

**PROJECT
REPORT ON
ROUTING PROTOCOLS IN
INTERNET OF THINGS
USING FUZZY LOGIC
BY CUPCARBON**

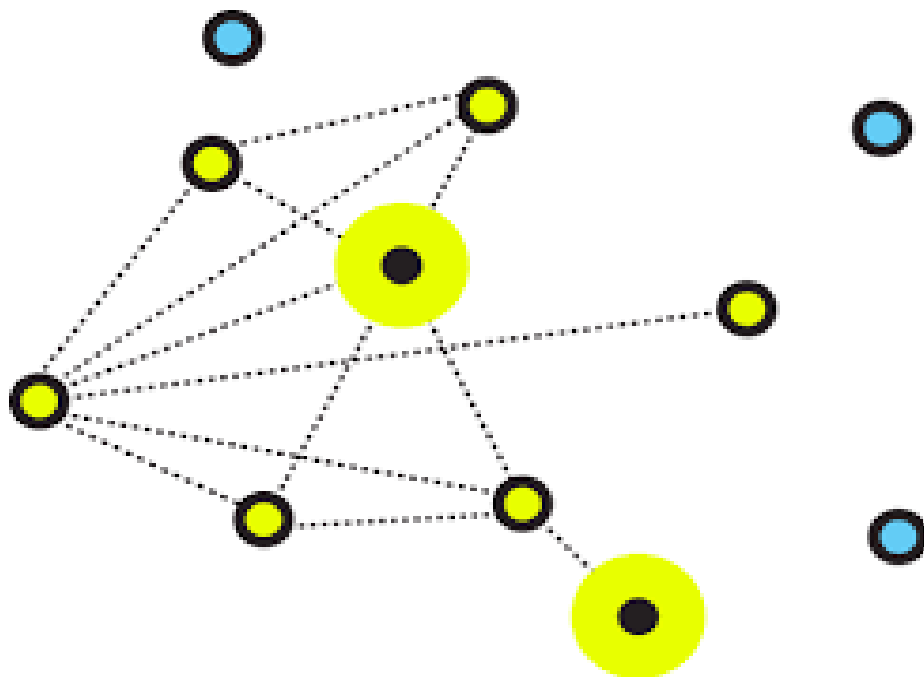


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ABSTRACT

The Internet of Things (IoT) is a future of the coming generation due to 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 an important 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 develop 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 that a fuzzy logic concept will work better in this case and fuzzy logic is expanding its domain from artificial intelligence to other fields as well, 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 common 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 greater challenge in the routing of networks therefore routing plays a significant role in IoT. Most existing routing protocols designed so far are not considering the dense architecture of IoT; therefore it is a great challenge to provide these algorithms according to the changing requirements of sensor-based IoT application. Therefore, these devices are not energy-efficient and they don't have fault-tolerant capabilities for such mobile IoT and 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 quoted

"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 why 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.

APPLICATION	smart city, smart homes, demand response, etc
NETWORK	communication protocols, wired or wireless network, M2M, etc
PERCEPTION	sensors, controller, machines, etc

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 the improvement and enhancement of Innovations. The supplier will analyze the data information from different car sensors and store the data to improve their design and make them much 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 plant 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 both looking for new ways to decrease consumption and to 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. For 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 being 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 the 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 & performance high tools. IoT helps the government to go through real-time information and better services such as health care, transportation, education, and so on.

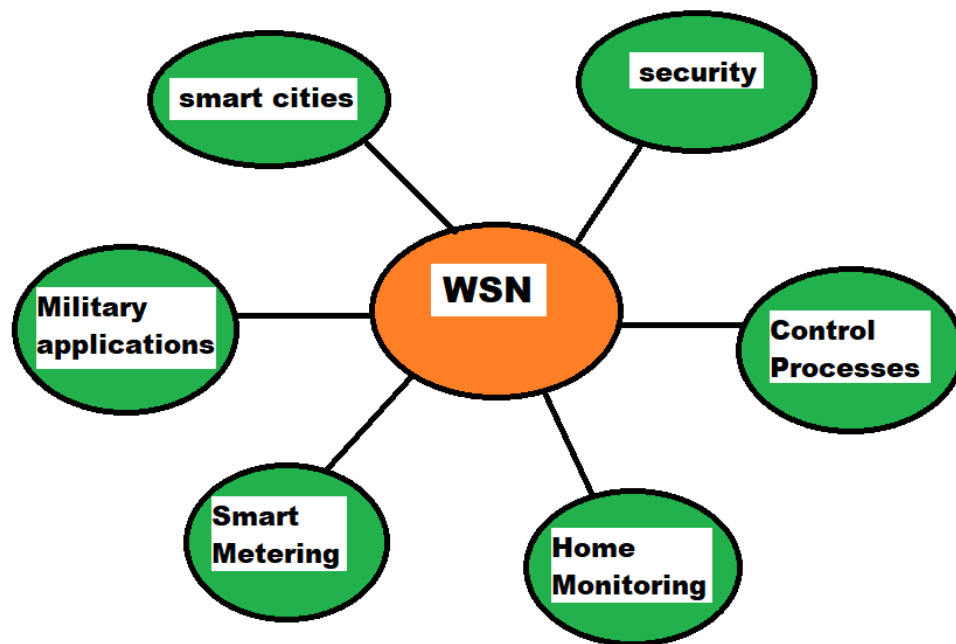


Fig.2: applications of wireless sensor network.

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 the security of consumers. 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 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 that 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 are unable to process open service 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 data on an ongoing basis, so the data collected must be turned into smartness for the creation of an intelligent environment. This smart architecture will play a vital role in the network's data routing. Many nodes in IoT are constantly moving, which can lead to intermittent interconnectivity between devices that can 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 Station connections, multi-hop mesh topology, nodes supplied by the battery, and often modified network topology, routing problems are becoming increasingly difficult.

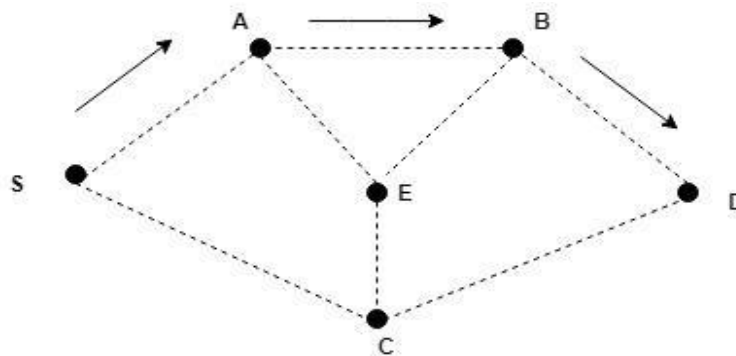


Fig 3: routing from source(s) to destination(d)

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 in the near future. 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 some 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; 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 the use of 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

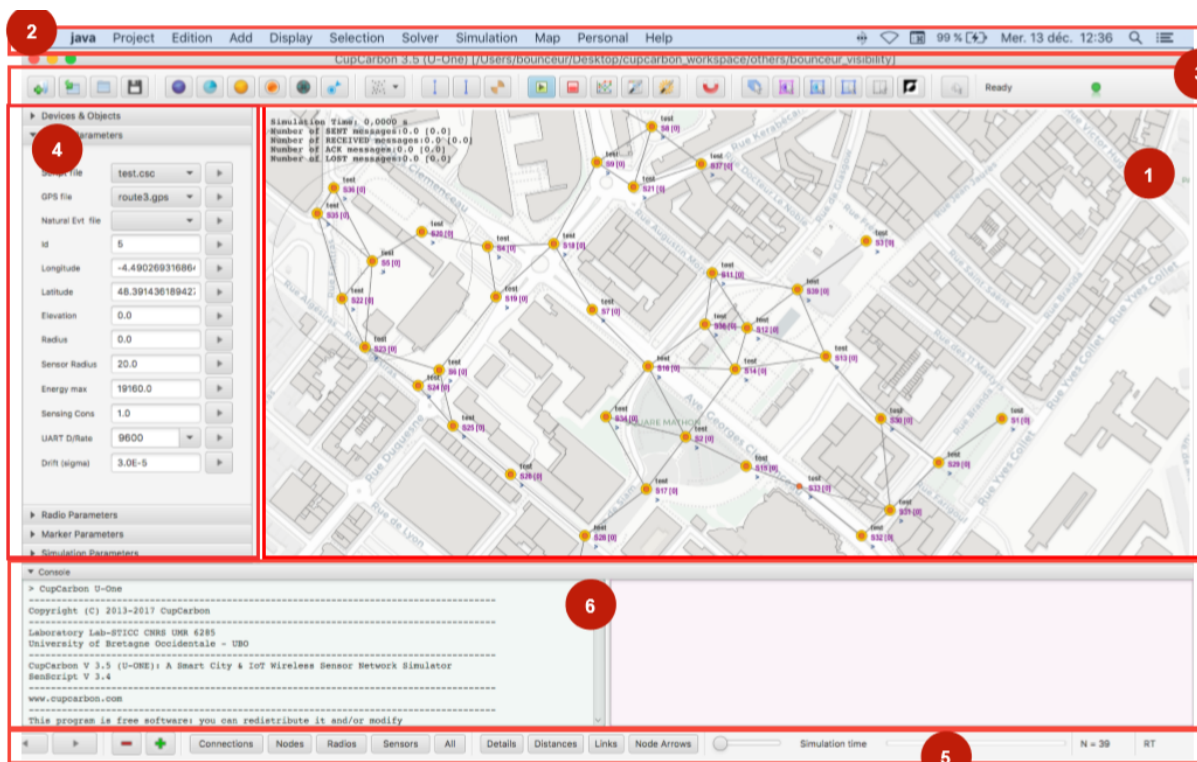


Fig 4: environment of CupCarbon

3.4 Flow Diagram of CupCarbon

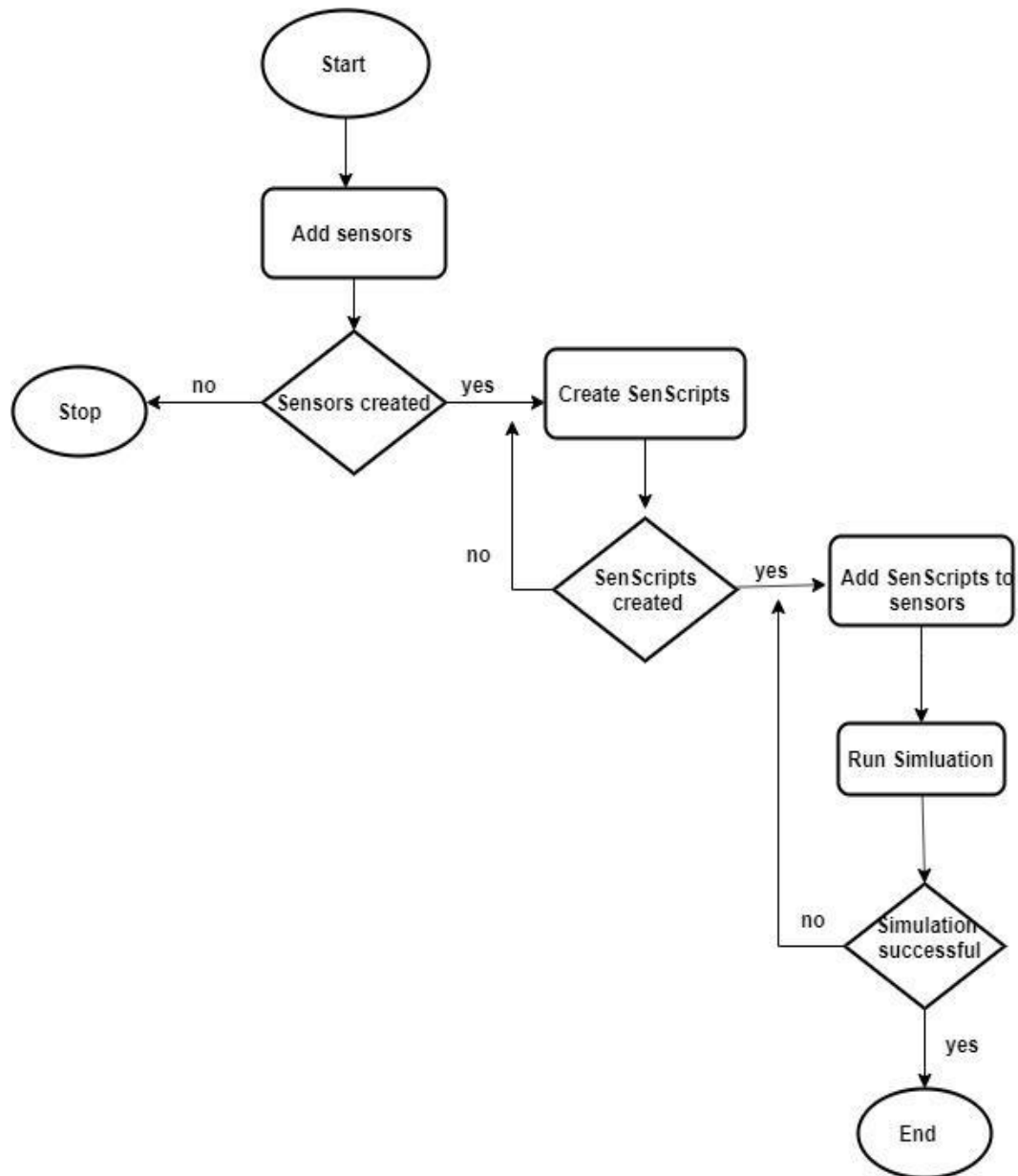


Fig 5: Flowchart of cup carbon

3.5 CupCarbon Modules

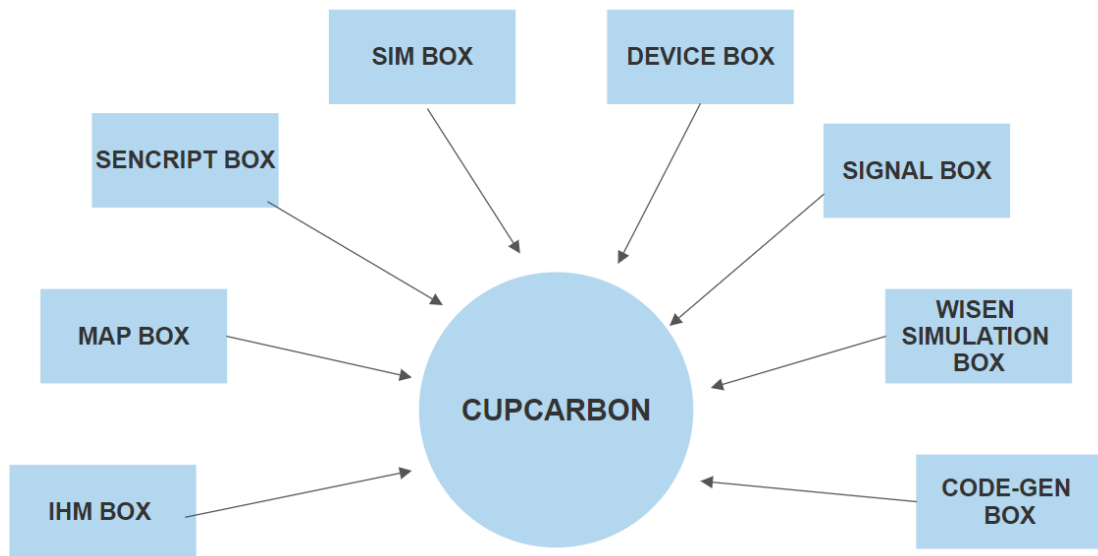


Fig. 6: modules of cupcarbon.

3.6 MAIN COMPONENTS OF CUPCARBON

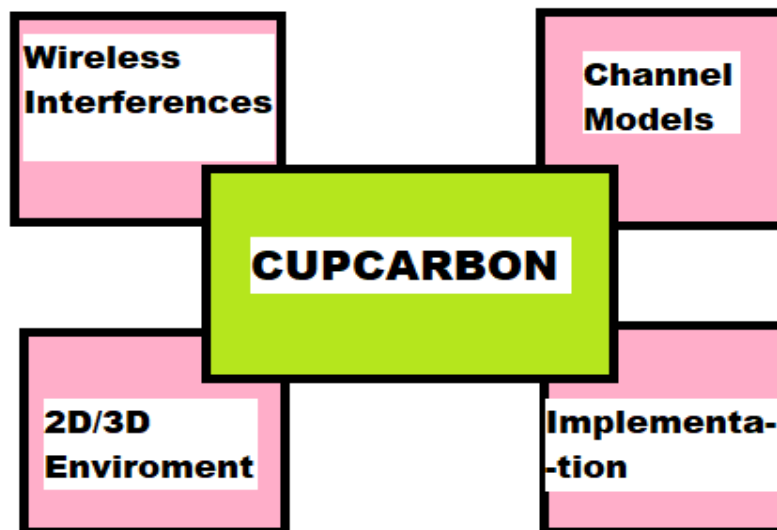


Fig 7: Cupcarbon main component

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 it 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 need to be applied according to the inputs.
4. Defuzzification: It basically finds output, that is it converts the fuzzy sets which we get from inference engine to a crisp value as output.

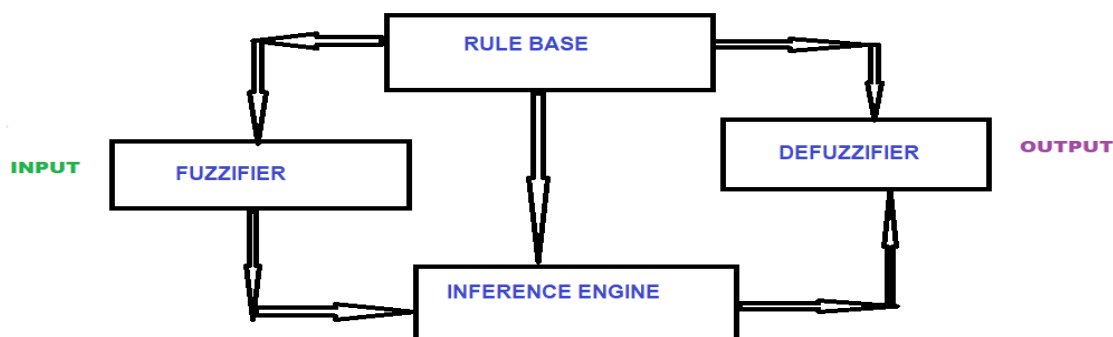


Fig.8: flow diagram of fuzzy logic

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 boundaries in classes of objects.
They are defined by crisp boundaries.	They are defined by uncertain boundaries.
The location of the set of boundaries is clear.	The location of the set of boundaries is ambiguous.
It is mostly used in digital systems.	It is only used in fuzzy controller systems.

Table 3

4.3 SIMPLE EXAMPLE OF FUZZY LOGIC

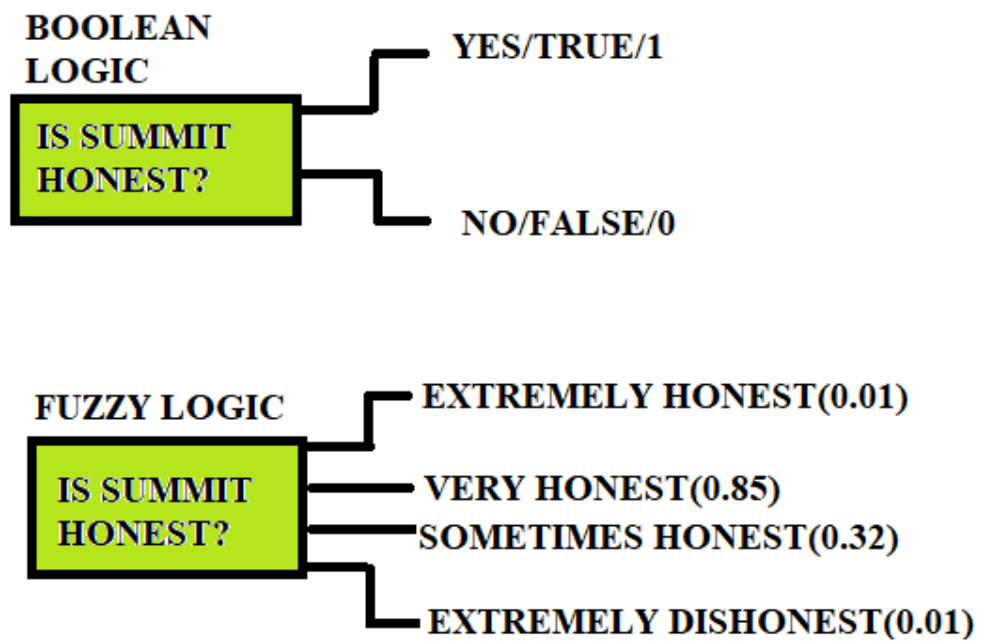


Fig.9: fuzzy logic example

4.4 ADVANTAGES OF FUZZY LOGIC

- Fuzzy Logic systems structure is basic and comprehensible.
- Fuzzy logic is commonly used commercially and in reality.
- It helps power machines and consumer goods.
- It does not have correct reasoning but 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 it will carry the future IoT based network demand.

In [1] the author had 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 numbers of sensor nodes capable of collecting, sending, and receiving environmental data autonomously through wireless communication. Simulators like NRL Sensors, based on modules, and RTNS 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 developing new protocols and test their scalability are discussed.

Cupcarbon mobility and communication scripts, 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 Occupied, and to select the optimal route from 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 will send the information of the accident 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

$F(n) = D(n) + \text{availability}(n)$ (1) Where n is a specific route from accident to hospital, $D(n)$ is the distance from the accident to the hospital, and $\text{availability}(n)$ 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

$F(n) = \text{Traffic}(n) + \text{availability}(n)$

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 $\text{availability}(n)$ 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 collection of information 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 the processing of information, 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 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 3 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 takes into account the reduction in traffic that is 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. In keeping safe routes within the IoT network, this paper focuses on confidentiality and integrity. Confidentiality ensures that information is not diverted to the wrong source. The integrity that guarantees in transit the information received by the final node has not been modified. The architecture of IoT is divided into the layer of perception, network layer, and a 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 Suitable for networks where nodes can be mounted connected to the 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 the management of 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. To realize the node's telescopic view, an ontology coding scheme is used.

In [7] presented the routing protocols for underwater wireless sensor networks, the network in underwater goes through many problems such as high path loss, few available bandwidth, restricted battery Power and high attenuation is needed to maintain an underwater network with a balanced and efficient network of energy consumption. 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 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 that are significantly higher than the average remaining energy to regulate the energy usage of the network between the successors and the mediator nodes.

In [8] 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 in nature, that is, it can be applied to routing protocol in various domains.

In [9] the authors presented the importance of IoT in our daily life 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 on.

In [10] the author's proposed applications of IoT and a literature survey was done in a systematic way 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 understand the concepts of IoT.

In [11] they address the issue of context-awareness in routing protocols. The simulation was performed in Contiki os in 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 is the network (how congested is 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 efficiently find the best parent from a candidate parent set.

In [12] 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 make 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 the concepts depend on the energy remains of the nodes in the path. They have also done a comparison of 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 results of limited memory, less power, and processing capabilities. Their proposed algorithm reduces the loss of packets and raises the lifetime of the network. 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, it 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, business layer. Opportunistic networks

architecture is divided into the application layer, opportunistic service layer, opportunistic pervasive networks layer, resources layer, human social layer. Later on, 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. to find a suitable IEEE802.15.4 protocol according to the hospital environment. 2. Giving information and doing analysis with respect to link quality protocol. 3. now implement this in real-time to find actual versus analyzed data. 4. to design a fuzzy logic system that will map experimental to the proposed fuzzy logic system for optimizing the results.

In [17] The motive of this research is 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 is used for optimizing the performance of the network. The protocol uses the fuzzy inference system for choosing 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 NTFIS(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 so that it can 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 confidence of fire which is used to optimize and to decrease the number of rules to be explored while doing decision making. This protocol will reduce the number of activities of sensors and will increase the battery life of the sensors. Representational state transfer (RESTful) services are used to get the real-time verification of the proposed work.

In[21] The researchers showed the importance of WNS(wireless sensor network) that has various application security, tracking, and health monitoring. Every sensor acts as a routing element for the other sensor in 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 so as to decrease the effects of uncertainty produced by the noise of the environment.

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

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 then a fuzzy logic concept is implemented to optimize the boundary nodes that are found after fuzzy logic implementation few nodes are selected which will broadcast the message. As in IoT network sensor nodes are moving continuously which leads to change 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 10 random sensor nodes are placed and all are assigned a random value between 0 and 1 that is a fuzzy value and that 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 PROTOCOL

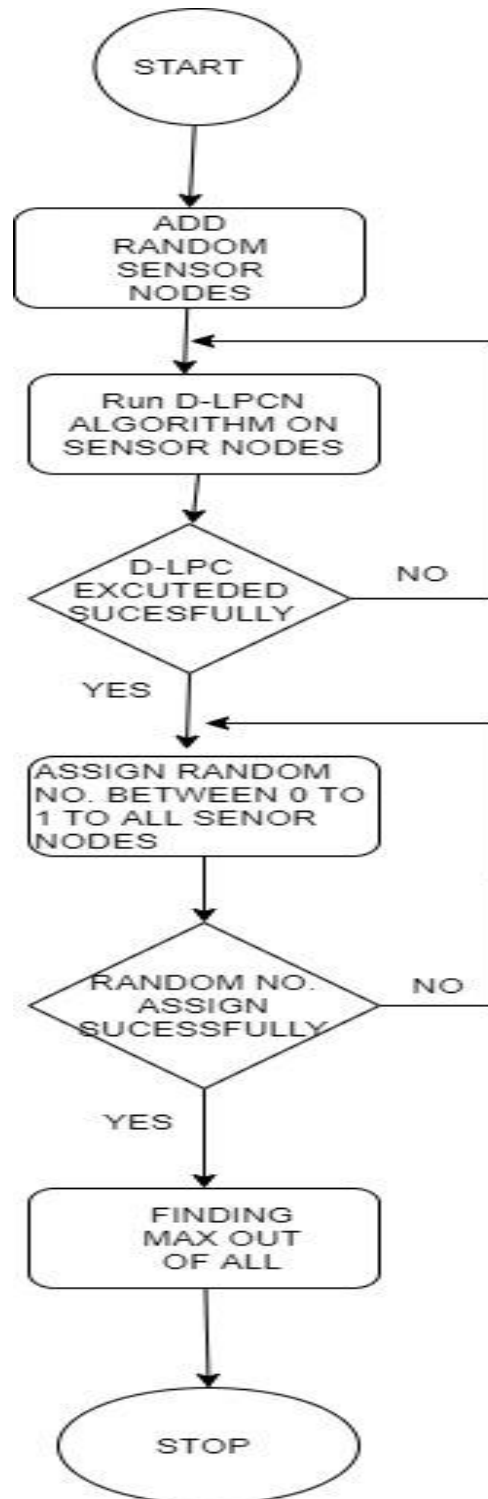


Fig.10: flowchart of the implemented algorithm

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

```

1) boundary = false; s = 10;
2) c id = getId(); c coord = getCoord();
3) boundary set =  $\emptyset$ ;
4) n = getNFN(); i=0;
5) Run Algorithm 1 to determine the value of first node;
6) if (first node) then
7) boundary = true;
8) p coord = (c coord.x-1, c coord.y);
9) send(c id+"|"+"AC", *);
10) end if
11) repeat
12) id = read();
13) type = read();
14) if (i==n) then
15) boundary set = boundary set  $\cup$  {c id};
16) send(c id+"|"+"SN"+"|"+"c coord"+"|"+"boundary set, n id);
17) end if
18) if (type=="AC") then
19) send(c id+"|"+"CS"+"|"+"c coord, id);
20) end if
21) if (type=="CS") then
22) n coord = read(); i=i+1;
23) s- = angleWI(p coord, c coord, n coord, boundary set);
24) if (s<s min) then
25) s min = s; n id = id;
26) end if
27) end if
28) if (type=="SN") then
29) boundary = true; s min = 10; i=0;
30) p coord = read();
31) boundary set = read();
32) 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

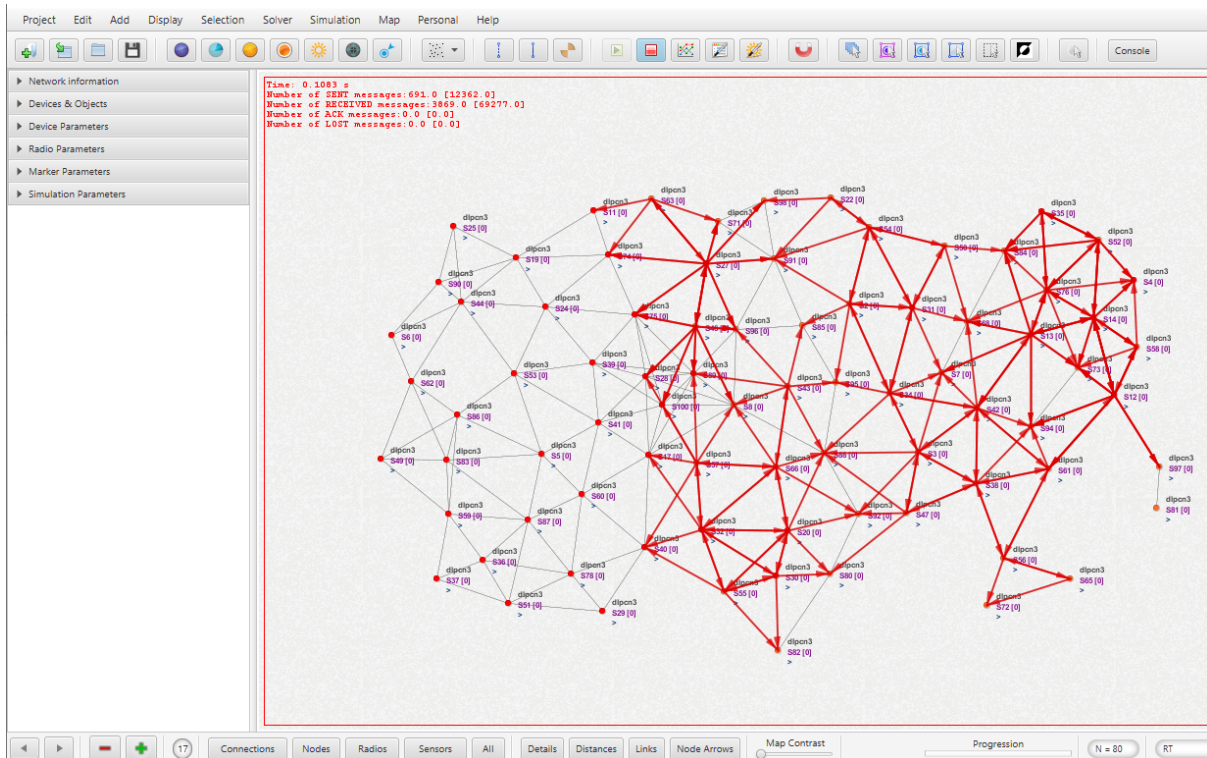


Fig.11: implementing D-LPCN for 100 sensors

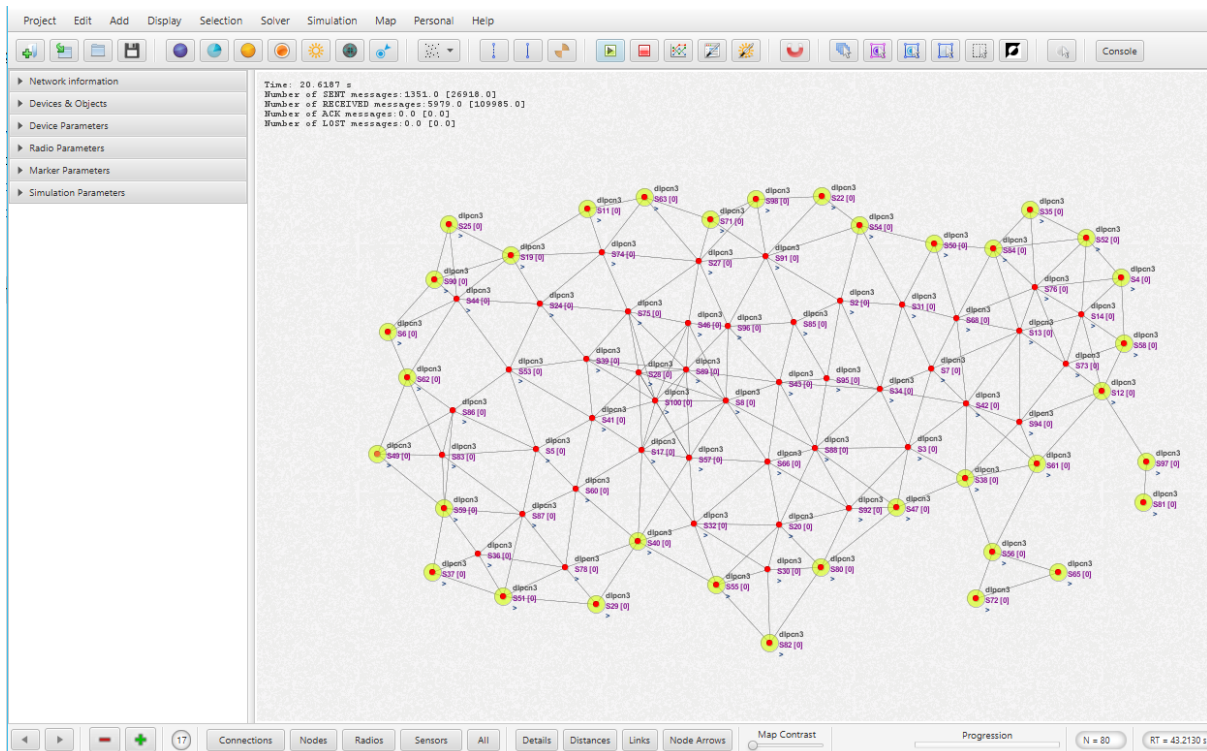


Fig.12: finding boundary nodes for 100 sensors

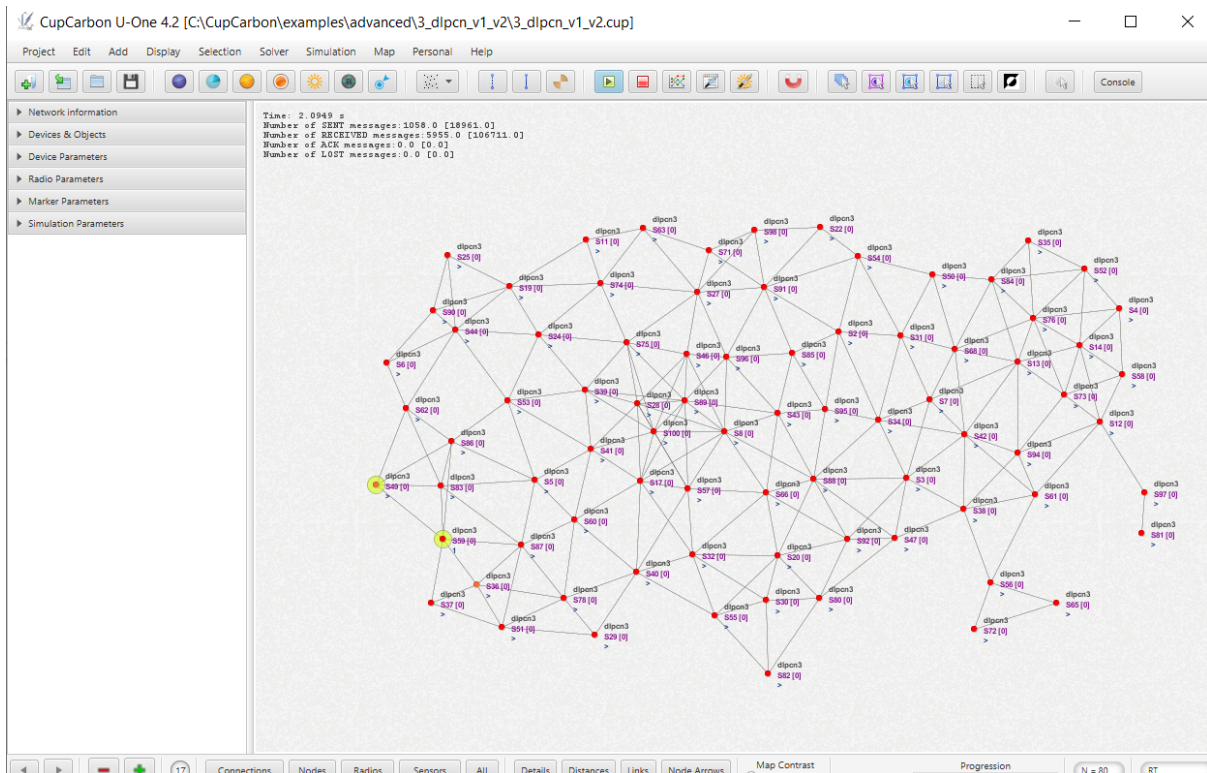


Fig.13: fuzzy logic implementation for 100 sensors

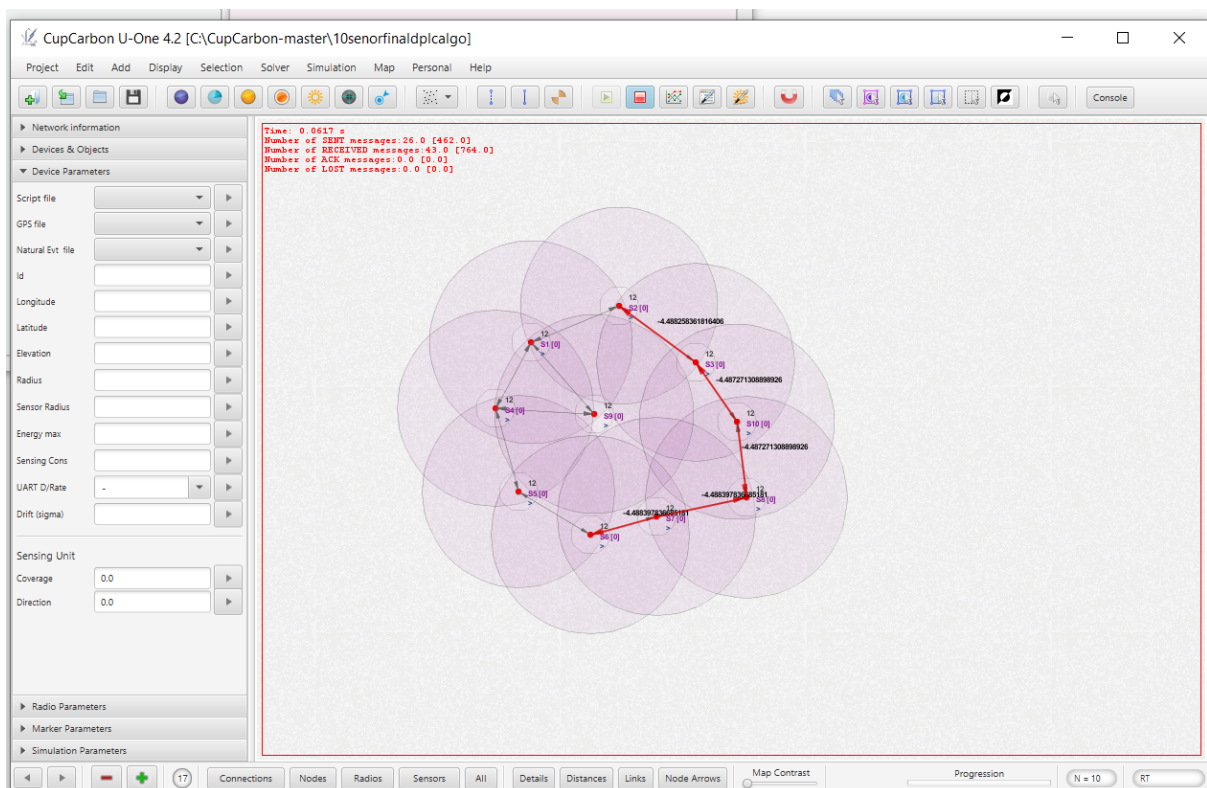


Fig.14: implementing D_LPCN algorithm for 10 sensor nodes

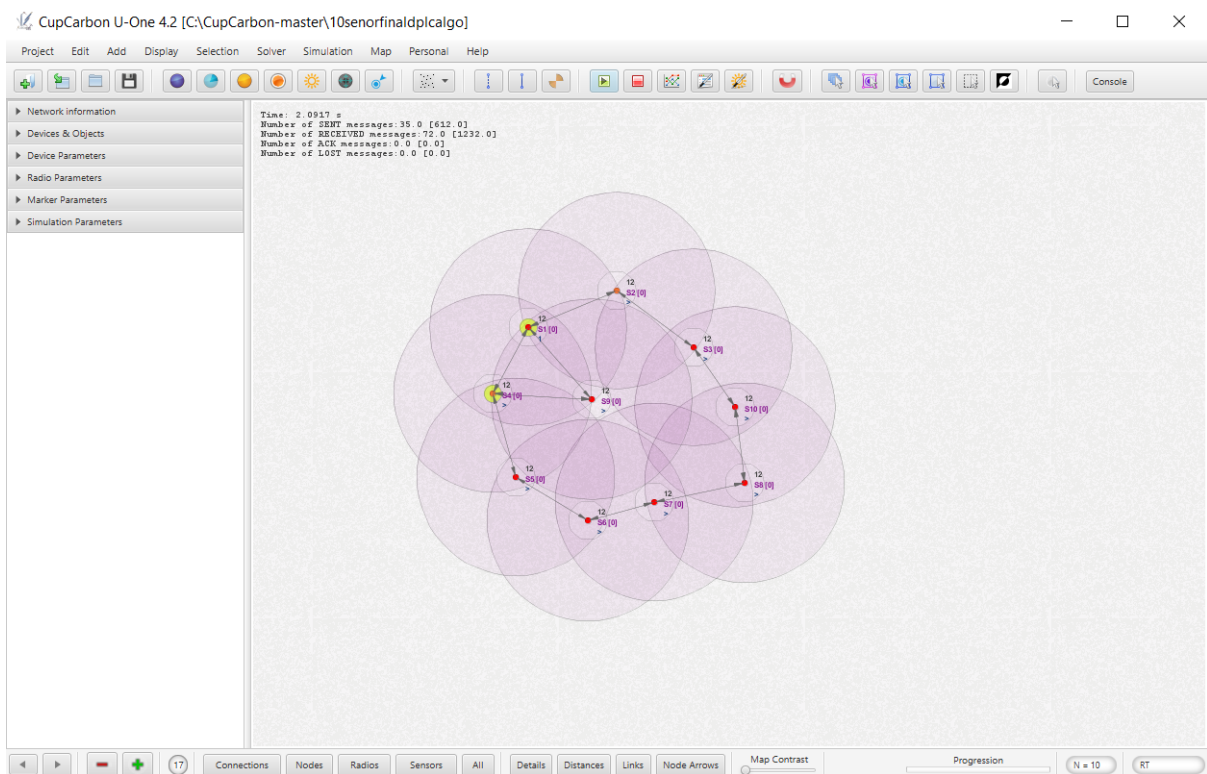


Fig.15: fuzzy logic implementation for 10 sensor nodes

10. RESULT OBTAIN

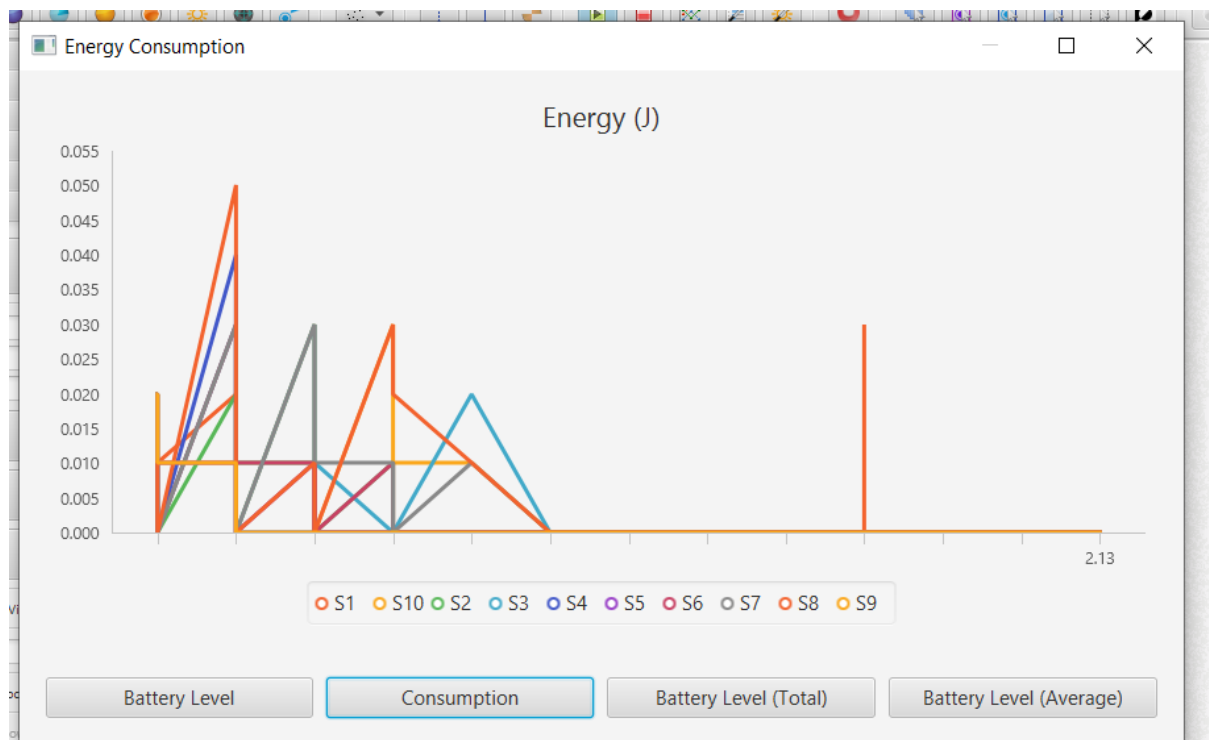


Fig.16: energy consumption of 10 sensors after simulation

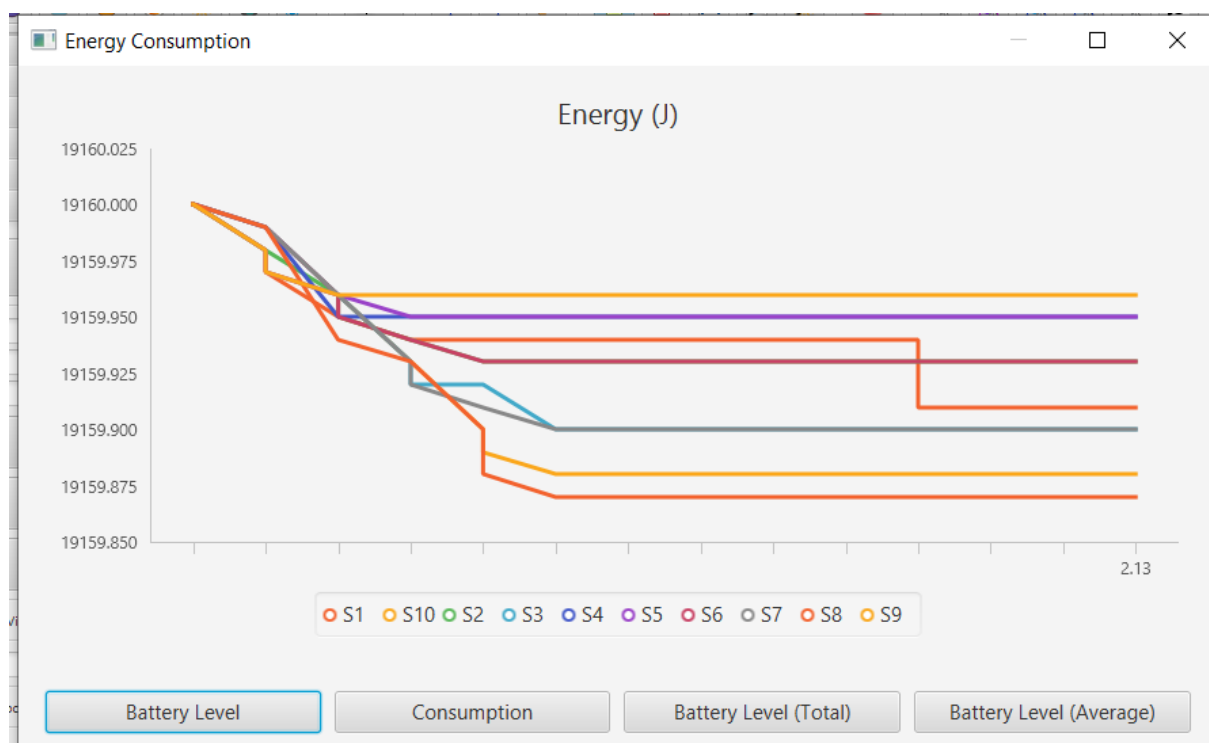


Fig.17: battery level of 10 sensors after simulation

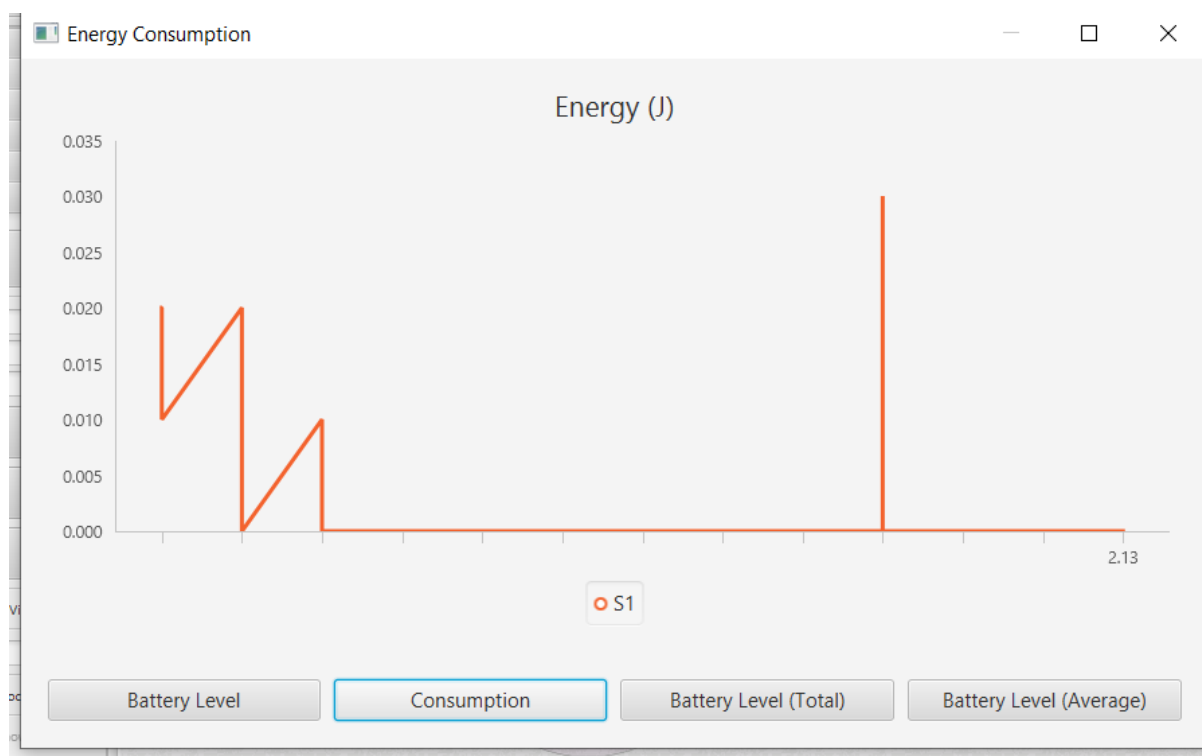


Fig.18: energy consumption selected sensor after fuzzy implementation (s1)

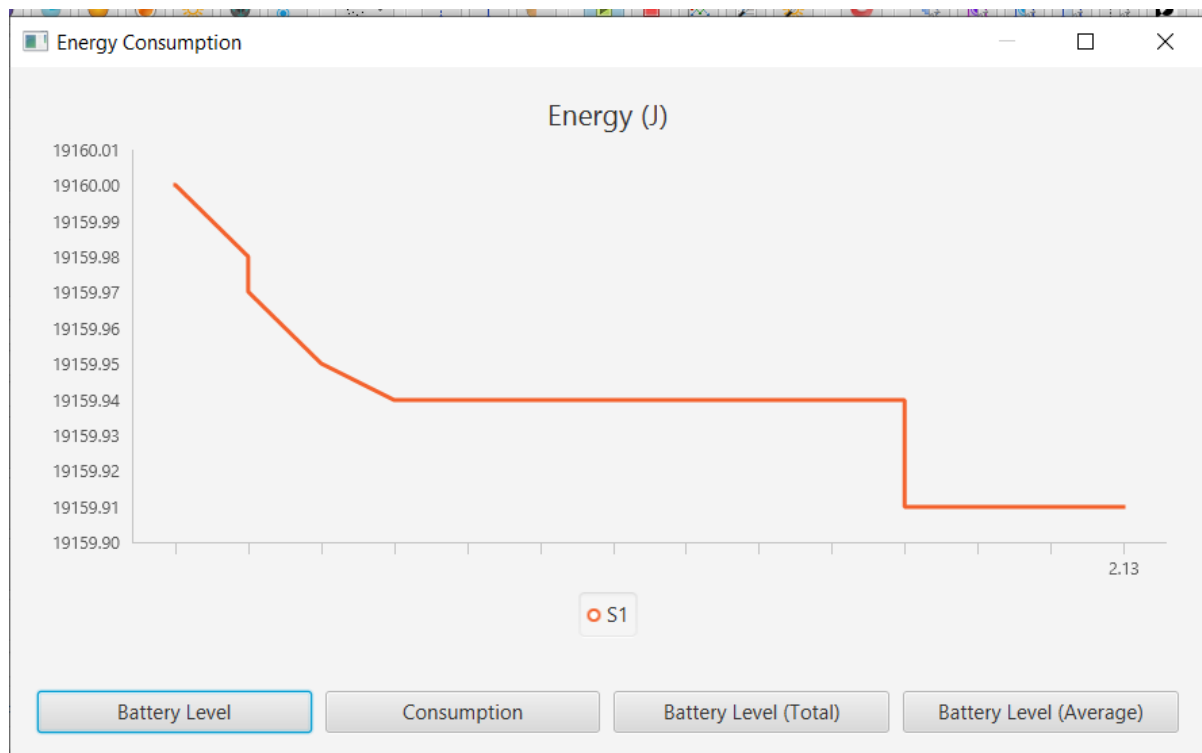


Fig.19: battery level selected node after fuzzy implementation (s1)

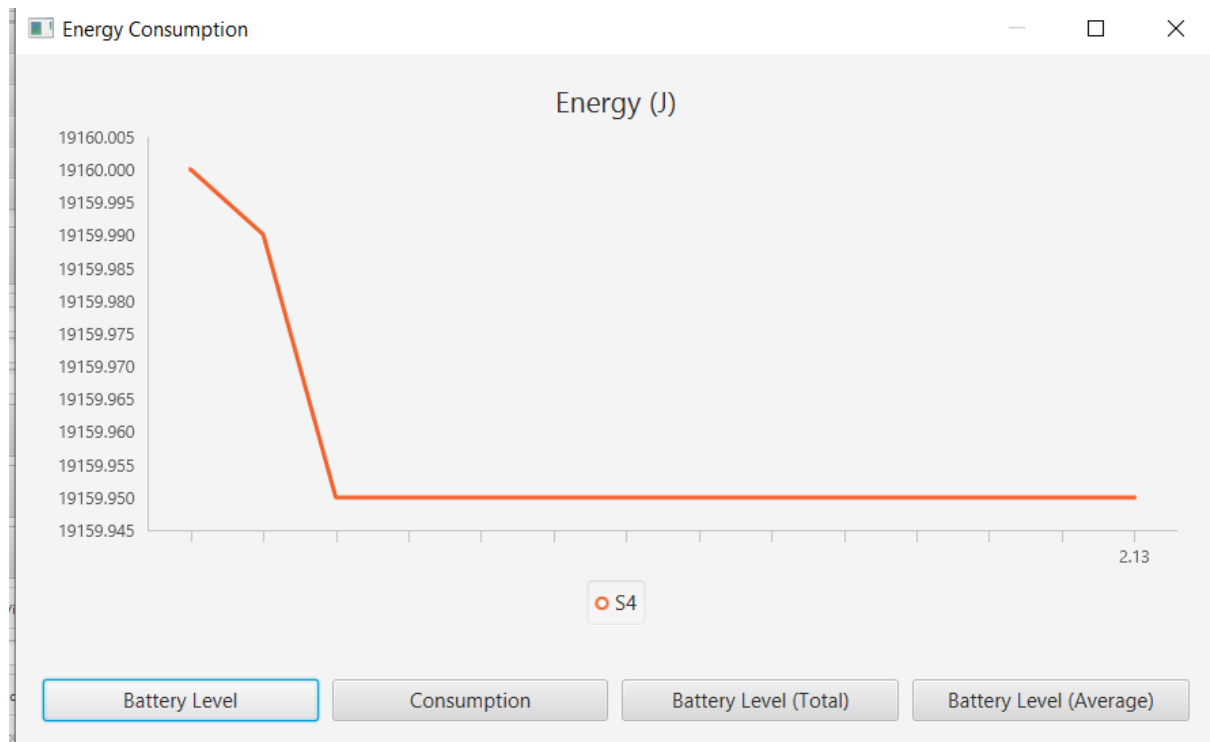


Fig.20: energy consumption selected node after fuzzy implementation (s4)

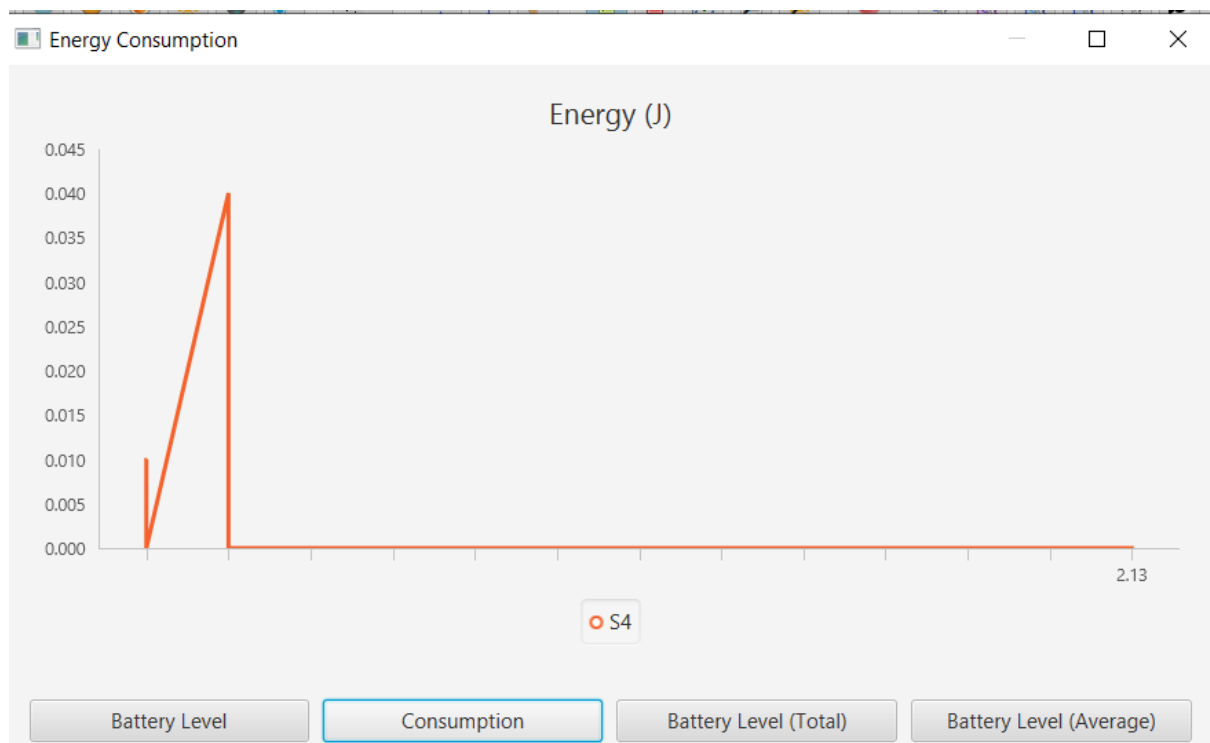


Fig.21: Battery level selected node after fuzzy implementation (s4)

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 send messages = 691.0
3. Number of received messages = 3869.0
4. Number of acknowledge 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 send messages = 35.0
3. Number of received messages = 72.0
4. Number of acknowledge messages = 0.0
5. Number of lost messages = 0.0

11.3 Observations

1. D-LPCN Message Complexity is $O(d n_b + n)$.
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 depends on 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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