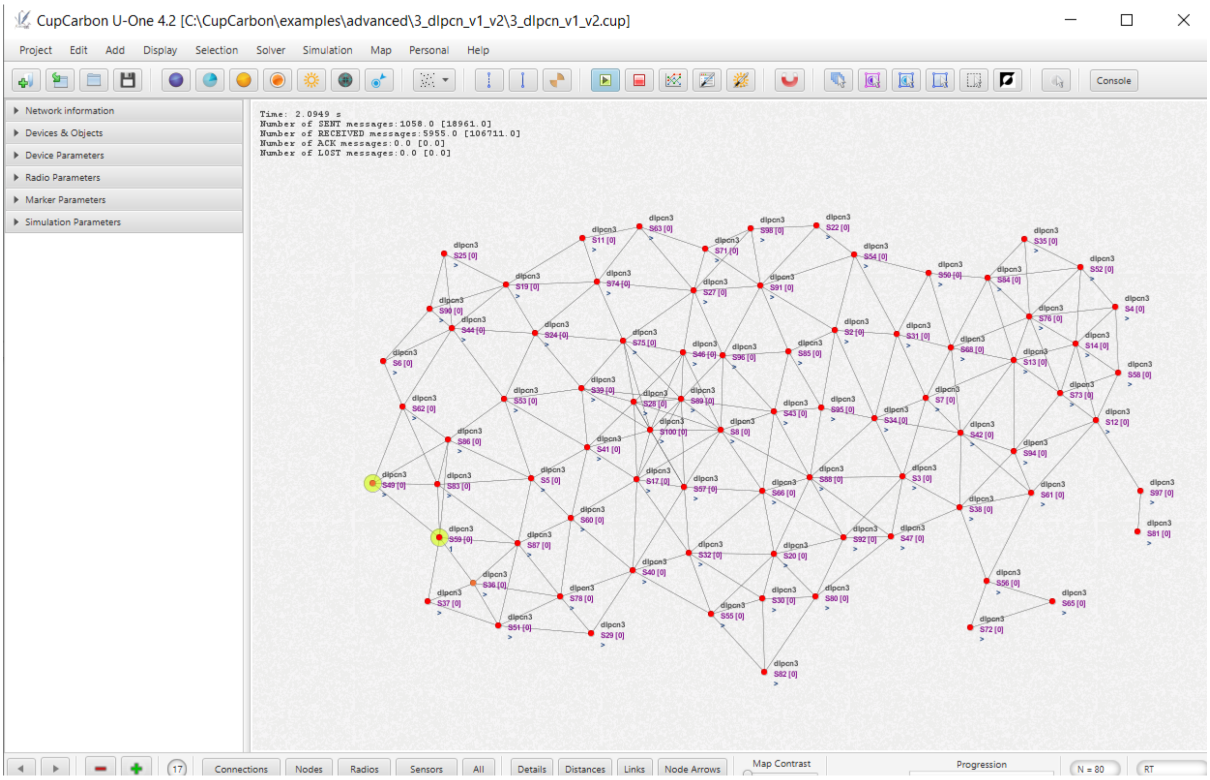

Fig.13: fuzzy logic implementation for 100 sensors

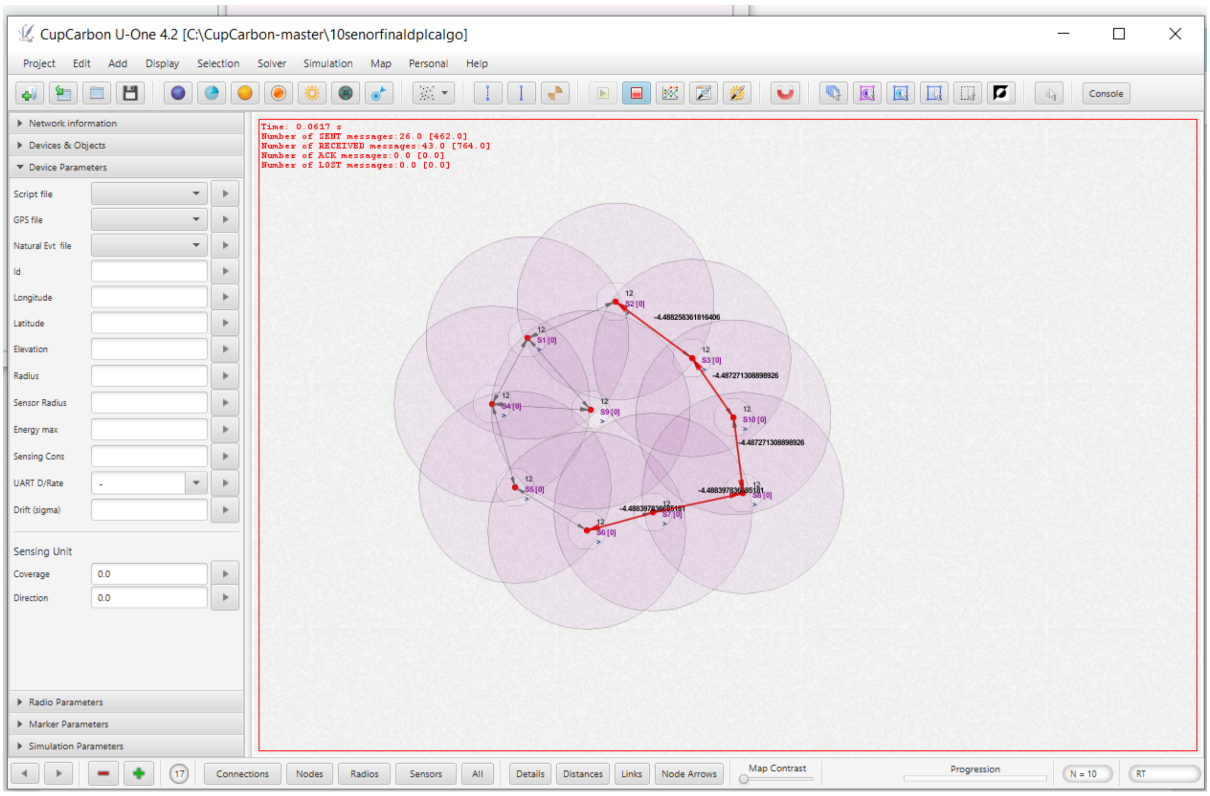

Fig.14: implementing D_LPCN algorithm for 10 sensor nodes

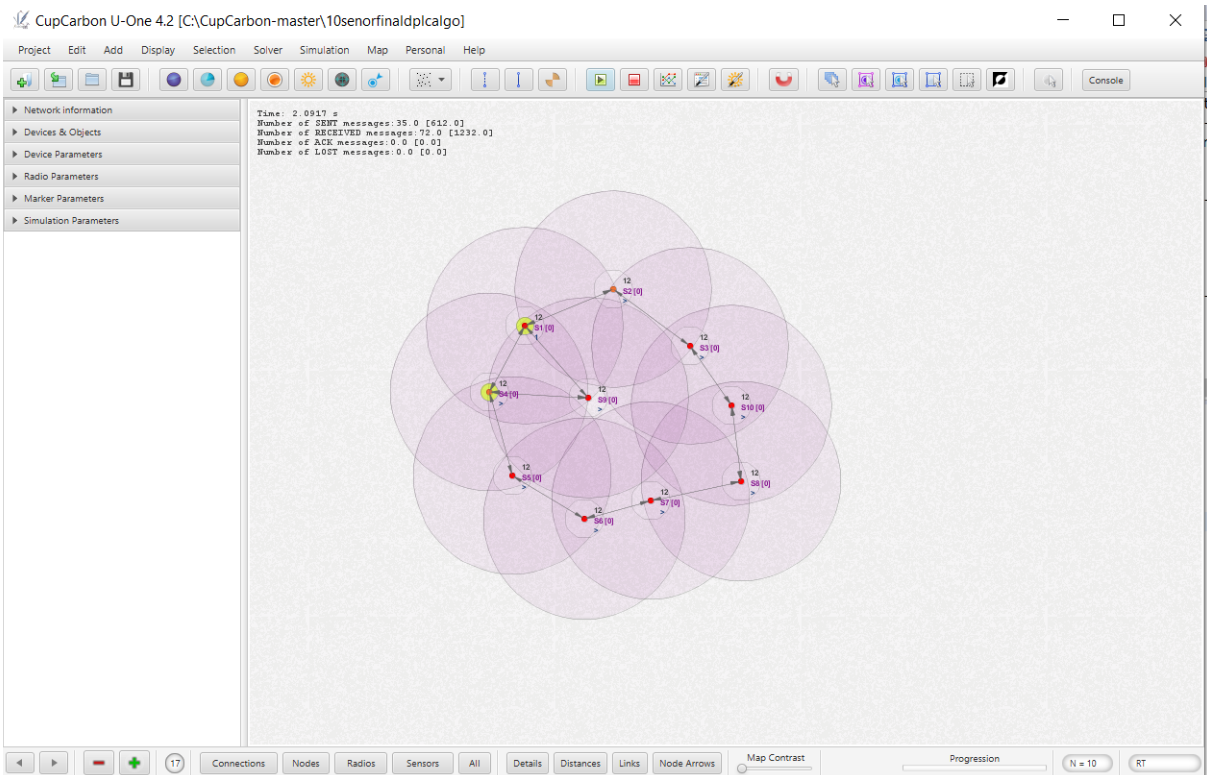

Fig.15: fuzzy logic implementation for 10 sensor nodes

10. RESULT OBTAIN

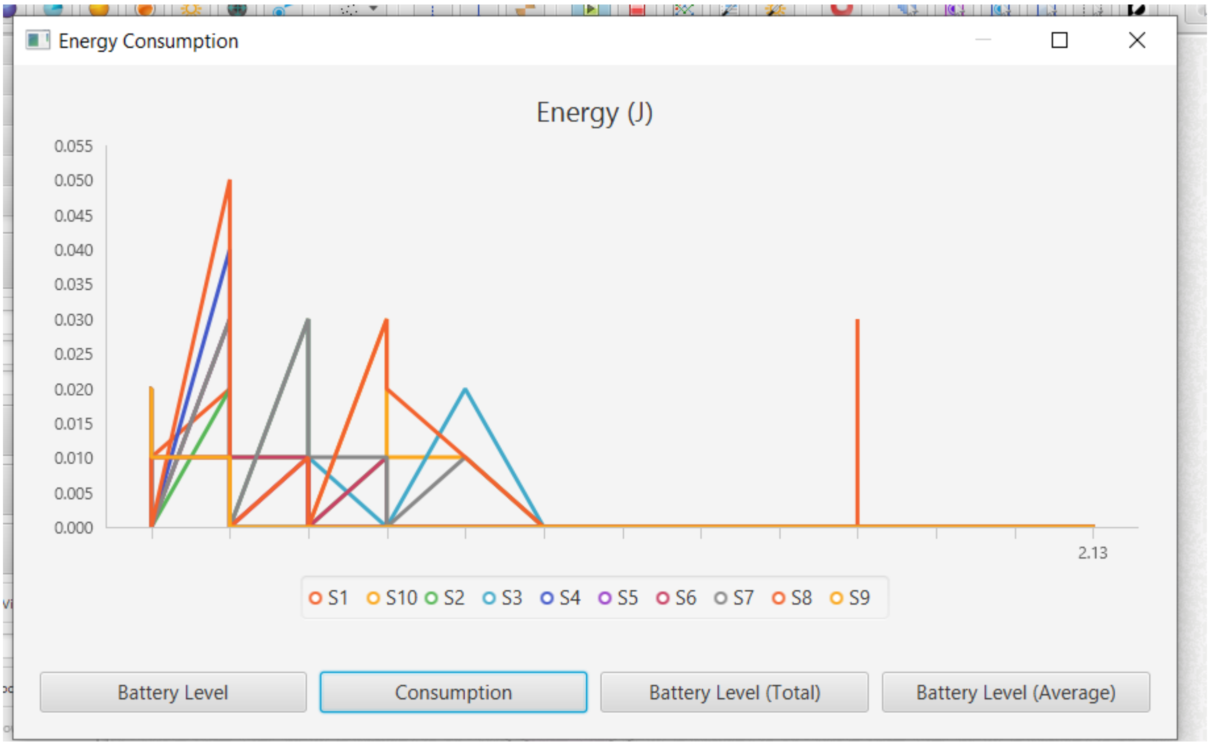

Fig.16: energy consumption of 10 sensors after simulation

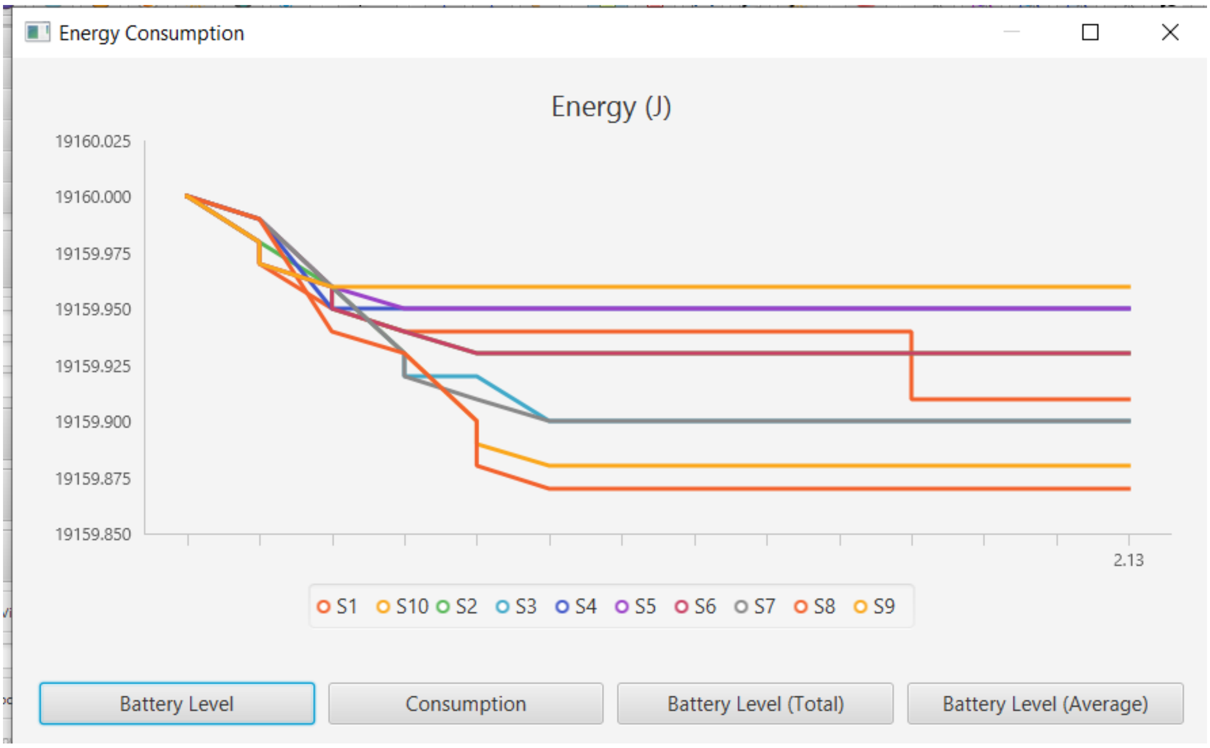

Fig.17: battery level of 10 sensors after simulation

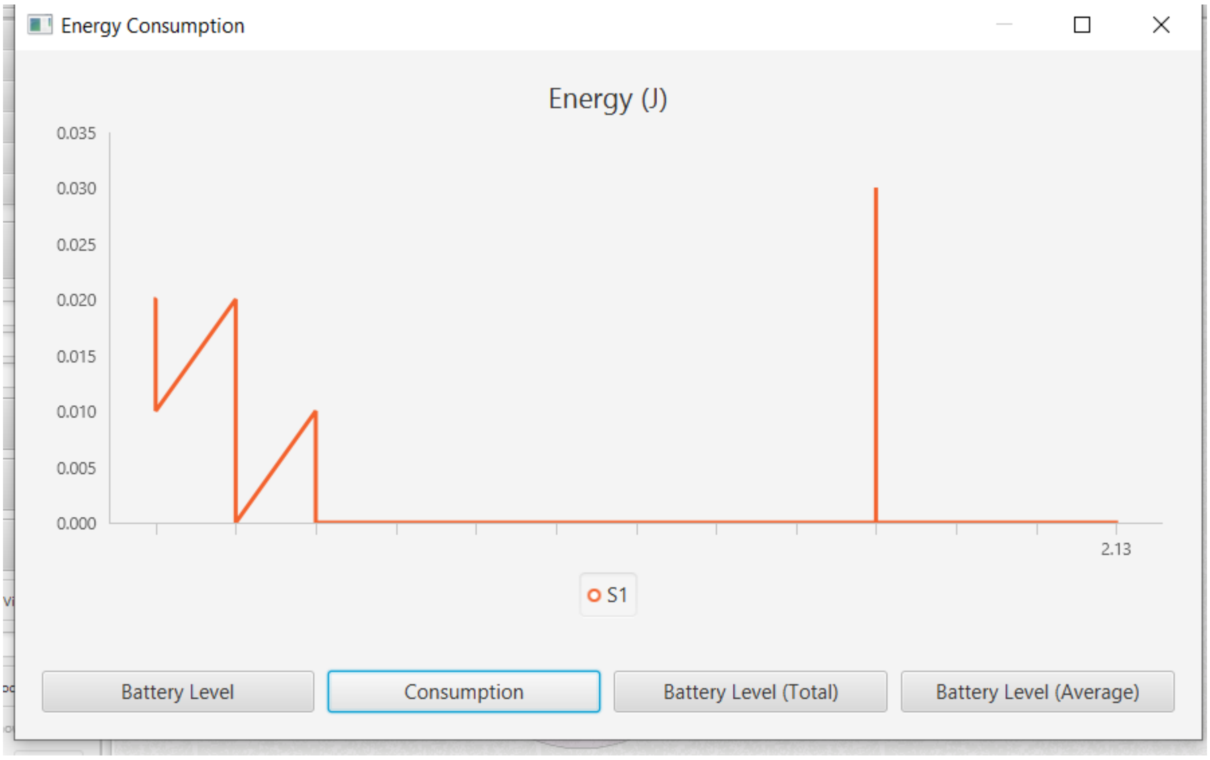

Fig.18: energy consumption selected sensor after fuzzy implementation (s1)

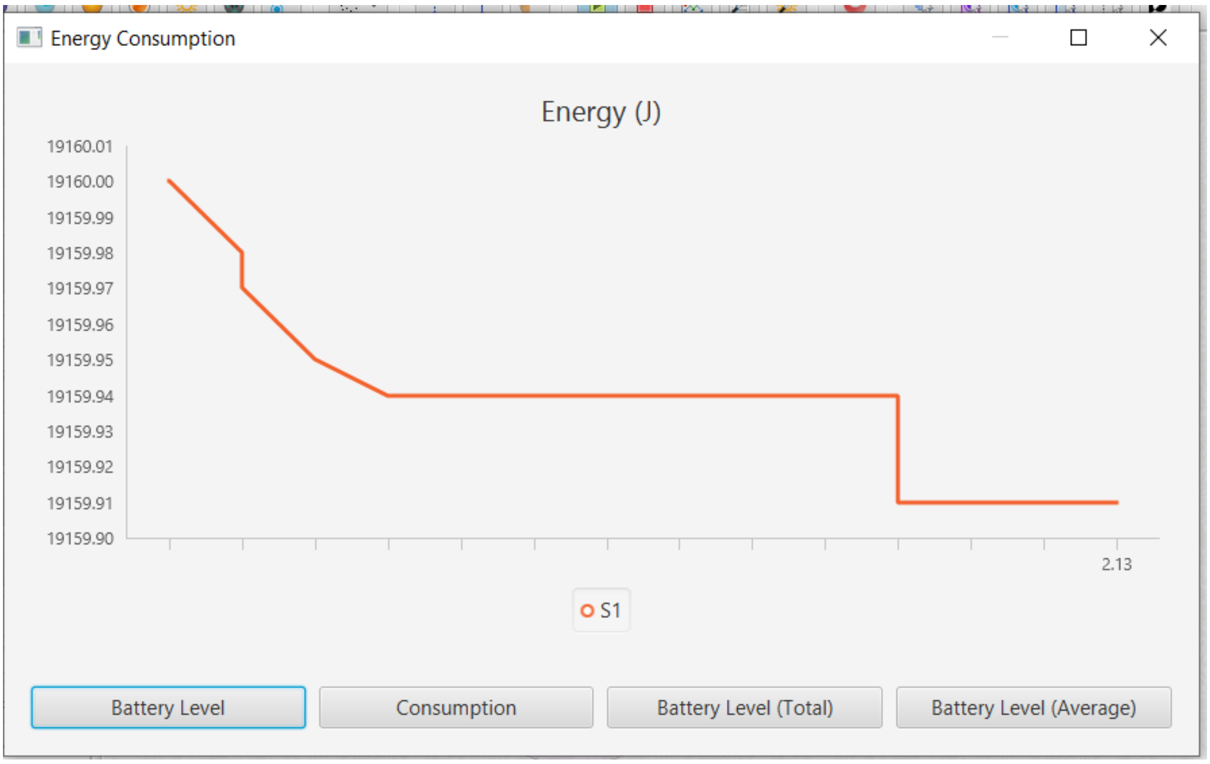

Fig.19: battery level selected node after fuzzy implementation (s1)

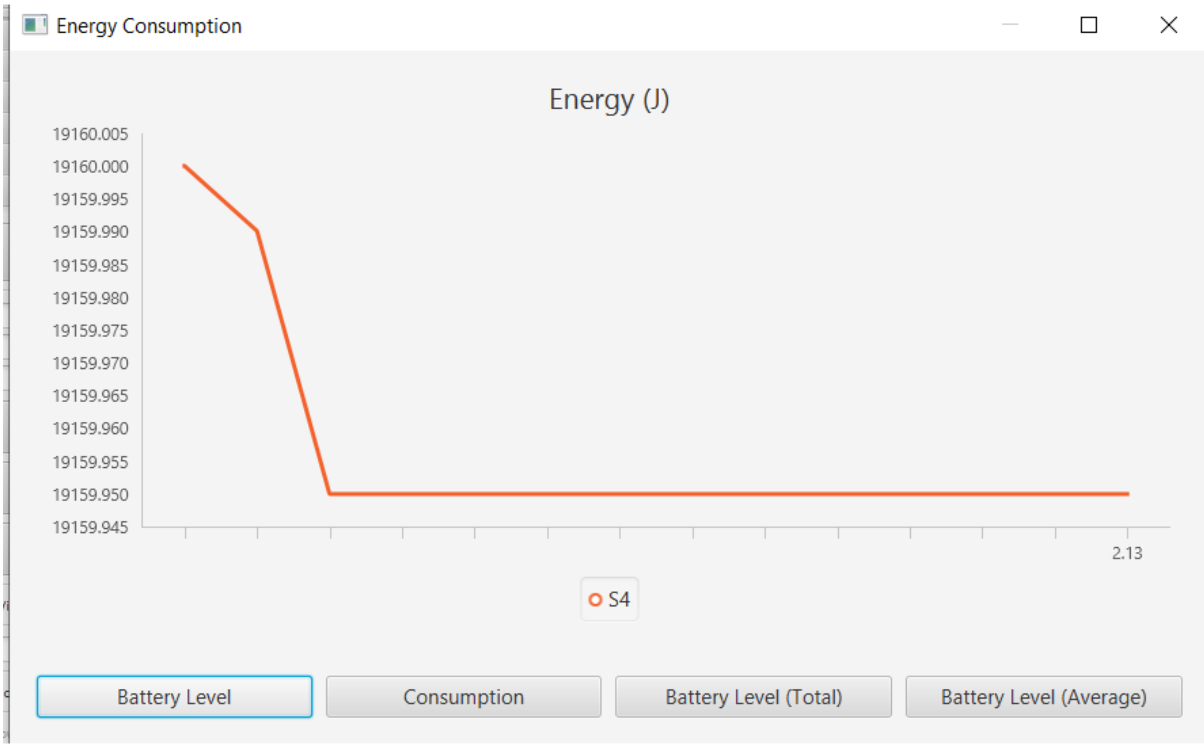

Fig.20: energy consumption selected node after fuzzy implementation (s4)

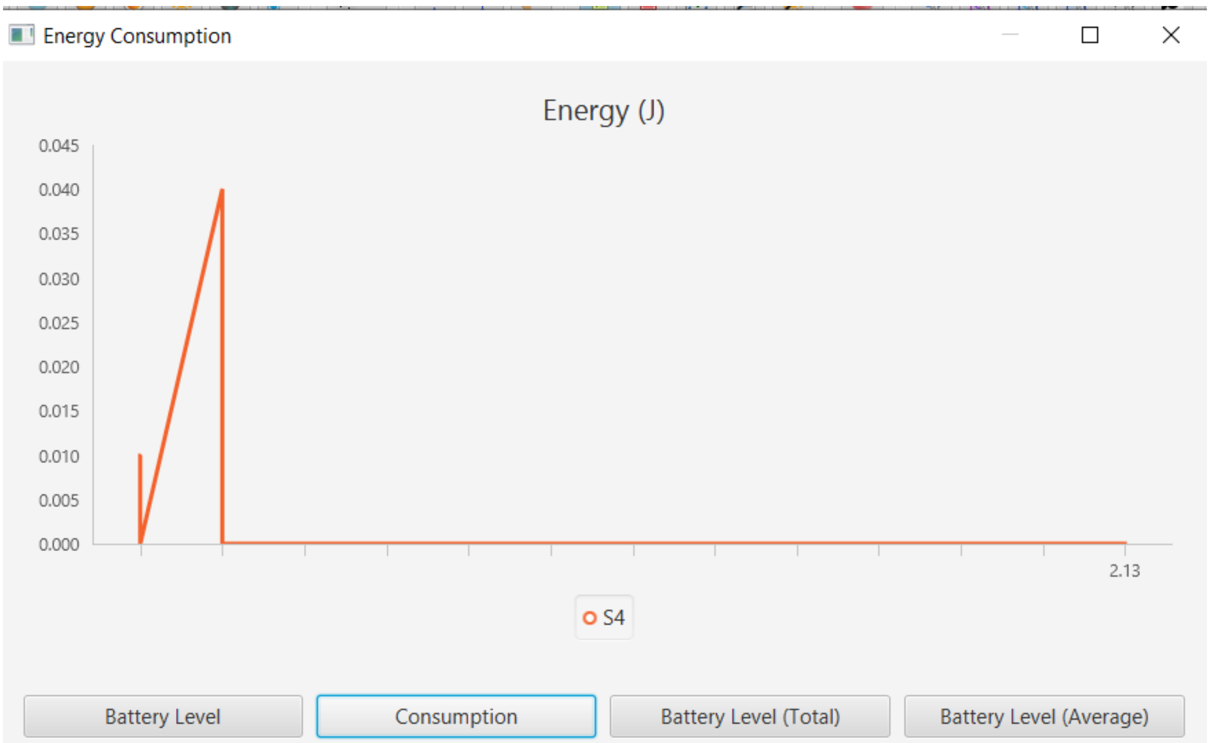

Fig.21: Battery level selected node after fuzzy implementation (s4)

11. REPORTS

11.1 In 100 sensor nodes

11.1.1 Simulation Parameter

1. Simulation Time:864000.0s

2. Mobility: false

3. Simulation Speed:0

4. Arrow Speed:50

5. Results: true

11.1.2 List of radio Modules for the Sensors

1. Current_Radio_Name:radio1

2. Radio_Standard: ZIGBEE

3. Radio_Channel:0

4. Radio_Network_id:13108

5. Radio_Radius:100.0

6.Radio_Data_Rate:250000

11.1.3 Result after Simulation

1. Time = 0.103 s

2. Number of sent messages = 691.0

3. Number of received messages = 3869.0

4. Number of acknowledged messages = 0.0

5. Number of lost messages = 0.0

11.2 In 10 sensor nodes

11.2.1 Simulation Parameter

1. Simulation Time:864000.0s

2. Mobility: false

3. Simulation Speed:0

4. Arrow Speed:50

5. Results: true

11.2.2 List of radio Modules for the Sensors

1. Current_Radio_Name:radio1

2. Radio_Standard: ZIGBEE

3. Radio_Channel:0

4. Radio_Network_id:13108

5. Radio_Radius:100.0

6.Radio_Data_Rate:250000

11.2.3 Result after Simulation

1. Time = 2.0917 s

2. Number of sent messages = 35.0

3. Number of received messages = 72.0

4. Number of acknowledged messages = 0.0

5. Number of lost messages = 0.0

11.3 Observations

1. D-LPCN Message Complexity is O(d nb + n).

2. Accuracy is 100%

3. It is observed that communication and energy are reduced, and only the nodes and their neighbors are used.

4. It is observed that the energy consumed does not depend on the number of nodes of the network nor the number of the boundary nodes, rather, it depends on the number of the neighbors of the boundary.

12. CONCLUSION AND FUTURE WORK

It is noted that IoT is the dominant technology for the future as it has two aspects that everything in the world will be smart and intelligent, and everything in the world will be supported by the cloud.

Routing protocols are an important aspect of IoT. In this project, we take into consideration the use of IoT and the routing protocols developed so far and we try to enhance them using the CupCarbon simulator.

The routing protocols developed so far are more static in nature and more theoretical, which are difficult to implement. In the future, we can develop more dynamic routing protocols that will enhance IoT and will be easy to implement. These protocols can be optimized using fuzzy logic, and a more real-time fuzzy system can be developed.

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