LORA BASED WSN SYSTEM FOR FLASH FLOOD DETECTION AND ALARMING

PROJECT REPORT

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to

the APJ Abdul Kalam Technological University
in partial fulfillment of the requirements for the award of the Degree

of

Bachelor of Technology
in
Electronics and Communication Engineering

Department of Electronics and Communication Engineering

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JUNE 2020

DECLARATION

We undersigned hereby declare that the project report "LoRa based WSN System for Flash Flood Detection and Alarming", submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under the supervision of Prof. Riyas K S. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

This is to certify that the report entitled **LoRa based WSN System for Flash Flood Detection and Alarming** submitted by **Joyalin Mary Mathew(KTE16EC035), Muhammad Bilal S.(KTE16EC042), Vishnupriya K.(KTE16EC060)** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering is a bonafide record of the project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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ACKNOWLEDGEMENTS

The success accomplished in this project report would not have been possible without the timely help and guidance tendered by many people to whom I feel obliged and graceful.

Firstly, we thank God almighty for his blessings, for guiding us in the selection of this topic and shining the light in our path without which we would have stumbled upon many obstacles.

We are thankful to Dr. JALAJA M. J., honourable Principal of Rajiv Gandhi Institute of Technology, Kottayam for her support and encouragement.We express our sincere thanks to Dr.CIBILE K. KANJIRATHUMKAL, Head of Electronics and Communication Department for her support and guidance throughout.

We use this occasion to express our deep and profound feelings of gratitude to Prof. RIYAS K. S., our guide for the help and suggestions he rendered in the right time, making the success of the project. We would like to express our heartfelt gratitude to Prof. SUJITHAMOL S., the co-ordinator for giving us instructions and for being the hand behind us that ensured the successful completion of our project.

We would also like to put across our profound appreciation to the ICFOSS organisation for the help they have done by providing us with information about this relatively new technology and helping us in times of dire need. We would like to extend our words of thanks to Mr. P. M. Shaji, who acted as a guide for our inquisitive survey and provided us with invaluable informations that were crucial to the making of our project. We would like to thank all the other faculty members of ECE department who have helped us in the research and documentation of this seminar. Above all, we express our sincere gratitude to our parents and classmates who have helped us to complete this project.

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ABSTRACT

In this project, we propose a system for developing a flood alert system in the Indian environment, particularly in the state of Kerala, which has faced unprecedented flood, causing widespread devastation in the past two years (2018 and 2019). The extent of damage could have been reduced if an early notification system were installed. The designed system uses LoRaWAN protocol to communicate the data, collected using wireless sensor network (WSN). The collected data is processed to detect and alarm the people about the flood. LoRa™ is a wireless modulation technique for long-range, low-power and low-data-rate applications developed by Semtech. The incorporation of this state-of-the-art communication technique which has gained strong momentum (since its inception in 2015) not only reduce the cost factors but also provide a dedicated channel without depending on third-parties.

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LIST OF ABBREVIATIONS

ADR	Adaptive Data Rate
AWS	Amazon Web Service
CSS	Chirp Spread Spectrum
EWS	Early Warning System
GPIO	General Purpose Input Output
HTTP	Hyper Text Transfer Protocol
IMD	Indian Meteorological Department
IoT	Internet of Things
LoRa	Long Range
PSLV	Polar Satellite Launch Vehicle
TTN	The Things Network
URL	Uniform Resource Locator
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

From June to August 2018, the state of Kerala experienced the worst ever floods in its history since 1924. Torrential rain ravaged the state, causing floods and landslides in all its 14 districts. An estimate of 5.4 million people were affected, and about 433 lost their lives. As per the Indian Meteorological Department (IMD) data, the state had received cumulative rainfall that was 42% in excess of the normal average. Due to the rapid onset, this flood was legibly a flash flood and the authorities got very little time to warn the population. The flood hit the state again in the consecutive year, 2019. Even though, the efficiency of disaster management was increased this time, the situation in the state once again pointed to the absence of a scientific flood forecasting.

As indicated and predicted by the Fifth Assessment Report published by the Intergovernmental Panel for Climate Change (IPCC) in 2014 [1], the floods caused by heavy rainfall in a short span of time,can be comprehended as an evident example of global climate change causatum. The major reason for the increased mimpact on the populace was the huge gap between the predicted rainfall data by Indian Meteorological Department (IMD) and the actual rainfall amount. Another reason for the large number of casualties was the lack of proper water control measures like dams in many of the water bodies leading to uncontrolled flow of water. Evidently, the absence of an advanced monitoring system, apart from manually monitoring the water gauges had a noticeable impact on the flood damage. According to latest reports, there is a high possibility of Kerala facing intense rainfall leading to catastrophic flooding for a third year. Experts have emphasized on the need for large scale planning and research to minimize flood-related damages in the future. The idea of flood forecasting and warning is acknowledged as the most important non-structural term for reducing flood damage. An efficient flood forecast system must provide sufficient lead time for communities to respond. A reliable forecast provides as much advance notice as possible of an impending flood to the authorities and the general public.

Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. They are well suited for long term environmental data acquisition and thus can be deployed to monitor and detect the possibility of flood in flood prone areas. They are a beneficial means of carrying out the monitoring of rural as well as urban rivers and other natural environments since they have a number of attractive features like low cost (particularly with regard to the infrastructure), low energy consumption ,the provision of access to inhospitable surroundings, simple to install and are high-precision sensors which are adaptable to environmental changes. In the current system, we get the input data from hydrometeorology flood forecasting [2]. Sometimes these data come after a long time and may be quite insufficient. Therefore, the need to have Wireless Sensor Networks (WSNs) monitored data such as water level and flow of water in river is essential in order to make a reasonable decision on the action necessary to detect flood.

In the proposed system, WSN is implemented using star topology to collect data. LoRa is a wireless connectivity technology supporting the Internet of Things (IoT) system. This technology is an alternative to other wireless connectivity modules that have already been popular such as GSM modules, Wi-fi Modules and Bluetooth (BLE). The use of the LoRa network serves to increase the range of wireless cells that can reach distances up to 15 kilometers while still having low power consumption. Hundreds of nodes can be incoperated within a single LoRa network. Hence, this system has the potential to be implemented in urban as well as rural areas with wide range of connectivity.

According to United Nation International strategy for disaster reduction (UNISDR) the definition of early warning system (EWS) is, "The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss." The cost of damage caused by flooding correlates closely with the warning time. The warning time given before a flood event determines the amount of time and this makes flood monitoring and alarming a critical one in minimizing the same. The focus of this work is to propose a LoRa based Wireless Sensor Network (WSN) system for flash flood detection and alarming which could help to intimate flood well in advance in order to control human loss by evacuating individuals to secure locations and also protect precious characteristics.

1.1 MOTIVATION

The aim of the project is to propose a real time flood monitoring and warning system in the context of vast devastation that occurred in Kerala due to flood. A flash flood, triggered by widespread landslips in the high ranges of Kottayam district caused huge damage including death of many in the low-lying areas of Pala and Kottayam town, located on the river bank of Meenachil River. From the inquisitive survey that we conducted as part of the project, we get into the conclusion that landslips at Adukkam in the Teekoy ranges is the reason for sudden rise in the water level in the Meenachil River. Marmala, a tributary of Meenachil river which is flowing through Teekoy played a crucial part in this upsurge of water in Meenachil river. Marmala originates from Western Ghats and have its major length in less populated area. There is no existing system in the region to alarm people about the increasing water level. By deploying the proposed system in the various geographically important areas along the river length, the possibility of flood can be detected and precautions can be taken timely leading to low number of casualties.

1.2 ORGANISATION OF REPORT

The report begins with introduction and significance of the work in Chapter 1 followed by an extensive survey on the literature in Chapter 2. A description of the proposed system is given in Chapter 3 followed by hardware and software descriptions in Chapters 4 and 5 respectively. In Chapter 6, a detailed account of the inquisitive survey that we conducted as a part of this work is given. In Chapter 7, performance evaluation and results of the project are provided. Finally, the report is wrapped up with the conclusion in Chapter 8.

CHAPTER 2

LITERATURE SURVEY

Early warning systems are an integral component of Disaster risk management process and an extension of weather forecast. It aims to provide the communities with information on relevant variables like rainfall as well as advisory information so that they can assess the level of risks based on their experience and have the option to undertake informed decisions. Continuing with the prevalent models, for a long time, two early types of flood detection and warning systems have been established: A) Non-Wireless Sensor Network and B) Wireless Sensor Network

2.1 NON-WSN SYSTEMS

Non-WSN systems can be broadly classified into two: Traditional manually operating system and satellite and telemetric system.

2.1.1 Traditional manually operating system

Several methods have been developed to tackle the issue of flood detection over time. The conventional methods had a larger involvement of humans than in the current system. In the earlier days, rain gauges where used which required manual observation and emptying at regular intervals. As technology advanced, the system started to be more and more automated. Alert gauges that sensed and communicated data on rainfall were developed. The communication could be via radio, cellular and satellite telemetry. An improvement to the alert gauges was the integrated data logging system that used radar water level sensor and communicated data via satellite. While the alert gauges only checked for rainfall, the data logging system checked for the presence of flood. Neither of these methods proved effective in case of predicting flood.

2.1.2 Satellite and Telemetric system

The current system in India uses satellites for both detection and alarming. The satellite used by Indian Meteorological Department (IMD) is INSAT-3D/3DR, which was developed and launched by Indian Space Research Organization in July 2013. It is an advanced weather satellite with improved Imaging System and Atmospheric Sounder. It is designed for enhanced meteorological observations, monitoring of land and ocean surfaces, generating vertical profile of the atmosphere in terms of temperature and humidity for weather forecasting and disaster warning. It provides rapid and valuable information on cloud patterns and meteorological parameters. Even though they are useful in flood localization they fail to image the surface water conditions in presence of clouds. Microwave remote sensing techniques have unique advantage in which electromagnetic radiation penetrate the clouds and senses the surface hydrological characteristics. SCATSAT-1 is one such satellite providing weather forecasting, cyclone prediction and tracking services to India. The data from SCATSAT-1 (launched by PSLV-C35) was used for the detection of flood situations over India. The studies show that even though SCATSAT-1 mission in detecting and monitoring extreme events such as flood showed high temporal resolution it also failed when it comes to prediction. Recent developments have led to automated telemetry systems. Even these are expensive as they require periodic installation of repeaters and transmitters. Most of the telemetric systems follow a centralized computational technique. Also, deployment of a large number of telemetric systems to cover the entire region becomes impractical due to the large expenses involved. In spite of having these issues, the non-WSN systems are operating in many countries in the world.

2.2 WIRELESS SENSOR NETWORK (WSN) SYSTEMS

Wireless Sensor Network (WSNs) can be defined as low power, low cost, multi-hopping systems that are independent of external service providers, which can form an extendable network without line of sight coverage. Every node in a Wireless Sensor Network (WSN) can act as a data acquisition device, a data router and a data aggregator. This architecture maximizes the redundancy and the reliability of the entire flash-flood monitoring system. Nowadays, almost all the flood forecasting systems available are WSN-based as in [3][4][5]. In majority of the data-driven statistical flood-prediction models, details of the landscape, soil composition, and land cover, along with atmospheric conditions and hydro-meteorological measurements like soil moisture are required as in [3][4]. Reference [6] suggests a distributed node deployment to ensure proper communication in a WSN. The proposal of [7] puts across the table, a monitoring system that focuses on floods. According to this proposal, sensor networks must be topographically distributed along a body of water(say a river). Although the sensors that are implemented in this proposal are not specified, they have mentioned that this architecture measures variables such as river water level, rainfall, wind speed data, and air pressure. Here the communication used is Xbee protocol.

The communication protocol chosen for the development of this prototype is LoRa since it is a wireless communication protocol that has a considerable range of about 15 km. Compared to other wireless technologies like Wi-Fi, Bluetooth, Zigbee etc, Lora offers multiple benefits like low power consumption, long range and network capacity. In a work done by [8], we can see the potential of the LoRa communication protocol, because it performs a series of tests to determine the range of the loss of data packets. It carries out its tests in forest environments along river banks in different settings (urban, semi-urban and rural) and describes in detail the characteristics of the places where the tests were carried out.

Elizabeth Basha et.al. has implemented an Early Warning Flood Detection System, in Honduras[9]. The system is the closest that has come to implementing a successful flood alert system. The work of Elizabeth Basha has helped us a lot along our project by giving us the basic grounds to work on. The system mainly consists of four operations as sensing, computation, government and office interface, and community interface. To get the information related to the river flooding they measure the river level, rainfall and air temperature at the different nodes which are powered by the solar panels. It allows model-driven control for optimizing the prediction capability of the system. The authors have used a centralized form of the prediction model, with a network implementation and element testing. Deployed on the banks of river in Massachusetts, they got the effective results of the experiments on-field. In this system a few number of nodes are deployed across river basin and a unique heterogeneous communication system is used for reading real-time sensing of data, self-monitoring for failure and adaptation of measurement schedules is done to capture disaster events.

CHAPTER 3

SYSTEM DESCRIPTION

This project demands the deployment of a Wireless Sensor Network in flood prone areas which constantly monitors the environmental parameters such as water flow rate, water level etc. The wireless network should be a standalone network which is independent of third parties. The instantaneous data collected by the sensor network is uploaded to an internet server through the intermediate relay station ie, the gateway. Once the server is capable of instantaneously receiving the environmental parameters, the data can be used to assess the situations and the authorities can act upon it. Moreover, the installation of alarm points makes the situation much easier to handle.

The proposed system can be subdivided into three. (i) A Monitoring System which constantly monitor the fluid parameters using a wireless sensor network; (ii) A Data Management System which collect, process, analyze and interpret the data and (iii) An Alarming System which receives the triggers from the server and sounds the alarm based on the received trigger.

3.1 BLOCK DIAGRAM

Figure 3.1 Block diagram of the proposed system

3.2 BLOCK DESCRIPTION

3.2.1 Monitoring System

Determining the exact water flow parameters from a water body especially during flood conditions is one of the challenging tasks that has to be primarily accomplished. Deploying a single water flow sensor in an area to measure the water flow parameters such as speed, pressure, level and quantity will not be enough to get accurate results since the turbulent flow of water is highly unpredictable in nature (especially during the course of floods). The installation of sensor network over an area is an effective resolution to overcome the crisis. Taking the mean value of the sensor outputs increases the accuracy of measurement, thereby contributes to the exact extraction of a clear picture. Key elements of the Monitoring System are described in the following pages.

(i) Wireless Sensor Network (WSN)

Wireless Sensor Networks are one of the emerging technologies particularly used for the purpose of data collection. It can be defined as a network of devices (say sensors) that can communicate the information gathered from a monitored field (say flood prone areas) through wireless links. An embedded system having a Lora Module, a micro-controller and an antenna is interfaced with the sensor since the sensor itself is not capable of sending information through a wireless channel. The embedded system (ie the transmission unit) along with the sensor is termed as a Node. The data gathered by the sensors is forwarded through multiple nodes. This data is connected to other networks like wireless Ethernet via a gateway acting as a Central Hub or a Base Station.

Based on the architecture, the topology of a Wireless Sensor Network can be divided into to two. (a) Star topology – in which each sensor node individually communicates with the Base station and there will not be any direct communication between two sensor nodes(Figure 3.2). (b) Mesh topology – in which each sensor node can communicate with other nodes and thereby establish communication with the Base Station(Figure 3.3).

The Wireless Sensor Network (WSN) referred here is a network composed of a finite set of ultrasonic sensors (for water level detection) and water flow sensors(flow rate determination) geographically distributed in flood prone environment. It gather environmental data and transmits the data into the gateway. In this work, Star Topology is used in order to avoid the inter-nodal communication breaks and to increase the speed and reliability of the system by reducing the workload of individual nodes.

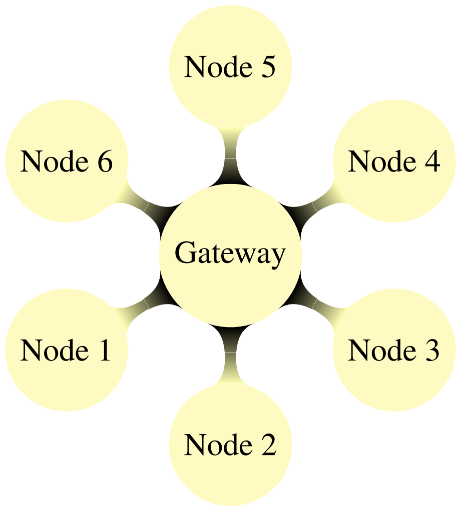

Figure 3.2 Star Topology

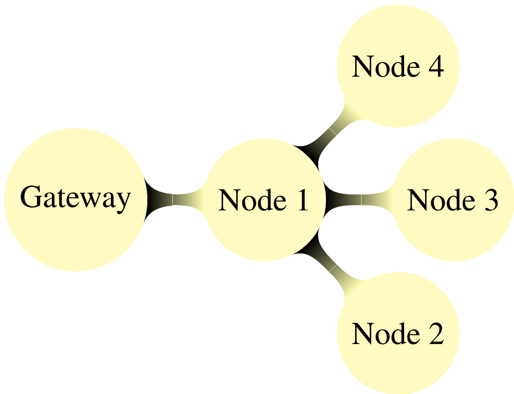

Figure 3.3 Mesh Topology

(ii) LoRaWAN

For decades, wireless developers faced the dilemma of choosing between longer range and lower power consumption. Even though there are many existing devices used for wireless communication like Zigbee wireless technology, GPS, Bluetooth, Wi-Fi, satellite etc. all of them failed in balancing these two strategies.comparison between the previously used techniques and LoRa technology is given in Table 3.1. With the growing Internet of Things, Microchip offers wireles.s technology solutions to address increasing demands for end devices that need long range connectivity, low-power battery operation and low infrastructure costs for volume deployment. [10] LoRa (short for Long Range) is a low power wireless standard intended for providing low data rate communication, mainly targeted for machine to machine and IoT networks. LoRaWAN offers a very compelling mix of long range, low power consumption and

Attributes	Bluetooth	Zigbee	Wi-Fi	LoRa
Transmission distance	10-100 m	10-100 m	300 m	15 km
Maximum signal rate	1 Mbps	250 kbps	54mbps	0.3-50 Kbps
Nominal Tx power	0-10 dBm	(-25)-0 dBm	15-20 dBm	20dBm
Channel bandwidth	1 MHz	2 Mhz	22 MHz	125 KHz, 500 KHz
Modulation type	GFSK	BPSK(+ASK) ,O-QPSK	BPSK, QPSK	Chirp Spread Spectrum Modulation
Operating frequency	2.4 GHz , 5 GHz	2.4GHz	868 MHz, 915 MHz,2.4 Ghz	433 MHz, 868 MHz, 928 MHz
Battery life	1-7 days	3-5 years	Hours	10 years

Table 3.1 Comparison between the different communication techniques

secure data transmission, making it one of the top technology choices for battery-powered end-devices that need long range connectivity. The other key features include,

a. Low cost: Reduces costs three ways: infrastructure investment, operating expenses and end-node sensors

b. Standardized: Improved global interoperability speeds adoption and roll out of LoRaWAN-based networks and IoT applications

c. Geolocation: Enables GPS-free, low power tracking applications

d. Unlicensed spectrum

Several studies are being conducted on LoRaWAN and its applications. Various LoRa parameters are discussed below.

(a)LoRa versus LoRaWAN

LoRa is a physical layer modulation technique, which enables the long-range communication. LoRaWAN on the other hand, is a standardized MAC layer protocol which defines the various specifications of the communication(refer figure 3.4). These two terms are not indistinguishable and the protocol stack shown below is an indication of this fact. LoRa enables peer to peer communication between nodes by using the LoRa modulation developed by Semtech. LoRaWAN implements the communication protocol and system architecture for the network. It was developed by LoRa Alliance to ensure interoperability among devices.LoRa follows IEEE802.11ah protocol of wireless communication.IEEE 802.11ah is a wireless networking protocol published in 2017 to be called Wi-Fi HaLow.The protocol's low power consumption competes with Bluetooth and has the added benefit of higher data rates and wider coverage range.

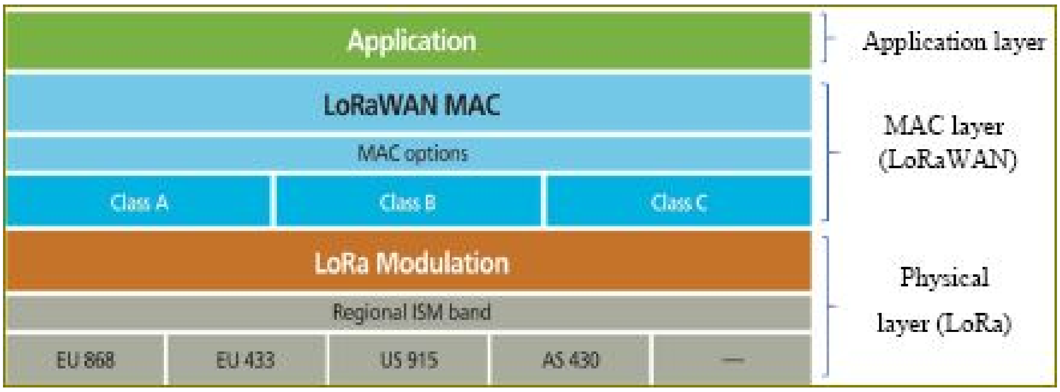

Figure 3.4 LoRa vs. LoRaWAN

(b)Adaptive data rate (ADR)

The Long-Range Wide Area Network (LoRaWAN) baud rates range from 0.3 kbps to 50 kbps which is more than sufficient for most remote monitoring applications like in the case of this project. The communication between nodes using LoRa can be established using multiple data rates and frequencies depending upon the requirements. This flexibility is widely known as Adaptive Data Rate (ADR) scheme. Adaptive data rate is a mechanism for altering the data rate for the network. LoraWAN devices comes with three classes of functionalities viz. Class A, B and C(Figure 3.5). Each class have different data rate and power consumption. One may select the class of operation based on the requirements. Here, Class A mode of operation is used where the power consumption is comparatively very low and matches with the requirements of the project.

The communication from the server to the End-device is termed as downlink communication and the reverse is called uplink communication. Only uplink communication is used in the work since the requirement is to solely monitor the environmental conditions using the sensor network and not to activate any actuators.

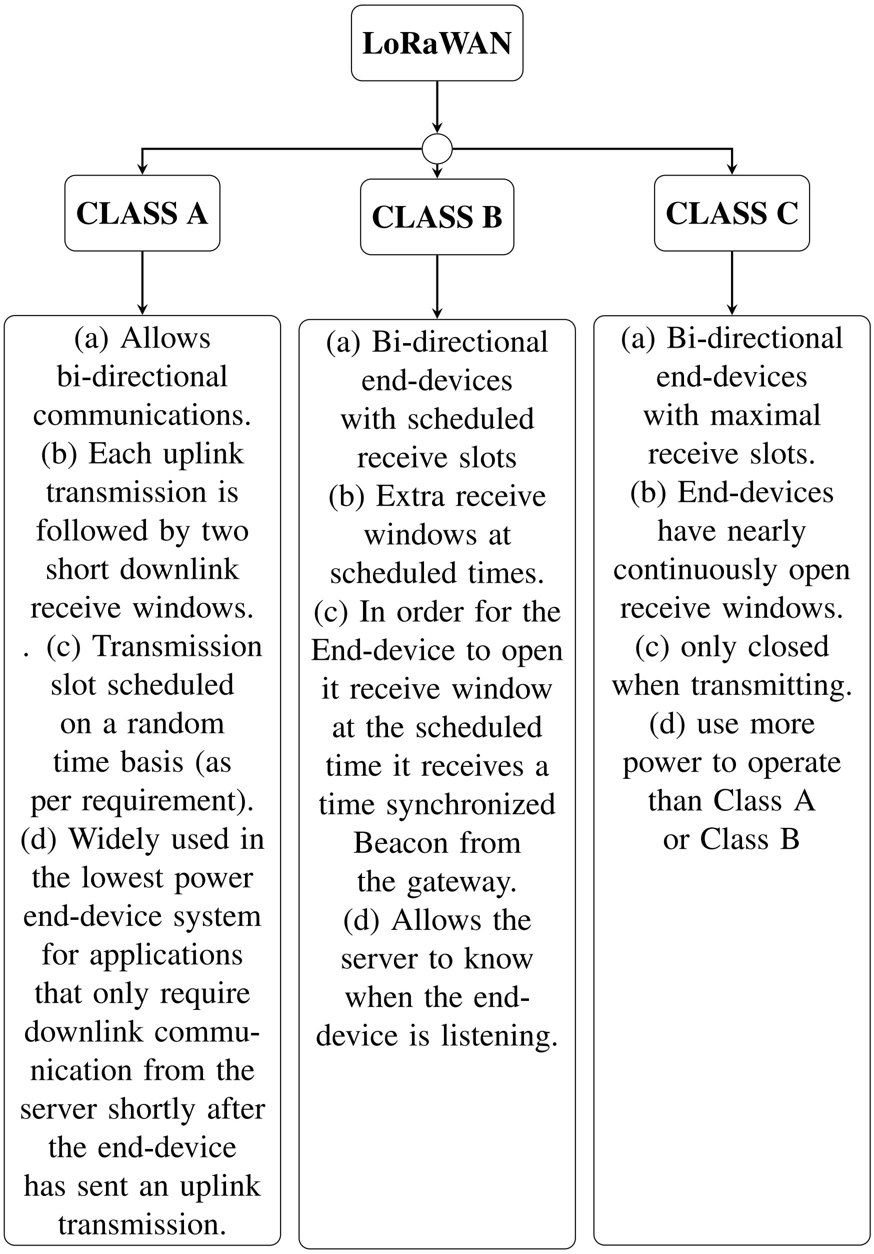

Figure 3.5 LoRaWAN Classification

(c)Spread Spectrum, bandwidth and spreading factor

In LoRa modulation technique, spreading of spectrum is obtained by generation of a chirp signal which varies continuously in frequency. Thus, the modulation technique is known to be **Chirp Spread Spectrum Modulation (CSS)**. The key feature of this modulation technique is that it keeps equal timing offset and frequency offset between the LoRa transmitter and receiver modules. This avoids complex algorithms and makes the receiver design very simple. Moreover, frequency bandwidth of chirp is equivalent to spectral bandwidth of the LoRa modulated signal. CSS uses its entire allocated bandwidth to broadcast a signal, making it robust to channel noise. CSS is more robust modulation technique compare to other spread spectrum techniques such as DSSS. Further, because the chirps utilize a broad band of the spectrum, chirp spread spectrum is also resistant to multipath fading even when operating at very low power. CSS is resistant to the Doppler effect, which is typical in mobile radio applications. It addresses all the issues encountered in the DSSS and at the same time provides low cost and low power-based solution. The relationship between bit rate, code rate and symbol rate of LoRa modulation is given by,

$$R_b = SF.\frac{\frac{4}{(4+CR)}}{\frac{2^{SF}}{(BW)}}.1000$$

where

R_b- Bit Rate or Data Rate in bps

SF- Spreading Factor (6,7,8,9,10,11,12)

C.R- Code Rate (1,2,3,4)

BW- Bandwidth in KHz.

LoRa uses 3 bandwidths 125 kHz, 250 kHz and 500 kHz (we use 125 kHz since this is the bandwidth suited to Indian region, as per ISM band regulations) whose entire portion is used by the chirp signal. The duration of the chirp is determined by the spreading factor. In keeping with the bandwidth, the device itself chooses a spreading factor based on regional parameters specified by regulations. As the spreading factor increases, for the same bandwidth, the time on air increases hence the data rate per unit time decreases. For different regions, LoRaWAN uses a different configuration of bandwidth, spreading factor and data rate.

3.2.2 Data Management System

The next task that has to be done immediately after the monitoring and transmission of environmental parameters is the collection of transmitted data and to process them at the server level. The Data Management System includes the cloud platforms which are used to store, compute and represent them in various formats and the inter-communication between various cloud platforms for further analysis, storage and research. Moreover, we can make use of various cloud computing techniques to systematically analyze the collected data and can develop algorithms that helps in the prior prediction of the floods.

In this project, **The Things Network (TTN)** is the cloud service used for the purpose of Cloud Computing that performs the processing of the transmitted data. It is a global community having more than 8000 members from over 100 countries across the world. This platform is completely free for the LoRaWAN users abiding to certain rules for the regulation of gateway traffic. The network is also flexible as it allows third party integrations such as Tago IO, Amazon Web Service (AWS), ThingSpeak etc which can be linked to the TTN server for the inter-transfer of data.

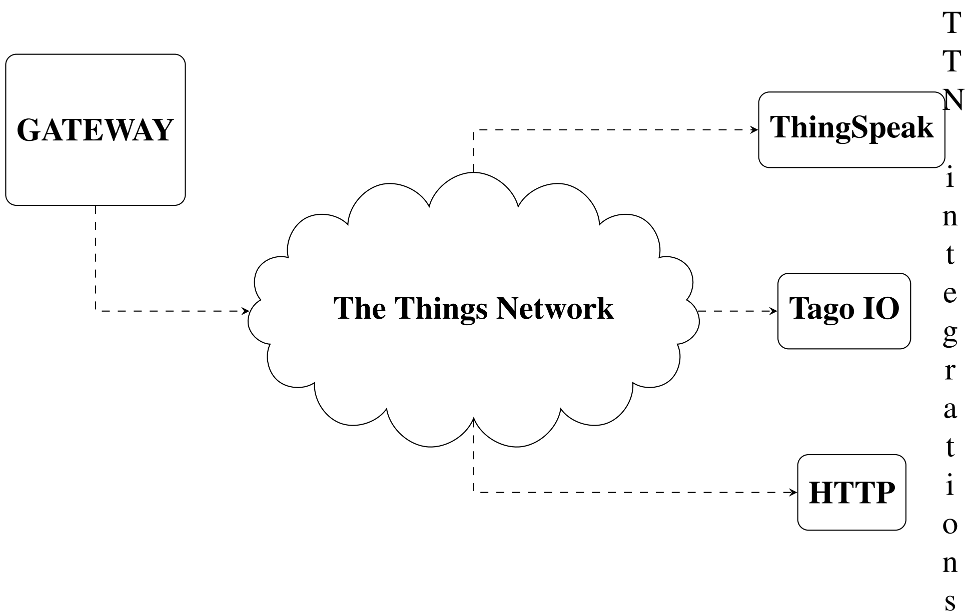

Figure 3.6 Block representation of data management system

The third-party integrations used in the project in addition to the TTN network are ThingSpeak and Tago IO(Figure 3.6). ThingSpeak is a powerful platform developed by MathWorks having advanced features for data representation and analysis. Tago IO is a dashboard platform solely developed for live display of the data gathered. Hyper Text Transfer Protocol(HTTP) integration is another powerful integration provided by TTN network which grants the flexibility of transferring the gathered data into any webpage using HTTP protocol. This gives wide range of opportunities and scope for future developments of the project.

3.2.3 Alarming System

The concerned people concerned should be alarmed of the situation whenever necessary. This is done with the implementation of an alarming system(Figure 3.7). This project proposes the installation of a number of Alarm Points at some relevant localities where the inhabitants are highly vulnerable to the threat of isolation due to various geographical factors. It is better to install these Alarm Points at government local bodies such as Police Stations, Panchayath Offices, Agricultural Office etc. because of the easiness in notifying the people and the readiness to take urgent measures.

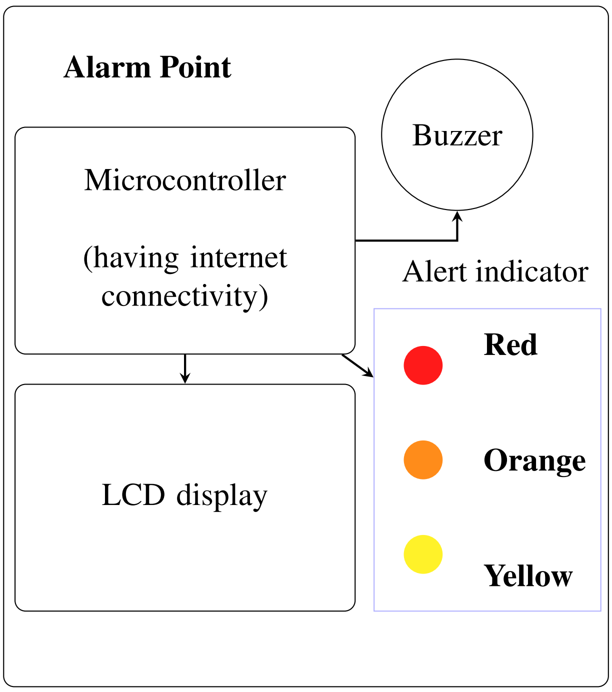

Figure 3.7 Block diagram of the Alarm Point

The Alarm points are designed in such a way that it requires internet facility for its functioning. As mentioned above, the alarm points are supposed to be installed at government bodies where there is no difficulty in availing internet connectivity. Moreover, this assures the possibility of installing the Alarm Points across a wide area eliminating any issues related to long distance communication. Based on the collected data from the environment, calculations are made and they are normalized to a single parameter or value namely, Normalized Value. This process is done at the server level (say TTN). It is the fluctuations in this Normalized Value that determines the threshold limit and the instant at which the alarm is programmed to ring.

One of the advanced features of the designed system is that the system provides flexibility for setting **multiple thresholds for distinct areas**(Figure 3.8). As the Alarm points are located at different geographically categorized areas, the threshold value which determines the threshold for alarming needs to be different. Hence, each alarm point is programmed differently which ensures that the threshold value assigned to each alarm point is specific and customized. The unique value for each alarm point should be determined on the basis of thorough analysis, simulations and trials. This makes the system more flexible and capable of handling the changing situations.

Figure 3.8 Flow diagram of server to alarm point communication

The Figure 3.8 clearly shows the distinction between the threshold values set for each alarm point. The need for a Multiple Threshold comes from the vast irregularities in the geographic contours. Each area is situated at different altitudes, taking the Mean Sea level as a common benchmark. The risk pertaining to various localities is also highly variable in nature. Thus, jumping to a conclusion based on a single threshold would be dramatic. That is why the Multiple threshold mechanism gains great currency regarding this project.

The communication between Alarm Point and the TTN network is based on HTTP integration. The changing value of data (V_N) can be accessed through a URL assigned by the TTN network. The alarm point is programmed in such a way that it requests the instant value of V_N at fixed intervals. A **get**() function which follows **HTTP protocol** is particularly used for the fetching of information from a web address. Once the data is accessed by the internet facilitated microcontroller, then the processor checks and compares the value with the previously assigned threshold value. The alert intensity is subdivided into three viz. Red, Orange and Yellow in the respective order of decreasing intensity. The range of V_N values for each interval is also programmed in the microcontroller. The controller constantly monitors the instantaneous value of V_N and compare it with the interval sets. Finally, a decision is taken whether to sound the alarm or not and which Alert is to be announced. For instance, if the value of V_N comes within the interval of Red alert, then the Red Signal glows along with the sound of Alarm.

CHAPTER 4

SOFTWARE DESCRIPTION

The software section of the project includes Cloud Management, HTTP integration, programming section of the nodes and alarming points and the finally the setting up of Gateway. The node and the gateway were previously familiarised in the hardware section. Integration of these hardwares with an efficient software is the basis of the working of a successful project.The use of highly flexible and developing platforms such as cloud computing makes the project upgradeable and opens tonnes of opportunities.

4.1 CLOUD MANAGEMENT

As mentioned earlier, the data received by the LoRaWAN gateway is uploaded to the cloud server, particularly The Things Network (TTN)(Figure 4.1) for this work. It is ann open platform for IoT based systems in which the users can register their devices and integrate them with several other IoT platforms such as Amazon Web Service (AWS), Tago IO, ThingSpeak etc. Also, the TTN is a prominent contributor member of LoRa Alliance, the agency that sets the protocols and fair use policies related to LoRa based applications.

HTTP integration is one of the integrations provided by the Things Network which allows the user to integrate the TTN console with any web page provided by the user. It helps to access and display the data in a customised and flexible manner. The ThingSpeak developed by Mathworks is one of the important integrations provided by the TTN network.

Figure 4.1 The Things network Logo

4.2 PROGRAMMING THE NODES AND THE ALARM POINT

The sensors are connected to TTGO LYLIGO board in which ESP32 is embedded within it. The TTGO board comes with an embedded LoRa32 module and an antenna along with it. ESP32 can be easily programmed using Arduino IDE by making some appropriate changes in the pin mapping. In addition to this, the alarm point consists of an ESP8266 node MCU which is also programmed in the same manner. The codes for each is given in Appendix C.

4.3 PROGRAMMING THE RASPBERRY PI

The gateway is set up using RAK831 concentrator module and R.Pi 3 in which the R.Pi is loaded with resion OS. The software required for the functioning of gateway is readily available in the github file repository. We need to customise some features in the file repository such as frequency plans, pin mapping etc. The Pi can be configured to Wi-Fi by providing the credentials while loading the operating System. The detailed steps involved in the software loading and software installation is provided in the Appendix A.

CHAPTER 5

HARDWARE DESCRIPTION

The whole system has hardware modules only in the two ends, in the monitoring and alarming section. The data processing system that works between the data collection and alarming is a hardware free system as it uses the web servers for its functioning. The monitoring section has sensors to collect the information, which are connected to the different nodes. The information collected by the node is transferred to the data processing system via a concentrator module set up with a processor. The communicated data is received by the alarming module, used for representation of data and indicating the water levels along with alarming the people of the impending calamity.

5.1 MONITORING SYSTEM

The purpose of this section is to continually collect data about the water level at very short intervals and transmit the information to the processing unit. Figure 5.1 shows the basic structure of the hardware connected together to form the monitoring system. The Ultrasonic sensor and the water flow sensor deployed help us in accurately tracking the water flow concerned with the flooding. The sensors are all attached to nodes which form a network and communicate with the processing system via a concentrator.

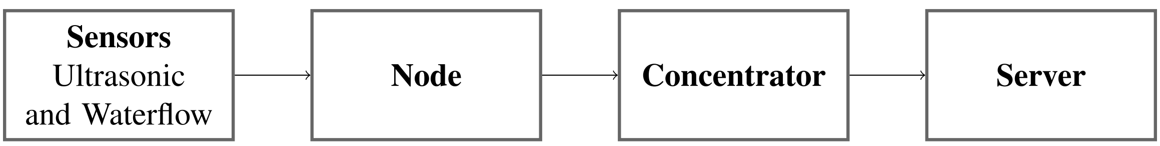

Figure 5.1 Block Diagram of the monitoring section

5.1.1 Sensors

Sensors play a very crucial role in today's automatic systems. Today we can find various types of sensors in the market. With the advancement in technology, sensors have evolved in their functioning and size. From the early size of cm units, size of sensors has shrunk to the scale of nm. As sensors played a major role in the functioning of the system, selecting an appropriate sensor was an important step that we had to take. The aim was to measure parameters of the water that can help in timely detection of flood. Water level and the water flow were two simple features that contained ample information to calculate the chance of flooding and predict the time it would take to cause damage to different areas. The ultrasonic sensor and the water flow sensors were used to monitor these parameters.

(i) Ultrasonic sensor

Similar to the radar and sonar technologies, ultrasonic transducers(Figure 5.2) are used in systems which evaluate targets by interpreting the reflected signals. The typical ultrasonic distance sensor consists of two membranes. One membrane produces sound and the other catches the reflected echo. Basically, they act as a speaker and microphone. The sound generator generates short (the length is a couple of periods) ultrasonic impulses and triggers the timer. Second membrane registers the arrival of the sound impulse and stops the timer. From the timer's time it is possible to calculate the distance traveled by the sound

The sensor convert electrical signal into ultrasonic signal of range above 18 kHz using a transducer. That is, the transducer in the signal has transformed the electrical energy into sound energy of ultrasonic range. This ultrasonic signal emitted out is reflected back after hitting a surface. The time taken for the signal to travel back and forth can be used to calculate the distance to the surface concerned. Thus, they are best used in the cases of non-contact detection of level, position and distance. Since they are independent of light, smoke, dust, color and material (except for soft surfaces like wool, because the surface absorbs the ultrasonic sound wave and doesn't reflect sound), they are used in a wide range of applications.

Placing an ultrasonic sensor at a known height from the water body gives us the normal distance from the sensor to the water surface. Any reduction in this distance would indicate that the water surface has come closer to the sensor (That is, the water level has risen). Different places like the underside of a bridge, rock side etc. were identified as suitable areas for the placement of the sensor.

Figure 5.2 Ultrasonic Sensor

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit. The basic principle of working is the using of IO trigger for at least 10us high level signal. The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back and if the signal is reflected back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time$*$velocity of sound (340M/S) / 2

There are 4 pins in the sensor, pins 1 and 4 are for power supply and the ground respectively. Pin 2 is the Trigger pin and the pin 3 is the echo pin . The Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending US wave. The echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the US wave to return. The specifications of the ultrasonic sensor are given in the table below(Table 5.1).

Operating voltage	+5V
Working Current	15mA
Theoretical Measuring Distance	2cm to 450cm
Practical Measuring Distance	2cm to 80cm
Accuracy	3mm
Max Range	4m
Min Range	2cm
Trigger Input Signal	10uS TTL pulse
Measuring angle covered	$< 15 degrees$
Operating Current	$< 15mA$
Operating Frequency	40Hz

Table 5.1 Specifications of ultrasonic sensor

(ii) Water flow sensor REES52 YF-S201

Water flow sensor gives an amazing solution for measuring the flow rate of liquids. The figure 5.3 shows REES52 YF-S201, the water flow sensor used in this work. It consists of a plastic valve that sits in line with the water column and through which water can pass. A water rotor along with a hall effect sensor is present to sense and measure the water flow. There is a pinwheel sensor inside which measures the amount of water flowing through it. When water flows through the valve, the water rotates the rotor. As the flow of water increases or decreases, a corresponding change can be observed in the speed of the motor. This change is calculated and is treated as a pulse signal by the hall effect sensor. The integrated hall effect sensor outputs an electrical pulse with every revolution. Thus, the rate of flow of water can be measured.

The main working principle behind the working of this sensor is the Hall effect. The Hall effect is the production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current. That is, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor. This induced voltage difference is transverse to the electric current.

Figure 5.3   Water flow sensor REES52 YF-S201

When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor and displayed on the LCD display. These sensors are available in different diameters, with different flow rate ranges and can be used with all types of waters. Placing an array of water flow sensors and averaging out the outputs from each gives a reliable value for analyzing purpose.

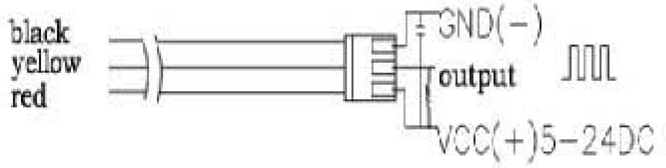

Figure 5.4   Connection of REES52 YF-S201

The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output)(Figure 5.4). They are normally of 1/2" nominal pipe connections, 0.78" outer diameter and 1/2" of thread with a size of 2.5" x 1.4" x 1.4". By counting the pulses from the output of the sensor, you can easily calculate water flow. Each pulse is approximately 2.25 milliliters. The Table 5.1 shows the specifications of the REES52 YF-S201 water flow sensor.

Operating Voltage	5 to 18V DC (min tested working voltage 4.5V)
Max current draw	15mA @ 5V
Output Type	5V TTL
Working Flow Rate	1 to 30 Liters/Minute
Working Temperature range	-25 to +80C
Working Humidity Range	35%-80% RH
Maximum water pressure	2.0 MPa
Output duty cycle	50% +-10%
Output rise time	0.04us
Flow rate pulse characteristics	Frequency (Hz) = 7.5 * Flow rate (L/min)
Pulses per Liter	450
Durability	minimum 300,000 cycles
Cable length	15cm

Table 5.2 Specification of Water flow Sensor

5.1.2 TTGO LILYGO LoRa 32 868MHz NODE

The TTGO LoRa32 SX1276 OLED(Figure 5.5) is a development board with an ESP32, a built-in LoRa chip and an SSD1306 OLED display. It is connected to the sensors using wires and has an antenna to transmit signals. Th LILYGO TTGO nodes are capable of communicating not only with the gateway but is also capable of communicating with other nodes. Thus, establishing a network of star architecture.

ESP32 is a single 2.4 GHz Wi-Fi-and-Bluetooth combo chip designed with the TSMC ultra-low-power 40 nm technology. It is designed to achieve the best power and RF performance, showing robustness, versatility and reliability in a wide variety of applications and power scenarios. It features all the state-of-the-art characteristics of low-power chips, including fine-grained clock gating, multiple power modes, and dynamic power scaling. Low-duty cycle is used to minimize the amount of energy that the chip expends. The output of the power amplifier is also adjustable, thus contributing to an optimal trade-off between communication range, data rate and power consumption. ESP32 is a highly-integrated solution for Wi-Fi-and-Bluetooth

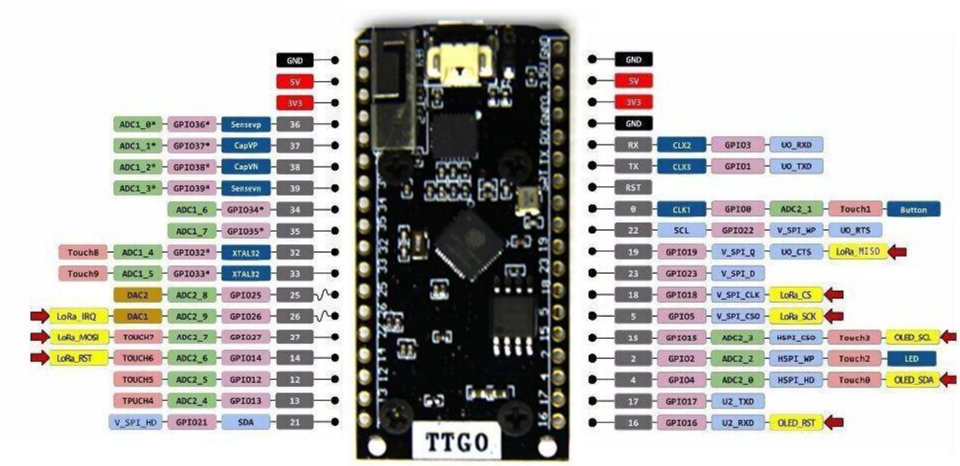

Figure 5.5 TTGO LILYGO LoRa 32 868MHz Node Pinout

IoT applications, with around 20 external components. ESP32 integrates an antenna switch, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. The LILYGO TTGO node basically acts as a LoRa remote modem working at 868MHz frequency. It has high sensitivity which is over -148 dBM. +20dBM and is highly reliable in nature. It also has a long range of transmission. As it uses LoRa technology, the transmission range it can cover is up to a distance of 10Km, that too consuming very low amount of power. The onboard transmission antenna is of length 0.96 inches length and uses a lithium battery charging circuit with a life of three years. CP2102 interface and USB serial chip are built onto the board and makes the perfect support for development environment. It can also be used for program checking very easily and faster. The board comes with a blue OLED display. The Table 5.3 shows the specifications of TTGO LILYGO LoRa 32

Operating Voltage	3.3 to 7V
Operating temperature range	-40degree C to +90 degree C
Data rates	150 Mbps @ 11g, 11Mbps @ 11b
Transmit power	19.5 dm @11b, 16.5 dBm @11g, 15.5 dBm @11n
Receiver sensitivity	up to -98 dBm
UDP	sustained throughput of 135 Mbps

Table 5.3 TTGO LILYGO LoRa 32 868MHz specifications

5.1.3 Gateway

As the name indicates, the aim of a gateway is to act as a gateway for the data communicated from the network of nodes to pass through to the server. It consists of a concentrator module set up with a processor. The data from the nodes received using LoRa technology is regulated and sent to the server via the concentrator using internet facilities to the server for further processing. Here, we have used the RAK 831 Concentrator Module set up with a Raspberry Pi 3B to act as the gateway(Figure 5.6).

RAK 831 Pin	Description on silk screen	RPi physical pin
1	+5V	2
3	GND	6
19	RST (Resent pin)	22
18	SCK (SPI Clock)	23
17	MISO	21
16	MOSI	19
15	CSN (Chip Select)	24

Figure 5.6 Gateway connection mapping

(i) RAK 831 Concentrator Module

The concentrator module RAK831(Figure 5.7) is targeted for a huge variety of applications like Smart Metering, IoT and M2M applications. It is a multi- channel high performance Transmitter/Receiver module designed to receive several LoRa packets simultaneously using different spreading factors on multiple channels. The concentrator module RAK831 can be integrated into a gateway as a complete RF front end of this gateway. It provides the possibility to enable robust communication between a LoRa gateway and a huge amount of LoRa end-nodes spread over a wide range of distance.

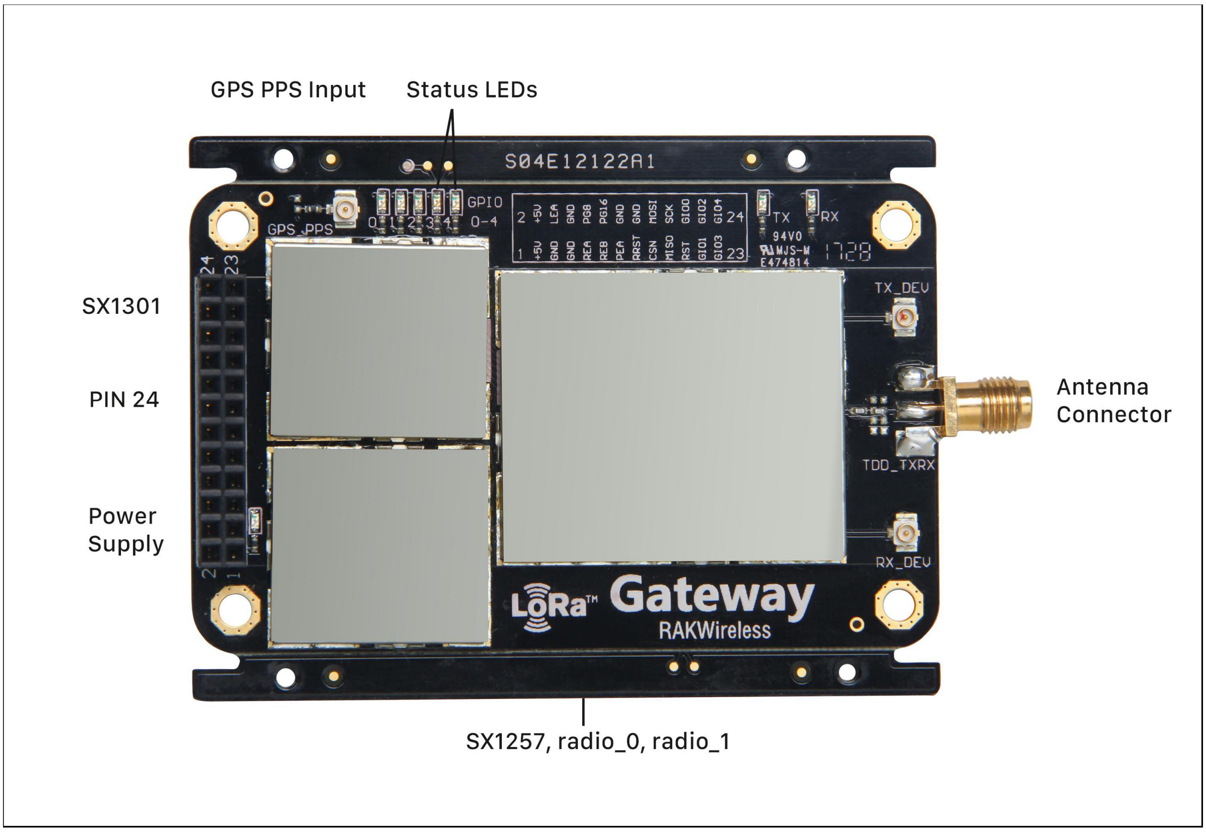

Figure 5.7 RAK 831

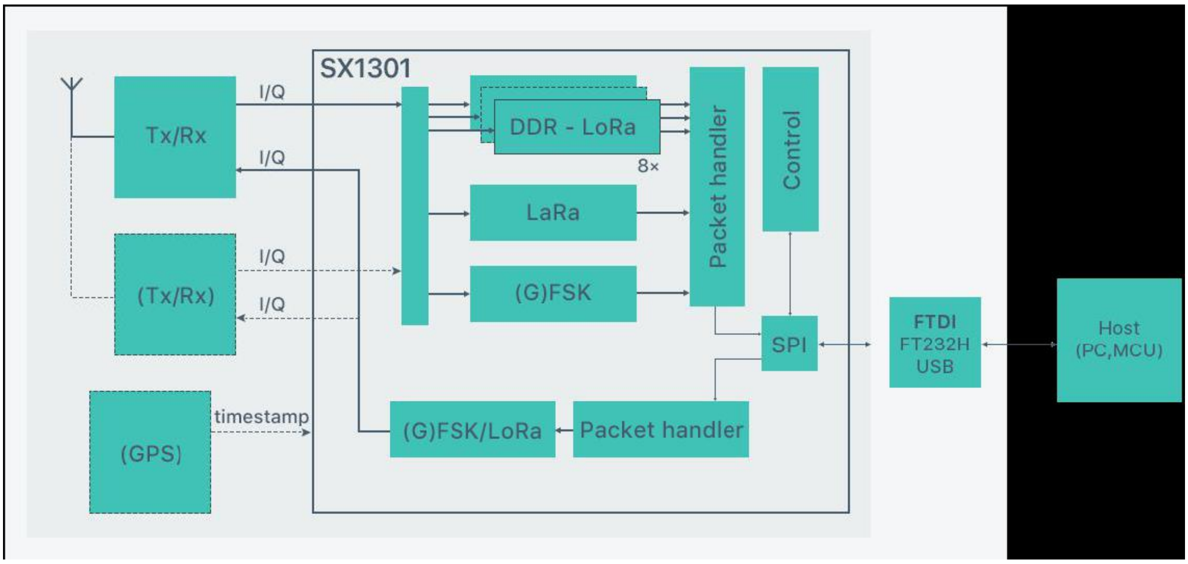

Figure 5.8 Internal diagram of RAK 831

The SX1301(Figure 5.8), used in the RAK831 is a smart baseband processor for long range ISM communication. In the receiver part, it receives I and Q digitized bit stream for one or two receivers (SX1257), demodulates these signals using several demodulators, adapting the demodulators settings to the received signal and stores the received demodulated packets in a FIFO to be retrieved from a host system (PC, MCU). In the transmitter part, the packets are modulated using a programmable (G)FSK/LoRa modulator and sent to one transmitter (SX1257). Received packets can be time-stamped using a GPS PPS.

The RAK831 needs a host system for proper operation. This is an ideal modular product that helps you realize the whole Lora system development. With the USB-SPI converter module FT2232, you can quickly make the software development in your PC. But also, you can integrate the concentrator module to your production product to realize the Lora gateway function. This is an economic way to address for a huge variety of applications like Smart Grid, intelligent Farm and Other IoT applications. The RAK831 needs a host system like Raspberry Pi or WisAP (OpenWRT based) or WisCam for proper operation. The host processor can be a PC or MCU that will be connected to RAK831 via USB or SPI RAK831 is able to receive up to 8 LoRa packets simultaneously sent with different spreading factors on different channels. This unique capability allows to implement innovative network architectures advantageous over other short-range systems.

The concentrator is available in different frequencies and in different countries, primarily in 433,470,868,915MHz. It has sensitivity down to -142,5 dBm and a maximum link budget of 162 dB. Another key feature of the module is its orthogonal spreading factors. It requires a supply voltage of 5V and gives an output power at a level up to 23 dBm. The pin out of the RAK831 is given in Table 5.4.

Pin	Name	Type	Description
1	+5V POWER	+5V	Power Supply Voltage
2	+5V POWER	+5V	Power Supply Voltage
3	GND	GND	GND
4	LNA_EN_A	Input	SX1301 Radio C Sample Valid
5	GND	GND	GPS Module LDO:Enable Pin
6	GND	GND	GND
7	RADIO_EN_A	Input	SX1257_A_EN
8	PA_G8	8 PA_G8 Input PA GAIN 0 8	PA_G8 Input PA GAIN 0
9	RADIO_EN_B	Input	SX1257_B_EN
10	PA_G16	Input	PA GAIN 1
11	PA_EN_A	Input	PA EN
12	GND	GND	GND
13	RADIO_RST	RST	SX1257_A_B RESET
14	GND	GND	GND
15	CSN	SPI	SX1301 SPI_NSS
16	MOSI	SPI	SX1301 SPI_MOSI
17	MISO	SPI	SX1301 SPI_MISO
18	SCK	SPI	SX1301 SPI_CLK
19	RESET	RST	SX1301 RESET
20	GPIO0	GPIO	SX1301 GPIO
21	GPIO1	GPIO	SX1301 GPIO
22	GPIO2	GPIO	SX1301 GPIO
23	GPIO3	GPIO	SX1301 GPIO
24	GPIO4	GPIO	SX1301 GPIO

Table 5.4 Pin map of RAK831 concentrator module

(ii) Raspberry PI

The Raspberry Pi 3 model B(Figure 5.9) is used to work as the processor for the working of the RAK831 concentrator module. It is the latest version of the Raspberry Pi computer. It was released in February 2016 with a 1.2 GHz 64-bit quad core processor, on-board 802.11n Wi-Fi, Bluetooth and USB boot capabilities. Other features are Power over Ethernet (PoE) (with the add-on PoE HAT), USB boot and network boot (an SD card is no longer required). Table 5.5 contains further specifications of the Raspberry Pi module.

Figure 5.9 Raspberry Pi

The biggest change that has been enacted with the Raspberry Pi 3 is an upgrade to a next generation main processor and improved connectivity with Bluetooth Low Energy (BLE) and BCM43143 Wi-Fi on board. Additionally, the Raspberry Pi 3 has improved power management, with an upgraded switched power source up to 2.5 Amps, to support more powerful external USB devices.

Processor	Broadcom BCM2387 chipset 1.2GHz Quad-core ARM Cortex-A53(64*bit*)
LAN	IEEEN802.11 b/g/n Wi-Fi protocol: WEP,WPA WPA2,algorithms AES-CCMP(maximum key length of 256 bits), the maximum range of 100 meters
Bluetooth	IEEE802.15 Bluetooth,Symmetric Encryption Algorithm Advanced Encryption Standard(*AES*)
GPU	Dual Core Video Core *IV*® Multimedia Co-Processor. Provides Open GL ES 2.0, hardware-acceleratedOpen VG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	1GB LPDDR2
Operating System	Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V1, 2.5A
Connectors:Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 and 1.4) Composite RCA (PAL and NTSC)
Audio Output	Audio Output 3.5mm jack HDMI USB 4 x USB 2.0 Connector
GPIO Connector	40 pin 2.54mm(100 mil) expansion header: 2x20 strip Providing 27 GPIO pins and +3.3 V,+5 V and GND 9 supply lines
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
Memory Card and Slot List	Push or pull Micro SDIO

Table 5.5 Specifications of R. Pi 3B

5.2 ALARMING SYSTEM

The alarming system(Figure 5.10) receives the processed data from the data managing systems and alerts the people nearby of the possible flood that they are to face. It consists of a Node MCU set up along with a buzzer and lights. The Node MCU checks the incoming value and compares it with the threshold, if the value input to the board is above the threshold, it sounds the buzzer, Further, the data is checked again to determine the colour of bulb of be lighted, indicating the severity.

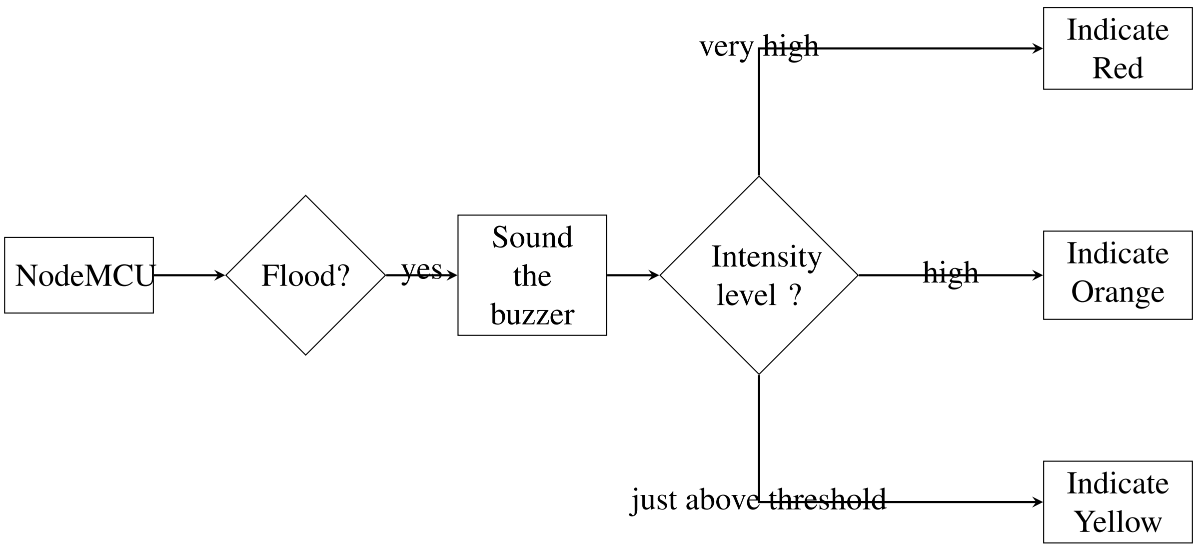

Figure 5.10 Alarm System

5.2.1 NodeMCU

NodeMCU is an open source firmware for which open source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). The term "NodeMCU" strictly speaking refers to the firmware rather than the associated development kits. The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. The Figure 5.11 contains the picture of a NodeMCU module along with its pinout.This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. It can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface. The Figure 5.11 shows the picture of a NodeMcu board and its pins.

ESP8266EX offers a complete and self-contained Wi-Fi networking solution; it can be used to host the application or to offload Wi-Fi networking functions from another application processor. When ESP8266EX hosts the application, it boots up directly from an external flash. In has integrated cache to improve the performance of the system in such applications. Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any micro controller-based design with simple connectivity (SPI/SDIO or I2C/UART interface). The Table 5.6 contains the pinout and descriptions of ESP8266. ESP8266EX is among the most integrated Wi-Fi chip in the industry; it integrates the antenna switches, RF balun, power amplifier, low noise receive amplifier, filters, power management modules, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor, with on-chip SRAM, besides the Wi-Fi functionalities. ESP8266EX is often integrated with external sensors and other application specific devices through its GPIOs; sample codes for such applications are provided in the software development kit (SDK).

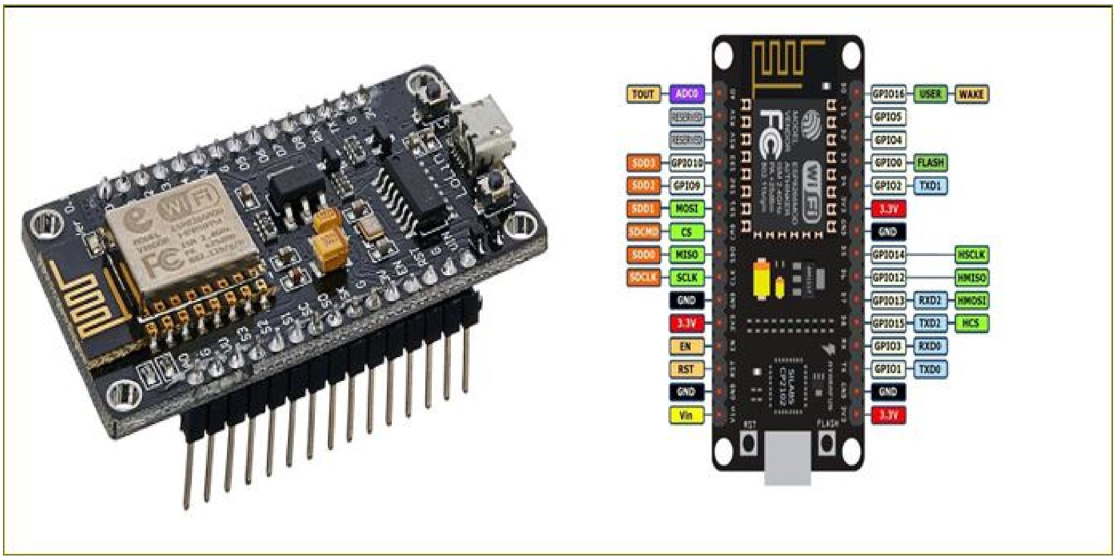

Figure 5.11 NodeMCU

Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106

Operating Voltage: 3.3V

Input Voltage: 7-12V

Flash Memory: 4 MB

SRAM: 64 KB

Clock Speed: 80 MHz

USB-TTL based on CP2102 is included onboard, Enabling Plug n Play The NodeMCU is programmed to identify the incoming data as above a set threshold or not. The threshold differs

Pin Category	Name	Description
Power	Micro-USB, 3.3V, GND, Vin	Micro-USB: NodeMCU can be powered through the USB port 3.3V: Regulated 3.3V can be supplied to this pin to power the board GND: Ground pins Vin: External Power Supply
Control Pins	EN, RST	The pin and the button resets the microcontroller
Analog Pin GPIO Pins	A0 GPIO1 to GPIO16	Used to measure analog voltage in the range of 0-3.3V NodeMCU has 16 general purpose input-output pins on its board
SPI Pins	SD1, CMD, SD0, CLK	NodeMCU has four pins available for SPI communication.
UART Pins	TXD0, RXD0, TXD2, RXD2	NodeMCU has two UART interfaces, UART0 (RXD0 & TXD0) and UART1 (RXD1 & TXD1). UART1 is used to upload the firmware/program.
I2C Pins		NodeMCU has I2C functionality support but due to the internal functionality of these pins, you have to find which pin is I2C

Table 5.6 Pinout of ESP8266

depending on the area it is placed at. Once this threshold is set, any incoming data is run to find the possibility of a flood. Along with the sounding of the buzzer, the board is also programmed for the lighting up of different coloured lights to indicate the severity of the flooding.

5.2.2 Buzzer

A buzzer(Figure 5.12) is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure and hence can be easily used on a breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications.

There are two types are buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beeeeeeppp.... sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep.

Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown(Figure 5.12) here is most widely used because it can be customized with help of other circuits to fit easily in our application.

Figure 5.12 Buzzer

Pin Number	Name	Description
1	Positive	Identified by (+) symbol or longer terminal lead. Can be powered by 6V DC
2	Negative	Identified by short terminal lead. Typically connected to the ground of the circuit

Table 5.7 Buzzer pinout

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The Table 5.7 shows the pinout and the description of the buzzer used in this work. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval. It is normally used in alarming Circuits, where the user has to be alarmed about something.

Rated Voltage: 6V DC

Operating Voltage: 4-8V DC

Rated current: <30mA

Sound Type: Continuous Beep

Resonant Frequency: 2300 Hz

Small and neat sealed package

Breadboard and Perf board friendly

The buzzer sounding will alert the people of the upcoming disaster and ask them to wake from their dormant life and switch to survival mode. Since the alarm is sounded way in advance to the flood, the people get ample time to prepare themselves and move to safety without panic.

CHAPTER 6

INQUISITIVE SURVEY REPORT

Kottayam district, situated in the central Kerala is enriched with several rivers like Meenachilar, Manimala etc. The district which is located in the basin of the Meenachil River has an average elevation of 3 metres (9.8 ft) above sea level. The district is highly vulnerable to flood because of its topological and hydrological conditions. From June to September, the south-west monsoon brings in heavy rains, as Kottayam lies on the windward side of the Western Ghats. In the year of 2018, the district received a cumulative rainfall that was 180% excess than the normal average leading to a flash flood in the region. The major river in the district, the Meenachil river along with its all 38 tributaries contributed to wide spread devastation and major casualty in the human history.

As part of our research to build an efficient system to forewarn the people of the onset of flood, we had gone to a place Earattupetta, in Kottayam district to gather data and study the geography. Marmala(Figure 6.1) is a seasonal river, situated at a distance of 8kms from Teekoy, is a place where frequent flash floods occur. The river originates from the forests of the Western Ghats from the Sahya Mountain range and joins the Menachilar way down at Erattupetta along with many other tributaries. Water from these streams reaching Meenachilar only take about 2 hours to cause a flood at far away regions like Pala.

Figure 6.1 (a)Satellite view of visited site (Marmala). (b)Picture taken during the visit.

The context of conducting the inquisitive survey was the widespread damage and deaths caused by the flash floods in the year 2018 and 2019. From the research, we unnderstood that landslips at Adukkam in the teekoy ranges is the reason for the sudden rise in the water level in the Meenachil River and, Marmala which is a major tributary of Meenachil River flowing through Teekoy played a crucial part in the upsurge. The continuing heavy inflow of water from high ranges compounded to the misery of people living in the low-lying western areas of Kottayam and caused death of many.

Since these tributaries are all in a very remote area it is difficult to monitor the water level. Presently, only manual monitoring systems are available in the region. The habitants in the location, after analysing the amount of rainfall, predict the possibility of flood from their experiences and convey the water level to others using mobile phone or any other methods. The authorities are then informed after which an alert signal is generated to the people. Evidently, the current system fails in early forecasting of flood. Similar situations were also faced at different regions like in the areas near the river Pamba, Achankovilar etc. The flood has caused large scale damage throughout Kerala and from our studies we learnt that most of the time it was the lack of proper monitoring and communication that caused the major damage.

Figure 6.2 Sensor deployable site

A flood forecasting system must be reliable in terms of its proper functioning, range of coverage, longevity, low power consumption etc. In addition, the system must be a standalone unit. Even though several technologies like Wi-Fi, Zigbee, Bluetooth, GSM modules etc offer wireless communication, they are not admissible in terms of several factors like consumption of power, range of communication etc. LoRa is a wireless technology which has several characteristics like low power consumption, long range and a longevity of up to 2 years. Hence LoRa meets all the requirements that are necessary for a forecasting system. In the proposed system, communication between the remote points and the outside world is established using LoRa based communication system. Lora communication system called for the installation of nodes at different spots along the pathway of the river.

We identified different locations like big rocks and bridges(Figure 6.2) to set up the water flow sensor and water level sensor. Here we make use of Wireless Sensor Network (WSN) to gather data from multiple sensors like flow sensor and water level sensor that will be densely deployed in the site. The flow sensor can be used to measure the differential water pressure thus giving us added accuracy. The level sensors would measure the distance from the surface of water. In this manner, the rise of water can be constantly monitored by the sensors. After sensing the parameters, sensors send these data to the respective nodes from where it is sent to cloud. The control unit compare these data with the values that are already stored in the server. According to this comparison, three different alert (Yellow, Orange and Red) signals will be generated which implies that all people near the Meenachilar should evacuate as per the situation demands. Such a system enables both private and government organizations to work on the emergency evacuation and mitigation plans for saver move before the flood situation gets worse.

CHAPTER 7

RESULTS AND DISCUSSIONS

The proposed system is implemented as a prototype in which the entire idea is conveyed through a demonstrative apparatus. The step by step realizations of output are as follows.

7.1 GATEWAY TRAFFIC

After the configuration of the gateway and the wireless sensor network, the sensor nodes started communicating with the gateway. The gateway traffic is shown in Figure 7.1.

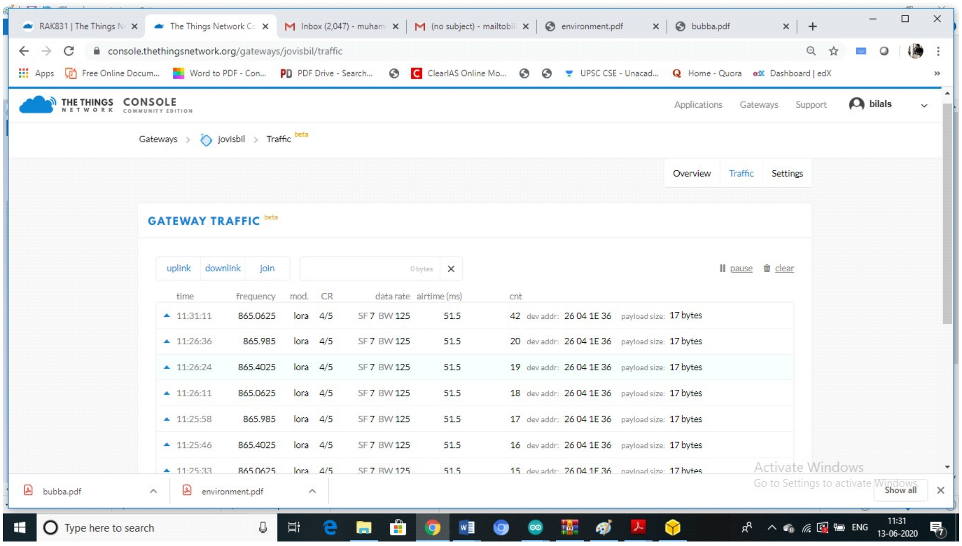

Figure 7.1 Gateway traffic.

Hence, realized the gateway communication and observed the traffic.

7.2 NODE TRAFFIC

Water flow sensor node and ultrasonic sensor node has successfully started communicating with the gateway. The traffic observed at node level is shown in Figure 7.2.

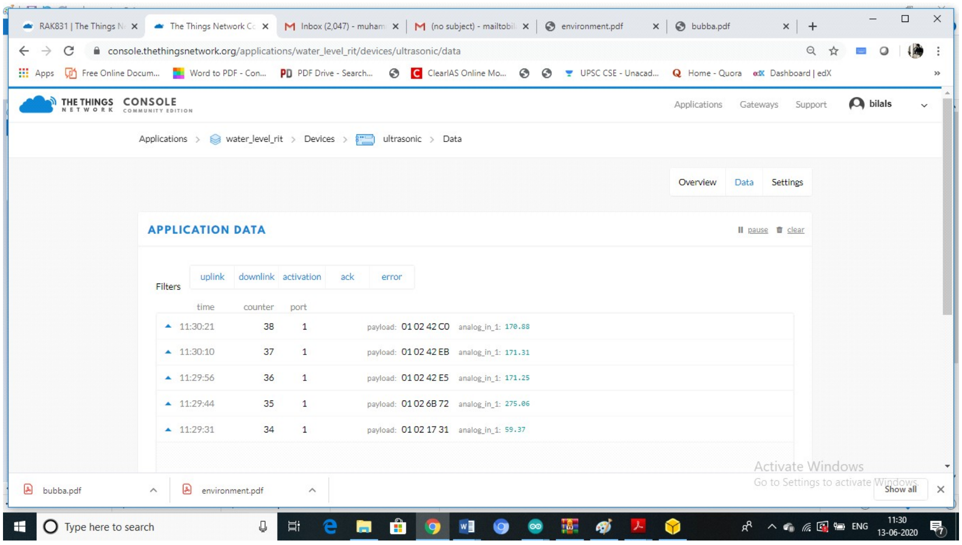

Figure 7.2 Data sent by the node.

Hence, the node communication is realized and the traffic is observed.

7.3 DASHBOARD DISPLAY

The TTN integrations are created and synchronized for live preview and advanced representation of the gathered data. The two integrations used in this project are Tago IO and ThingSpeak. The dashboard display of the same are shown in Figure 7.3 and Figure 7.4.

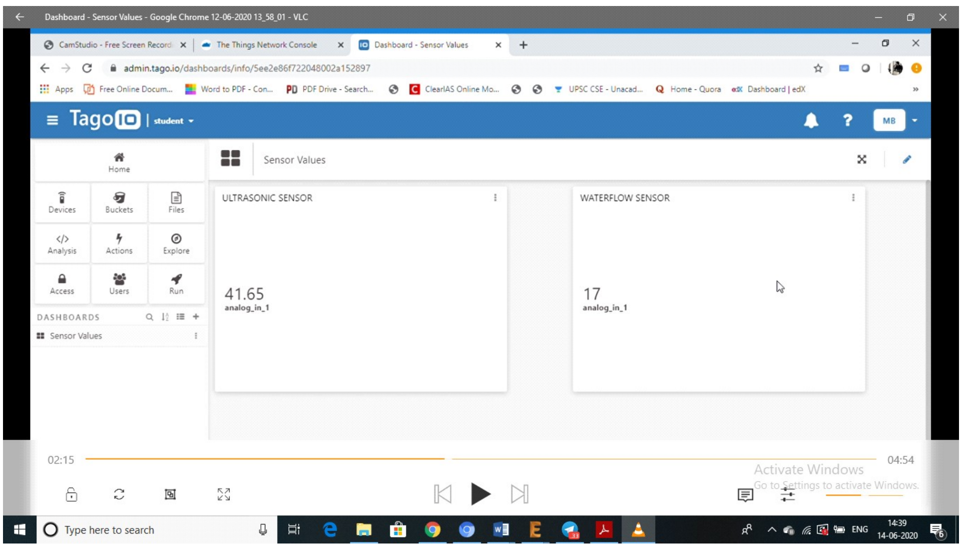

Figure 7.3 Display of Tago IO dashboard

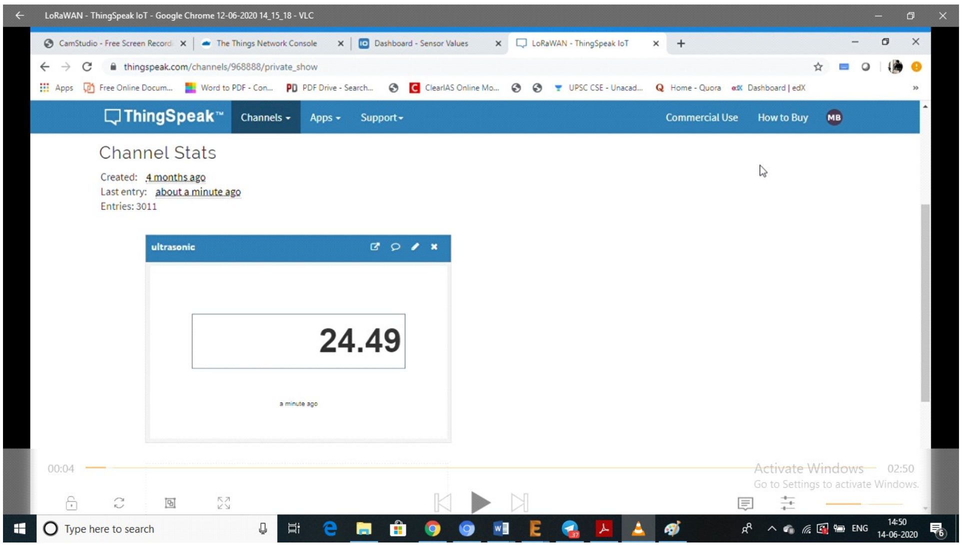

Figure 7.4 Display of ThingSpeak dashboard.

Hence, the TTN integration is successfully created and live monitoring of data through the dashboard is realized.

7.4 ALARM POINT

The alarm point is programmed and set a specific threshold. When the threshold value goes beyond the threshold the buzzer began to ring and the indicator LED glows(Figure 7.5).

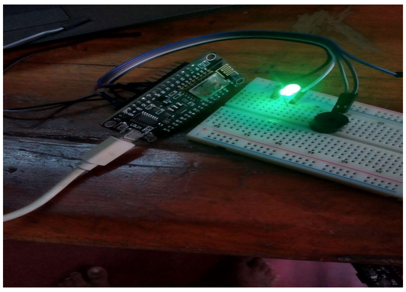

Figure 7.5 Alarm point- during alert interval.

Hence, the alarm point is set up successfully and observed the alarm sound whenever the sensor value crossed the threshold value.

7.5 INFERENCES

The sensors connected with the nodes form a wireless sensor network that communicates with the gateway at fixed intervals. The communication between the gateway and the wireless sensor network uses LoRa modulation technique. After receiving the signals coming from the network, the gateway processes the payload and upload it into The Things Network. The data traffic can be observed on the TTN console in both the gateway and the device level (node level). This data is then transferred to Tago IO and ThingSpeak using TTN integration facility. Tago IO and ThingSpeak shows the data in their respective dashboards in various formats such as graph, digital display etc. These platforms also help in the storage of data and that can be further downloaded and stored remotely. HTTP integration enables the alarm point to access the data from the server. The alarm point continuously computes the data for the possibility of flood. The alarm point compares the instantaneous updates with the previously assigned threshold value and sounds the alarm whenever the value crosses the threshold limit. An indicator light also blows on, alerting the people in the surroundings.

CHAPTER 8

CONCLUSION

According to the research done at Marmala, the paramount emphasis on the necessity of a faithful prediction was observed distinctly. Thus, deploying a wireless sensor network for monitoring and prediction is a feasible solution. The monitoring sensors forming a network that communicates with the servers using LoRaWAN technology. The availability of low power nodes having a battery longevity of 2 years increases its significance for commercial practice. Unlike Wi-Fi, Bluetooth and Zigbee which are primarily short-range wireless protocols, LoRa is capable of communicating up to the range of 2 to 4 kilometres in urban areas, 10 kilometres in sub-urban areas and up to 15 kilometres in open environments. This feature of long-range communication with low power consumption is a notable trait which differentiates LoRa from other wireless protocols particularly used in IoT.

In this project, we have designed a LoRa based wireless sensor network system for flash flood detection and alarming. The system mainly consists of three components; data monitoring, data management and alarming system. It uses different sensors WSN technology for real-time data collection and transmission of water level information from remote hydrological stations to the main data centre where the data is analysed and used for warning the citizens as per situation demands. In addition, the system also has several advantages like low cost, small size, ease of configuring, scalable WSN nodes etc. The system is a stand-alone unit since it is independant of subscribing to any third party network. Hence, no additional devices or systems are required to work with it. The entire project aims at giving a prior warning to the inhabitants for leaving the locality much before a calamity strike upon them. This also helps the people to take away essential gadgets along with them thereby reducing the economic loss as well as minimising the life casualties.

The gateway built here is only a demonstration of a real-world multi-channel gateway. However, the results are promising and indicative of the possibilities of using LoRa. The number of end-nodes in the prototype developed is two. But in practice if needed, it can be multiplied by dozens of end-nodes. By scaling up the number of nodes and the gateways in a star network, a low cost, long range and low power network can be deployed which connects even the most remote areas. A possible means of power supply is via solar cells. The use of solar energy will provide cheaper source of power to the entire system to operate especially if the system is placed in a remote location. The data gathered from the proposed system can be utilized for various purposes such as algorithm development, simulations and reliable prediction mechanisms. The system can be linked to a visual and audio unit to display warnings and alerts the users via text displays or traffic light system in an event of flooding. The possibility of mathematically modelling the geographical contours and waterbodies using analytical tools MATLAB, FLUENT, etc. open doors for future advancements. This model can also be made applicable to several areas of application such as industries, hospitals, etc.

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APPENDIX A

FAMILIARISATION OF LORA

LoRaWAN[11] networks typically are laid out in a star-of-stars topology in which gateways relay messages between end-devices and a central network server at the backend. Gateways are connected to the network server via standard IP connections while end-devices use single-hop LoRa™ or FSK communication to one or many gateways. All communication is generally bi-directional, although uplink communication from an end-device to the network server is expected to be the predominant traffic.

Communication between end-devices and gateways is spread out on different frequency channels and data rates. The selection of the data rate is a trade-off between communication range and message duration, communications with different data rates do not interfere with each other. LoRa data rates range from 0.3 kbps to 50 kbps. To maximize both battery life of the end-devices and overall network capacity, the LoRa network infrastructure can manage the data rate and RF output for each end-device individually by means of an adaptive data rate (ADR) scheme.

End-devices may transmit on any channel available at any time, using any available data rate, as long as the following rules are respected:

- The end-device changes channel in a pseudo-random fashion for every transmission. The resulting frequency diversity makes the system more robust to interferences.
- The end-device respects the maximum transmit duty cycle relative to the sub-band used and local regulations.
- The end-device respects the maximum transmit duration (or dwell time) relative to the sub-band used and local regulations.

APPENDIX B

MARMALA INQUISITIVE SURVEY

The snaps taken during the inquisitive survey is shown below in Figure B.1

Figure B.1 The sites spotted for the deployal of wireless sensor network

APPENDIX C

PROTOTYPE FOR DEMONSTRATION

The proposed system is demonstrated as shown below ...

Figure C.1 The picture of prototype set up for demonstration

The prototype show in Figure C.1 is solely prepared for demonstrative purpose only. The practical deployment of the system requires identification of suitable spots (Appendix D) and more sophisticated fabrications and enclosures. See the two reservoirs placed at different heights in the above figure. The water flow sensor is placed in the middle of the pipe so that the water flows through the sensor path and reaches the lower reservoir. The ultrasonic sensor is placed just above the collecting reservoir which serves the role of a water body having rising water level which in turn add account to the flash floods.The arrangements of the sensors and other apparatus are shown in Figures E.2,E.3 and E.4. The implemented setup of the gateway and the alarm system is shown in Figures E.5 andE.6 respectively.

Figure C.2   Nodes along with the sensors

Figure C.3   (a) Ultrasonic sensor along with TTGO Board and antenna (b) Waterflow sensor along with TTGO Board and antennae

Figure C.4 Gateway- RAK831 concentrator module along with Raspberry pi 3B

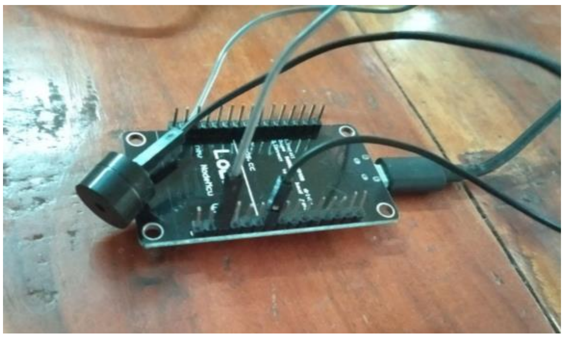

Figure C.5 Alarm Point- ESP8266 connected to buzzer alarm