IBM PROJECT

Real-Time River Water Quality Monitoring and Control System

Batch: B1-1M3E

Team ID: PNT2022TMID47455

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Team Members:

- ***HARIHARAN K***
- ***KRITHIGA M***
- ***VAISHALI S***

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1. INTRODUCTION

a. Project Overview:

Water pollution is one of the biggest fears for the green globalization .In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time.River water which is used as drinking water is a very precious commodity for all human beings.The system consists of several sensors which are used for measuring physical and chemical parameters of water. Therefore, there is a need for continuous monitoring of water quality in real time monitoring of water quality in IOT(Internet Of Things)and control it.The parameters such as temperature, pH, and turbidity of the water can be measured. Using this system a person can detect pollutants from a water body from anywhere in the world.

b. Purpose:

Monitoring can be conducted for many purposes. Five major purposes are to:

- Characterize waters and identify changes or trends in water quality over time;
- Identify specific existing or emerging water quality problems;
- Gather information to design specific pollution prevention or remediation programs;
- Determine whether program goals -- such as compliance with pollution regulations or implementation of effective pollution control actions are being met; and
- Respond to emergencies, when the measured value exceeds the actual value.

2. LITERATURE SURVEY

a. Existing problem:

- ✓ Rivers and streams drain water that falls in upland areas. Moving water dilutes and decomposes pollutants more rapidly than standing water, but many rivers and streams are significantly polluted all around the world.
- ✓ The creation of dams and water-diversion systems blocks migration routes for fish and disrupts habitats. Water withdrawal for human use shrinks and degrades habitats. Runoff from agricultural and urban areas hurts water quality.

b. References:

The implementation of a robust and cost-effective water monitoring system demands a good level of research and development. Many researchers have proposed different models in order to implement such a system.

Jayti Bhatt,Jignesh Patoliya entitled “Real Time Water Quality Monitoring System”.This paper describes to ensure the safe supply of drinking water, the quality should be monitored in real time for that purpose new approach IOT (Internet of Things) based water quality monitoring has been proposed. In this paper, we present the design of IOT based water quality monitoring system that monitor the quality of water in real time. This system consists some sensors which measure the water quality parameter such as pH, turbidity, conductivity, dissolved oxygen, temperature. The measured values from the sensors are processed by microcontroller and this processed values are transmitted remotely to the core controller that is raspberry pi using Zigbee protocol. Finally, sensors data can view on internet browser application using cloud computing.

Shruti Sridharan, et al., addressed about developing an efficient wireless sensor network (WSN) based water quality monitoring system, that examines water quality, an important factor as far as,irrigation, domestic purposes, industries, etc. are concerned. The parameters involved in the water quality monitoring such as the pH level, turbidity and temperature are measured in real time by the sensors that send the data to the base station or control/monitoring room. As the monitoring is intended to be carried out in a remote area with limited access, signal or data from the sensor unit will then be transmitted wirelessly to the base monitoring station. The application of wireless sensor network (WSN) for a water quality monitoring is composed of a number of sensor nodes with networking capability. Such monitoring system can be setup emphasizing on the aspects of low cost, easy ad hoc installation, easy handling and maintenance. The use of wireless system for monitoring purpose will not only reduce the overall monitoring system cost in terms off acilities setup and labour cost but will also provide flexibility in terms of distance or location. In this paper, the fundamental design and implementation of WSN featuring a high-power transmission Zigbee based technology together with the compatible transceiver is proposed. It is chosen due to its features that fulfill the requirement for a low cost, easy to use,minimal power consumption and reliable data communication between sensor nodes. The development of graphical user interface (GUI) for the monitoring purposes at the base monitoring station is another main component. The GUI should be able to display the parameters being monitored continuously in real time. The developed GUI platform using MATLAB is cost effective and allows easy customization.

Mohammad Salah Uddin Chowdury et al. have proposed a system for monitoring the quality of water in a river with the aid of an embedded

system consisting of wireless sensor network and IoT. Deep learning models have been used to assess the quality of water and SMS alert is sent in case the value of a sensor has crossed the threshold. Soundary Pappuetal have used a pH and aTDS sensor to determine the quality of water with the Arduino microcontroller and the Raspberry Pi3. K-means clustering algorithm is used to predict the quality of water based on the sensed values.

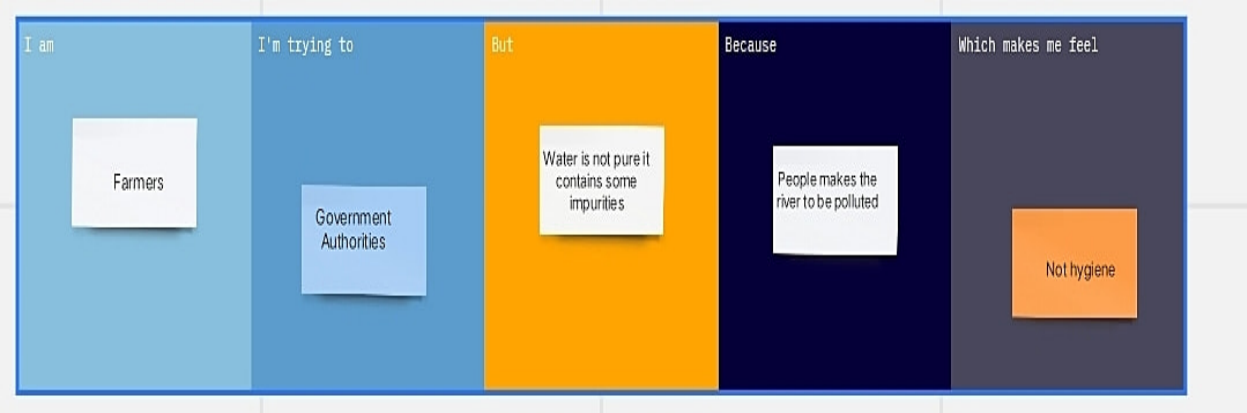
Omar Faruq et al. (2017) A water quality monitoring system based on microcontrollers for people living in Bangladesh's outskirts, where safe drinking water is not available, is provided in this paper. The device has been designed with a high degree of accuracy and is sensitive to several water parameters such as temperature, turbidity and hydrogen potential (pH) displayed on the LCD monitor. Finally, in this paper, each of the parameter values is compared with the predefined equipment, and sensor values and error are calculated.

Stephen Brosnan investigated a WSN to collect real time water quality parameters (WQP). Quio Tie-Zhn,developed online water quality monitoring system based on GPRS/GSM. The information was sent by means of GPRS network, which helped to check remotely the WQP. Kamal Alameh presented web based WSN for monitoring water pollution using ZigBee and WiMAX networks. The system collected, processed measured data from sensors, and directed through ZigBee gateway to the web server by means of WiMAX network to monitor quality of water from large distances in real time. Dong He developed WQM system based on WSN . The remote sensor was based on ZigBee network. WSN tested WQP and sent data to Internet using GPRS. With the help of Web, information was gathered at remote server. Vijayakumar etal.,designed a low cost system design for real time water quality monitoring in IoT utilizes sensors to check many important physical and chemical parameters of water. The

parameters such as turbidity, temperature, pH, dissolved oxygen conductivity of water can be measured. In our project, we proposed a water quality monitoring and consystem based on IoT.

c. Problem Statement Definition:

A problem statement is a concise description of the problem or issues a project seeks to address. The problem statement identifies the current state, the desired future state and any gaps between the two.

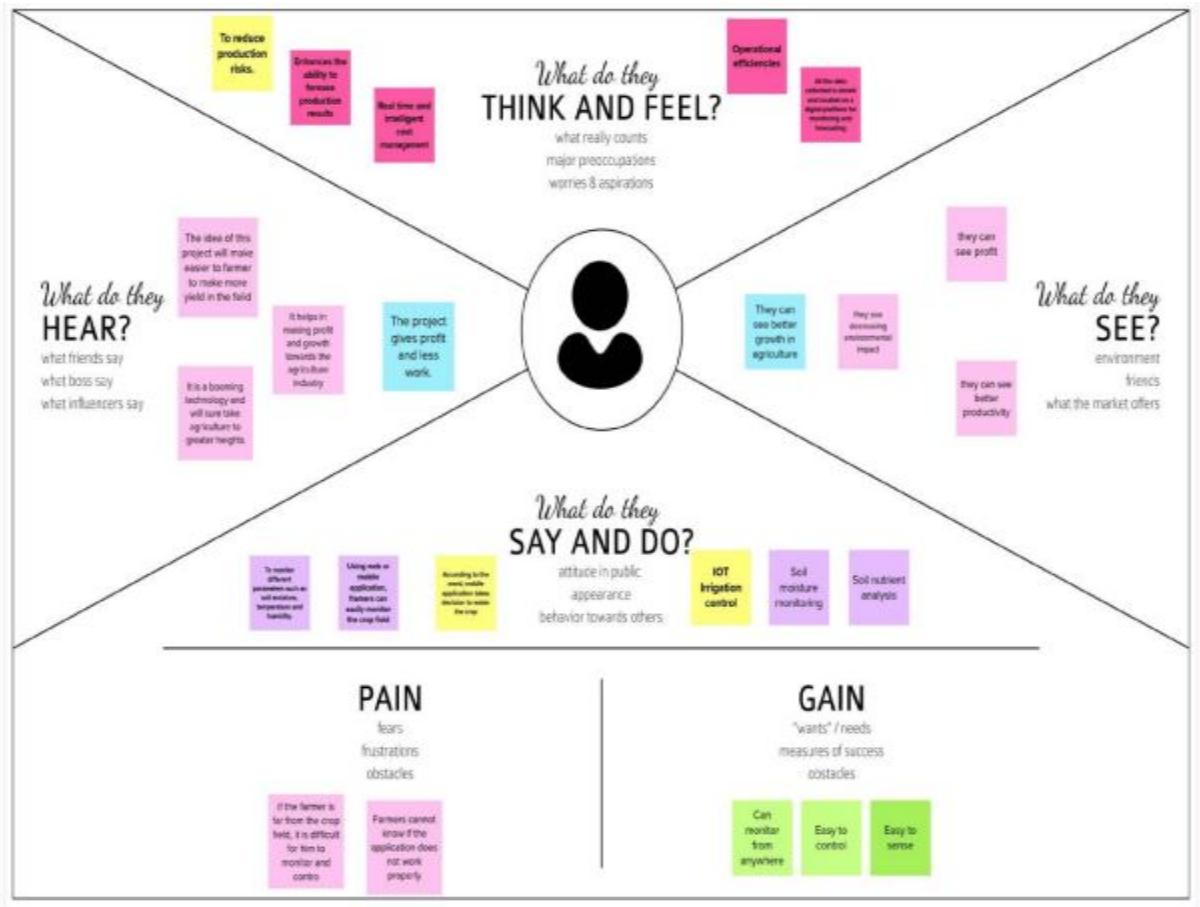


Problem Statement (PS)	I am (Customer)	I' mtrying to	But	Because	Which makes me feel
PS-1	Farmers	Get pure water to cultivate crops	Water is not pure it contains some impurities	People makes the river to be polluted	Not hygiene
PS-2	Government Authorities	Reduce the pollutants in river	People not aware about pollutants	Lack of knowledge about pollutants	Cause diseases

3. IDEATION & PROPOSED SOLUTION

a. Empathy Map Canvas:

An empathy map is a collaborative tool teams can use to gain a deeper insight into their customers. Much like a user persona, an empathy map can represent a group of users, such as a customer segment. The empathy map was originally created by Dave Gray and has gained much popularity within the agile community.This tool helps build Empathy towards users and helps design teams shift focus from the product to the users who are going to use the product.



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b. Ideation & Brainstorming:

PROBLEM

HOW TO MONITOR AND CONTROL THE QUALITY OF RIVER WATER IN REAL-TIME?

REPORTS:

Each and every data like pH, turbidity temperature of the river water are measured and generated in the application in up-to-date.

The comparison between the water bodies in different areas are also generated graphically.

The report shows the actual value and the measured value of the water bcdy.

FUTURE PLANNING:

Charging the batteries of the system by using solar energy.

Underground water system development to get the data for each and every second.

Can measure the natural variabilities and also the equipment performance.

QUALITY IMPROVEMENT:

Controlling the pollution of water by alerting the authorities when the water bodies exceeds the polluted level.

Error detection as well as correction.

Statistical technique to improve a process quality.

ALERTS AND NOTIFICATIONS:

This system continuously monitors the river water parameters (pH, temperature, turbidity).

Each and everyday the sensed value of the river water is measured and notified to the user.

The sensed value is above or below to the actual value and it automatically alerts the user.

FINANCIAL MANAGEMENT:

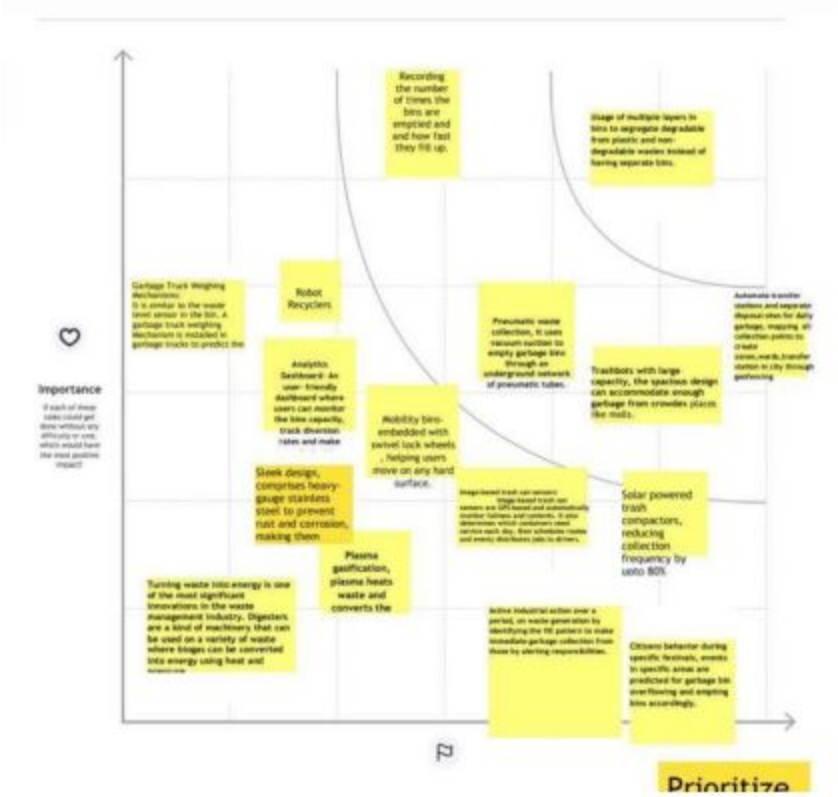
Cost effective equipped system.

App installation is user friendly and flexible with free of cost.

AUTOMATION:

The app also gives the exact location of the polluted water body with the help of GPS to make the user to know the correct location.

The values are already fed into the system which helps the user to know the actual values to compare with measured values.



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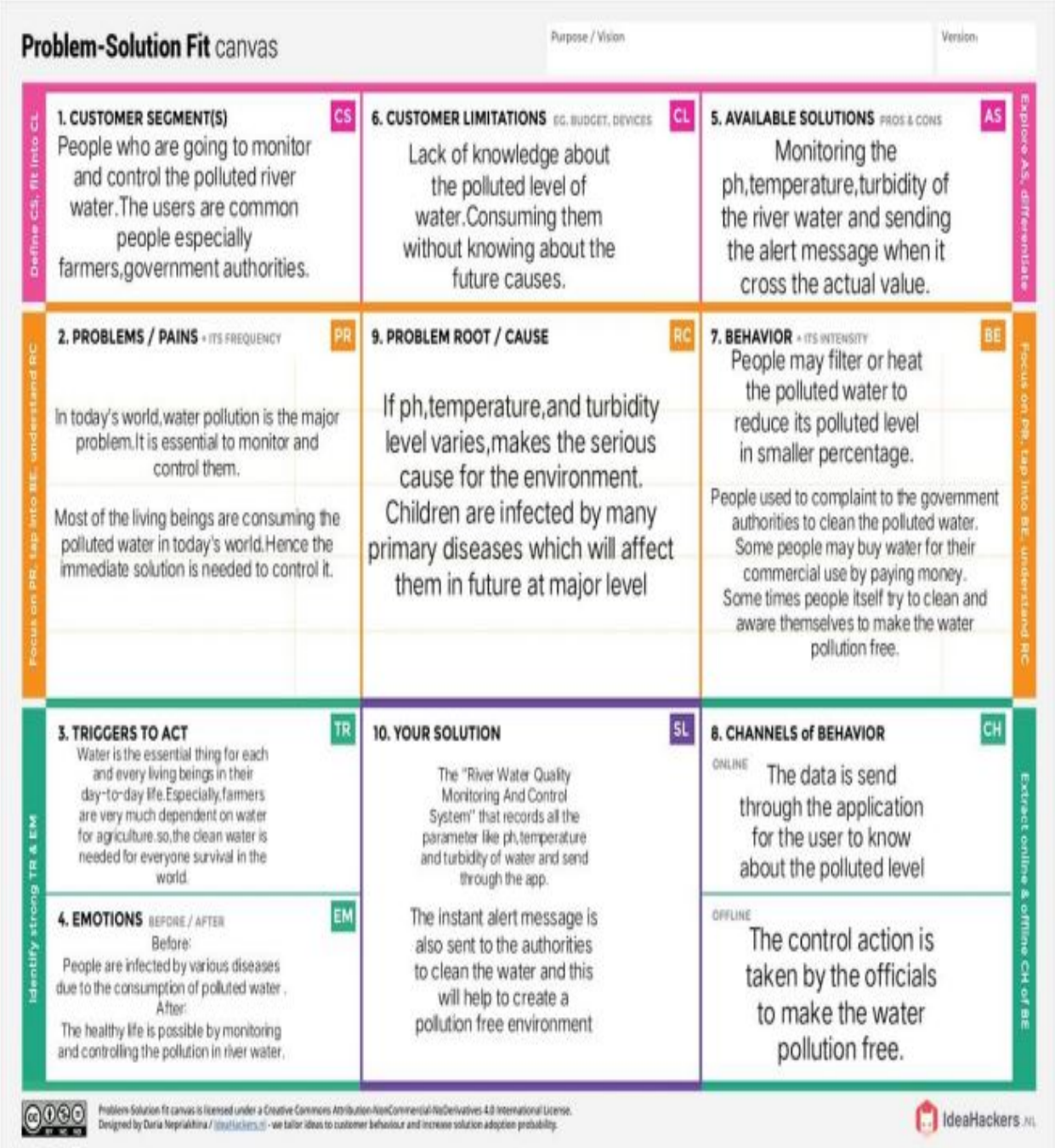
c. Proposed Solution:

A problem statement is a concise description of the problem or issues a project seeks to address. The problem statement identifies the current state, the desired future state and any gaps between the two.

S.NO	*Parameter*	*Description*
1	Problem Statement (Problem to be solved)	Water pollution is one of the biggest fears for the green globalization .In order to ensure the safe supply of the drinking water the quality needs to be monitor in real time.
2	Idea / Solution description	By developing the REAL-TIME RIVER WATER QUALITY MONITORING AND CONTROL SYSTEM, the system sense and sends the random value of water bodies such as pH, turbidity and temperature to the IoT platform. And also the sensor values are viewed in the web application. Notifies the admin if the random values cross the threshold values.
3	Novelty / Uniqueness	Error free data access management. Statistical Process Control(SPC) facility, to make the application user friendly.

4	Social Impact / Customer Satisfaction	It is estimated that around 70% of surface water in India is unfit for consumption. By this system, the method of monitoring and controlling decreases this percentage level and helps the people to drink healthy water.
5	Business Model (Revenue Model)	Cost effective equipped system. *The system budgets around the level, which makes the people to afford. *Application installation is also free of cost and flexible to user.
6	Scalability of the Solution	The proposed system has less complexity and high performance by collecting and managing the data with the help of IoT and cloud services.

d. Problem Solution fit:



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4. REQUIREMENT ANALYSIS

a. Functional requirement:

FR.NO	*Functional Requirement(Epic)*	*Sub Requirement(Story/Sub-Task)*
FR.1	User Registration	1.Registration through Gmail. 2.Registration through mobile number.
FR.2	User Confirmation	1.Confirmation via Email. 2.Confirmation via OTP.
FR.3	User Access	1.Accepting all the terms and conditions. 2.Confirmation of reCAPTCHA.
FR.4	User Mode	Online
FR.5	User Alert	Alert sms to the registered mobile number if the measured value crosses the threshold value.

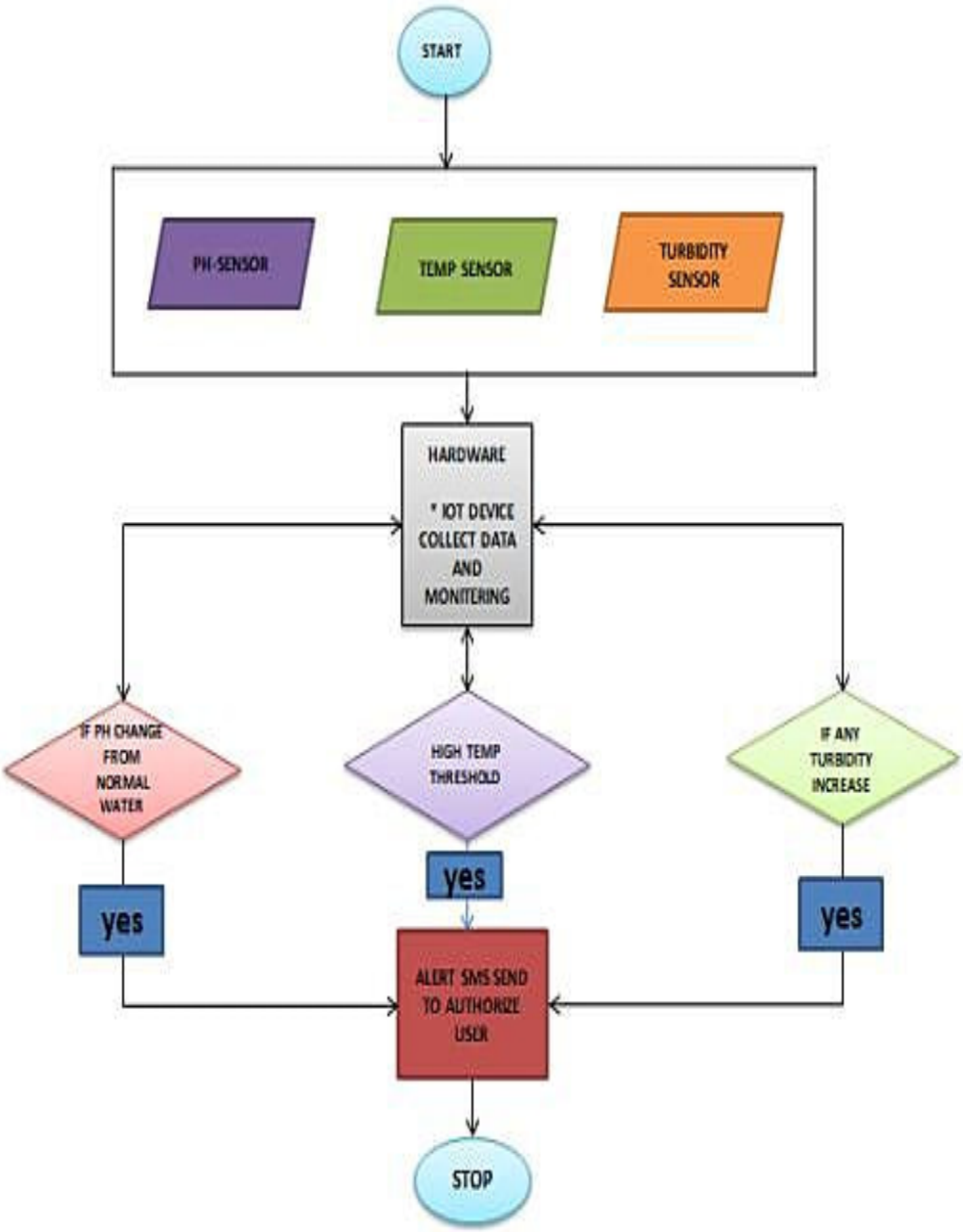
b. Non-Functional requirement:

NFR.NO	*Non-Functional Requirement*	*Description*
NFR.1	Usability	1.Easy to use. 3.Effective, Efficient, Engaging, Error tolerant. 4.Easy to learn.
NFR.2	Security	1.Accepting Terms and Conditions. 2.Confirmation via Email and OTP. 3.Confirmation via recaptcha. 4.Strong cryptography skills. 5.Software security architects also have experience with malware, intrusion detection and prevention and firewalls.
NFR.3	Reliability	1.Great user interface. 2.Software operating without failure while in a specified environment over a set duration of time
NFR.4	Performance	Fast loading of the result time and high performance.

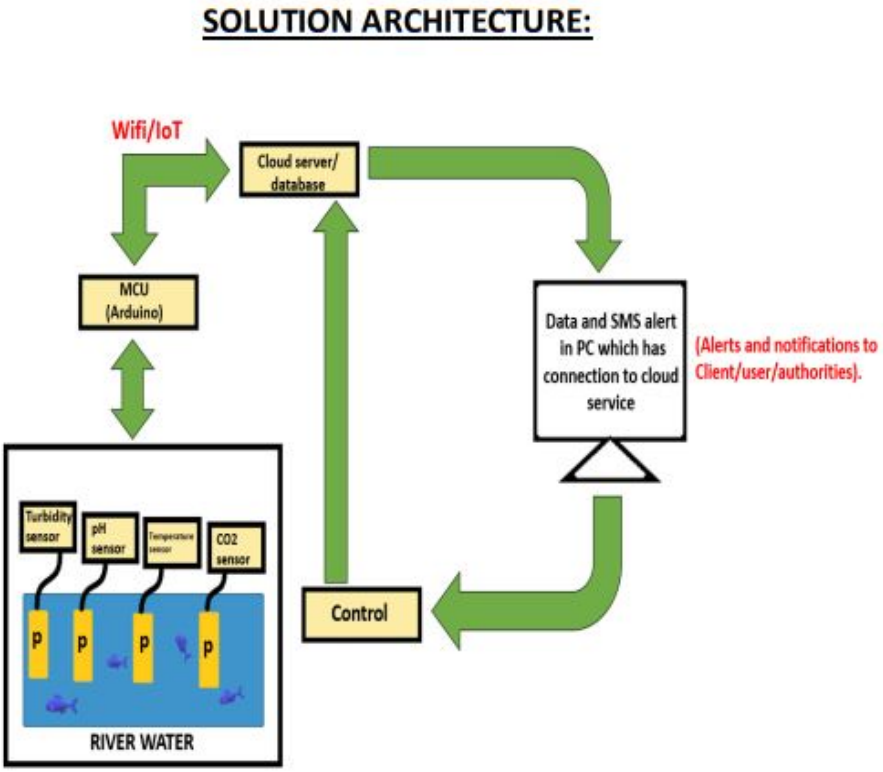
NFR.5	Availability	Easy installation.
NFR.6	Scalability	1.Optimizing SQL queries and implementing indexing strategies. 2.By building articles and authors into a single query, we can dramatically reduce the volume of queries we're running

5. PROJECT DESIGN

a. Data Flow Diagrams:



b. Solution Architecture:



Key points:

- In the image, p denotes probe.
- From the block river water to Arduino the system is known as WiFi Sensor Network System (WSN).
- PC which gets the alerts and notifications should have node red SDK.
- Data and alert messages are viewed on smartphone/PC/laptop.

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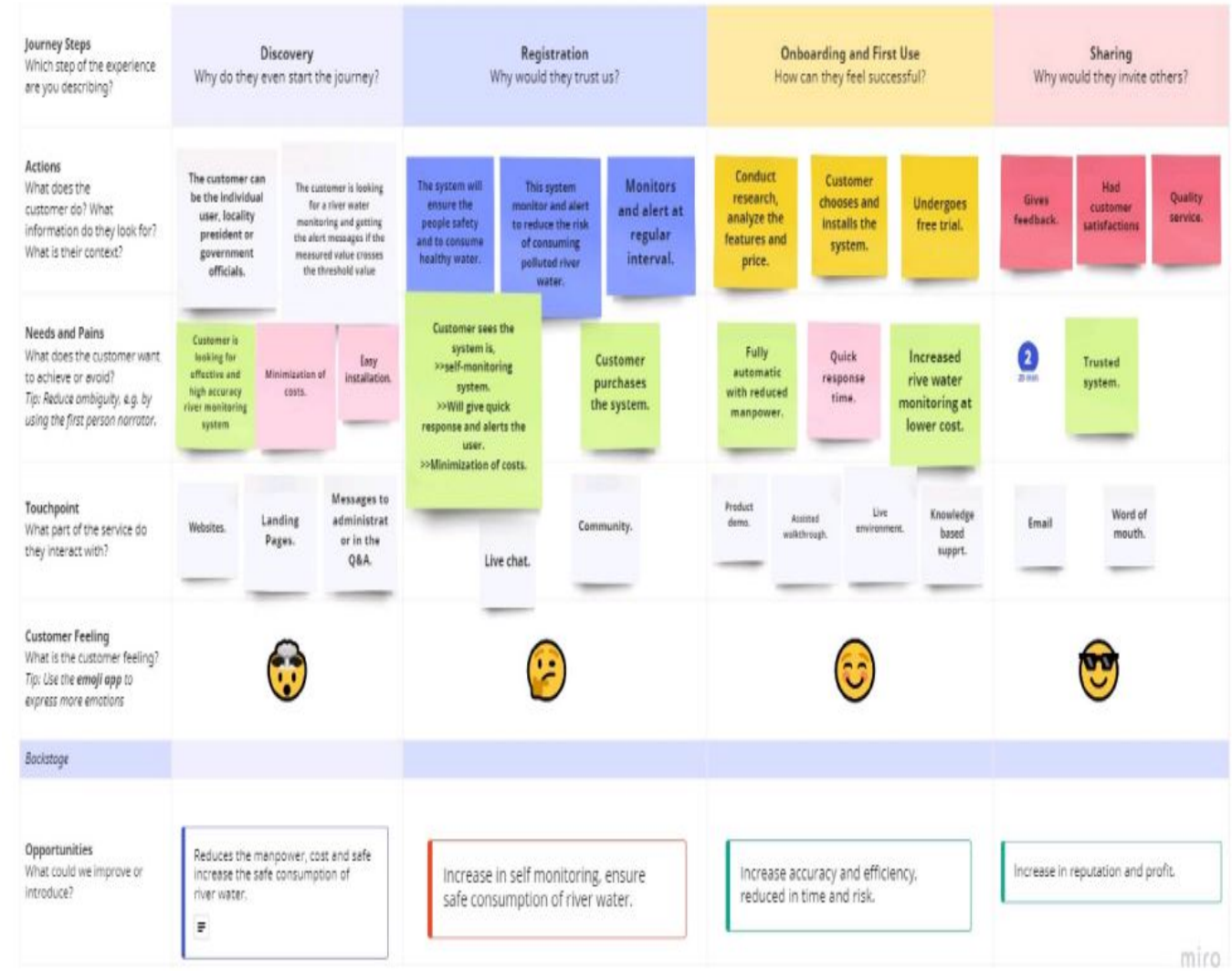
c. User Stories:

USER STORIES:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
		USN-3	As a user, I can register for the application through Gmail		Medium	Sprint-1
	Login	USN-4	As a user, I can log into the application by entering email & password		High	Sprint-1
	Dashboard	USN-5	As a user,I can have user information,data display,super chart,maps,location,web page button.		High	Sprint-2
Customer (Web user)	Login	USN-1	As a user,I can log into the application by entering email & password.	I can access my account or dashboard.	High	Sprint-1
		USN-2	As a user, I can confirm the captcha as I am not a robot.	Security prioritize.	High	Sprint-1
Customer Care Executive	Resolving issues	USN-1	As a customer care executive,I can resolve all the issues regarding to the user application.	I can access user login details.	High	Sprint-2
Administrator	Managing and Controling	USN-1	As an administrator,I can manage the application and control the issues in higher level.	I can access each and every details in the application of the particular user.	High	Sprint-1



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d.Technology Stacks and Architecture:

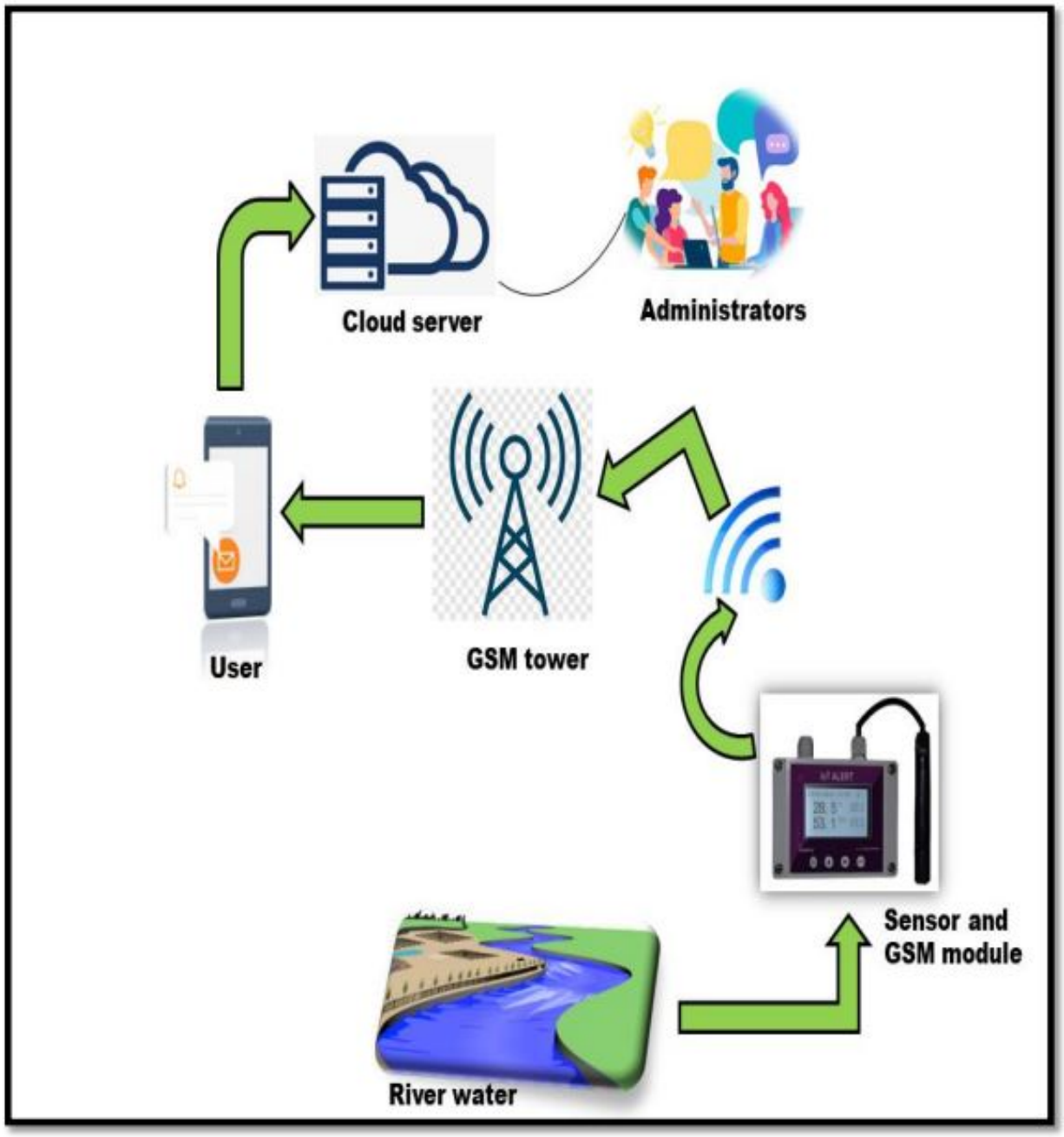

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Table-1: Components and Technologies:

S.No	Component	Description	Technology
1.	User Interface	Web UI, Mobile App	HTML, CSS, Python Script
2.	Application Logic-1	Available water resources to detect and to search location	Python Script
3.	Application Logic-2	Statistical random values and graphical analysis	IBM Watson STT Service
4.	Application Logic-3	Alert messages to the user	IBM Watson Assistant
5.	Database	Random values of pH level, turbidity and temperature in river water	MySQL, NoSQL
6.	Cloud Database	Database service on cloud by the administrator	IBM Cloudant
7.	File Storage	Storing the random values to compare with threshold value	IBM Block Storage
8.	External API-1	Effective data generation	IBM Watson API
9.	External API-2	Google sign-in	Google API
10.	Machine Learning Model	To recognize file pattern(here, graphical mode of statistical data is generated)	Object Recognition Model(IBM Watson and Node-RED)
11.	Infrastructure(Server/Cloud)	Software Library Workspace, expanding Application Management	Cloud Foundry(IBM Cloudant), adding @EnableConfigServer annotation in Spring Boot Application Class file.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Open source code freely available and modified according to the requirement-Net(Microsoft Framework) Zend Framework	Linux operating system, Angular Js, Bootstrap
2.	Security Implementations	Login credentials, PINs, biometric scans and security tokens. Firewall: governs traffic to, from or by application.	Encryption, MAC(Mandatory Access Control),SHA-256 Firewall: Cloudflare Spectrum
3.	Scalable Architecture	Handle a growing user base without affecting the user experience and the app's performance.	Cloudinary using degree of AI.
4.	Availability	Computing environments configured to provide nearly full-time availability.	React Native, jQuery Mobile
5.	Performance	Ensures stable functioning Creating Offline mode	Python, React Native

6. PROJECT PLANNING & SCHEDULING

a. Sprint Planning & Estimation:

Sprint	*F.R*	*User story Number*	*User story/Task*	*Story Point*	*Priority*	*Team Members*
Sprint-1		US-1	Creating IBM Cloud and using its services.	6	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-1		US-1	Configure the IBM cloud service and creating IoT platform	4	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-1		US-1	IBM Watson IoT platform acts as the mediator to connect the web application to IoT devices, hence Launching IBM Watson IoT platform.	5	Low	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-1		US-1	In order to connect the IoT device to the IBM Cloud, create a device in the IBM Watson IoT Platform and get the device credentials.	5	Medium	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-2		US-1	Configure the connection security and create API keys that are used in the NODE-RED service for accessing the IBM IoT Platform.	10	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-2		US-1	Create a Node-RED service.	10	High	Ajaysaran B Hariharan K Krithiga M

						Vaishali S
Sprint-3		US-1	Develop a python script to publish random sensor data such as temperature, turbidity and pH to the IBM IoT Platform.	7	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-3		US-1	After developing python code, commands are received just print the statements which represent the control of the devices.	5	Medium	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-3		US-1	Publish data to the IBM Cloud.	8	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-4		US-1	Create Web UI in Node-RED.	10	High	Ajaysaran B Hariharan K Krithiga M Vaishali S
Sprint-4		US-1	Configure the Node-RED flow to receive data from the IBM IoT Platform and also use Cloudant DB nodes to store the received sensor data in cloudant DB.	10	High	Ajaysaran B Hariharan K Krithiga M Vaishali S

b.Sprint Delivery Schedule:

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 22	29 Oct 22	20	29 Oct 22
Sprint-2	20	6 days	31 Oct 22	05 Nov 22	20	05 Nov 22
Sprint-3	20	6 days	07 Nov 22	12 Nov 22	20	12 Nov 22
Sprint-4	20	6 days	14 Nov 22	19 Nov 22	20	19 Nov 22

c. Reports from JIRA:

Jira

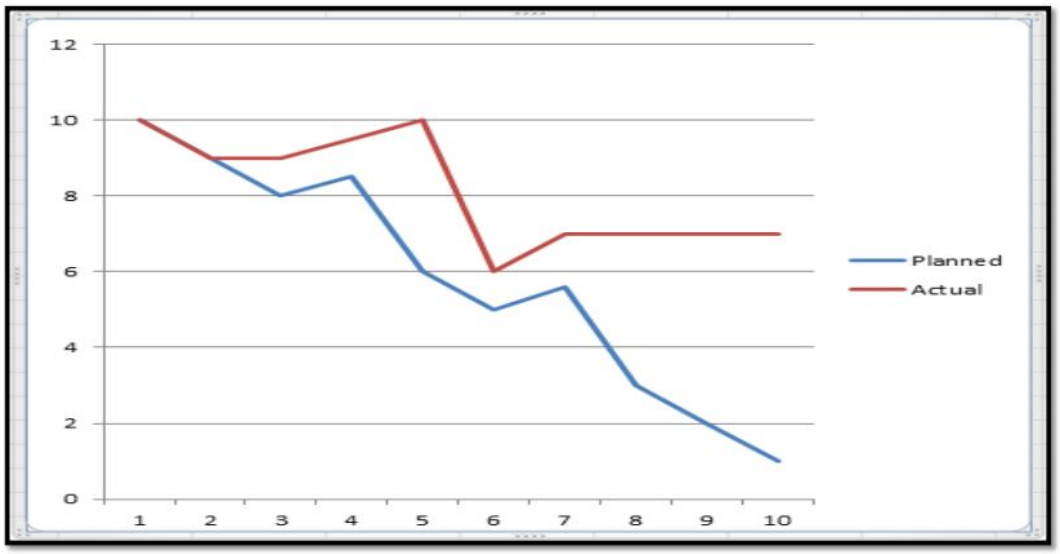
Sorted by: Created descending

1–10 of **10** as at: **18/Nov/22 9:22 AM**

T	Key	Summary	Assignee	Reporter	P	Status	Resolution	Created	Updated	Due
	RTRWQMCS-11	Publish	AJAYSARAN B	AJAYSARAN B	=	DONE	Done	17/Nov/22	17/Nov/22	19/Nov/22
	RTRWQMCS-10	Develop	Vaishali S	AJAYSARAN B	=	DONE	Done	17/Nov/22	17/Nov/22	12/Nov/22
	RTRWQMCS-9	Configure	M.Krithiga	AJAYSARAN B	=	DONE	Done	17/Nov/22	17/Nov/22	05/Nov/22
	RTRWQMCS-8	Create	HARIHARAN K	AJAYSARAN B	=	DONE	Done	17/Nov/22	17/Nov/22	29/Oct/22
	RTRWQMCS-7	CREATE AND CONFIGURE IBM CLOUD SERVICES	HARIHARAN K	AJAYSARAN B	=	DONE	Done	29/Oct/22	17/Nov/22	
	RTRWQMCS-5	CREATE AND CONFIGURE IBM CLOUD SERVICES	Vaishali S	AJAYSARAN B	=	DONE	Done	29/Oct/22	17/Nov/22	
	RTRWQMCS-4	PROJECT DESIGN PHASE-1	AJAYSARAN B	AJAYSARAN B	=	DONE	Done	29/Oct/22	29/Oct/22	
	RTRWQMCS-3	IDEATION PHASE	HARIHARAN K	AJAYSARAN B	=	DONE	Done	29/Oct/22	29/Oct/22	
	RTRWQMCS-2	PROJECT SPRINT	M.Krithiga	AJAYSARAN B	=	DONE	Done	29/Oct/22	17/Nov/22	
	RTRWQMCS-1	PROJECT DEVELOPMENT PHASE	AJAYSARAN B	AJAYSARAN B	=	DONE	Done	29/Oct/22	17/Nov/22	

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 such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



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7. CODING & SOLUTIONING :

a. Feature 1

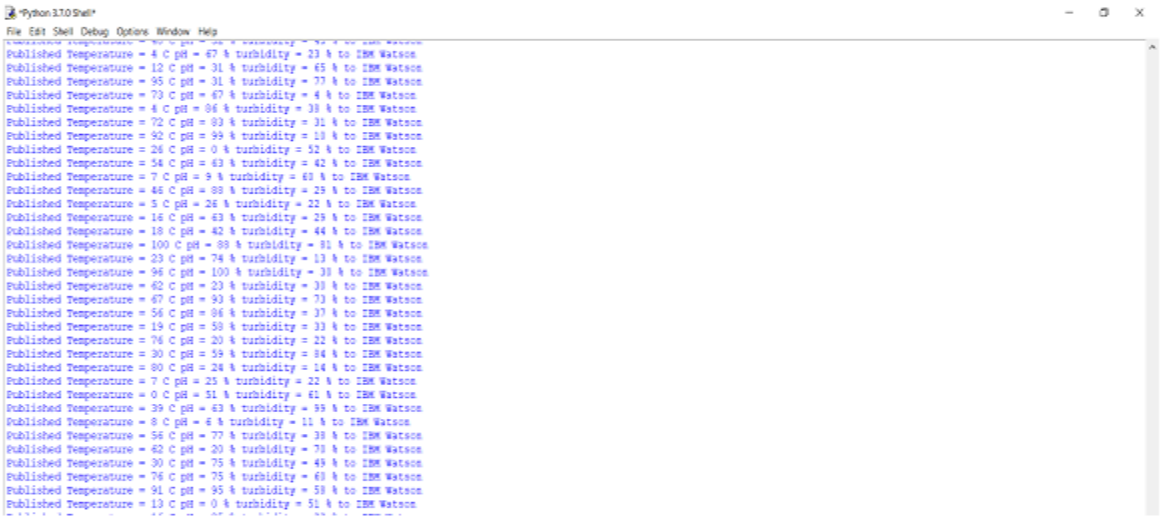
PYTHON CODE:

```
import time
import sys
import ibmiotf.application
import ibmiotf.device
import random


#Provide your IBM Watson Device Credentials
organization = "w1nouz"
deviceType = "riverwatermonitor1"
deviceId = "monitorsensor1"
authMethod = "token"
authToken = "!yjEh7zDC6(Cf@s&Rz"

# Initialize GPIO
def myCommandCallback(cmd):
   print("Command received: %s" % cmd.data['command'])
   status=cmd.data['command']
   if status=="Light on":
      print ("LED is on")
   else:
      print ("LED is off")

   #print(cmd)

try:
        deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-method":
authMethod, "auth-token": authToken}
        deviceCli = ibmiotf.device.Client(deviceOptions)
        #.....................................

except Exception as e:
        print("Caught exception connecting device: %s" % str(e))
        sys.exit()
```

```
# Connect and send a datapoint "hello" with value "world" into the cloud as an event of type
"greeting" 10 times
deviceCli.connect()

while True:
        #Get Sensor Data from DHT11

        temp=random.randint(0,100)
        pH=random.randint(0,100)
        turbidity = random.randint(0,100)

        data = { 'Temperature' : temp, 'pH' : pH, 'turbidity' : turbidity }
        #print data
        def myOnPublishCallback():
            print ("Published Temperature = %s C" % temp, "pH = %s %%" % pH, "turbidity = %s %%"
%turbidity ,"to IBM Watson")

        success = deviceCli.publishEvent("IoTSensor", "json", data, qos=0,
on_publish=myOnPublishCallback)
        if not success:
            print("Not connected to IoTF")
        time.sleep(1)

        deviceCli.commandCallback = myCommandCallback

# Disconnect the device and application from the cloud
deviceCli.disconnect()
```

b. Feature 2

OUTPUT



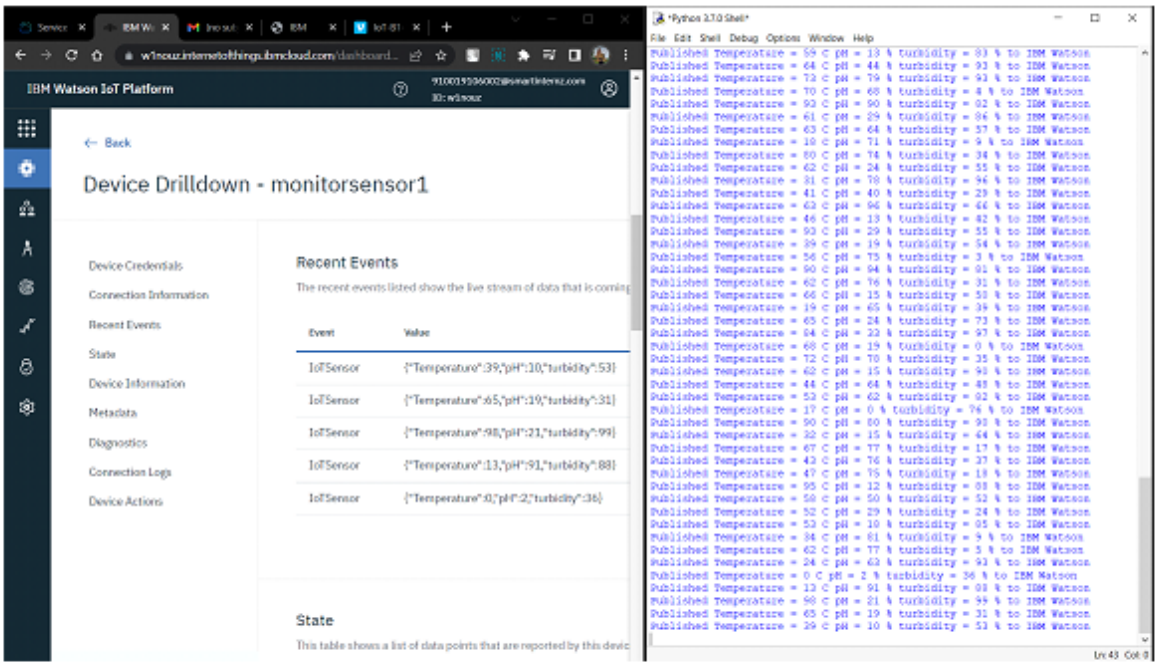


Fig 1

TESTING:

a. Test Cases

b. User Acceptance Testing

RESULTS:

a. **Performance Metrics**

ADVANTAGES:

- IoT-based water quality monitoring application is beneficial in treating wastewater before it is transferred to freshwater bodies. Vital parameters such as turbidity, pH, and temperature can be easily studied using the sensors. This is also important for safely carrying out agricultural activities.

- No one intends to hamper the crop production quality. Water suspended with toxic elements can negatively affect crop growth and health. The IoT technology can stop this by smartly monitoring.

- Some other advantages are:
    - >> Informative Insights
    - >> Illustrative Historical Reports,
    - >> Preventive maintenance checks,
    - >> Instant alerts,
    - >> Seamless communications,
    - >> Cost reduction,
    - >> Scalable solution,
    - >> Multiple alerts.

DISADVANTAGES:

- Proper server maintenance is needed.
- Real-time running errors can't be neglected.

CONCLUSION:

Monitoring of Turbidity, PH & Temperature of Water makes use of water detection sensor with unique advantage. The system can monitor water quality automatically, and it is low in cost and does not require people on duty. So the water quality testing is likely to be more economical, convenient and fast. The system has good flexibility. Only by replacing the corresponding sensors and changing the relevant software programs, this system can be used to monitor other water quality parameters. The operation is simple. The system can be expanded to monitor hydrologic, air pollution, industrial and agricultural production and so on. It has widespread application and extension value. By keeping the embedded devices in the environment for monitoring enables self protection (i.e., smart environment) to the environment. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through

the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi.

FUTURE SCOPE:

- Detecting the more parameters for most secure purpose
- Increase the parameters by addition of multiple sensors
- By interfacing relay we controls the supply of water
- Other parameters which was not the scope of this project such as total dissolved solid, chemical oxygen demand and dissolved oxygen also be quantified.

APPENDIX:

➤ **PROJECT DEMO LINK**

➤ **GITHUB LINK**

➤ **PRESENTATION LINK**