

Developing an Intelligent Flood Alert System Using Internet of Things

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I. INTRODUCTION

Abstract— Long Range (LoRa) is a low power wide area network protocol that uses radiofrequency bands to transmit data. The best option of this wireless technology is long coverage range, low power consumption required, secured end-to-end encryption, and low cost. Some of the wireless technologies like, Wi-Fi, Bluetooth, and Zigbee are other types of wireless technology that consumed more energy and have shorter coverage areas compared to LoRa. By using wireless technology, various problems are being solved, for example, issues related to education, agriculture, health, natural disaster, etc. Based on my findings I found that there are still some issues related to range, cost, stability, and availability, for flood alert systems. In this project, a LoRa-based wireless network is developed, that works as an intelligent flood alert system. To meet the objectives, a testbed is designed and developed, where two different nodes performing as an end node and gateway in the network. The testbed is used to provide a complete flood alert system with LED light and buzzer sensor which is more user friendly than the previous technologies. Also, to measure the performance of this network in different situations and time and the maximum coverage distance it can send data. It was tested on different days and at different timing of a day to collect the network performance and to check the packet loss ratio, end to end delay, and throughput. The experiments are conducted in different scenarios such as for water level alert, to check the surrounding effects, time duration, and the maximum successful transmission coverage. Also, in all the experiments, the data packet is sent for 20minutes and sometimes for 1 hour. The results show that the flood alert system can provide alert by green, yellow and red LED and with different types of sound. This network can successfully cover up to 700 meters. So the different color LED light and different types of sound by the buzzer sensor for different water level proves that this network can perform as a real-time intelligent flood alert system and the maximum coverage range, surrounding effects, and time duration experiment shows this network can provide a stable and consistent performance with a longer coverage range. The experiment concludes that this network can perform strongly in different surroundings and time duration for a longer distance.

Keywords—LoRa; Wireless sensor network; Performance metrics; Natural disaster

The internet of things or IoT is the upcoming leading technology for smart communication technology. IoT is a meaning of some physical objects network where some of the communication technologies allow Ito to communicate and interact with each other and provide data. Objects like mobile phones, radio frequency identification (RFID) tags, actuators, and sensors. In this current world, IoT has a big impact which affects human nature as well. IoT can affect the domestic and working field of a private user [1]. To meet the user requirements IoT applications have to change different types of data communication according to demand. IoT is now related to logistics, automation, industrial manufacturing, business, transport, and so on. Statistics show that in the year 2020 there will be 50.1 billion users will be connected to IoT [2]. So, the development of IoT is moving forward according to future expectations. The advantages of IoT in the current world and the future is huge but the technology also adopting the deriving threats. To ensure the security of this big number of data and devices it is confirmed that related risks should be minimized [3-4]. Infect IoT and the risk issues should be analyzed before it widely accepted. Besides those issues IoT applications have been deployed in different contexts.

Long Range (LoRa) is a wireless technology with a longer coverage range. LoRa has spread spectrum modulation techniques derived from chirp spread spectrum technology. LoRa offers different features for IoT applications. It uses low power consumption, high secure data transmission within low cost [5]. LoRaWAN is a protocol-based network that uses Low Power Wide Area Network (LPWAN) protocol. LPWAN is used to deliver the data in this technology. The structure of this LoRaWAN follows star network topology. The network consists of an end node, gateway, and sever. The data from the end node sends to gateway and from the gateway, the data is forwarded to a server to visualize. This technology can utilize in public, private, and hybrid networks. LoRa uses 169MHz, 433MHz, 868MHz, and 915MHz radio frequency bands [6]. LoRa can transmit data up to 10km in rural areas.

In this paper, we proposed a LoRa-based wireless network to improve an intelligent flood alert system to measure different water level, particularly in possible flood

affected areas. The testbed is also used to evaluate the maximum distance of data transmission by this network and the performance during different indoor and outdoor environments. We experimented with this wireless network by taking the Packet Delivery ratio (PDR), Packet loss ratio (PLR), End to end delay (E2E) and Throughput.

II. RELATED WORKS

Previous studies have been focusing on applications of LoRa technology. In [7], a wireless sensor-based smart application system has built by the researchers to cultivate mushroom based on the wireless and mobile computing technology. To build the smart system, researchers have used temperature, humidity, and CO₂ sensors to evaluate the data of the greenhouse environment. This type of greenhouse environment of mushroom cultivation changes the environmental factors frequently, so this automated sensor network can full fill the requirements. It requires A/D converter, sensor, memory, microcontroller, wireless transceiver, and power module to build the wireless sensor node. Temperature and humidity requirements for mushroom incubation area and growth area are 75-85% humidity, 18-25 Celsius day, and 15-18 Celsius night in and 85-95%, 22-25 Celsius day and 12-15 Celsius night. The experiment results of this research show that the temperature and humidity in growth are is 17 degrees Celsius and 42% and in incubation is 24 degrees Celsius and 90%. So, this wireless smart network can provide the information about the environment and increase their income.

In [8], monitor the packet delivery ratio during rain attenuation, researchers have proposed a mesh network system based on LoRa technology. The effects of atmospheric attenuation in the signal transmission process at different line-of-sight and non-line-of-sight has been monitored by deploying the network in several situations. Also, the experiments have been conducted by collecting the maximum successful data transmission range of this network. To set up this network, the end node, master node and gateway was deployed. The end node was made up with LoRa RFM shield, Arduino UNO microcontroller, and DHT 11 temperature sensor. The master node and gateway were set up with LoRa RFM shield, Arduino UNO microcontroller. In this network, the end node collects the temperature value by the DHT 11 sensor and sends it to the master node and the master node collects the data and sends it to the gateway. In the gateway, all the data sent from the end node can visualize in the serial monitor. The number of data send from end to and the number of data received by the gateway are collected to measure the PDR (Packet Delivery Ratio). The experiment result shows that during the different volumes of rain the PDR decreases significantly from 100% to 89.5%. Another experiment

result shows that this mesh network can successfully transmit data up to 1.7km in line-of-sight and up to 1.3km in a non-line-of-sight environment with 100% PDR.

In [9], best performance of spreading factor in different distance variation has been tested and analyzed by the researchers by using the 925MHz ISM frequency band of QoS performance analysis on various reading factor. Different types of throughput are required like for maximum Throughput value SF7, for the balanced high throughput and long-range capabilities SF8 is required and for maximum range and optimal range SF11 is required. The variation of distance starts from 500meter to 1100meter. Where this network measures the Packet Loss, Throughput, End to End Delay, and RSSI value. The network was designed with the Arduino UNO and LoRa shield for client node and LG-01 as gateway. This network used 925MHz, ISM frequency band, transmitting power of 13dbm, bandwidth of 125 kHz and the code rate was 4/5. Experiment results show that the SF12 provides the maximum number of packet loss in every range of distance variation. SF8 provides a similar number of packet loss like SF12. For the experiments of throughput, the result shows that the SF7 provides the best throughput value up to 1927.3 bit/s for a short distance and SF8 provides the best throughput value of 1204.6 bit/s in the longer distance. Based on all the experiment result, it shows that the SF7 has the best performance for maximum throughput value, SF8 has the high throughput value with longer distance and SF11 has the best performance with maximum range and optimal range.

In research work [10], researchers have proposed a network setup in a suburban and rural area. By this network, they have collected the performance of this network in different line-of-sight and non-line-of-sight environments. As a result, they found, there is a huge role of environment in the signal transmission process. I have proposed a LoRa based network to develop a flood alert system to study the issues and characteristics of IoT floor alert system and IoT wireless communication technology.

Research in [11], A LoRaWAN network has been proposed by the researchers to increase the message delivery success rate. The network has been proposed as two approaches to network that can solve this problem. The network was equipped with a 3.54dBi antenna with an RN2483 LoRa module and the gateway was equipped with IC880A LoRa concentrator and 8dBi antenna. 8 different sensor boxes were deployed in the rooftop, where those were using the RN2483 module. The experiment results of this research show that the message delivery rate can highly increase in this network approach. But in some cases this network provides the message delivery rate from 100% to 25.51% and also the multi-helper reacts differently.

III. PROPOSED NETWORK

Tab.1 The proposed network Architecture

This section shows the proposed network model and the description of the physical components and software used in this project. A LoRa compatible water level sensor is attached to the end node for measuring the level of water. Nodes are deployed at different locations, taking reading at different conditions like indoor and outdoor and also in different distance. The reading of water level is sent from the end node to the gateway. The network is built with LoRa RFM 915MHz shield, Arduino UNO board, 915MHz SMA antenna, LED light sensor, buzzer sensor and 5V power supply is required to power this network. We show the complete design diagram of this proposed network in Fig.1.

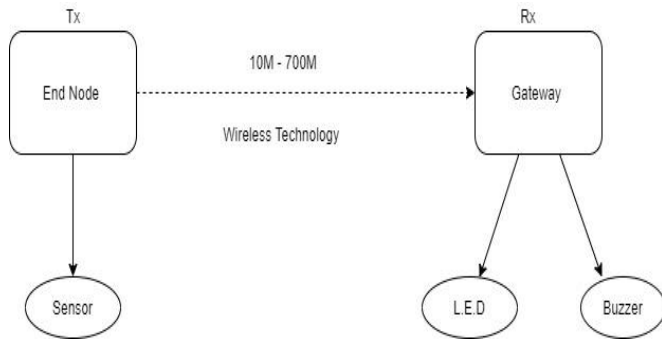


Fig.1 Complete Design diagram.

To notify the peoples living near the possible flood affected areas, the LED light sensor and buzzer sensor response according to value of end node. In the end node side, 0mm to 100mm of water level is considered as Low level of risk, from 101mm to 200mm is considered as a medium level of risk, and from 201mm and above is considered as a high level of risk. In the gateway side when the water level is in between 0mm-100mm the green LED turns on and the buzzer beep in every ten seconds. If the water level is in between 101mm-200mm the yellow LED turns on and buzzer beeps in every 5 seconds. For 201mm and above the red LED turns on and the buzzer beeps every second. In table.2 shows the different types of alert for different level of water.

Tab. 2 Different types of alert for different water level.

Water Level	LED Color	Alert Type/ Time
0-100 mm	Green	10 sec
101-200 mm	Yellow	5 sec
201- above mm	Red	1 sec

In this project, the LoRa shield is used to transmit data for a long-range. The Ardouni UNO is used as the microcontroller board. In the second part of this network, a gateway collects data from the end node and activated the LED sensor and buzzer sensor according to the value of water level. Gateway is connected to the application server through the USB port of Arduino UNO, so that the data can be visualize. In Tabel.1 the network architecture is shown.

In this research, PDR, PLR, E2E and Throughput is taken to measure the performance evaluation. To calculate PDR, PLR, E2E and Throughput value, the following equations are used:

$$(PDR) = \frac{\text{Total packets received}}{\text{Total packets sent}} * 100 \quad (3.1)$$

$$PLR = \frac{(\text{Number of packet send} - \text{Number of packet received})}{\text{Number of packet send}} * 100 \quad (3.2)$$

$$E2E \text{ Delay} = \frac{(\text{Packet received time} - \text{Packet send time})}{\text{Number of packets received}} \quad (3.3)$$

$$\text{Throughput} = \frac{\text{Received packet size}}{(\text{Stop time} - \text{start time})} \quad (3.4)$$

End node	Gateway
LoRa RFM 915MHz	LoRa RFM 915MHz
Arduino UNO	Arduino UNO
915MHz SMA antenna	915MHz SMA antenna
5V power supply	5V power supply
Water level sensor	Traffic LED light module
	Buzzer sensor

We have chosen different indoor and outdoor environment and different location to deploy our network and carried out the experiments. Data received by the gateway is calculated to obtain the value of PDR, PLR, E2E and throughput by using the expression in (3.1, 3.2, 3.3, and 3.4). All data are visualized in the serial monitor of the gateway. The results show the performance, stability and consistency of the network,

Fig. 2 shows an example of devices installation at different places for the experiments. The figure shows the distribution of node and gateway.

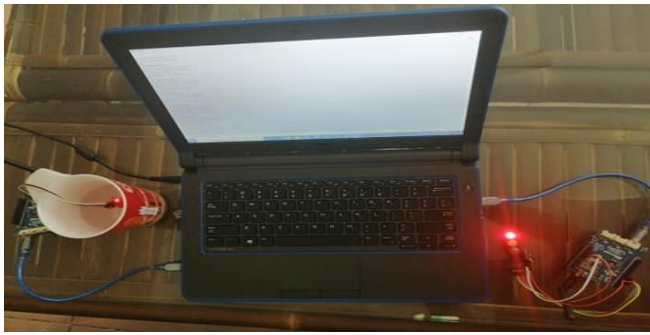


Fig.2 Distribution of nodes.

IV. RESULTS AND DISCUSSION

In this study, five types of experiments were conducted at different times of the day and different location. Five categories of experiments are performed as follows, i) Water level alert ii) Surrounding effects, iii) Time duration iv) To measure maximum coverage range, iv) Performance metrics evaluation.

1. Water level alert

For the low water level experiment, the water level sensor is drowned for a height of low level water which means 0mm-100mm. As a result, the gateway side shows that the GREEN LED light is turned on and the buzzer starts the beep every 10 seconds. At the same time, in the serial monitor of the Arduino IDE application, I can see that the gateway receives data where the value of the water level is between 15mm-32mm.

During the medium water level experiment, the result shows that, in the gateway side, the YELLOW light is turns on and the buzzer is beeping in every 5 seconds. In the serial monitor, is visualized that the height of the water level was from 107mm-127mm.

For the experiment of a high water level, results shows that the LED light of the gateway side turns RED and the buzzer is beeping every second. In the serial monitor, the value of the water level is viewed in between 243mm-290mm. In Fig. 3 the experiment results of low, medium and high water level, with the value of the water level sensor and the functions of LED lights are shown.

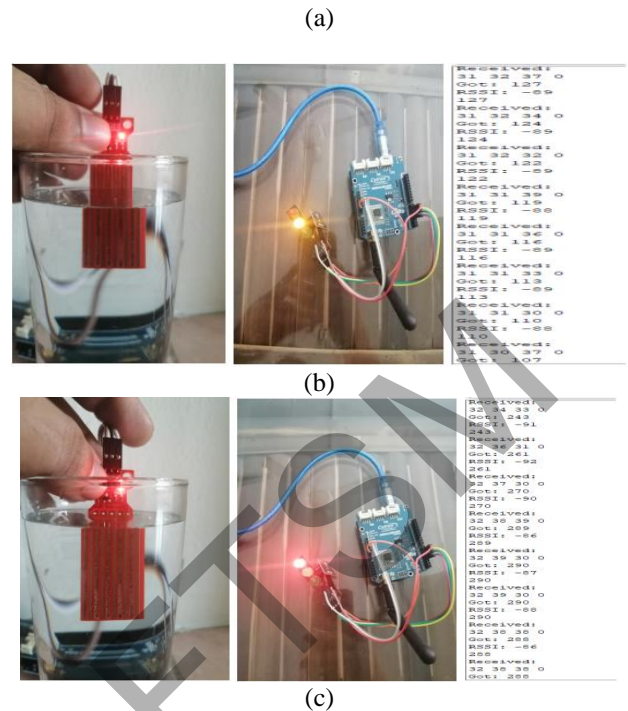


Fig. 3 Experiment in Low, Medium and High level water.

2. Surrounding effects

To check the stability of this proposed network, network is deployed in different environments. So that the performance of this network can verify. Experiments were conducted in indoor and outdoor environments. The time duration of each experiment was one hour. During the experiment, the water level sensor was drowned in 100mm-200mm of water to produce the communication between the devices. Five experiments were conducted indoor and the other five were conducted outdoor. For the indoor experiments, devices were installed 10meter away from each other. Experiments are done in five different days so that it can be easy to check if this network can provide the same performance every day or not. The results of all this indoor experiment shows that, for each time, this network can actively perform. Outdoor experiments were conducted in an area of 10meter distance on five different days. The results show that in this environment also this network can perform actively. Fig. 4 shows the results on indoor and outdoor experiments in different date.

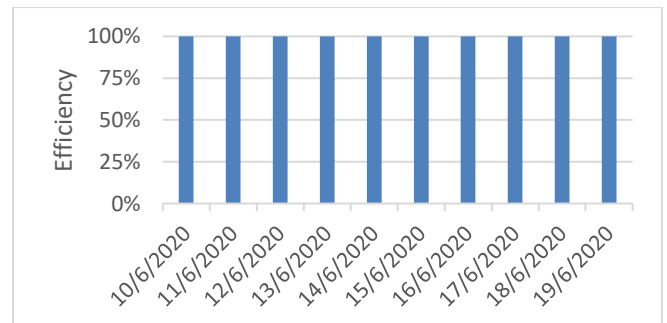


Fig.4 Surrounding effects on different days.

3. Time duration

Experiments to check the consistency of this proposed network are conducted in an indoor environment by sending and receiving data for a long duration. Distance between the end node and gateway was 10meter away from each other and there were some obstacles in between. Experiments were performed from 10.00 am till 10.00 pm, on the same day. During the experiments, data was collected at 10.00am and 11.00am in the morning, 12.00pm, 01.00pm, 02.00pm, 03.00pm, 04.00pm, and 05.00pm in the afternoon, 06.00pm, 07.00pm, 08.00pm, 09.00pm, and 10.00pm in the evening. For the experiment, the water level sensor was drowned in 101mm- 200mm water to continue the communication between the devices. As a result, it shows that the network provides the same performance in every situation of the time. It also shows that the device can perform activities for a long duration. In Fig. 5 the effects of time duration is shown.

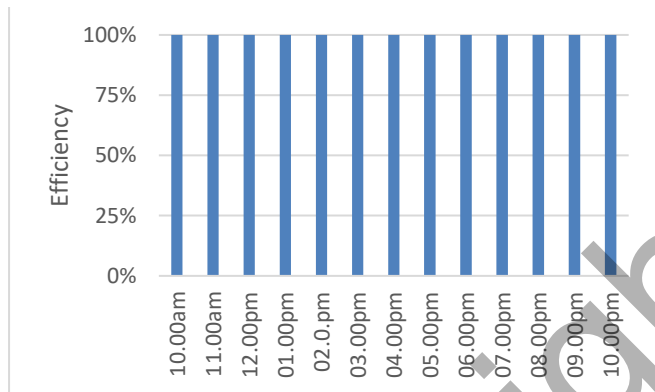


Fig. 5 Effects of different time.

4. Maximum coverage range

In this proposed network, the end node sends data to the gateway, where the gateway performs as a notifier. To get the maximum distance of successful data transmission by this network, the network has deployed at different distances. Experiments were started from a 100m distance by sending data of medium level water, within five minutes of time duration. The gateway was installed in 0m and the end node was installed in 100m away from the gateway. Distance between the end node and gateway increased gradually until the gateway stops receiving signals from the end node. Experiments shows that this network can communicate until 700m. After this distance, this network stop the communication. The results show that up to 700m this device can send and receive data actively but in 800m and 900m this network remains not active. So that the maximum coverage range for this network is 700m. Fig. 6 shows the experiment results in different distance.

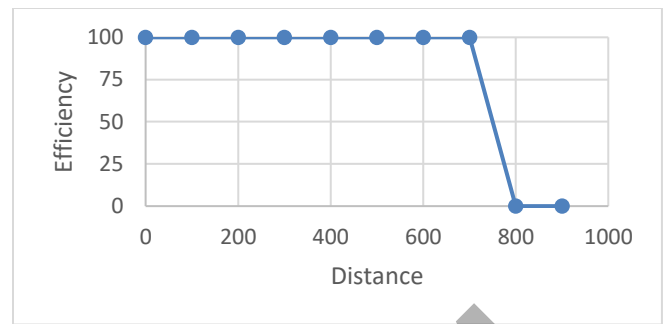
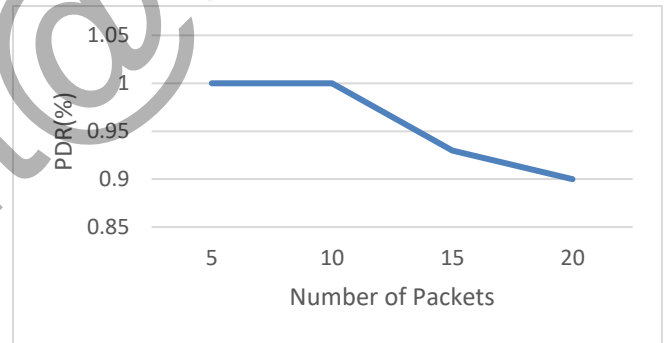


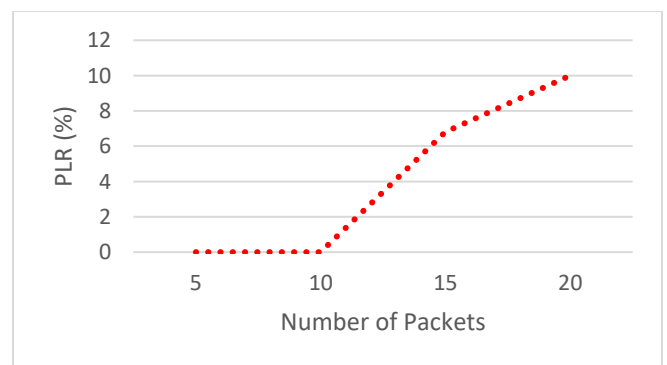
Fig.6 Results in different distance.

5. Performance metrics evaluation

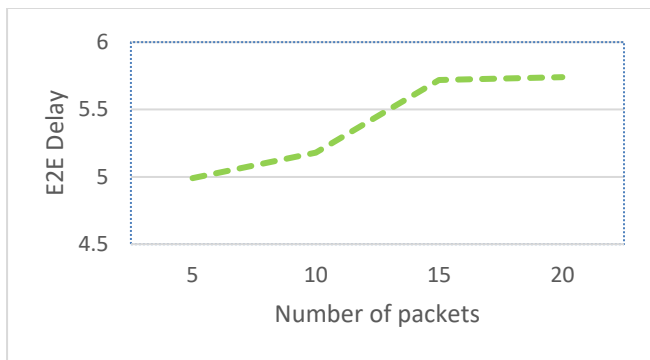
To check the performance metrics of this proposed setup, the Packet Delivery Ratio, Packet Loss Ratio, End to End Delay, and Throughput is measured by calculating the different amounts of data. For doing this experiment, different numbers of data packets are sent from the end node to the gateway. The number of packets that are sent is 5, 10, 15, and 20 packets. In Fig.7 the results of PDR, PLR, E2E, and Throughput for different number of packets are shown:



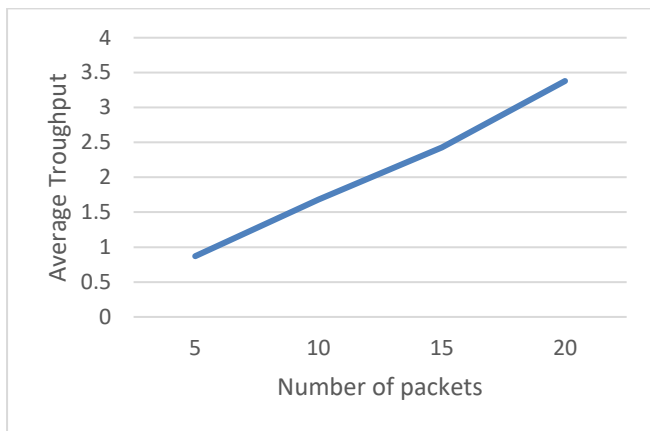
(a)



(b)



(c)



(d)

Fig. 7 Result of Packet Delivery Ratio (a), Packet Loss Ratio (b), End to End Delay(c), and Throughput (d).

V. CONCLUSION

LoRa is the wireless technology which becomes one of the most advanced wireless technology. Other wireless technologies like Zigbee, WiFi, and Bluetooth are less coverage range with high cost and requirements. Though there are some issues regarding LoRa wireless technology and the transmission process, although different innovation based on LoRa technology, helps to improve daily activity. In this dissertation, a new LoRa based network is proposed, that helps to overcome a few issues regarding flood alert system. This network presents a new way to notify the peoples that live near flood-affected areas. By providing longer range, buzzer system, LED light, and low power consumption, this network overcome some of the limitations of other wireless technologies and previous works based on LoRa. Results of different locations, time and data, environment, performance evaluation, and various distance shows the strong stability and consistency of signal strength with a longer distance of coverage. This network behaves differently when the distance between devices increase gradually and from 800meter and above is stops data transmission but is still shows a better performance than other wireless technologies. Also, the LED light and buzzer

sensor make this network more effective for people with visual impairment and impervious. One significant result obtained from the experiment shows that in different date and time and different environment like indoor and outdoor environment, this network can perform with the same level of stability. On the contrary, this project can successfully show the best performance and characteristics of this LoRa based setup and developed an intelligent flood alert system using long-range wireless communication technology.

REFERENCES.

- [1] Shahidul Islam, M., Islam, M., Almutairi, A., Beng, G., Misran, N. and Amin, N. (2019). Monitoring of the Human Body Signal through the Internet of Things (IoT) Based LoRa Wireless Network System. *Applied Sciences*, 9(9), p.1884.
- [2] F. Jindal, R. Jamar, and P. Churi. 2018. *Future and Challenges of Internet of Things*. *International Journal of Computer Science & Information Technology (IJCSIT)*, vol. 10, no. 2, April.
- [3] M. Hasan, M. Rahman, M. Faruque, and M. Islam, "Bandwidth enhanced metamaterial embedded inverse L-slotted antenna for WiFi/WLAN/WiMAX wireless communication", *Materials Research Express*, vol. 6, no.8, 085805, 2019.
- [4] D. Dahnil, S. Selamat, A. Bakar, R. Hassan, and A. Ismail, "A New Method for Battery Lifetime Estimation Using Experimental Testbed for Zigbee Wireless Technology. *International Journal on Advanced Science*", *Engineering and Information Technology*, vol.8, no.6, pp.2654-2662, 2018.
- [5] N. Husein, A. Hadi, and D. Putri, "Evaluation of LoRa-based Air Pollution Monitoring System", *International Journal of Advanced Computer Science and Applications*, vol. 10, no. 7, pp. 391-396, 2019.
- [6] A. Rahman, and M. Suryanegara, "The development of IoT LoRa: A performance evaluation on LoS and Non-LoS environment at 915MHz ISM frequency", 2017 International Conference on Signals and Systems (ICSigSys), pp-163-167, 03 July 2017.
- [7] Mohamed Rawidean Mohd Kassim; Ahmad Nizar Harun; Ismail Mat Yusoff; Ibrahim Mat; Chan Pick Kuen. 2017. *Applications of wireless sensor networks in Shiitake Mushroom cultivation*. <https://ieeexplore.ieee.org/document/8304516>.
- [8] Hossin; Dahlila.2019. *Enhancement of Packet Delivery Ratio during Rain Attenuation for Long Range Technology*. (IJACSA) *International Journal of Advanced Computer Science and Applications*, Vol. 10, No. 10, 2019.
- [9] Eko Didik Widianto; Michael S.M. Pakpahan; Al Arthur Faizal; Risma Septiana. 2018. *LoRa QoS Performance Analysis on VariolSpreading Factor in Indonesia*. <https://ieeexplore.ieee.org/document/8605471>.2018 International Symposium on Electronics and Smart Devices (ISESD), 2018
- [10] A.K. Ahmed, J.D. Segaran, F.R. Hashim, M.T. Jusoh. (2018). " *LoRa propagation at 433 MHZ in tropical climate environment* ". Published online:10 september,2017.
- [11] Shie-Yuan Wang, Tzu-Yang Chen. (2018). " *Increasing LoRaWAN application -layer message delivery success rates*". 2018 IEEE symposium on computers and communications, PoD. 1530-1346,19 November, 2018.