INTERNSHIP

in

INTERNET OF THINGS

by

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Contents

Chapter 1

Introduction

My internship at ICFOSS started at 18 June 2018,we initially formed a group of three to work on project on open-IOT(Internet Of Things). later two other members joined the team.Our project was to create a system of edge devices that monitor the sources and amount of water pollution in the Thettiyar River that flows through Techno park and its neighboring areas. Each individual device monitors several parameters of water quality such as dissolved oxygen, turbidity, temperature and humidity. The devices are then connected over the LoRa network and transfer data to the Things Network cloud. The data from the cloud is then stored in a database which is consequently used for visualization and analysis. Our project aims to identify the major sources of pollution of the Thettiyar River and also collect data regarding the level of contamination of the river so that it can be used to take necessary action to preserve the river.

Chapter 2

Project Overview

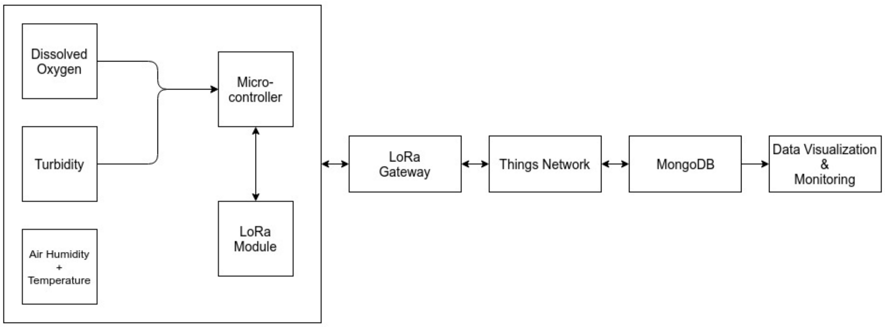

Figure 2.1: Block diagram

we introduce a way to identify the source of pollution by the use of IoT Technology . This can be done by measuring PH as well as the oxygen level of water. This data can be processed and transmitted to cloud using Lora Technology and visualized using D3.js

Water quality is identified by using different parameters such as pH, Dissolved Oxygen , Turbidity, Air Temperature and Air Humidity.

pH holds an important part of determining whether aquatic life can use it or not. They greatly influence the availability and solubility of all chemical forms in the lake and may aggravate nutrient problems, the high pH level

may be affected from the high algae and water plant growth. The pH scales from 0 to 14, and the normal lake waters hovers between 6.5 to 8.5.
High levels of nutrients fuel algae blooms, which can initially boost dissolved oxygen levels. But more algae mean more plant respiration, drawing on DO, and when the algae die, bacterial decomposition spikes, using up most or all of the dissolved oxygen available. This creates an anoxic, or oxygen-depleted, environment where fish and other organisms cannot survive. Such nutrient levels can occur naturally, but are more often caused by pollution from fertilizer runoff or poorly treated wastewater, the DO level of a shallow water in the lake supposed to be around 4-15 mg/L, the higher the better for freshwater fish to survive.
Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. Particulate matter can include sediment - especially clay and silt, fine organic and inorganic matter .High turbidity can significantly reduce the aesthetic quality of lakes and streams, having a harmful impact on recreation and tourism. It can increase the cost of water treatment for drinking and food processing. It can harm fish and other aquatic life .

Temperature is also important because of its influence in water chemistry. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life.
The proposed method help to analyze the source of pollution through an effective way.

Chapter 3

Learning Outcome

Internship at ICFOSS made me learn a great deal of things. I came in touch with lot of existing implemented ,non-implemented technology as well as learned some things about some of the of upcoming technology. ICFOSS provided us software as well as hardware support and guidance for completion our project. Heres some of the things i learned while working on the project.

3.1 LoRa

LoRa is a patented digital wireless data communication IoT technology developed by Cycleo of Grenoble, France, and acquired by Semtech in 2012. LoRa uses license-free sub-gigahertz radio frequency bands like 169 MHz, 433 MHz, 868 MHz (Europe),915 MHz (North America) and 865-867MHz (India). LoRa enables very-long-range transmissions (more than 10 km in rural areas) with low power consumption.
LoRaWAN is the network on which LoRa operates, and can be utilized by IoT for remote and unconnected industries. LoRaWAN is a media access control (MAC) layer protocol for managing communication between LPWAN gate-

ways and end-node devices, maintained by the LoRa Alliance. LoRaWAN defines the communication protocol and system architecture for the network, while the LoRa physical layer enables the long-range communication link. LoRaWAN is also responsible for managing the communication frequencies, data rate, and power for all devices. As LoRa can be used to achieve large range communication as well as ultra low power consumption, it was the perfect technology for our project. The end device we wanted to install on various parts of thettiyar could use same gateway. Also it could be powered on same battery for years without manual recharging.the drawbacks i learned of LoRa WAN is that it can only be used for low data rate applications, also it requires a LOS for uplinking and downlinking.

3.2 Things Network

The Things Network is building a network for the Internet of Things by creating abundant data connectivity. It uses LoRa WAN technology for achieving this. In our project we used community version of Things network. It provides each user privilege to create their own personal applications as well as to add their own gateway to extend the LoRa network.in each application we can add number of LoRa devices. we can register each device either by ABP method or OTA method.

- **Over-the-Air Activation (OTAA)** is the most secure way to connect with The Things Network. Devices perform a join-procedure with the network, during which a dynamic DevAddr is assigned and security keys are negotiated with the device.

- **Activation by Penalization (ABP):**Using ABP join mode requires the user to define the following values and input them into both the device and Things network: Device Address, Application Session Key,Network Session Key.

The data from each device received as a series of bytes.These bytes can be encoded from the end node. which can be decoded and represented in suitable form by using payload formatting option.The bytes will be represented in hex code,so while decoding each byte has to be left shifted(8 bits) to correctly represent the data.

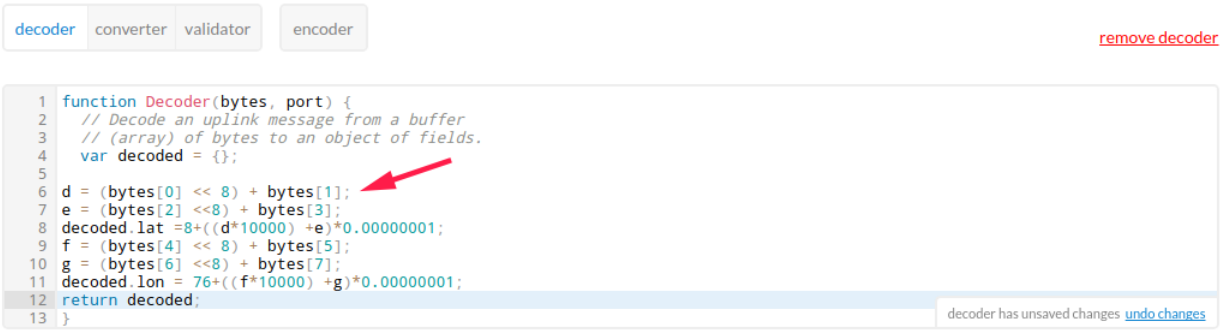

Figure 3.1: Example of payload formatting

Things network provides various integrations such as Swagger(NoSql Storage) ,http integration(To provide a an external api access to the data from the devices.)In our project we designed and implemented an api on our sever and connected it as an integration to fetch the water quality data from the things network.

3.2.1 Things UNO

It is one of the hardware product of things Network.The Things Uno is based on the Arduino Leonardo (not the Arduino Uno) with an added Microchip LoRaWAN module. It is fully compatible with the Arduino IDE and existing shields.The Things Uno was designed with a low barrier for building

Figure 3.2: Things UNO

proof of concepts for IoT projects using LoRaWAN in mind. Make an existing project wireless with up to 10km range by simply swapping the current Arduino board with the Uno. It is an Arduino Leonardo based embedded SBC solution with an integrated Microchip LoRaWAN (Long Range WAN) RN2483 module and on-board antenna.

3.3 LoRa32u4

LoRa32u4 is a light and low consumption board based on the Atmega32u4, a 433MHz LoRA module RA02 from AI-Thinker and an LiPo/Li-ion USB battery charging circuit.The RA02 LoRa module is fitted with an U.FL (IPX) external antenna connector.

The ATmega32u4 is clocked at 8 MHz and 3.3 V. This chip has 32 K of flash, 2 K of RAM and built-in USB to Serial communication allowing debugging and programming capabilities without the need for an external FTDI chip, it can also act as an USB HID device (mouse, keyboard, USB MIDI device, etc).

This board is equipped with a LiPo and Li-ion charging circuit and a standard battery interface. It is fully compatible with Arduino. A white user led is tied to pin 13. An orange LED is showing battery charging status.

Specifications:

- ATmega32u4 @ 8MHz with 3.3V logic/power
- 3.3V regulator with 500mA peak current output
- USB native support, comes with USB bootloader and serial port debugging
- Hardware Serial, hardware I2C, hardware SPI support
- SX1278 RA02 LoRa based module with SPI interface
- 8 x PWM pins
- 10 x analog inputs
- +5 to +20 dBm up to 100 mW Power Output Capability (selectable in software)
- 300uA during full sleep
- 120mA peak during +20dBm transmit
- 40mA during active radio listening.
- U.FL (IP) antenna connector

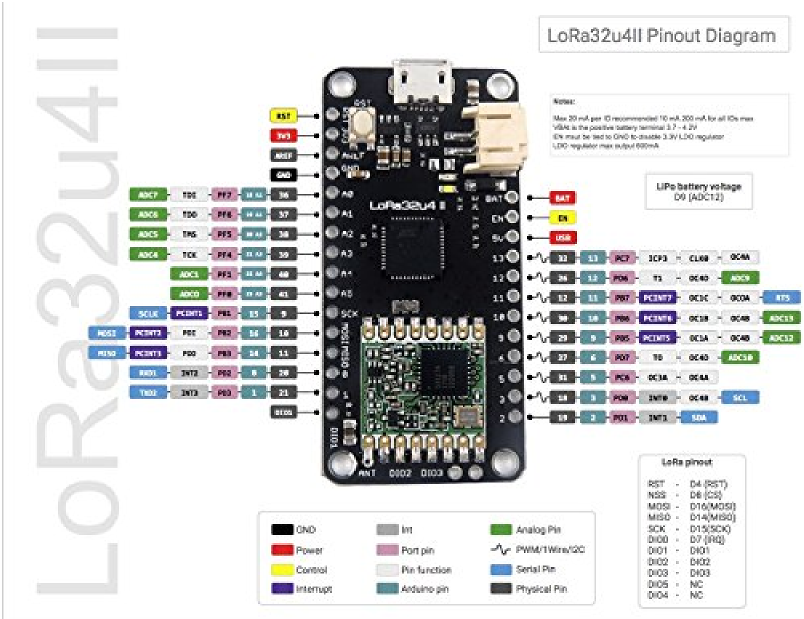

Figure 3.3: lora32u4 pinout

3.4 Sensors

We mainly used three sensors in this project.

- Dissolved oxygen sensor.
- Turbidity sensor.
- Air temperature and humidity sensor.

3.4.1 DO Sensor(SEN0237-A)

This is a dissolved oxygen sensor kit, which is compatible with Arduino micro controllers. This product is used to measure the dissolved oxygen in water, to reflect the water quality. It is widely applied in many water quality applications, such as aquaculture, environment monitoring, natural science and so on.

Figure 3.4: Analogue Dissolved Oxygen Sensor

Theory:

The dissolved oxygen sensors are mainly of three types:

1. Optical Dissolved Oxygen Sensors
2. Electrochemical Dissolved Oxygen Sensors
3. Polarographic Dissolved Oxygen Sensors.

Considering feasibility,availability etc... we chose electrochemical sensors though it requires some maintenance over time. There are two types of electrochemical DO sensors: galvanic and polarographic.our sensor uses a galavanic probe.Both galvanic and polarographic DO sensors use two polarized electrodes, an anode and a cathode, in an electrolyte solution. The electrodes and electrolyte solution are isolated from the sample by a thin, semi-permeable membrane.When taking measurements, dissolved oxygen diffuses across the membrane at a rate proportional to the pressure of oxygen in the water . The dissolved oxygen is then reduced and consumed at the cathode. This reaction produces an electrical current that is directly related to the oxygen concentration . This current is carried by the ions in the electrolyte and runs from the cathode to the anode. As this current is proportional to the partial pressure of oxygen in the sample , it can be calculated by the following figure:

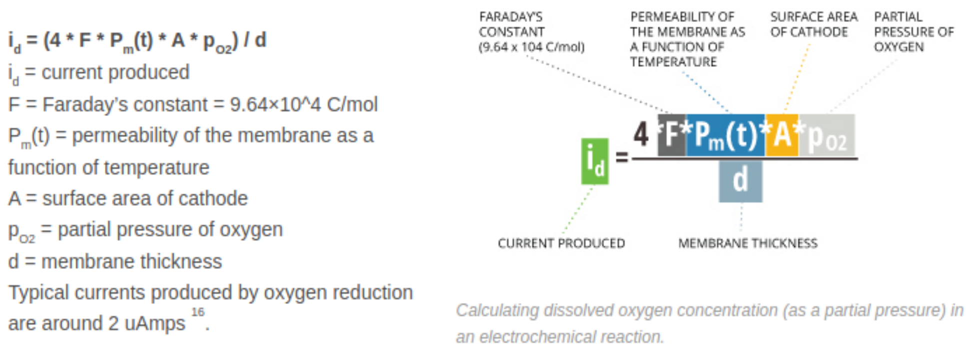

Figure 3.5: Dissoved oxygen current equation

Working:

For a new dissolved oxygen probe, 0.5 mol/L NaOH solution should be added into the membrane cap firstly as the **filling solution**.This solution had to prepared from chemistry lab of CET, by dissolving **2g NaOH crystals in 100ml distilled water.** The procedure to fill the solution is given in figure below. The output signal from the probe is then converted to voltage range of

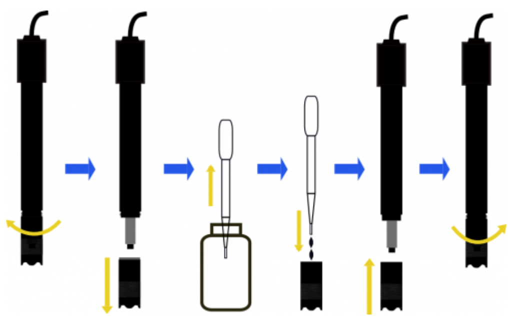

Figure 3.6: Filling the membrane cap

0-5 v using a signal converter board.The output analogue signal from signal converter board is fed to the lora32u4. At first, we have to calibrate the sensor in fresh water at constant temperature.As permeability of the galvanic probe also depends upon temperature ,the resulting voltage variation may not be that of DO variation. Thus temperature compensation must be reduced in the output.This can be done in arduino code.Temperature compensation can be calculated by using a table of saturated DO value at different temperature stored in the **EEPROM**.we used sample code provided by DFrobot.com for calibration and modified it for actual implementation(for memory and performance optimization). dissolved oxygen value equation:

$$doValue = Voltage \ / \ SaturationDoVoltage \ {*}SaturationDoValue(with \ temperature \ compensation)$$

The sensor probe can be dipped in any flowing/still waater bodies and do value can be obtained.

3.4.2 Turbidity Sensor(SEN0189)

The gravity arduino turbidity sensor detects water quality by measuring the levels of turbidity. It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. Turbidity sensors are used to measure water quality in rivers and streams, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research and laboratory measurements. This liquid sensor provides analog and digital signal output modes. we used analogue mode for our application.
The output voltage signals had to converted to NTU(Nephelometric Turbid-

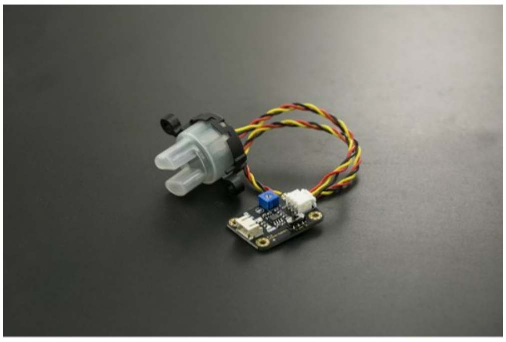

Figure 3.7: Turbidity sensor

ity Units) By using following graphical data.

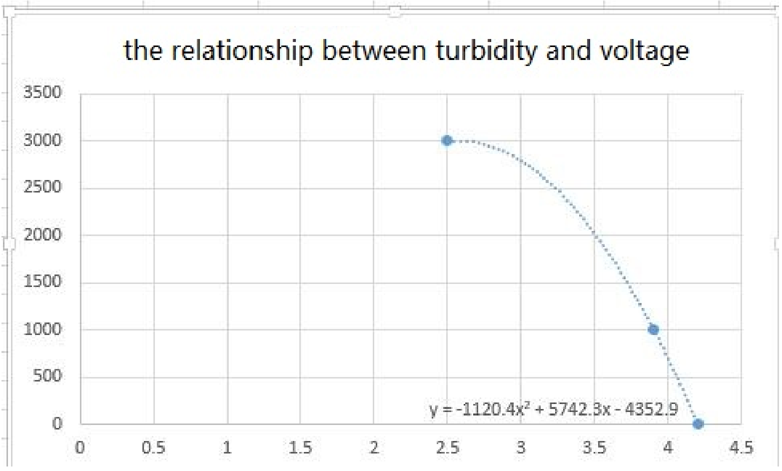

Figure 3.8: Relation between voltage and NTU

firstly we have to convert 0-5v voltage output to 2.5-4.13 v range. secondly,we have to convert the voltage to NTU by implementing the above quadratic equation.

Due to memory limitation of lora32u4 and for ease of transmitting the data all the above conversions are done in payload formatting of Things network console.

```
//turbidity
vol=  (bytes[6]<<16) | (bytes[5]<<8) |bytes[4];
vol1= vol*0.01;decoded.value = vol1;
x= (0.327309*vol1)+2.493455;decoded.val=x;
tur = (-1120.4*(x*x))+(5742.3*x)-(4352.9);
decoded.turbidity = tur ;
```

Figure 3.9: voltage-voltage-NTU conversion

3.4.3 Air temperature/Humidity Sensor (DHT11)

As DO sensor requires temperature value , we used a air temperature moodule to measure the temperature also normalize it to water temperature.(Water temperature sensor is in the proposed model, due to non availability dht11 considered.) Also temp/humidity value helps for proper maintenance of node. The DHT11 measures relative humidity. Relative humidity is the amount of water vapor in air vs. the saturation point of water vapor in air. At the saturation point, water vapor starts to condense and accumulate on surfaces forming dew. The saturation point changes with air temperature. Cold air can hold less water vapor before it becomes saturated, and hot air can hold more water vapor before it becomes saturated.

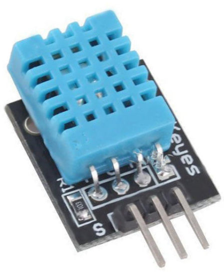

Figure 3.10: DHT11 sensor

The DHT11 detects water vapor by measuring the electrical resistance be-

tween two electrodes. The humidity sensing component is a moisture holding substrate with electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes.
The dht11 outputs digital value,hence a library named **dht.h** for measurment.the signal pin of dht11 connected in a digital pin of lora32u4(pin:10). specify the pin, then temperature and humidity can be read by following lines of code in *void Loop()*:

$$int\ chk = DHT.read11(DHT11_PIN);$$
$$int\ temp = DHT.temperature;$$
$$int\ hum = DHT.humidity;$$

3.5 LoRa32u4 Coding

Lora32u4 comes with a usb connector and programmer.it can be programmed with arduino IDE. lora32u4 uses ATmega32u4 board. in order to program it we have to add the **Adafruit feather32u4** board from the Adafruit avr board packages.

it uses a Rfm95 model lora module, so **Imic.h** can be used to program the up linking and down linking of data. we use ABP personalization method so we add dev address,network session key and app key to link the device to lora.we can define it as static global variables of the code.

imic.h works on a OS concept, It waits for a free channel,doing other operations in void loop at the time. It transmits the data when it gets a free channel.it also listens for a downlink.

All of our sensor data read to variables in a struct variable.Then the struct variable is converted to bytes and transmitted using *void dosend()* function.Inorder to avoid any floating/null data all the sensor readings are taken inside *void dosend()* function.

Chapter 4

Conclusion

The forty-five day internship at ICFOSS has given me so much experience and knowledge, that will be helpful for my career. I got much exposure on many technologies such as LoRa WAN. ICFOSS given most the hardware/software requirements for our project,Also Good working environment and expert guidance from our mentors.During the time at internship i realized the importance of open source community in realizing and implementing latest technology in good and efficient use. I wish to contribute my maximum to open source community throughout my career.
we were able to complete the prototype of our project, the full product requires much more efficient power supply system, more senors, More compact casing etc...The product also requires much more research in making it more cost-effective,reliable and durable.I hope that this product will be realized and installed on prominent water bodies such as Thettiyar in order to monitor and control the pollution level in it.