Signs With Smart Connectivity for Better Road Safety

IBM

PROJECT REPORT

Submitted by

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In partial fulfilment for the award
of the degree Of

BACHELOR OF ENGINEERING

In

COMPUTER SCIENCE AND ENGINEERING

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The Safe System (SS) approach to road safety emphasizes safety-by-design through ensuring safe vehicles, road networks, and road users. With a strong motivation from the World Health Organization (WHO), this approach is increasingly adopted worldwide. Considerations in SS, however, are made for the medium-to-long term. Our interest in this work is to complement the approach with a short-to-medium term dynamic assessment of road safety. Toward this end, we introduce a novel, cost-effective Internet of Things (IoT) architecture that facilitates the realization of a robust and dynamic computational core in assessing the safety of a road network and its elements. In doing so, we introduce a new, meaningful, and scalable metric for assessing road safety. We also showcase the use of machine learning in the design of the metric computation core through a novel application of Hidden Markov Models (HMMs). Finally, the impact of the proposed architecture is demonstrated through an application to safety-based route planning.

CHAPTER 1
INTRODUCTION

The primary method of connecting cities and villages is through roads. Due to how simple it is to go by road, cars are now the most common mode of transportation. The vehicle accidents (Vas) are more likely now since there are more automobiles on the road. When travelling, especially in inclement weather, one never knows what may happen on the next road (BWC). Due to the poor sight, driving can be challenging in this circumstance and may result in an accident. Additionally, it was shown that in BWC, informational delays might lead to multiple vehicle accidents (MVCs), which are dangerous.

According to one research by the Islamabad police, there were 9582 accidents between 2016 and 2017 involving 11,317 cars nationwide in Pakistan, which resulted in 5047 fatalities and 12,696 injuries.

Road safety regulations are changing as a result of digital technology like the Internet of Things (IoT). Around the world, several technological projects are being done to create smarter, safer roadways that can communicate with both vehicles and pedestrians. Several technology-based solutions have been created upon the presumption that accidents may be avoided by providing the driver with information about vehicle technology. The Internet of Things provides the foundation for the newest technologies that academics are developing (IoT). Data is the key to IoT. The world is starting to value data as a resource.

IoT has being embraced by many sectors and companies to enhance communication, manufacturing, energy, and health care performance while reducing mistakes. In its "Save LIVES: Road Safety Technical Package," the WHO lists many actions that can be taken with little financial impact. Realizing economic systems for "monitoring road safety by enhancing data systems" is a cornerstone of these measures.

Meanwhile, a prominent element in the package is encouraging the use of a Safe System approach, which is a comprehensive approach to road safety that differs from standard management methods by stressing safety by design.

Mobile phone applications identify the speed limit depending on environmental conditions using built-in sensor data.

The main contributions of this research are

1. A brief overview of the state of the art in pre-accident and post-accident models, frameworks, and techniques;
2. Identifying and disclosing limitations in prior research on accident detection;

3. The notion of a smart road with event sensing capabilities, as well as its implementation and testing through numerous tests;

4. An innovative and contemporary technique for communicating with adjacent vehicles and EOCs and promptly detecting accidents is demonstrated.

If an incident is not reported to an EOC in a timely manner, there may be an increased risk of fatalities, injuries, and other harm. By delivering timely accident information via an automated process, lives can be saved. Additionally, an alarm system and speedy car collision detection are needed to safeguard approaching automobiles from an MVC. In order to prevent accidents, a number of strategies have been used in advanced vehicles (Avs). A threat of an accident is identified using either smartphone sensors or sensors fitted in automobiles. Accelerometers, smoke detectors, IR obstacle sensors, proximity sensors, and biosensors have all been employed by earlier researchers to identify accidents.

1.1 Project Overview:

The main goal of this project is to assist people in automating the roads by giving them access to a Web App that allows them to track road conditions like temperature, speed limit, and visibility. Additionally, they provide services for displaying signage for restaurants, hospitals, and school guides.

1.2 Purpose:

Many scholars and practitioners are engaged in extensive research in the areas of accident prevention and accident alarms. Numerous methods are used to improve safety in order to prevent accidents. The literature on accident detection and avoidance is divided into stand-alone, cooperative, and hybrid techniques for convenience of reference. While cooperative systems rely on V2X technology and hybrid approaches, stand-alone approaches employ sensors for accident avoidance and detection, such as radar and light detection and ranging (LiDAR).

CHAPTER 2
IDEATION PHASE

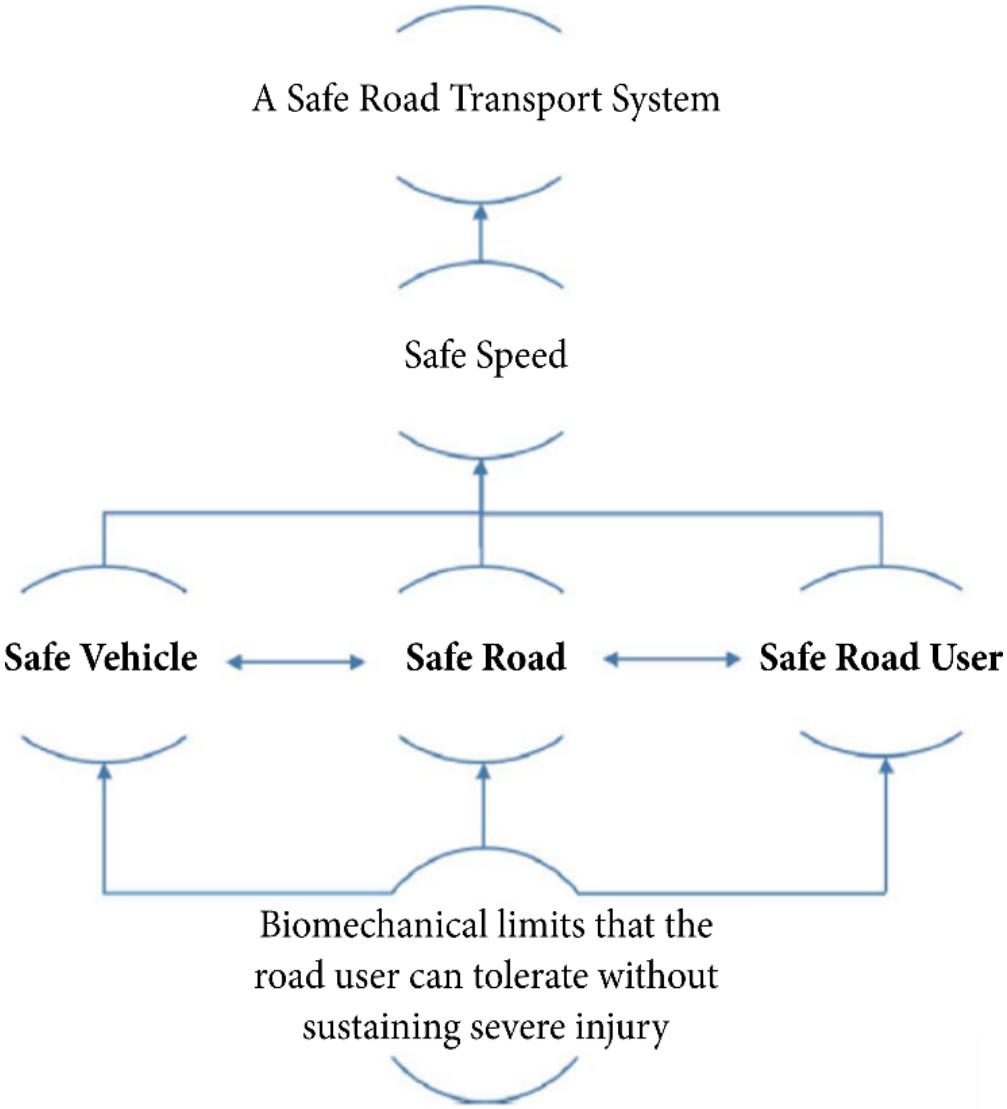
2.1 LITERATURE SURVEY

In its Global Status Report on Road Safety – 2015, the World Health Organization (WHO) noted that the worldwide total number of road traffic deaths has plateaued at 1.25 million per year, with tens of million either injured or disabled. Different initiatives, such as the United Nations' initiative for the 2011-2020 Decade of Action for Road Safety, have led to improvements in road safety policies and enforcements. However, the WHO notes that the progress has been slow and has maintained the call for urgent action to reduce these.

Added to the losses in human lives and wellbeing, considerable monetary losses are incurred in medical expenses, infrastructure repair, and production downtime. While the worldwide figures have plateaued, the Global Status Report does indicate higher road fatalities and injuries in low-income countries. Such disparity, as noted in, signals a barring-limitation in low-income countries to improve road-safety by adopting solutions implemented in high-income countries.

2.1.1 The Safe System Approach:

The Safe System (SS) approach to transport networks originated with the "Safe Road Transport System" model developed by the Swedish Transport Agency. In its essence, the approach migrates from the view that accidents are largely and automatically the driver's fault to a view that identifies and evaluates the true causes for accidents. Through the categorization of safety into the safety of three elements (vehicle, road, and road user), SS minimizes fatalities and injuries by controlling speeds and facilitating prompt emergency response. The model has been widely adopted



since its introduction and is currently motivated by the WHO as a basis for road safety planning, policy-making, and enforcement.

Elements of the SS approach are as follows:

(1) Safe Vehicle: Emphasis on vehicle safety is verified through mandated regulatory testing and rating, as well as technologies such as electronic stability control. Beyond this, enforced checks (e.g., upon license renewals) combined with on the road reporting work to review the status of vehicle safety.

(2) Safe Road: The assessment of road (or road network) safety is multifaceted. Road inspection enables clear and direct observation of the state of the road and assesses the need for repairs or modifications. The structure of the road network is amenable to safety assessment through partitioning into what is called "Traffic Analysis Zones (TAZs)". In addition, considerations for crash data and other supporting data offer further insights into general safety assessment. In 2011, the European Road Assessment Programme (EuroRAP) generated the European Road Safety Atlas for EU countries. The atlas indicated the safety level of roads with a star rating based on specially equipped vehicles for multimedia-based data aggregation. The EuroRAP efforts continue to implement an SS approach across the EU, along with several other national programmers within the International RAP, or iRAP, initiative.

(3) Safe Road User: There are several aspects to road user safety, including measures for education and awareness, travel distance, exposure, licensure, enforcement, and sober driving. The need for such characterization rises substantially as the findings of crash report analysis in cities typically note a critical dependence on either driver behavior or driver awareness. A great need is further established in these studies for innovative mechanisms to instill safe driving at the licensing and post-licensing stages.

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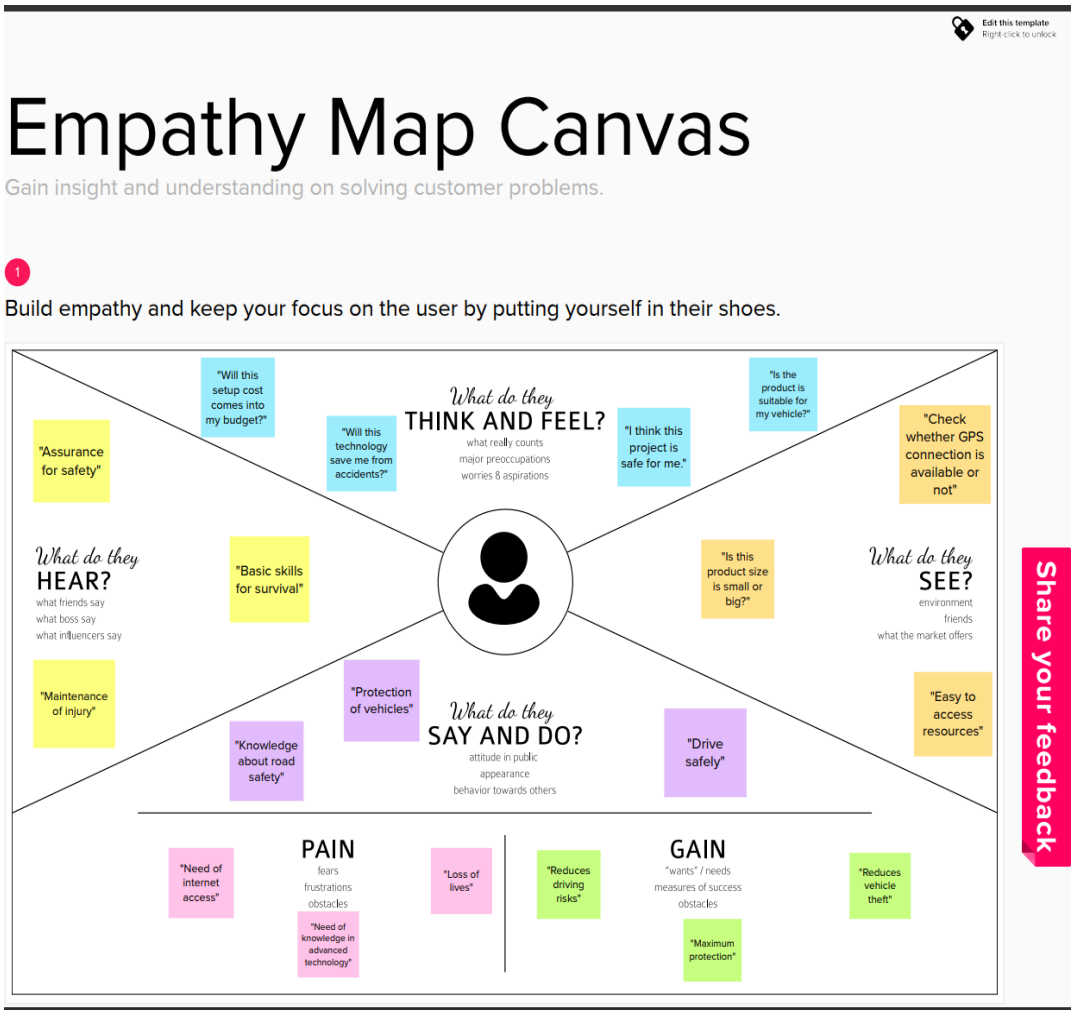
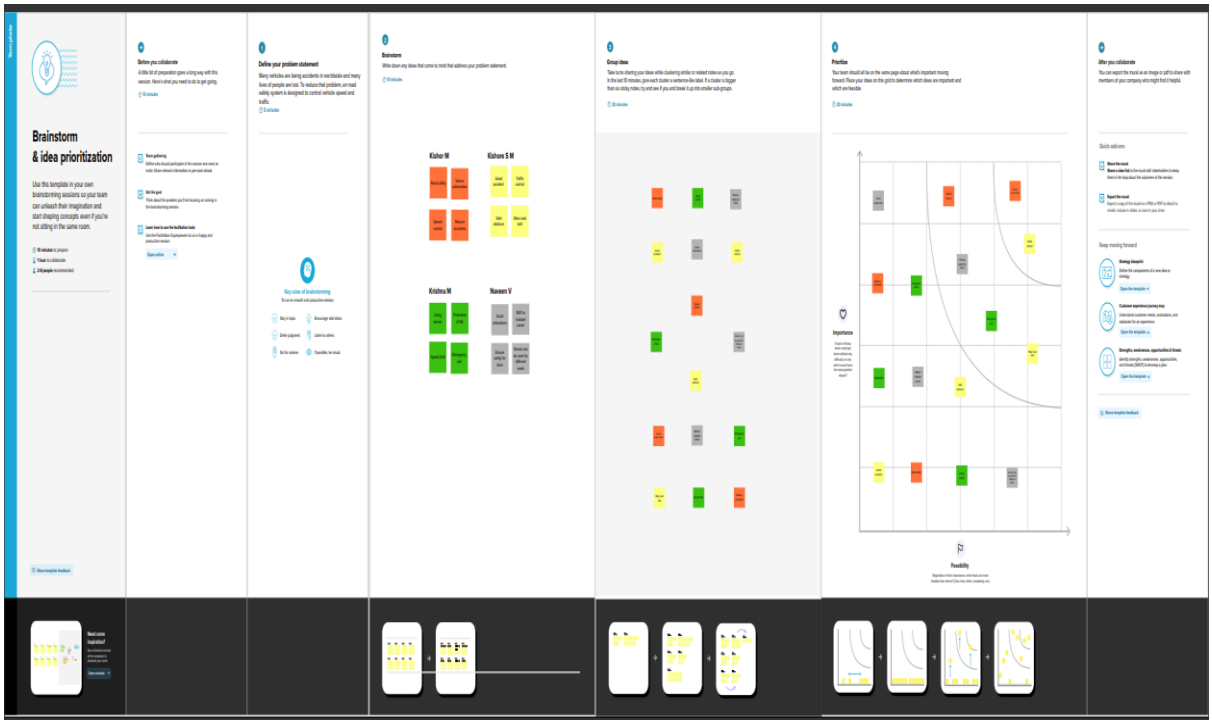
2.2 Empathy Map



2.3 Ideation and Brainstorming



2.4 PROBLEM STATEMENT

In this modern world, the people want everything to be faster than the usual speed. In case of road traffic, the people want to decrease their time to travel to their destination. Also, there are some crazy people who likes doing stunts using motorcycles in public roads. As a result, many people died due to such activities. The main reason for 90% of road accidents that are happened in the world is overspeed. To reduce such accidents our project will be the best solution. This project is based on IoT Arduino which senses the road and identify what type of road it is. Like a Highway or an Offroad or a city road. Based on the roads the sensor scans, the limit of the top speed of the vehicle will be changed. So that the people can't drive the vehicle more than the top speed. This project is used for the avoiding the road accidents made by overspeed. Also, the project has an additional feature which can avoid vehicle theft. The project contains an

authorization system through which the vehicle can be accessed using the person's driving license. By implementing this project to the world, the rate of road accidents will be reduced and the theft rate of high-cost vehicle will become 0. This project will be the best solution for such road transport activities.

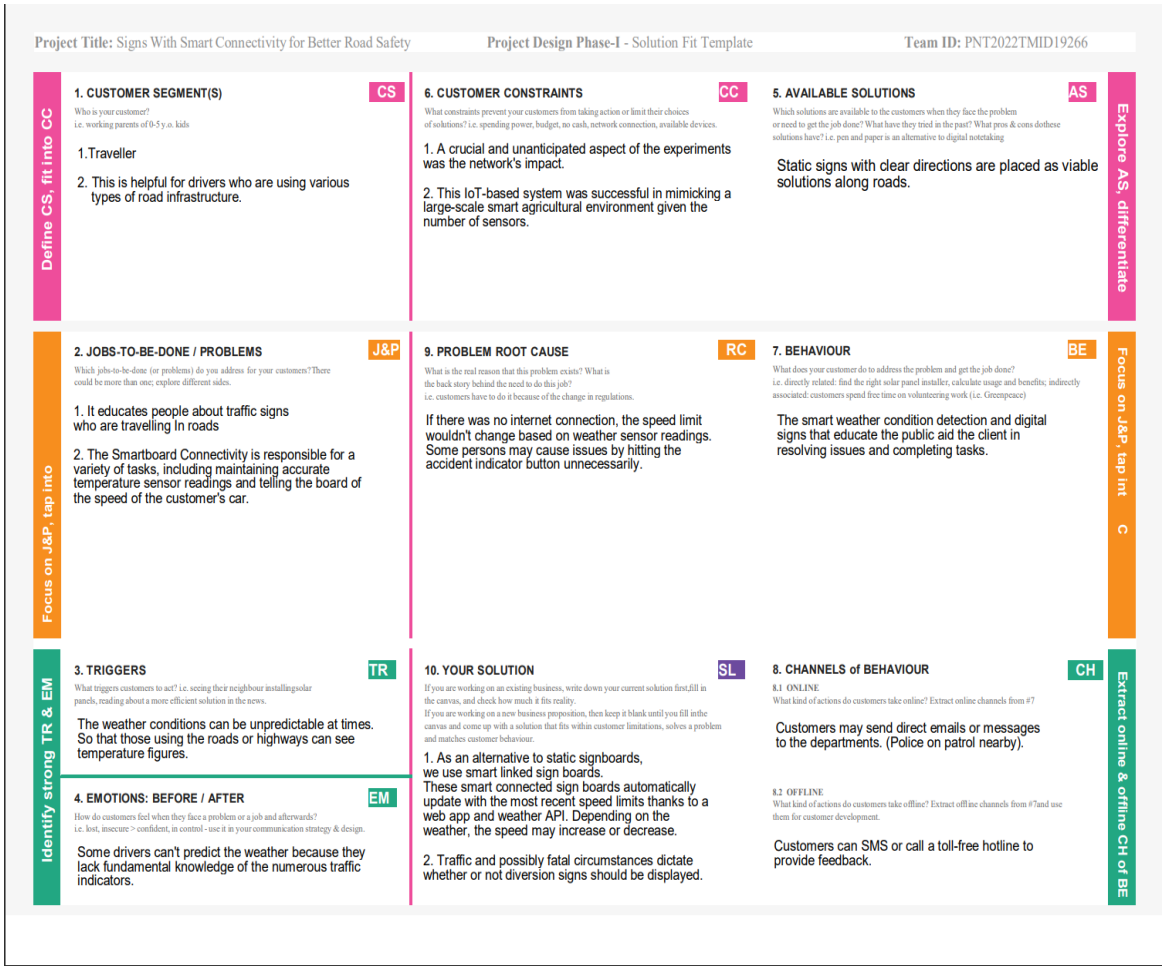
CHAPTER 3
PROJECT DESIGN PHASE – I

3.1 Proposed Solution

S.No	Parameter	Description
1.	Problem Statement (Problem to be solved)	The real issue is that motorists cannot determine whether the road conditions are safe for travel or not. Therefore, there will be a need for guide data to ensure safety and to prevent inconveniences when travelling to the location.
2.	Idea / Solution description	The solution to this issue is introducing the IR and GPRS Modules Traffic-sensing camera and sensor intensity even in shadowy places. Indicating weather on the same sign boards for drivers in areas where the weather is unpredictable and replacing the painted, man- made signs with digital ones that are more visible than the current ones.
3.	Novelty / Uniqueness	The location of the display board is adjusted to the traffic signal area, and voice indications are put nearby. As soon as it detects surrounding vehicles, it will alert the general public to any potential traffic hazards.
4.	Social Impact / Customer Satisfaction	If people are informed about traffic indicators, they are unaware that it digitally displays signs to avoid. Based on the accidents and weather indicators IOT is used to prevent accidents and primarily benefits two-wheeler riders.
5.	Business Model (Revenue Model)	Both public and commercial sectors can use the systems, which generates considerable money.

6.	Scalability of the Solution	It improves the quality of life for both drivers and passengers. By including more features, the product may be scaled to generate more revenue.

3.2 Problem Solution Fit

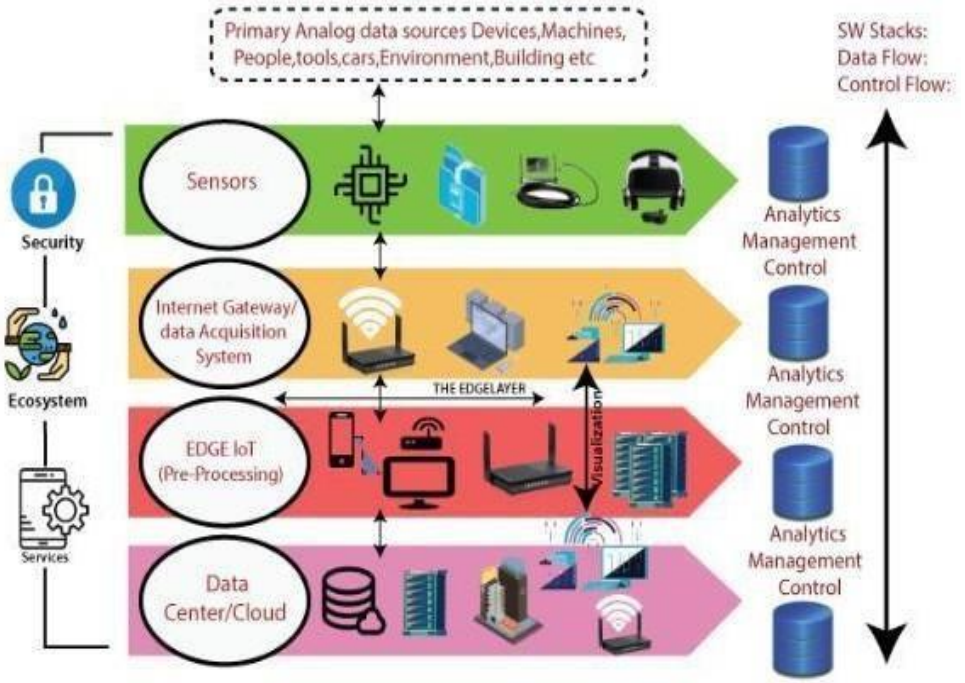


3.3 SOLUTION ARCHITECTURE

- Smart connected sign boards are used to replace static signboards.
- These intelligent, connected sign boards receive automatic updates of the speedlimits from a web application using weather API
- The speed could go up or down depending on the weather.
- The display of the diversion signs depends on the flow of traffic and potentialfatalities.

Additionally, the appropriate guide (for schools), warning (for hospitals), and service(for restaurants) signs are posted.

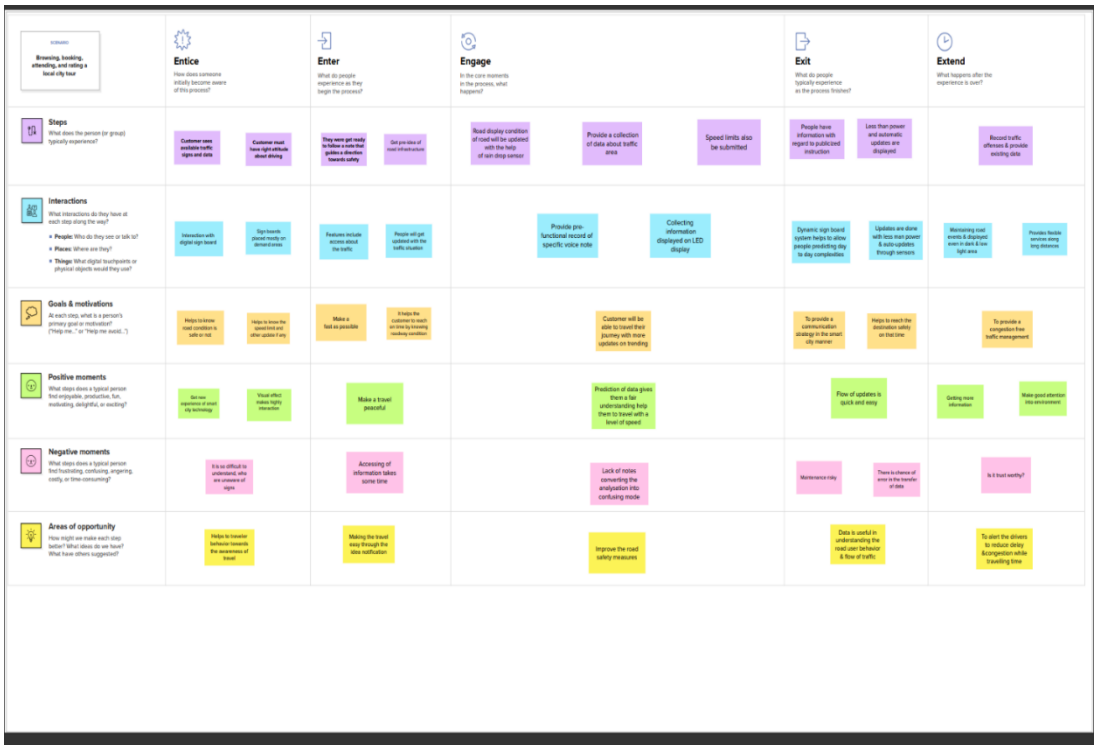
Example - Solution Architecture Diagram:



CHAPTER 4

PROJECT DESIGN PHASE - II

4.1 CUSTOMER JOURNEY



4.2 REQUIREMENT ANALYSIS

4.2.1 FUNCTIONAL REQUIREMENTS

Following are the functional requirements of the proposed solution.

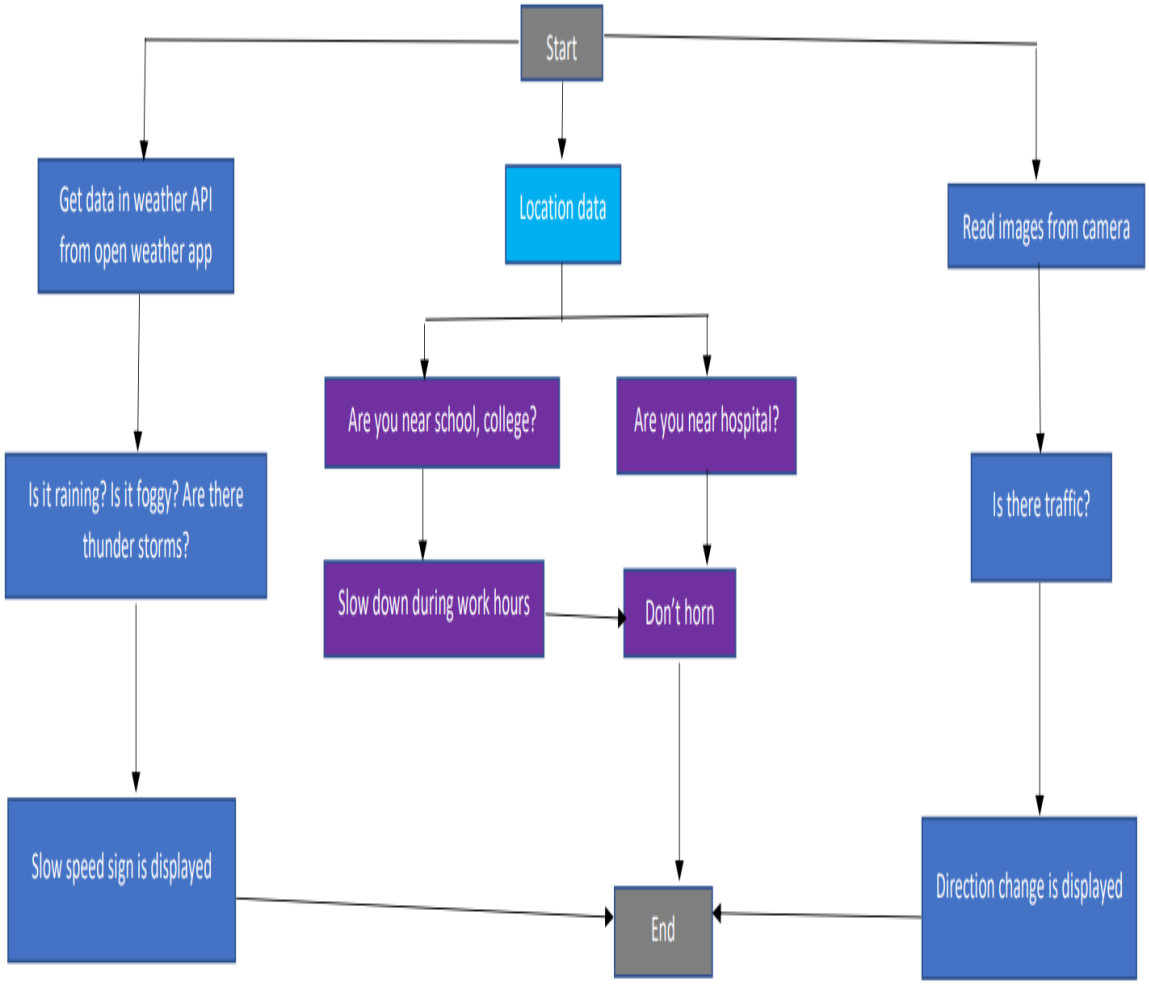
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Visibility	Sign boards should be built with LEDs that are colorful and brilliant in order to catch drivers' attention, but they shouldn't be too distracting or dazzling because that could cause accidents.
FR-2	User Need	To reduce user confusion when travelling, smart sign boards should be put more frequently where they are needed and less frequently where they are not.
FR-3	User Understanding	The signs should be big, clear, and legible to help the motorist understand them. They can also incorporate images to help the driver understand the instructions even better.
FR-4	User Convenience	The display ought to be large enough to be readily visible even from a distance.
FR-5	User Confirmation	Phone Confirmation, Email confirmation, OTP authentication.

4.2.2 Non-Functional Requirements

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Will offer a self-explanatory product that is easy to use and clear product instructions.
NFR-2	**Security**	Cloud data needs to stay within the network, collapsing needs to be avoided in real time, and the board will be closely watched at all times.
NFR-3	**Reliability**	Hardware will undergo regular testing.
NFR-4	**Performance**	The user experience on the smart board must be improved, and the output must be accurate.
NFR-5	**Availability**	Depending on the requirements of the client, all features and user requests will be met.
NFR-6	**Scalability**	It should be simple to modify and update in response to changes in requirements and needs.

4.3 Data Flow Diagram



4.4 Technology Architecture

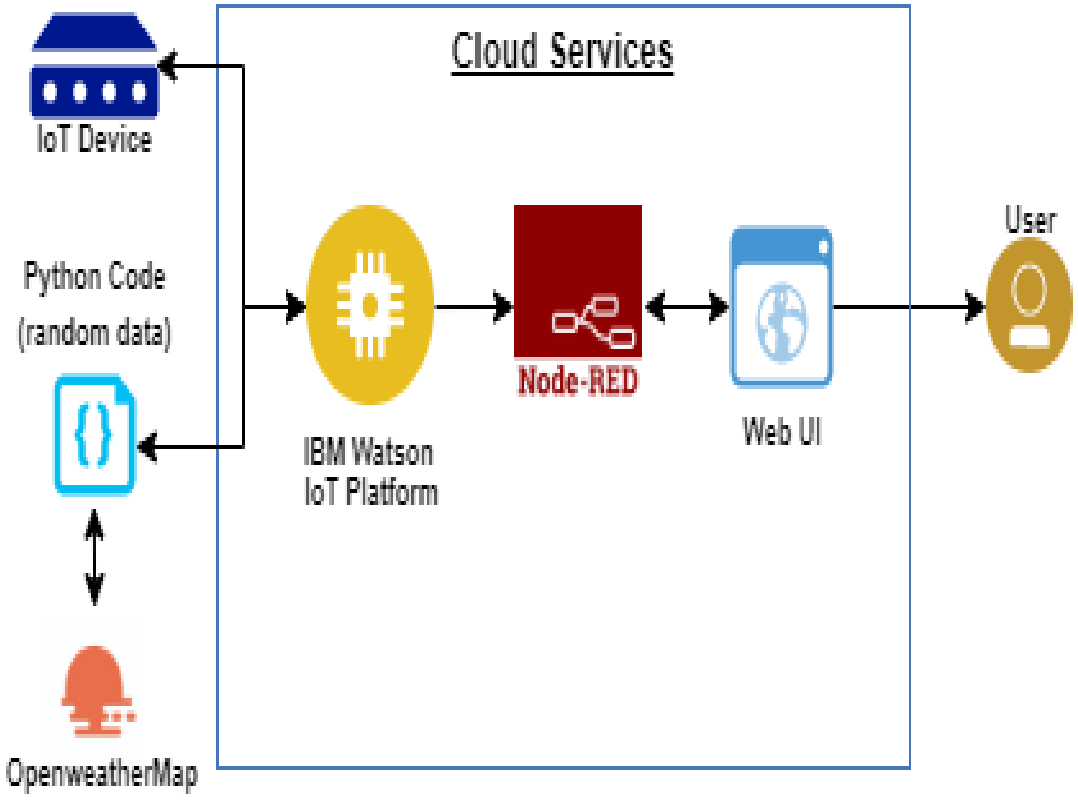


Table 1: Components & Technologies

S.No	Component	Description	Technology
1.	User Interface	How must we communicate with the application	Python
2.	Application Logic-1	Logic for a process in the application	Java / Python
3.	Application Logic-2	Logic for a process in the application	IBM Watson STT service
4.	Application Logic-3	Logic for a process in the application	IBM Watson Assistant
5.	Cloud Database	Cloud service with a database	IBM DB2, IBM Cloudant etc.
6.	External API-1	Purpose of External API used in the application	IBM Weather API, etc.

Table 2: Application Characteristics

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	Technology of Opensource framework
2.	Security Implementations	No one will have access to this without login information with very high security system	Firebase, Firewall, Cyber resiliency strategy
3.	Scalable Architecture	By expanding the operating system's bandwidthrange may be expanded	IOT Internet
4.	Availability	Available 24/7	IBM Cloud
5.	Performance	It can accommodate many users at once.utilising the technologies	IBM Cloud

CHAPTER 5
PROJECT PLANNING PHASE

5.1 Milestone and Activity List

TITLE	DESCRIPTION	DATE
Literature Survey	Literature Survey is done withhelp of some research paper which is available in websites.	15 SEPTEMBER 2022
Empathy Map	Empathy Map design is fully based on customer point of view**.**	15 SEPTEMBER 2022
Ideation	Our teammates work were work together to provide conceptual ideas towards brainstorm and idea prioritization.	17 SEPTEMBER 2022
Problem Statement	Problem Statement is entirely made with different perspective of customer requirement and issue based.	17 SEPTEMBER 2022
Proposed Solution	The proposed solution contains information such as ideas for satisfying customer satisfaction and providing a highly scalable business model as parameters.	19 SEPTEMBER 2022
Problem Solution Fit	Problem Solution Fit explore the customer behaviour and experience.	24 SEPTEMBER 2022

Solution Architecture	Solution Architecture fully focused on components and technology of our project.	19 SEPTEMBER 2022
Customer Journey	Customer Journey helps to analyze user interaction and kind of moments to attain the needs.	12 OCTOBER 2022
Functional Requirement	It is accomplished with task classification of functional requirement and non- functional requirement.	18 OCTOBER 2022
Data Flow Diagram	According to Data Flow Diagram exhibits the program architecture.	3 OCTOBER 2022
Technical Architecture	A technical architecture is a better understanding of the solution in which different technologies should be implemented in a project.	20 OCTOBER 2022
Milestone & Activity List	It shows our statistical data progress of our project deliverable state.	IN PROGRESS..
Sprint	A type of planning is defining what can be delivered in a sprint and what work needs to be done on a time basis.	18 CTOBER 2022

5.2 Sprint Delivery Plan

Product Backlog, Sprint Schedule, and Estimation:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Resources Initialization	USN-1	Create and initialize accounts in various public APIs like Open Weather API.	1	Low	Krishna M, Kishore S M, Kishor M, Naveen V
Sprint-1	Local Server /Software Run	USN-2	Write a Python program that outputs results given the inputs like weather and location.	1	Medium	Krishna M, Kishore S M, Kishor M, Naveen V
Sprint-2	Push the server /software to cloud	USN-3	Push the code from Sprint 1 to cloud so it can be accessed from anywhere.	2	Medium	Krishna M, Kishore S M, Kishor M, Naveen V
Sprint-3	Hardware initialization	USN-4	Integrate the hardware to be able to access the cloud functions and provide inputs to the same.	2	High	Krishna M, Kishore S M, Kishor M, Naveen V
Sprint-4	UI/UX Optimization & Debugging	USN-5	Optimize all the shortcomings and provide better user experience.	2	Low	Krishna M, Kishore S M, Kishor M, Naveen V

Project Tracker, Velocity & Burndown Chart:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	02 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	09 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	17 Nov 2022

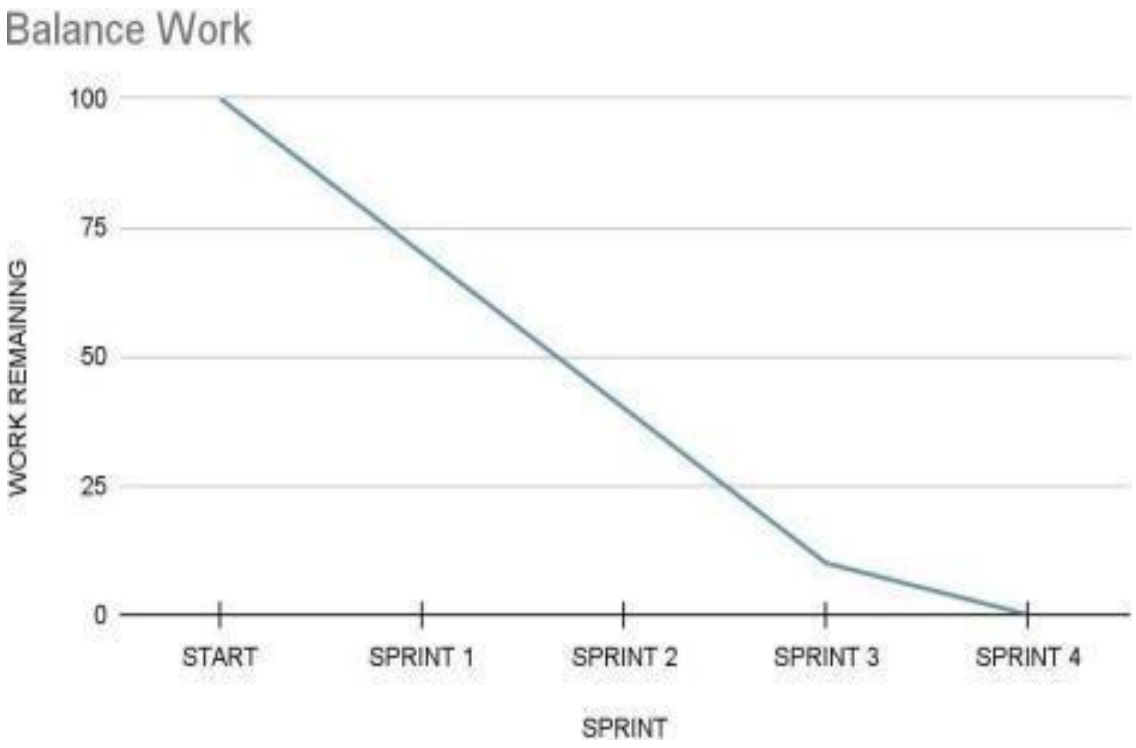
Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day).

$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies suchas Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



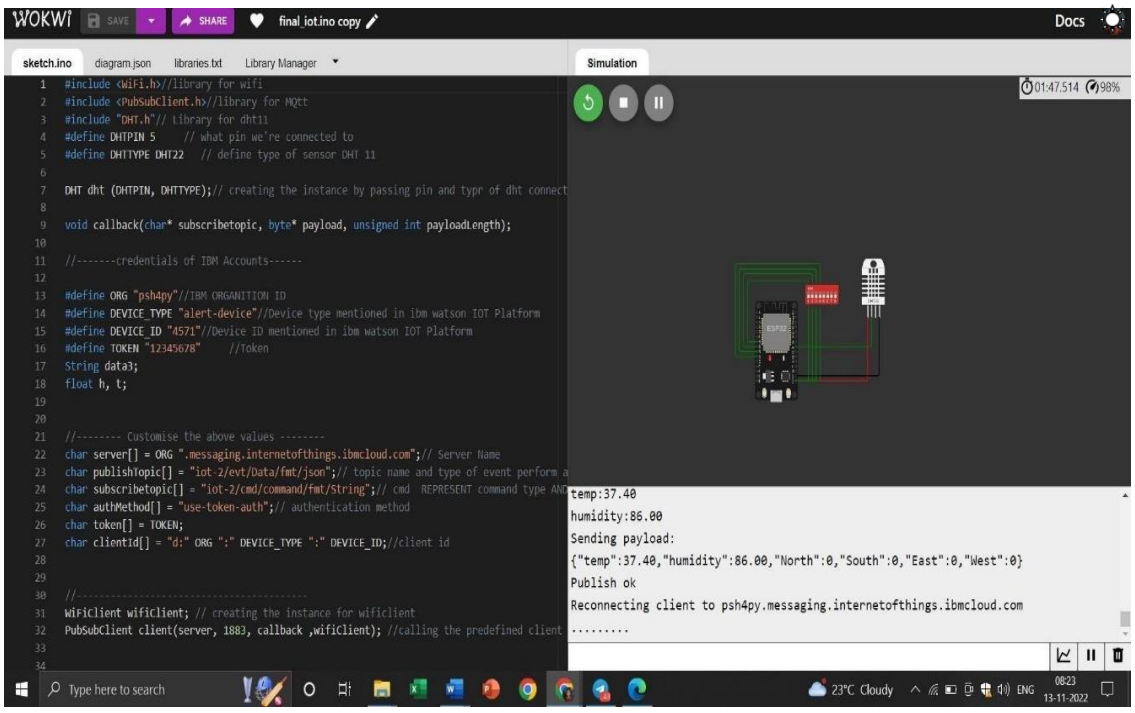
CHAPTER 6
PROJECT DEVELOPMENT PHASE

6.1 Delivery of Sprint - 1

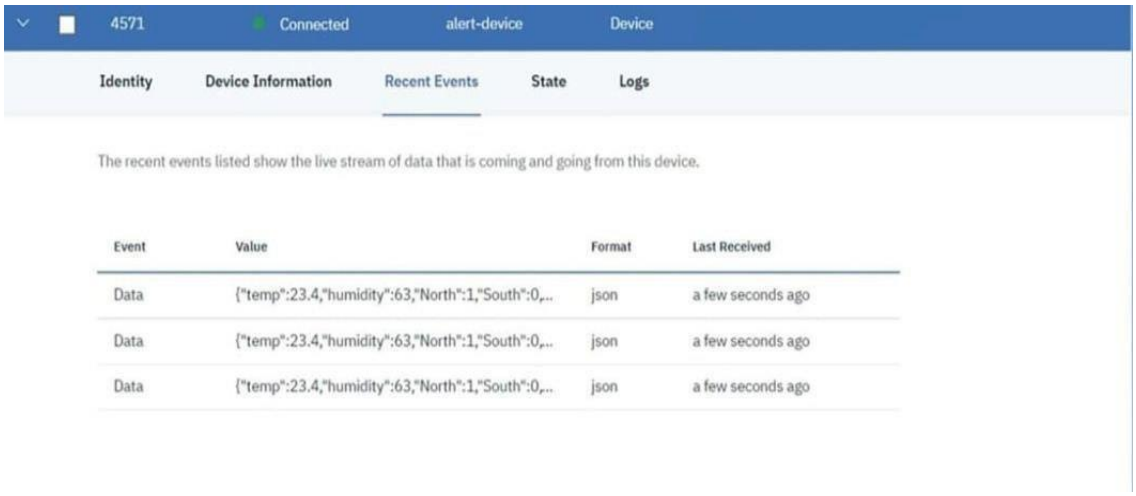
SPRINT TARGETS:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Dynamic Speed Limit	USN-1	Knowing the speed limit when travelling is crucial.	10	High	Kishor M Kishore S M Krishna M Naveen V
Sprint-1	Priority Vehicle	USN-2	Experimentation and circuit simulation.	2	High	Kishor M Kishore S M Krishna M Naveen V
Sprint-1	Weather SpeedLimit	USN-3	I should be aware of how the weather affects the speed limit for a ride as an observer.		Medium	Kishor M Kishore S M Krishna M Naveen V

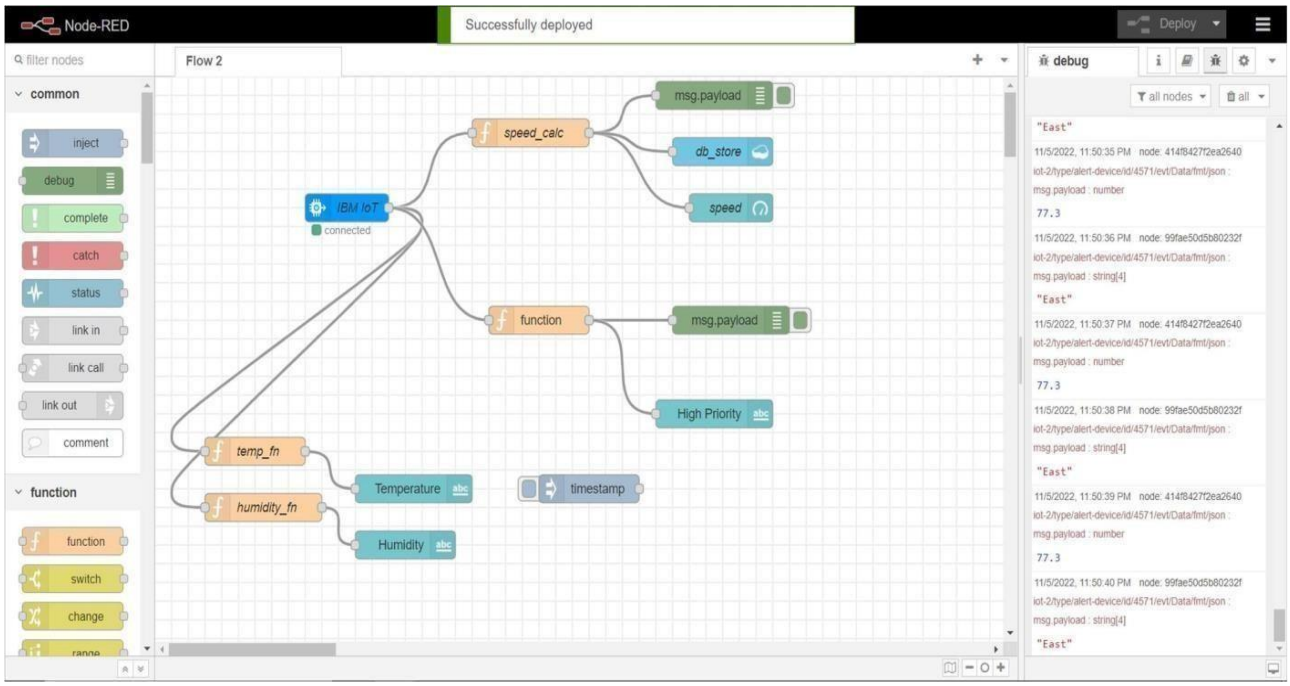
WOKWI Simulation:



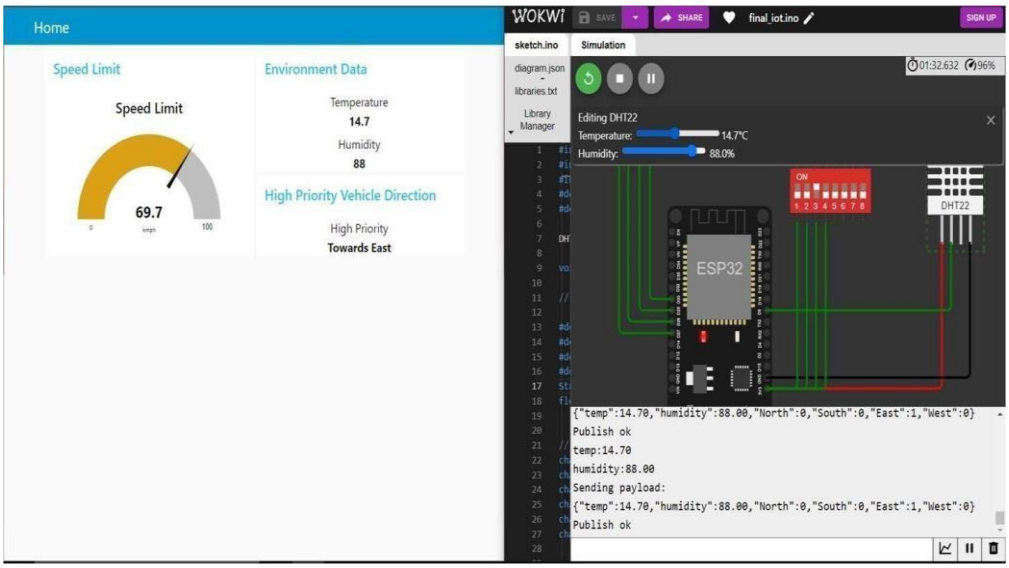
IoT Device – IoT Platform

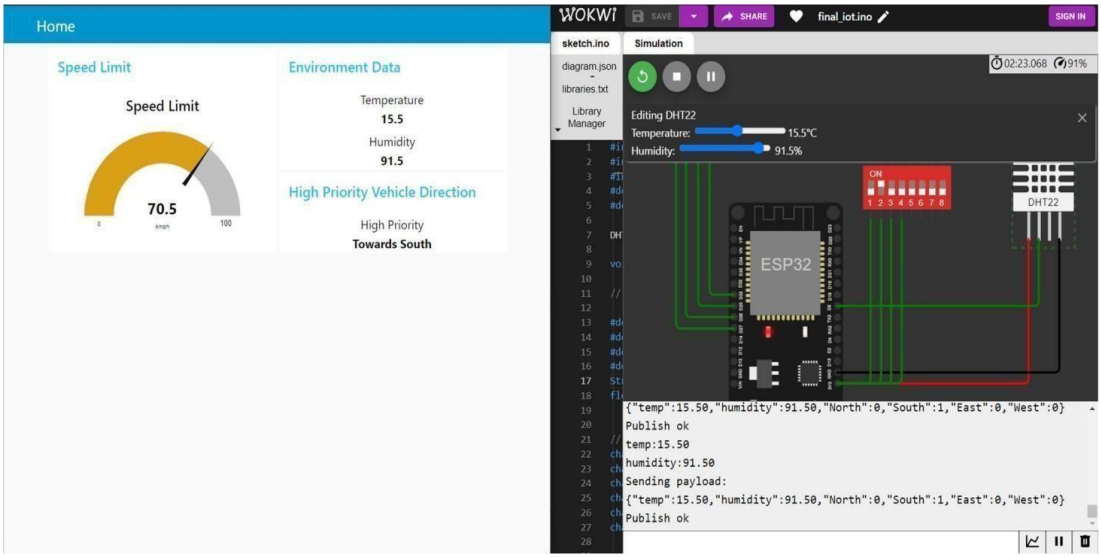


Node Red

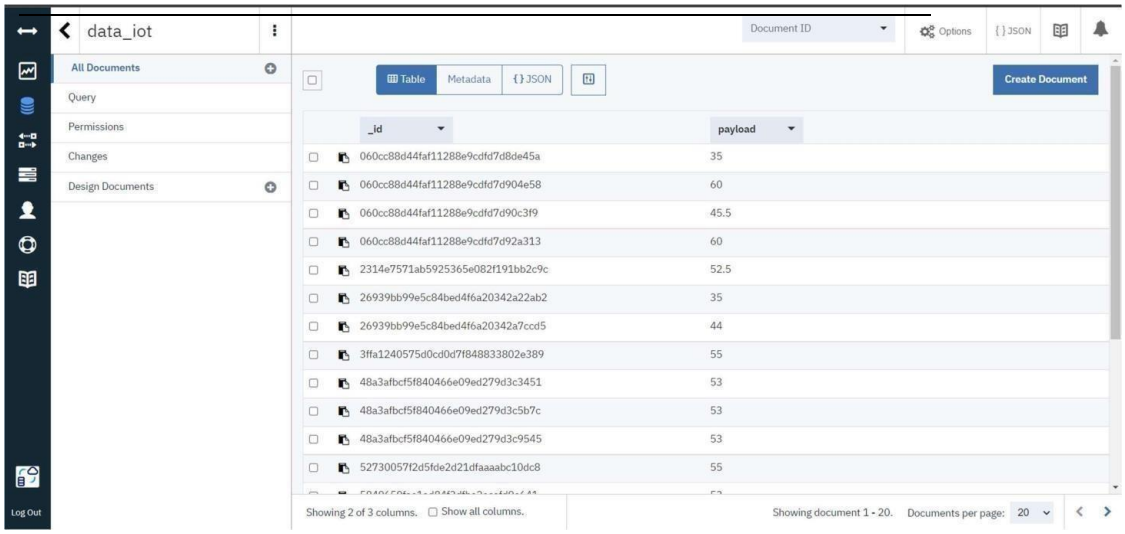


Node Red Web UI





Cloudant Database

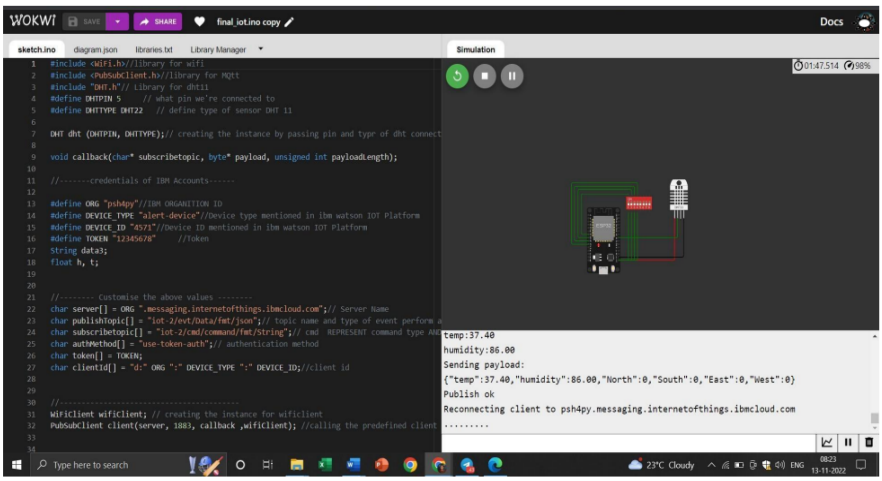


6.2 Delivery of Sprint – 2

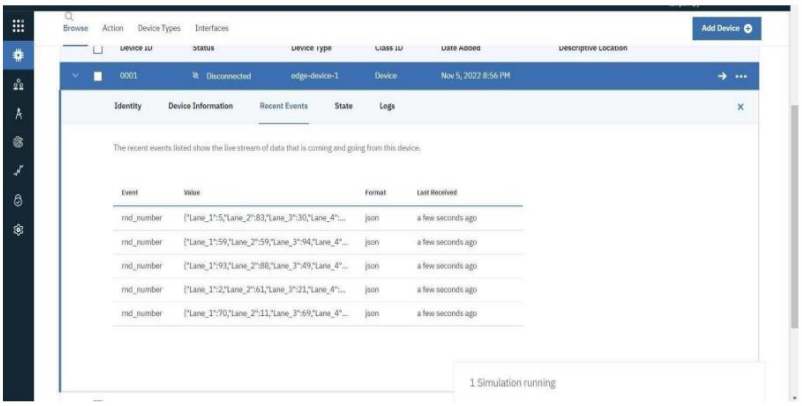
SPRINT TARGETS:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-2	Safe Ride	USN-4	I should experience a hustle-free voyage as a traveller.	20	Medium	Kishor M Kishore S M Krishna M Naveen V

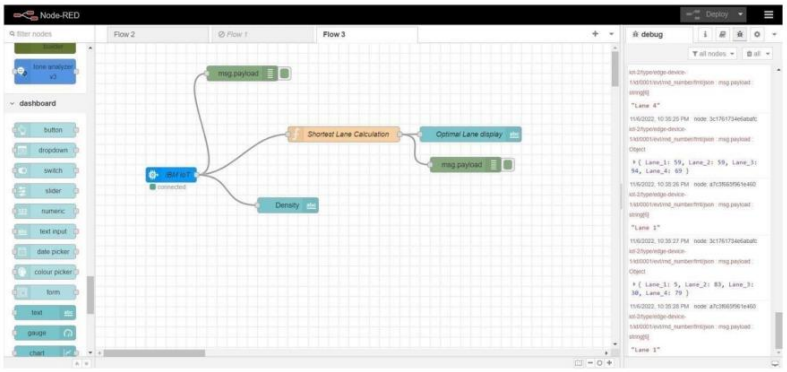
WOKWI Simulation:

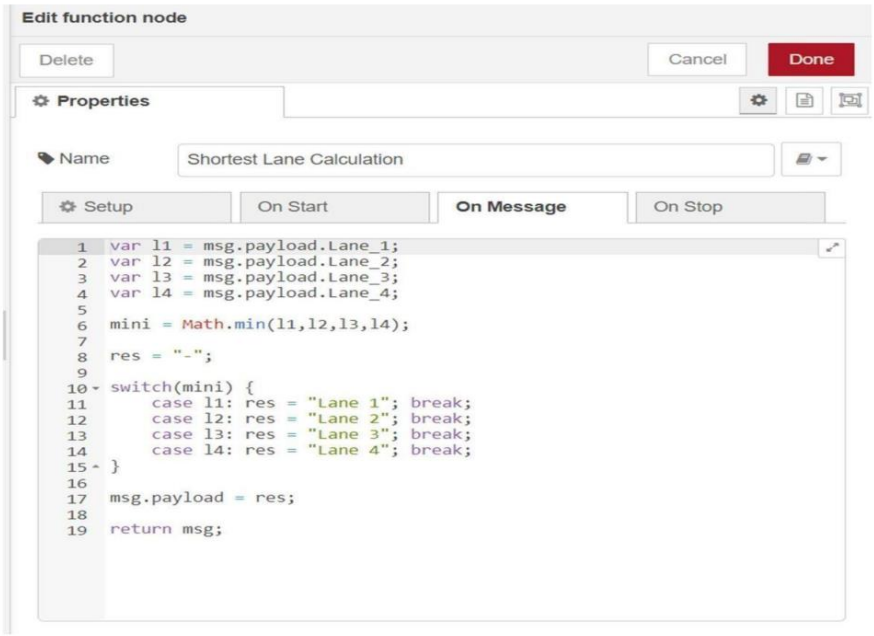


IoT Device – IoT Platform



Node Red





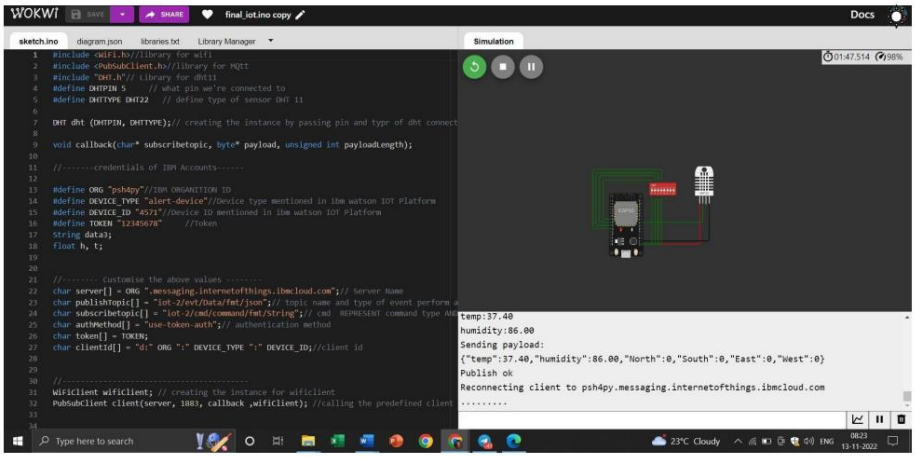
Node Red Web UI

6.3 Delivery of Sprint – 3

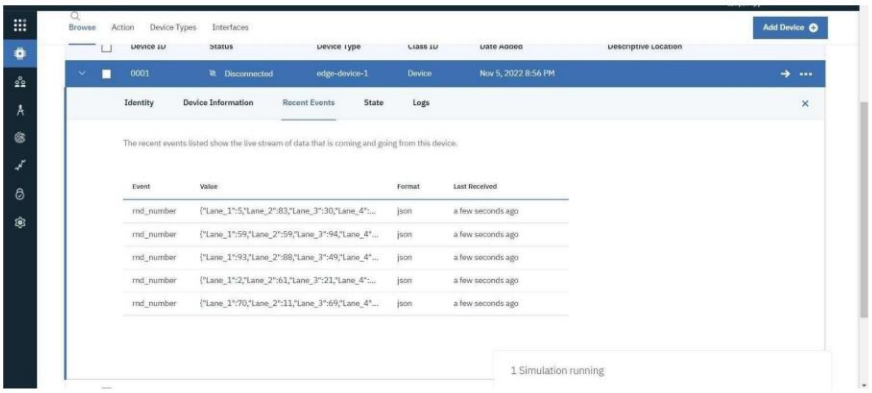
Sprint Targets:

Sprint	Functional Requirement (Epic)	User Story Number	User Story /Task	Story Points	Priority	Team Members
Sprint-3	Login	USN-5	I need a website account because I'm the administrator.	7	Low	Kishor M Kishore S M Krishna M Naveen V
Sprint-3	Dashboard	USN-6SSS	I should be able to watch over and add sign nodes as an administrator.	13	Medium	Kishor M Kishore S M Krishna M Naveen V

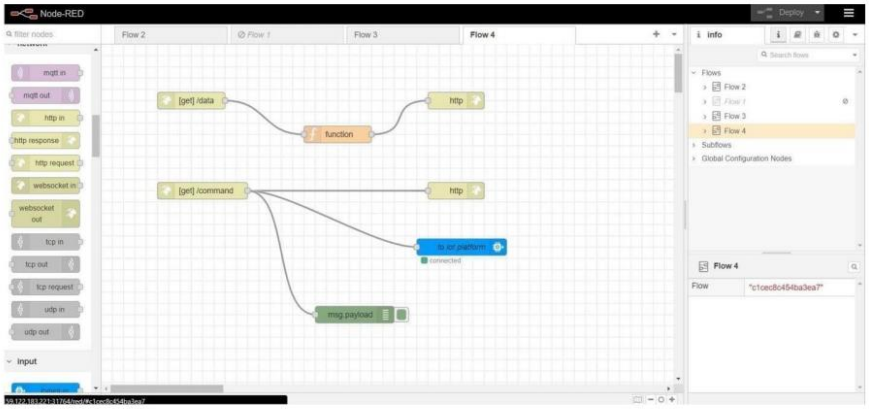
WOWKI Simulation:

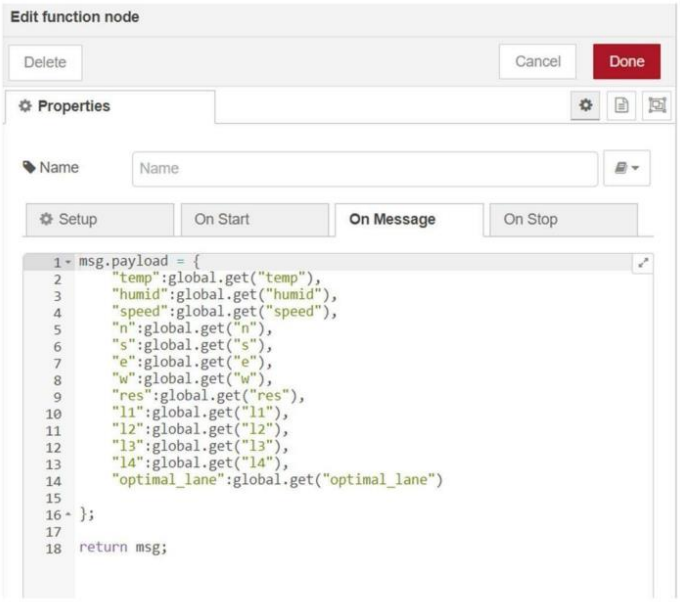


IoT Device – IoT Platform



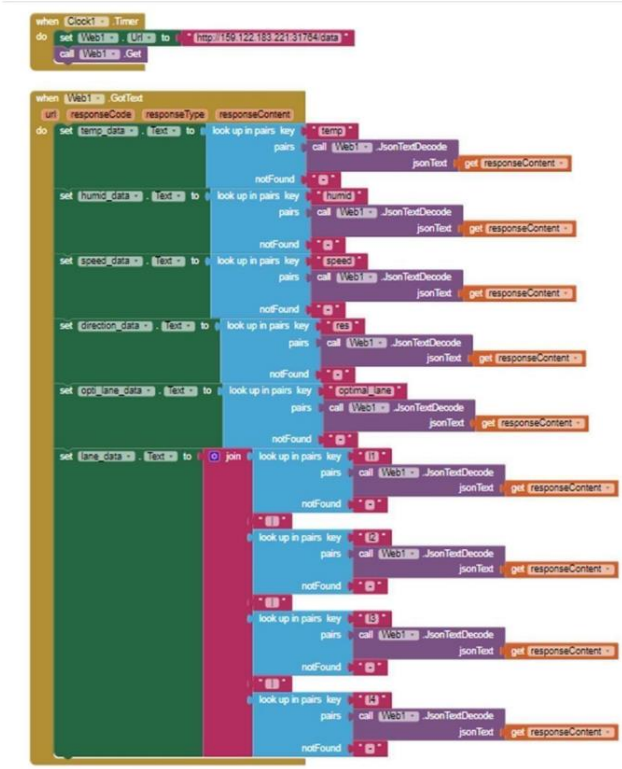
Node Red – Connect with MIT App Inventor:



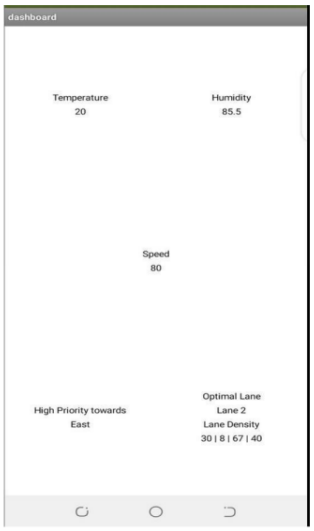


MIT App Inventor UI design:

MIT App Inventor Backend design:



(OUTPUT) Display from MIT App:



6.4 Delivery of Sprint - 4

Code for print the random temperature, Road signs, Speed limit, Message :

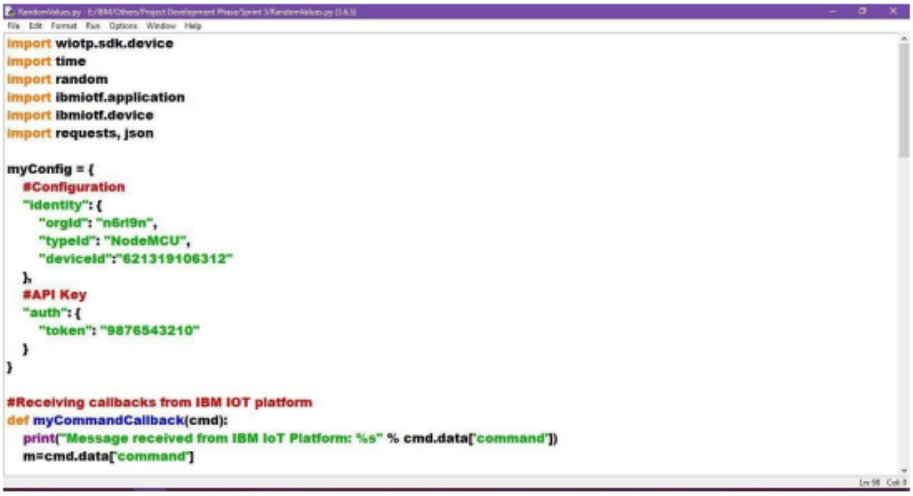
(RandomValues.py)

```
import wiotp.sdk.device
import time
import random
import ibmiotf.applicationimport
ibmiotf.device import requests,
json

myConfig = {
      #Configuration
      "identity": {
            "orgId": "n6rl9n",
            "typeId": "NodeMCU",
            "deviceId":"621319106312"
      },
      #API Key
      "auth": {
            "token": "9876543210"
      }
}

#Receiving callbacks from IBM IOT platformdef
myCommandCallback(cmd):
      print("Message received from IBM IoT Platform: %s" % cmd.data['command'])
      m=cmd.data['command']

client = wiotp.sdk.device.DeviceClient(config=myConfig, logHandlers=None)
client.connect()
```

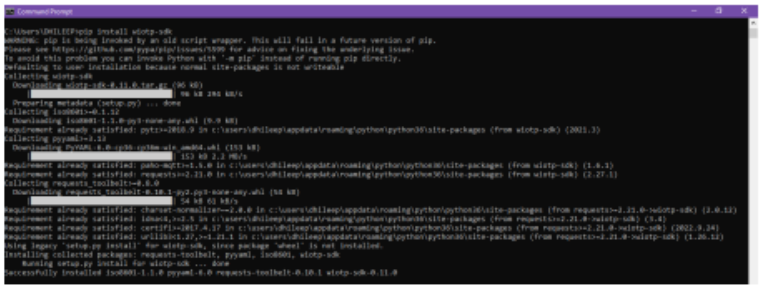
```
#OpenWeatherMap Credentials
BASE_URL = "https://api.openweathermap.org/data/2.5/weather?"CITY =
"Salem, IN"
URL = BASE_URL + "q=" + CITY + "&units=metric"+"&appid=" + "f58e4720c739a54c439aba9b05176839"

  while True:
        response   =   requests.get(URL) if
       response.status_code == 200:data =
                  response.json()
          main = data['main'] temperature =
          main['temp'] humidity =
          main['humidity']pressure =
          main['pressure']report =
          data['visibility']

          #messge part
          msg=random.randint(0,5)if
          msg==1:
                message="GO SLOW, SCHOOL ZONE AHEAD"
          elif msg==2:
                message="NEED HELP, POLICE STATION AHEAD"
          elif msg==3:
                message="EMERGENCY, HOSPITAL NEARBY"
          elif msg==4:
                message="DINE IN, RESTAURENT AVAILABLE"
          elif msg==5:
                message="PETROL BUNK NEARBY"
          else:
                message=""

           #Speed Limit part
          speed=random.randint(0,150)if
          speed>=100:
                speedMsg=" Limit Exceeded"elif
          speed>=60 and speed<100:
                speedMsg="Moderate"
          else:
                 speedMsg="Slow"

           #Diversion part
          sign=random.randint(0,5)if
          sign==1:
                signMsg="Right Diversion"elif
          sign==2:
                signMsg="Speed Breaker"
          elif sign==3:
                signMsg="Left Diversion"elif
          sign==4:
                signmsg="U Turn"
           else:
                  signMsg=""

            #Visibility
          if temperature < 24:
                 visibility="Fog Ahead, Drive Slow"elif
          temperature < 20:
                 visibility="Bad Weather"else:
                 visibility="Clear Weather"
       else:
          print("Error in the HTTP request")
```

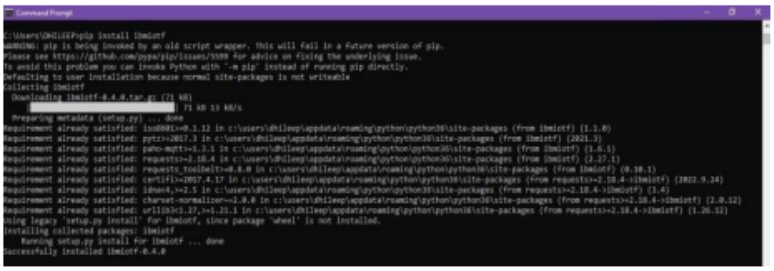
```
        myData={'Temperature':temperature, 'Message':message, 'Sign':signMsg, 'Speed':speedMsg,
'Visibility':visibility}
        client.publishEvent(eventId="status", msgFormat="json", data=myData, qos=0, onPublish=None)#PUBLISHING
TO IOT WATSON
        print("Published data Successfully: ", myData)
        print("
                                                                                                    ")
        client.commandCallback = myCommandCallback
        time.sleep(5)
client.disconnect()
```

Python Simulation:

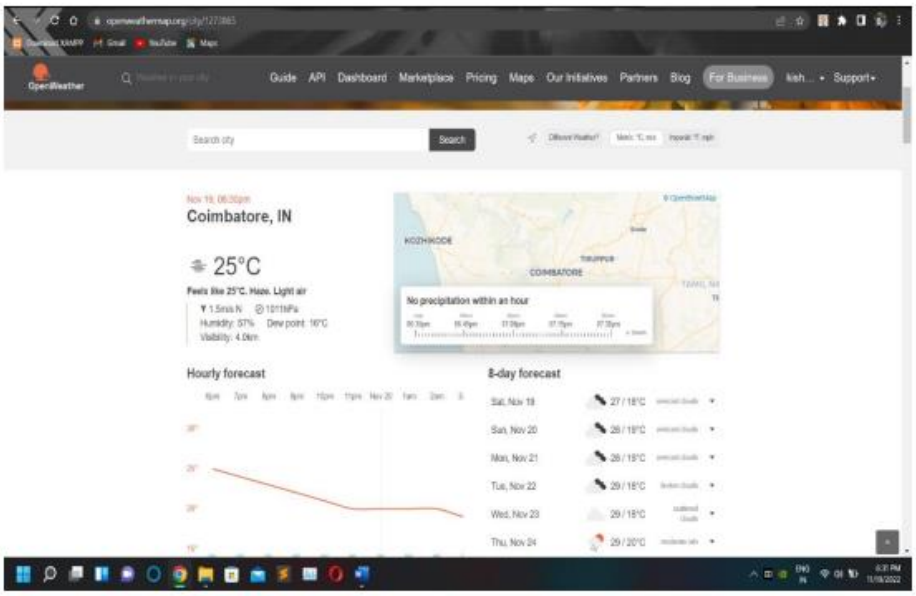


Import wiotp-sdk & ibmiotf:





OpenWeatherMap - (Ex., Coimbatore, IN):



Python IDLE Output:

CHAPTER 7
CONCLUSION

The world does not change on its own, but we can modify it to be safer, better, and more harmless. Since the road is not stated to be safe, let us make it safer using the technology that are currently accessible to us. One of the technologies that can bring us to safer roadways is the Internet of Things. So let us work together to build a better world with no accidents and a smart road for the next generation.