Role of Spread Spectrum Based Lora in Advanced Flood Monitoring and Warning System

Shaneel Saurabh Sao, M. Selva Balan and Prajakta A. More

December 7, 2021

"Role of Spread Spectrum based LoRa in Advance Flood Monitoring and Warning System"

Shaneel Saurabh Sao [1], **Dr. M. Selva Balan** [2,] **Prof. Prajakta A. More** [3]

[1] *Research Assistant, Instrumentation Division, Central Water & Power Research Station (CWPRS), Pune-411024, India;* Email : *shaneel2017@gmail.com*

[2] *Scientist- E, Instrumentation Division, Central Water & Power Research Station (CWPRS), Pune-411024, India;* Email : *selvabalan_m@cwprs.gov.in*

[3] *Professor, Department of Electronic and Communication, Zeal College of Engineering and Research, Pune-411041, India;* Email : *prajakta.more@zealeducation.com*

Abstract

All over the world flooding is a natural phenomenon and calls for serious issue for consideration. To limit these impacts, preventive measure should be taken and one of the precautionary measures is to efficiently sense and monitor flooding parameters such as river water level and rainfall in the remote area on a real-time basis. In the present-day scenario of River flood monitoring the GSM /GPRS or satellite data communication networks are broadly utilized, In no signal tower, remote location area these networks fail and also it is very expensive to manage satellite communication network, therefore we propose present paper LoRa based communication link here for the implementation of the efficient wireless network, we use LoRa (low power long-range protocol) as a method of data communication in a wireless network. LoRa is essentially a spread spectrum regulation strategy from chirp spread range (CSS) innovation and also explores the best predictive performance analysis configuration parameter for LoRa devices in the advancement of the observing framework. The overall project system involves the deployment of various water level sensor nodes at specific flood vulnerable remote location areas for real-time flood monitoring and detection with an efficient and optimized transmission power of essential data transmission in the hydrological network with the help of our dedicated LoRa wireless network. The full-length paper explains the design and development of a LoRa communication-based flood warning system developed using an embedded controller and being implemented at a nearby site in Pune.

Keywords: wireless sensor network, LoRa(Long Range), Internet of Things, chirp Spread spectrum, Line of sight.

1. Introduction

Among the new driving innovations around here, we consider LoRa, in light of the Chirp spreading spectrum (CSS) strategy. This innovation stands apart for its simple use, its high energy proficiency, and its phenomenal presentation in conditions where the signal-to-noise ratio (SNR) is low. WSN structures are especially valuable in natural marvels checking, particularly in situations where the event of an occasion can prompt critical security issues. Flooding is a typical occasion in provincial and metropolitan conditions where the presence of water is expected both to topographical highlights, like streams or lakes, and to the nearness of delicate metropolitan components. Flooding can introduce an undeniable degree of hazard. For instance, the flooding of streets can harm the foundation. Other than imperiling public wellbeing, this can have monetary and social repercussions. Flooding can be brought about by unfriendly downpour conditions, wind, temperature changes. A gauge dependent on a hypothetical way to deal with this occasion is unpredictable and frequently not quickly

possible; accordingly, the advancement of early notice frameworks is valuable and vital. In present study, a flood-checking framework was created, intended for the establishment and use in metropolitan and non-metropolitan settings, to get an early admonition of the conceivable marvel. This would empower the execution of countermeasures that would educate the client regarding the potential dangers or, in case of administration interruption, the execution of goal techniques. It incorporates the information assortment and transmission capacities and another significant determination is the particularity of the setup which will be examined later. The executed framework is shaped by a sensor hub dependent on a low utilization microcontroller, outfitted with a LoRa remote module for data information transmission. Utilizing this methodology, it was feasible to get a decent energy execution, while keeping up the chance of getting a wide inclusion range for radio correspondence. This paper is coordinated as follows. Toward the start, an outline of LoRa module is given. In a later section, the overall engineering of the framework is depicted. Then, at that point the plan and the reasonable execution of the equipment structure that makes the WSN sensor hub, just as the association and depiction of the web area for information control, are introduced. At long last, it is shown that the framework can be utilized to deal with the distantly gotten information, on which the early admonition can be carried out.

2. Literature Survey

Extensive literature discovered different papers proposing various frameworks on similar grounds which are followings, [1] Shahirah Binti Zahir1, Phaklen Ehkan2, Thennarasan Sabapathy, Muzammil Published Smart IoT Flood Monitoring System" It provides flexibility and smartly operation of flood monitoring with the help of microcontroller-based IoT system. [2] Konstantin Mikhaylov1, Marko Pettissalo2, Janne Janhunen1, and Jari Iinatti1 Published Performance of a low-power wide-area network based on LoRa technology: scalability, Doppler robustness, and coverage. it provides a low power consumption. LoRa has been manufactured by Semtech, also it uses advanced spread spectrum technologies. [3] Dola Sheeba Rani, Dr. Jayalakshmi G N, Dr. Vishwanath P Baligar Published Low-Cost IoT-based Flood Monitoring System Using Machine Learning and Neural Networks It evaluated the accuracy of artificial neural networks based smart decision support system during flood condition.

2.1 Technologies Comparison

In the field of IoT devices today, there are lot communication devices available for our specific requirements, apart from these, the most popular among them are Bluetooth and Wi-Fi. However, the issue with Wi-Fi and Bluetooth innovation is high Power utilization. Similarly they have various limitations like confined reach, limited paths, etc. Cell networks also have comparative issues of high energy usage and both LAN and Cellular associations are exorbitant to cover a wide district. The IoT undertakings introduced lots of developments, still none of them was ideal for IoT contraptions, as they expected to convey fundamental ongoing information to critical distances without using a ton of energy until the LoRa advancement was introduced. Lora offers low-power, long-range and secure data information transmission for IoT applications. LoRa is a spread range tweak innovation that is gotten from tweet spread range (CSS) innovation. LoRa Technology can perform amazingly long-arrived at transmission with low power use. The LoRa Ra-02 Sx1278 model is used in present study having an open-air Frequency band of 433 MHz with up to 15km range of data transmission. On another side, old technology has various drawbacks related to power consumption, cost, complex encryption, channel bandwidth, and so many other things.

Table 1 Comparison of Communication Technologies

SN.	Parameters	Wi-Fi	Bluetooth	GSM	LoRa
1	**Band Regulation**	License free ISM BAND	License free ISM BAND	Expensive Dedicated frequency channel	License free ISM BAND
2	**Range Category**	Up to100m Middle Range	Up to10m Short Range	Up to 35km very long Range	Up to 15km long Range
3	**Output power**	0.1W	0.003W	2W	0.025W
4	**Frequency Band**	2.4 & 5GHz	2.4GHz	900-1800MHz	433,868,915MHz
5	**Data Rate**	100Mb/s	1Mb/s	9.6- 14.4kb/s	0.3- 100kb/s
6	**Operating Cost**	High	Low	Very high	Very low
7	**Power Consumption**	31-100mW	1-10mW	30-100mW	0.01-300mW

3. Methodology

The framework of flood monitoring & warning system involves hardware component with spread spectrum based LoRa module with software coding or programming in IDE according to predefined algorithms and flow chart. In the software section, the Arduino Integrated Development Environment (IDE) is used to configure the LoRa module and all hardware components such as Microcontroller and sensors.
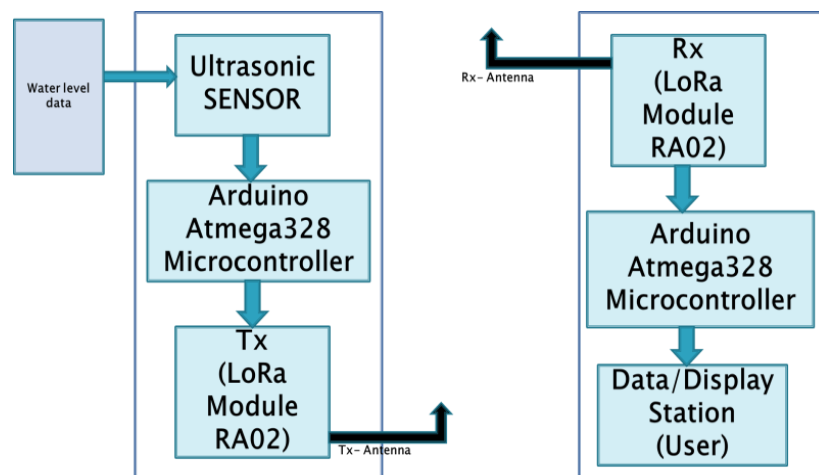

Figure 1 Block Diagram of LoRa System.

[1] Transmitter section- When setup is powered, the ultrasonic water level sensor measures the river height continuously and gives the sensed data information to atmega microcontroller unit, where the system analyzes the data information continually according to predefined program i.e. if the measured water level is greater than equal to optimum standard reference value during flood condition then the system forwards the data to LoRa module for wireless transmission purpose else it will measure the water level data through sensor again and again

in Real-time. The configured spread spectrum-based LoRa SX1278 module through coding by a set of some predefined commands in the Arduino IDE platform to achieve the best possible range for communication purposes on the receiver section.
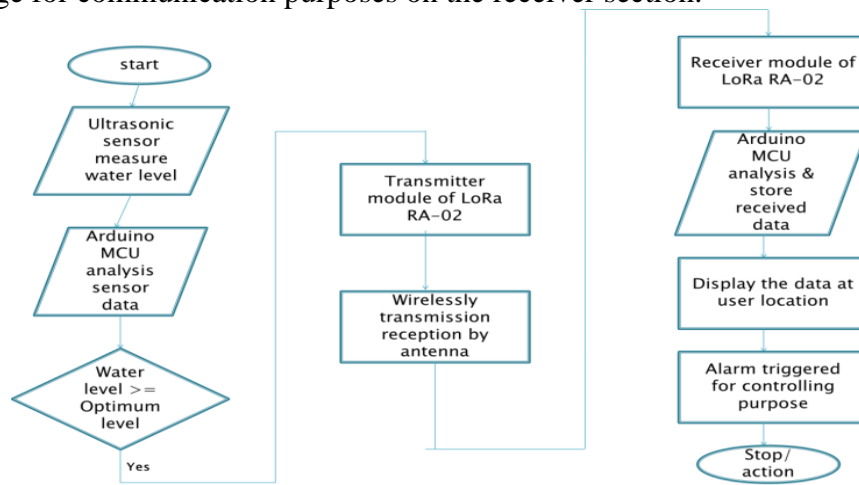

Figure 2 Flow Chart of LoRa based system

[2] Receiver section- An Frequency-matched LoRa SX1278 module receives the water level data digitally and sends it to the Arduino microcontroller unit for further analysis i.e. if the measured water level is high, it will indicate the user station by buzzer alarm & displaying an alert message on LCD for further controlling purpose. In our project framework, In present paper it is consider the flooding condition measurement of whole water body of river. It is categorize in three major section/ zone according to their water level height i.e. normal zone/ safe zone, critical warning zone, and last Red alert dangerous zone by our predefined set of coding commands, for getting best result during flood condition.

3.1 Experimental Setup

The experiment was set up at CWPRS Canal automation Lab with line-of-sight transmission to view LoRa communication.

Figure 3 LoRa Transmitter setup At Canal Side

In respect of this, a LoRa module is used Transmitter at one end of the canal side to access the flow of water through an ultrasonic water level sensor and added another sensor module for temperature and humidity (DHT11) measurement. Ultrasonic water level sensors capture the water level and transmit the electric signals to the Arduino microcontroller for transmission purposes after the connected LoRa module uses 433 MHz free band frequency to transmit the data on a real-time basis through a SMA antenna.
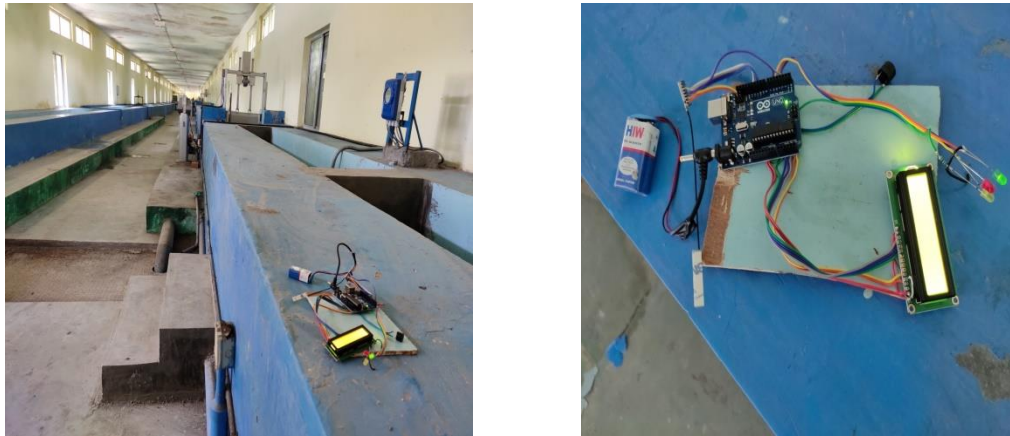
Figure 4 LoRa Receiver setup At Canal Side

At another end of the canal, Receiver based LoRA set up was displayed the variation of water level height during the flood condition through free band LoRa Communication experimental setup. On the receiver side, a 16x2 LCD display shows the received data from the transmitter terminal and three LEDs (Red, Green, yellow) indicate the warning alert according to predefined set of instructions as per requirement.

4. Results and Discussions

In this framework, related to LoRa communication using variations in different configurable factors in the Los and non LoS regions are studied in field. The device prototype has been developed and the project was conducted in a real-time data communication situation. Apart from this it was also observed that the Non-Los region dramatically reduces the distance of data transmission by 65-70%. The result of the study is to improve the reliable data transmission during Flood monitoring in Remote location. This study also suggests the best matching Configurable LoRa device parameter. The following table shows the performance evolution by various mode of configuration in LoRa SX1278 module.

Table 1 Performance Evolution by configuration setting in LoRa

Configurable Factors	Allowed Range	Variation in Distance	Power Utilization	Output Data rate
Bandwidth (BW)	41.7,62.5,125,250,500kHz	Decrease sequentially	Wide BW increase more power	Increases sequentially
Tx power output(TP)	2 to 17dBm.	Increases sequentially	More power utilize as increase TP	Increases sequentially
Code rate(CR)	4/5, 4/6, 4/7, 4/8	Increases sequentially	Large CR increase more power	Decrease sequentially
Spreading Factor(SF)	6, 7, 8, 9, 10, 11, 12	Increases sequentially	As SF increases more power utilize	Decrease sequentially

In The present project framework, the following configurable factors or parameters such as Carrier Frequency (CF), Spreading Factor (SF), Transmission Power (TP), Coding Rate (CR), and Bandwidth (BW) in the LoRa module varies LoRa data communication performance and signal transmission effectively according to our site location and necessary condition. Various configuration settings have been done during coding on Arduino IDE platform. The experiment was carried out in line-of-sight conditions to get stronger and focused signal transmission by using a different allowed range in the configuration setting. The value of coding rate has a greater influence on the transmissions as it will increase the time on-air and energy consumption. Thus, increase the time on air causes the packet data transferred prone to more collisions. Through the observation and experimental condition in various mode of configuration, it is observed that the most optimal configuration using Lora communication is **SF- 10 & 11, BW-250kHz, TP- 17dBm, and CR-4/8** give the best reliable data transmission.

4.1 Observation Graph

The Following table shows the Variation of water level height verses time for condition Observation on Real time basis Data communication through LorRa Network.

Table 1 Observation Table of flood Warning system

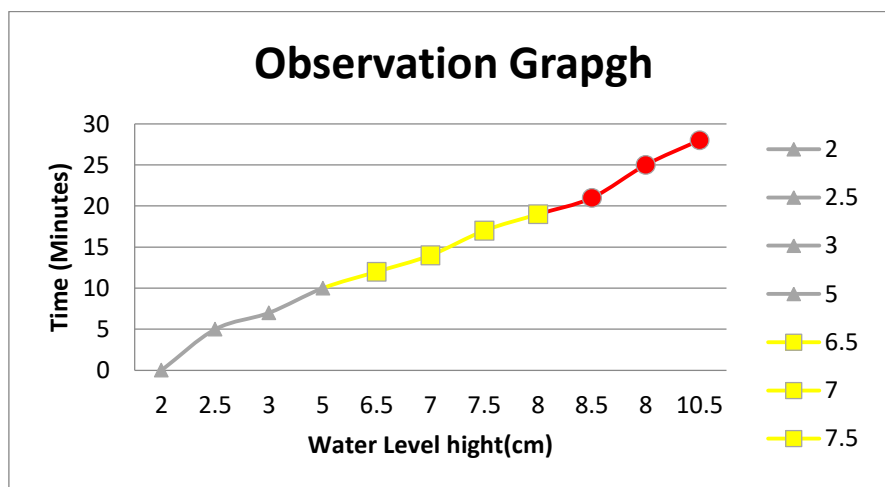| Water level height (CM)	Time variation(Minutes)	Conditions
2	0	Safe Condition
2.5	5	
3	7	
5	10	
6.5	12	Beware & alert
7	14	
7.5	17	
8	19	
8.5	21	Risky Red Alert
8	25	
10.5	28	

Figure 5 Time series plot of observed and predicted water level height

5. Conclusions

The overall study conclude that, a preliminary idea for result-oriented work is to obtain for flood monitoring system through LoRa communication device,The occurrence of flood due to dam breaks, heavily rainfall briefly delivering gigantic gallons of water. Execution of flood observing and cautioning framework using LoRa Communication module provides low power consumption and very high range transmission compare to other wireless communication technologies and also prompts minimization to flood openness, having time left to clear the region, getting time and help to flood control structures. Different perceptions of information through low force, minimal expense LoRa convention are seen which helps in executing the methodologies for expectation. An observation indicates by implementing system framework models that work well for the prediction of fluctuations in River water level due to excessive rainfall.

Acknowledgements

References

Ivan Stoianov, Lama Nachman, Sam Madden. PIPENET: A Wireless Sensor Network for Pipeline Monitoring. IPSN'07,Vol.3, No.1, pp 264-273, 2007

F. Shebli, I. Dayoub and J.M. Rouvaen.Minimizing energy consumption within wireless sensors networks. Ubiquitous Computing and Communication Journal, Vol.144, pp. 108- 116, 2007.

Sultanullah Jadoon, Salman Faiz Solehria, Mubashir Qayum1. A Proposed Least Cost Framework of Irrigation Control System Based on Sensor Network for Efficient Water Management in Pakistan. International Journal of Basic & Applied Sciences IJBAS-IJENS Vol.978, No.1, pp. 82-86, 2011

S. Azid, B. Sharma, K. Raghuwaiya, A. Chand, S. Prasad, and A. Jacquier, SMS based flood monitoring and early warning system, vol. 10. 2015

Victor Seal, Arnab Raha, Shovan Maity, Souvik Kr Mitra, Amitava Mukherjee and Mrinal Kanti Naskar. A simple flood forecasting scheme using wireless sensor networks. International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.3, No.1, pp 45-60, 2012

Theodore S. Rappaport 2nd Edition, Wireless Communication: Principle and practice. Prentice-Hall, 2002.

Chee-Vee Chong; Kumar, S.P., "Sensor networks: Evolution, opportunities, and challenges,"Proc IEEE, August 2003.

S. Hussin, M. N. Ismail, and H. Sofian, "Intelligent Flood Information System via SMS (IFIS)", Proc. of the 6th International Conference on Ubiquitous Information Management and Communication (ICUIMC'12), Kuala Lumpur, Malaysia, 2012.

M. Cattani, C. A. Boano, and K. Römer, "An Experimental Evaluation of the Reliability of LoRa Long-Range Low-Power Wireless Communication," 2017.

Wayne Tomasi, 5th Edition, "Electronic Communication Systems" Prentice-Hall. 2004.

E. Basha and D. Rus, "Design of early warning flood detection systems for developing countries," 2007 International Conference on Information and Communication Technologies and Development, Bangalore, 2007.