LORA BASED ALERT SYSTEM FOR REMOTE NATURAL DISASTER RESPONSE TO ENHANCE DISASTER PREPAREDNESS AND COMMUNICATION

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CERTIFICATE OF ORIGINALITY

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material to which to a substantial extent has been accepted for award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made in the text.

We also declare that the intellectual content of this thesis is the product of our work, even though we may have received assistance from others on style, presentation and language expression.

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DEDICATION

This research is sincerely dedicated to the people who have encouraged and inspired me throughout this study. To **my loving parents**, for their unending support and love. I want you to know how much I love you, always. To **Kuya Lander**, for his exceptional support in my studies despite the challenges, and for helping me through difficult times. To my thesis mates, **Reimarc** and **Clarice**, for their invaluable contributions and support. To **Tambunts**, Chariz, Christian, Gleizel, Harold, Johanna, Justin, and Rose Ann, for being supportive and helpful. Above all, to **Almighty God**, for providing courage, wisdom, and good health.

LAPB

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CMGC

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ABSTRACT

Title: LoRa Based Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication

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This study developed a LoRa-based alert system integrated with a mobile application to develop natural disaster preparedness and response in remote areas. Objectives included designing the wireless communication process, creating a program for the wireless connection, developing an information dissemination app, and evaluating the alert system. LoRa technology was chosen for its long-range, low-power capabilities, enabling alerts without internet or cellular networks. Interviews with MDRMMO and professionals ensured the system met local needs, and the app was designed for user-friendly accessibility. User trials confirmed the system's effectiveness in reliable data transmission. The study concluded that the LoRa alert system significantly improves disaster communication, allowing faster and more reliable information exchange between authorities and residents, reducing the need for manual patrols by local officials. These findings suggest the system is a viable solution for developing disaster preparedness and response in rural areas.

Keywords: alert system, disaster preparedness, LoRa technology, mobile application, natural disaster response, rural areas, and wireless communication

Chapter I

INTRODUCTION

Every year, new technologies emerge in various aspects of life, including communication. In the Philippines, many towns and islands struggle to access these technologies, which could improve community safety and security. Technology can empower people in rural and isolated regions by providing access to up-to-date information, weather forecasts, and urgent notifications crucial for preparedness.

Preparedness is essential against natural disasters, especially in rural areas where news and alerts are slow to reach, and necessary equipment is lacking. Traditionally, information is shared verbally, requiring local officials to patrol communities, which is time-consuming.

The World Bank (2005) highlights the impact of natural disasters on social and economic development and recommends better disaster risk management. Key recommendations include creating a Disaster Management Information System (DMIS) to enhance response capabilities by distributing timely and accurate early warning information through a national agency to local municipalities. Further studies on emergency communication and early warning systems are suggested to develop a comprehensive national disaster risk management framework.

The researchers considered it crucial to provide an additional alert system to reduce disaster risks and achieve development goals in rural areas like the islands.

Background of the Study

Patnanungan, Quezon, is one of the municipalities within the Polillo Group of Islands. This remote island is classified as a fifth-class municipality in the Philippines economy with an estimated population of 15,000 residents (PhilAtlas 2015). Despite this economic status, Patnanungan faces several challenges, particularly in terms of natural disaster preparedness.

One notable issue is the absence of an alert system for natural events in the area. Given its remote location, the province lags behind in economic development. It is difficult for them to import materials sourced from urban areas like Real, Quezon. One contributing factor is the municipality of Patnanungan's capacity to maintain a reliable power source. Because of this, it affects how information or news can be disseminated to the community. Additionally, the cellular signal is unstable and the internet connectivity is not accessible for most of the residents making it difficult for them to stay updated on current events, especially crucial weather updates and sudden natural events.

While the Municipal Disaster Risk Reduction and Management Office (MDRRMO) receives updates about natural disasters such as gale warnings, typhoon signals, or earthquakes, dissemination of this information is not straightforward. The

MDRRMO typically posts updates on their Facebook page, but not all residents have access online or use social media. Furthermore, local authorities conduct periodic rounds or patrols within the community, but these efforts are not persistent.

These challenges highlight the need for an effective and accessible alert system for natural disaster preparedness in Patnanungan, Quezon, and even for other remote rural areas. The implementation of a mobile application and wireless alert system without the need of the internet offers the residents accurate disaster alerts, overcoming challenges posed by limited connectivity and unreliable power sources. This innovative system ensures accessibility even in low-connectivity areas.

Objectives of the Study

The general objective of this study is to develop a system for natural disaster response and preparedness, utilizing both mobile application and LoRa modules. The specific objectives of the study are the following:

1. To plan and design the wireless communication process of the alert system.
2. To create a mobile application that will be used to send and receive the information.
3. To create a program for the wireless connection of the alert system.
4. To evaluate the efficiency of the mobile application and wireless alert system.

Significance of the Study

This study aims to create an alert system for natural disaster response and preparedness. Moreover, the following are the beneficiaries of the study:

Residents of Patnanungan, Quezon, this study may help the aforementioned community gain access to an innovative system for natural disaster response and preparedness.

MDRRMO, this study may benefit the office because they will no longer need to patrol the entire community to provide or announce information about natural disasters. They will just use the mobile application and instruct the system to give alerts to the people in the community or barangays.

For future researchers, this research can serve as a basis for further studies, with potential improvements and new ideas enhancing the system's benefits.

Scope and Limitations

The study focuses on the enhancement of natural disaster preparedness and response in municipalities, specifically in smaller towns and rural areas that often face challenges in disaster preparedness due to limited resources.

The study aimed to investigate the current challenges in disseminating warning alerts about natural disasters. It is focused on the development of mobile applications to be used by the Municipal Disaster Risk Reduction and Management Office and the residents of the community. Moreover, it addresses the establishment of wireless alert communication, determining the method through which alerts were disseminated and received responses. The MDRRMO uses a mobile application that sends announcements to be received around the community. Similarly, the residents can send responses to the MDRRMO.

The study has certain limitations. The efficiency of the system relies on the range that a LoRa module can achieve for sending and receiving data. The authorities only use the system for sending out alerts or announcements about typhoons, gale warnings, earthquakes, and other natural disasters or emergencies. The study does not predict natural disasters but relies on local authorities' assessments.

Definition of Terms

The following terms are defined conceptually and operationally for the easy understanding of the readers.

Cellular signal, refers to the signal such as globe and smart from the cell site tower in Patnanungan Quezon.

Facebook page, refers to the social media page where the MDRRMO posts their announcement regarding natural disaster updates, including typhoons and gale warnings.

Internet connectivity, refers to the networks where the devices establish a connection to the internet.

Master Node, refers to the prototype positioned in the office of MDRRMO and it is the mother of the communication that sends and receives data from/to slave nodes.

MDRRMO (Municipal Disaster Risk Reduction Management Office), refers to the office of the authority of Patnanungan Quezon that is assigned a task to disseminate information about natural disaster preparedness and response in the community.

Mobile application, refers to the user interface of the MDRRMO that sends and receives messages and responses to the community.

Natural Disaster, refers to the natural event that causes harm to the residents of the community.

Natural Disaster Preparedness and Response, refers to the action of the local authority and residents of the barangays regarding the natural disaster to make them ready and safe.

Patrol, refers to traditionally disseminating information of the MDRRMO in the community using megaphones and vehicles.

Received Signal Indicator (RSI), refers to the measurement of the signal received by the antenna.

Remote Island, refers to the island that has its own municipality but not keeping up with modern technology.

Rural areas refer to Patnanungan Quezon which is not like other municipalities with large establishments, numerous vehicles, and a high economy.

Slave Node, refers to the prototype positioned around the community, where the residents can receive and respond from/to the MDRRMO.

Social media refers to the platforms that enable the people in virtual communities and networks.

Transceiver, refers to the prototype that the MDRRMO and the community send and receive their information and response about natural disasters.

TTS, stands for text-to-speech, a feature in a mobile application that converts the text received from another device into speech.

Wireless alert system, refers to the dissemination of information without using a wired connection.

Chapter II

RELATED LITERATURE AND STUDIES

This chapter provides concise summaries of literature, research studies, and various published works relevant to this study. Additionally, it explores related materials. The internet serves as a primary information source, contributing to a deeper understanding and broader knowledge within the context of this research.

Related Literature

Natural Disasters in Remote Areas

Any catastrophic occurrence that arises from natural processes instead than human activity is referred to as a natural disaster. These occurrences have the potential to cause grave human casualties, environmental destruction, and harm to infrastructure and property. Events connected to weather, earthquakes, landslides, and other geological phenomena are all considered natural disasters. Although such disasters can strike anywhere, some varieties seem to strike more frequently in particular geographic locations.

Weather and climate-related natural catastrophes include a broad spectrum of occurrences. These include wildfires started by heatwaves and changes in precipitation patterns, windstorms, blizzards, and heavy snowfalls; flooding brought on by strong rainfall linked to typhoons; droughts that result in hunger. Volcanic eruptions and strong earthquakes are examples of Earth-driven disasters that can seriously harm populated regions. In addition, a combination of factors, such rainfall or seismic activity, may cause some disasters, like landslides. Massive ocean waves known as tsunamis can be caused by undersea earthquakes, volcanic eruptions, coastal or underwater landslides, or impacts from space. They can be dangerous across great distances (Natural catastrophe | Causes, Types, & Facts, Encyclopedia Britannica).

Despite having a negligible effect on the world's death statistics, natural catastrophes can have a significant impact, particularly on populations that are more susceptible in low to middle income nations. In these areas, inadequate infrastructure frequently makes it more difficult to respond to emergencies and provide appropriate protection (Natural Disasters, Hannah Ritchie, 2023).

The mentioned vulnerability parallelled to rural communities where depictions often romanticize qualities like remoteness and rustic charm, but these very characteristics expose rural communities to hazards and disasters. Limited financial resources, population constraints, and technology access challenges hinder rural areas' ability to build disaster resilience. Community resilience, vital for addressing hazards, involves capacity building, hazard mitigation, and effective response preparedness. However, rural communities face difficulties accessing funds, training, and equipment. To overcome these challenges, it is essential for rural areas to decrease dependence on federal resources and promote community responsibility, and collaborate with urban counterparts. Collaborative culture, leadership, and resource-sharing mechanic text message, including memoranda of understanding and mutual assistance compacts, play a key role in enhancing rural disaster resilience. Failure to implement such collaboration may create new vulnerabilities and compromise the ability to effectively address disaster impacts (Rural Resilience: Disaster Preparedness for Communities Off the Beaten Path).

Communication Technologies in Disaster Management

Communication technologies are vital in disaster management, facilitating swift information sharing among emergency responders, government agencies, and affected communities. Systems for managing catastrophe information and early warning rely heavily on communication technology. In Japan, specific early warning systems such as Earthquake Early Warning System, and Emergency Alert Mail are integral components of a larger warning system ecosystem. Lesson learned to include the importance of selecting warning systems based on local ICT context, redundant and diverse dissemination methods. (World Bank, 2019)

Early Warning Signs

Early warning signs are crucial for risk management and disaster preparedness, aiding in life-saving efforts and reducing calamities. Effective systems involve communities directly, educate the public, disseminate alerts swiftly, and maintain readiness for prompt action. An early warning system (EWS) produces and shares timely warning data, empowering individuals and organizations to prepare and respond effectively to potential hazards, minimizing harm. Point to point warning system connects recipients with those monitoring hazard data, ensuring timely alerts (Early Warning Systems - PrepareCenter, 2024).

Alert Systems

The Law Insider dictionary website provides the definition of alert systems as a unit that is worn by an individual or located in the individual's residence for the purpose of generating notification indicating the potential that an emergency has or may occur.

The Emergency Alert System (EAS) serves as a widely used public warning system at the federal level. The EAS is frequently used by state and local authorities to provide impacted areas with vital emergency information, such as weather updates, across radio and television channels. State and local warnings are freely broadcast by EAS participants, which include cable networks, satellite radio and television providers, radio and television broadcasters, and wireline video providers. On the other hand, in the event of a national emergency, they are required to transmit Presidential notifications, allowing the President to address the populace. The two main elements of the national public warning system are the EAS and Wireless Emergency Alerts. Alerts are sent out via this system by authorized federal, state, and local authorities.

The function of alerts and warnings is described in the book "Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions." Their goal is to spread vital information so that people are aware of it and may take the appropriate steps to protect themselves. Delivering timely messages to populations facing impending threats is the main goal in order to maximize the likelihood that people will take preventative action while minimizing any delays. The function of alerts and warnings is explained in the book "Emergency Alert and Warning Systems: Current Knowledge and Future

Research Directions." Their goal is to spread vital information so that people are aware of it and may take the appropriate steps to protect themselves. Delivering timely communications to populations facing impending hazards is the main goal in order to maximize the possibility that individuals would take preventative action while minimizing any delays.

The book also discussed the various events that could trigger the issuance of alerts and warnings, from the natural hazards or disasters, such as severe weather to human-made incidents such as terrorist attacks, civil unrest, and biological/chemical threats etc..

Alert Messages

The National Disaster Risk Reduction and Management Council (NDRRMC) in the Philippines disseminates warning messages through various channels, including the use of cell broadcasting technology. Cell broadcasting allows the NDRRMC to send messages simultaneously to multiple mobile phone users within a specific geographic area, ensuring widespread dissemination of crucial alerts and warnings during disasters. This technology enables efficient and rapid communication of critical information to the public, enhancing preparedness and response efforts (Saraiva, n.d.).

LoRa

LoRa is a wireless method that is used for sending messages via radio waves using chirp pulses, similar to how dolphins and bats communicate. LoRa signals are robust, and can travel long distances, enabling device-to-device communication without the need for the internet or mobile networks. This makes LoRa ideal for low-power sensors and devices that transmit small amounts of data. In the internet of Things (IoT), many devices are cost and power-limited, often needing to send data over long distances. Since cellular tech, Wi-Fi, and Bluetooth aren't well-suited for these scenarios, LoRa becomes particularly relevant (Introduction to LoRa, 2022).

Mobile Application

A mobile application, commonly known as an app, is a specialized software application meticulously crafted for optimal performance on mobile devices, ranging from smartphones and computers to tablets and other electronic gadgets. These applications are purposefully designed to fulfill specific functions, with their user interfaces and features tailored to enhance the user experience on the unique platforms of mobile devices. By leveraging the capabilities of these portable gadgets, mobile apps have become integral tools, providing users with efficient and user-friendly solutions for a diverse array of tasks and activities (Rouse, 2020).

Mobile App-Controlled Devices

Mobile App-Controlled Devices pertains to electronic devices that can be operated, monitored, or managed by using a mobile application installed on a smartphone. These devices are provided with connectivity features enabling communication with a mobile application, allowing users to interact with and control various functions or settings remotely.

Examples of such devices include smart home appliances (thermostats, lights, security cameras), wearable gadgets (smartwatches, fitness trackers), and other IoT (Internet of Things) devices that can be seamlessly integrated into a user's mobile ecosystem for convenient and remote control. The mobile app serves as a user interface, providing a platform through which individuals can access, monitor, and manage the connected devices with ease and flexibility.

Related Studies

The study “Dynamic modeling of an early warning system for natural disasters” by Perroni da Silva et al. (2019) explained that natural disasters result in various consequences, impacting human lives, property, economy, and the environment. To address and lessen these impacts, it is widely acknowledged that implementing early warning systems or alert systems is both effective and crucial. Early warning systems play a significant role in minimizing the damages caused by natural disasters by providing timely alerts and enabling timely preventive actions.

In the study of Leo (2022), implementing early warning systems in disaster preparedness faces several challenges in rural areas. These include inadequate infrastructure, limited access to modern technologies, and data gaps that hinder accurate disaster prediction. Low community awareness and poor institutional coordination further reduce the effectiveness of these systems. Improved technology integration, such as remote sensing and IoT devices, and capacity building through local training and community programs are essential. Community involvement is vital for effective early warning systems. These measures can enhance disaster preparedness and resilience in vulnerable areas.

As stated by Jabbar, H., and Jacksi, K. (2021) in their study entitled "An Automated Early Alert System for Natural Disaster Risk Reduction: A Review," many people have died because of natural disasters. Consequently, numerous researchers are seeking solutions and effective methods to mitigate disasters and risks. The development of various technology-aided systems for these problems is the primary focus of researchers. Some solutions presented by the authors are innovations from other researchers who integrated technology into their solutions. One of the studies reviewed by Jabbar and Jacksi involves the development of an Android-based application used as an earthquake and landslide early warning system to alert people, for them to prevent disasters, and ensure safety.

The suggested system in this study is controlled by a smartphone application that the researchers created. Sehgal and More's (2017) study, "Home Automation using IoT and Mobile App," highlights the ease offered to customers. Electrical technologies are coming together as automation keeps developing. Numerous intelligent systems have been created that may be operated using Bluetooth, the internet, or short message service (short texts). The authors suggest a smartphone app that combines functionality for voice-activated home appliance control with connection devices like the Internet of Things. With the use of this software, consumers can simply operate their appliances with their phones by giving them orders. In a time when time is limited and technology is everywhere, a mobile app like this one is an effective

The ramifications of LoRa technology across several urban sectors are examined by Roberto Omar Andrade and Sang Guun Yoo (2019) in their work, "A Comprehensive Study of the Use of LoRa in the Development of Smart Cities." Their qualitative investigation looks at pollution control, health monitoring, and transportation-related smart city solutions. Using the PRISMA approach, the study entails a systematic examination of the literature from five scientific databases. The authors present LoRa as a recommended technology for linking IoT devices in smart city frameworks by evaluating its strengths, weaknesses, opportunities, and threats (SWOT) within the IoT architectural model described by the ITU's Y.2060 guideline. The development of LoRa solutions has enormous potential for smart city mobility, healthcare, and energy efficiency. Prominent international consulting organizations forecast 10% annual growth rates in each of the subcategories of smart cities until 2025, and even higher investment levels in the years to follow. Additionally, the scholarly community has seen a significant growth in IoT LoRa research, as seen by the rise in scholarly publications from about 30 in 2016 to almost 400 in 2018.

Furthermore, LoRa sets itself apart as a flexible, scalable, and open technology that fosters interoperability across five essential components required for the creation of smart cities. Sensors, auxiliary technologies, data science, citizen engagement, and LoRaWAN are some of these components. The main goal is to gather information and improve visibility in a number of smart city subcategories, including smart transportation, smart agriculture, and smart health. In the end, this increased visibility helps with prompt and efficient decision-making.

Most farmers in Indonesia's rural areas struggle to set up Internet of Things devices since the country's connection infrastructure is still erratic. In response to concerns over cost and energy efficiency, the Long Range Wide Area (LoRa) communication protocol was developed. LoRa is ideal for monitoring isolated and rural regions since it is made primarily for long-range, low-power communication. For example, Prakosa S.W. et al. used sensor nodes to communicate half-duplex across the LoRa gateway in order to send sensing measurements. This gateway gathers data and functions as a virtual cloud inside the system. As a result, by utilizing acoustic data, users are able to take in their surroundings and base their judgments on current field circumstances.

In addition, the paper presents the electrical parts of the LoRa-based implementation. The Dragino LoRa IoT Kit served as the basic LoRa framework for the researchers' first experiment. This kit has a dynamic range RSSI of around 127 dB, runs at a frequency of 925 MHz, and has a maximum link budget of about 168 dB. Two different devices are used in the LoRa system setup, and they are placed at different places. The first device, an Arduino Uno with a LoRa shield, is called the client and is located in a remote place. This client uses three different sensors to gather data, which it then wirelessly communicates via LoRa. The Dragino LG-01P LoRa gateway is used to create a client-communication infrastructure that handles audio data by collecting and aggregating data sent by many clients.

In conclusion, the establishment of wireless communication systems such as the Internet of Things (IoT) for extended communication range has been developed, and the Dragino scheme, which is based on LoRa technology, proves to be a viable and effective option for deployment in agricultural regions for remote area monitoring. Consequently, numerous experiments have been undertaken to evaluate the functionality of the suggested design in terms of data transfer.

Wang et al. (2022) also noted that the spread spectrum approach is used by LoRa, a low-power, long-distance wireless modulation and demodulation technology. As the first ultra-long-distance wireless communication technique employing spread spectrum and linear frequency modulation, LoRa was promoted and implemented by Semtech Corporation of America. Compared to previous modulation systems, LoRa notably has a much better reception sensitivity and can communicate over longer distances.

Moreover, as per the findings of Sharma et al. (2023), their research demonstrated that the application of LoRa modules successfully tackled the constraints presented by cellular and Wi-Fi networks. In particular, LoRa technology guaranteed dependable communication coverage in difficult-to-reach areas. Its long-distance data transmission and reception capabilities, along with real-time position monitoring and emergency warnings, enable operators to react quickly. This quickness of response might increase the likelihood of survival in dire circumstances.

Recent years have demonstrated the vulnerability of individuals to natural disasters, revealing the formidable challenge of alerting or safeguarding people against such events. From the study of Arabboev Mukhriddin in 2021, he examined the integration of biomedical sensors with emergency alarm signals through the creation of a human health monitoring system and a remote emergency alarm device utilizing LoRa technology. This method proves valuable as it can provide information to alert others in case there is a necessity to locate survivors during emergencies. The proposed device can be used in the event of an emergency. An individual can generate a powerful alarm signal by pressing a button on the device, alerting nearby rescuers to their location and signaling the need for assistance. This device assists rescuers in obtaining remote health status information of survivors during emergency search and rescue operations. It streamlines the process, reducing the time required to locate and rescue individuals, ultimately leading to the saving of more lives.

The authors of the paper "Smart System Using LoRa Technology to Connect Rural Areas Underserved By Existing Internet and Telecommunication Technologies" created a system to solve the problems associated with providing internet and phone service to underserved rural regions. Using LoRa technology, this wireless communication, monitoring, and control system gets around some of the issues with existing IoT systems. In particular, the suggested system does not require an internet connection between the gateway and nodes since it uses LoRa wireless communication for main data transmission. The gateway in this IoT expansion research, which has the ability to store data in linked memory, guarantees data retention even in the event of internet disruptions. Any lost data is retrieved by the database as soon as the internet connection is restored.

In addition, the findings of the study were derived from observations made under controlled laboratory settings. The suggested wireless system for communication, monitoring, and control allows for easy adaptation to suit user requirements. It easily attaches to the node any existing sensors or electrical equipment, needing the least amount of adjustment in terms of connectivity and data interpretation. Notably, this system successfully addresses major issues with standard Internet of Things systems, such as a high reliance on internet access and power constraints.

The study written by Sciullo et al. (2020), utilizes LoRa technology to develop a mobile emergency management system. By harnessing LoRa's long-range wireless capabilities, the system enables seamless communication between emergency responders and a central command center, regardless of cellular coverage limitations. This facilitates real-time exchange of critical information such as location updates and emergency alerts, enhancing overall response efficiency. The study evaluates LOCATE's performance in diverse scenarios, including urban and outdoor environments, assessing factors like communication range, reliability, and battery life. These findings underscore LoRa's potential in bolstering communication during emergencies, thereby improving overall response effectiveness and ensuring timely assistance to those in need.

Key attributes of the proposed system include uninterrupted communication even during internet failures, independence from telecommunication networks (GSM, 4G, LTE), and no reliance on internet connections (WiFi, Ethernet) at end devices. It enables data monitoring and node control through both an embedded local dashboard (offline) and a remote dashboard (online), rendering it a fully operational smart system without internet dependency. Given these features, the system is particularly recommended for deployment in rural areas lacking sufficient internet and telecommunication infrastructure.

Conceptual Framework

The conceptual framework guided the research process in creating LoRa Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication. The input, process, and expected output of the study are illustrated in the following figure.

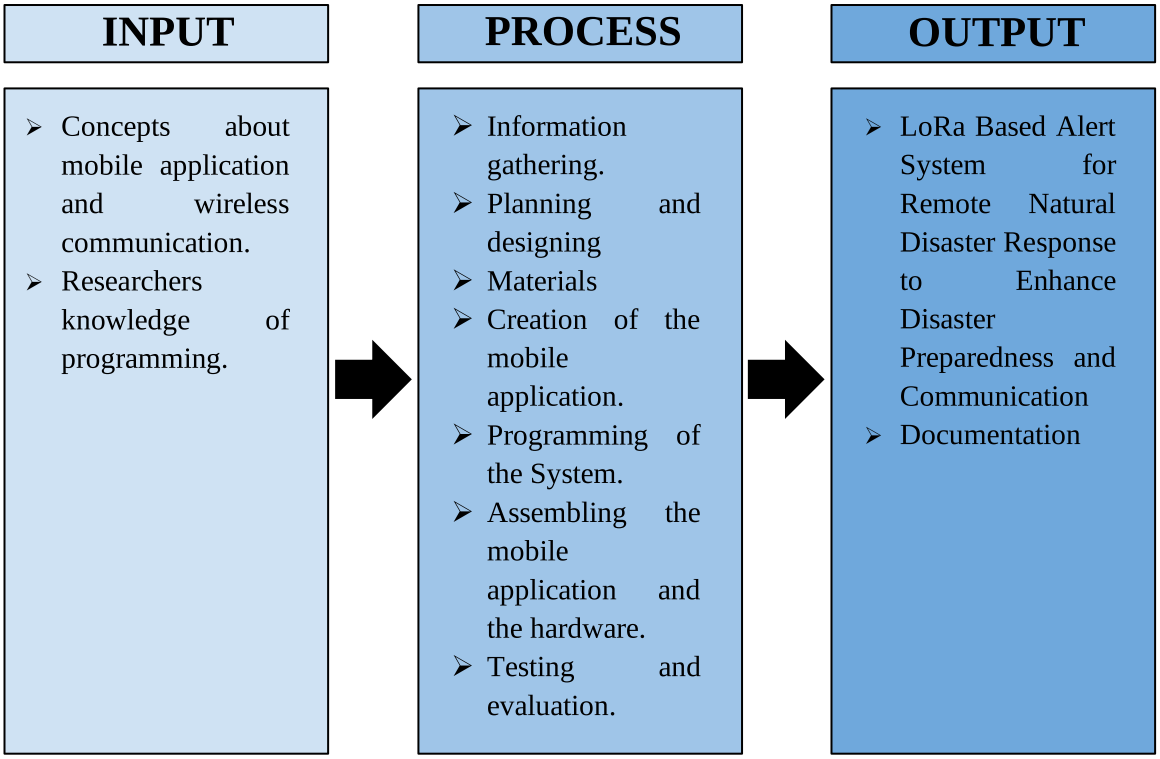

Figure 1 Conceptual Framework

Figure 1 shows the input-process-output model of the research process. The inputs of this study are the concepts about mobile application and wireless communication and the researchers knowledge of programming. The process includes planning and designing of GUI of mobile application and the hardware for wireless communication, preparing the components, creating programs for the mobile application, constructing and assembling the mobile application and the hardware, testing and evaluation, and the documentation. The output of the study is the LoRa-enabled mobile application for alert systems.

Synthesis Table

The synthesis table effectively summarized the relevant literature and studies by providing information on the theme of the study, author, year, title, and related statements.

Table 1. Synthesis Table of the Related Literatures and Studies and the Researchers' Statement

Theme of the Study	Author, Year & Title	Related Statements
Natural Disaster	Ritchie, H. *(2023). Natural Disasters*	The article examines the unequal impact of natural disasters on at-risk populations in low- and middle-income countries. Although natural disasters cause a relatively small proportion of global deaths, their effects can be severe, particularly for those living in areas with inadequate infrastructure and resources.
	Metych, M. (2023). *Natural disaster | Causes, Types, & Facts.*	The article explains the different types, causes, and effects of natural disasters. Natural disasters can be caused by weather and climate, Earth's forces, or a combination of both.
Rural Disaster Resilience	Kapucu, N. (2020). *Rural Resilience: Disaster Preparedness for Communities Off the Beaten Path.*	The article discusses rural disaster resilience, the difficulties of preparing for disasters in rural areas, and the importance of government teamwork in handling local emergencies. The challenges include a

		lack of resources, limited access to technology, and the unique vulnerabilities of rural communities.
Review of Disasters Technology-Integrated Solutions	Ali, H. J. H., & Jacksi, K. (2021). *An Automated Early Alert System for Natural Disaster Risk*	The journal article reviews numerous technology-integra- ted solutions to mitigate disasters and risks, as presented by researchers.
Early Warning System for Disaster Management in Rural Areas	Leo, R. J. (2022). *Early warning systems and their role in disaster risk reduction.*	The journal article is about the challenges and needs of implementing effective systems for potential disasters particularly in rural areas, highlighting the importance of technology integration, and community involvement.
Early Warning System for Natural Disaster	Da Silva, G. F. P., Pegetti, A. L., Piacesi, M. T., Belderrain, M. C. N., & Bergiante, N. C. R. (2019). *Dynamic modeling of an early warning system for natural disasters.*	The journal article acknowledges the effectiveness and significance of such a system in minimizing the damage caused by natural disasters.
Communication Technologies in Disaster Management	World Bank (2019). *Information and Communication Technology for Disaster Risk Management in Japan: How Digital Solutions are Leveraged to Increase Resilience through Improving Early Warnings and Disaster Information Sharing*	The book indicates that communication technologies are crucial in disaster management, facilitating rapid information sharing and enhancing early warning and information management systems.
Alert Messages	Saraiva, R. J. (n.d.). *Philippines – Cell Broadcast :: Cell Info :: SMS-CB :: Difusão celular :: PWS Public Warning*	The article is about how the NDRRMC issues its mobile warnings.

	System	
	Oscar M. Lopez Center (2022). PAGASA redefines Super typhoon, modifies wind signals.	The article states the forecast about tropical Cyclones. It indicates a different orientation of the wind signal. It has measurements to know the signal number of the tropical cyclone.
Mobile App	Sehgal, T., & More, S. (2017). *Home Automation using IOT and Mobile App.*	The article proposes and describes the creation of a mobile application that controls home appliances using speech recognition and IoT technology. It also emphasizes the convenience of controlling devices through a mobile app in today's technologically advanced world.
LoRa	Tanner, G. (2022). *Introduction to LORA.*	The article is about LoRa. It provides a basic overview of LoRa and how to get started using it.
	Mukhriddin, A. (2021). *LORA BASED HEALTH MONITORING AND EMERGENCY ALARM DEVICE.*	The article is about a wireless device for tracking health and sending alerts in emergencies using LoRa.
	Wang, C., Guo, W., Yang, K., Wang, X., & Qingjia, M. (2022). *Real-Time monitoring system of landslide based on LORA architecture.*	The article state that LoRa is low-power technology, that sends information long distance without wires.
	Prakosa, S. W., Faisal, M., Adhitya, Y., Leu, J., Köppen, M., & Avian, C. (2021). *Design and*	The article is about LoRa and its benefits.

	implementation of LORA based IoT scheme for Indonesian rural areas.	
	Sharma, D., Raghuwanshi, R. R., Chandak, T., & Ramdasi, D. (2023). *LORA-Based IoT system for emergency assistance and safety in mountaineering.*	The article is about a system that uses LoRa modules.

Synthesis Statement

The table above presents a compilation of relevant literature and studies that assisted the researchers in creating the LoRa Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication. Upon analyzing the diverse literature and studies conducted by various researchers, it becomes evident that the proposed system is feasible. Based on this assessment, the researchers have decided to proceed with their study to create a mobile app-controlled alert system using LoRa for natural disaster preparedness which can benefit individuals.

The studies explore how disasters impact different areas and ways to improve resilience. They reveal that disadvantaged regions suffer the most when there are disasters due to limited resources and infrastructure, as well as technology access. Collaboration and innovative solutions are crucial in addressing these challenges. Technology, such as mobile phones and the internet , plays a pivotal role in disaster management by enabling timely alerts and coordination. LoRa technology, known for its long-distance communication with low power usage, offers promising capabilities for real-time monitoring and emergency communication. By taking advantage of these technologies and encouraging collaboration, communities can strengthen their readiness and response to disasters.

Chapter III

METHODOLOGY

This chapter presents the methods and procedures used in conducting the study to provide readers with a comprehensive understanding of how the study was carried out and how data were collected to arrive at the conclusions.

Research Locale

The study was conducted in Patnanungan, Quezon. This municipality is an island and far from the urban areas, it is difficult for them to keep up with the modern technology used in people’s daily work, especially for the welfare of the people in the community. The municipality was chosen as one of the researchers resided in the area and observed a need for an alert system. The researchers observed that the MDRRMO traditionally goes around the community to distribute weather updates. This tradition was time-consuming and full of hassle for the MDRRMO to patrol when sending and receiving information.

Respondents

The researchers selected the MDRRMO authorities and barangay officials as respondents in this research. These respondents were selected since they were responsible for disseminating information to the community. Likewise, the local authorities served as the user of the system. An evaluation was administered to the respondents to evaluate the design, functionality, and ease of use of the system.

Research Design

Analyzing the problem through observations and studies in real world situations, the researchers referred to the problem-solving approach to conducting scientific investigations about giving alerts based on natural disasters in remote areas. This study is an applied type of research. In applied research, the primary goal is to address specific issues or problems and provide practical solutions or improvements in real-world situations. This type of research is focused on the application of knowledge to meet the needs of a particular context, industry, or community.

This study is applied research due to its practical and problem-solving nature. By focusing on creating mobile applications with applications of wireless devices for communication, the research addresses a critical and real-world issue for effective natural disaster preparedness and response in Patnanungan Quezon. The applied nature of this study is evident in its goal to provide a tangible solution to enhance the timely dissemination of alerts and information in local authorities and the community that are often geographically isolated and vulnerable to natural disasters. Through the development of the alert system, the research aims to directly improve the preparedness and responsiveness to such disasters, contributing to the practical application of technological advancements in the context of disaster management. The study's outcomes are anticipated to have immediate and actionable implications, emphasizing its applied research orientation in striving to make a positive impact on the safety and well-being of communities in remote areas facing natural disaster risks.

Research Instrument

In the pursuit of comprehensive data collection for the study, the researchers have carefully constructed a set of research instruments. These instruments are designed to systematically gather the necessary information essential for the development and analysis of the study

Internet. The researchers searched literature reviews, case studies, online books, and journals in web-based research to gather information on existing technologies, methodologies, and best practices related to transceiving messages/data in disaster management, and experiences with similar systems in remote areas.

Interview. The researchers used an interview to gather necessary information and advice from the research expert for verification regarding the topic to help in the build-up of the study. The results of this interview were used to consider in designing the hardware and the software of this study.

Questionnaire. Researchers used questionnaires to evaluate if the study is acceptable to the MDRRMO authority and barangay officials. The questionnaires were given to the

MDRRMO authority for them to evaluate the whole system. 5 point Likert scaling for agreement would be used to weight the interpretation of the data from strongly agree, agree, neutral, disagree, and strongly disagree.

Procedures

The following sections stated the procedures of how the researchers completed the research study.

A. Information Gathering

In this section, the researchers gathered information about how the dissemination of information about natural disasters is carried out by the authorities and barangay officials using traditional or existing methods. The researchers also conducted interviews and research to determine what messages or information are disseminated during natural disasters.

B. Planning and Designing

This section is about planning and designing of the alert system. The researchers will determine the conversion of traditional or existing dissemination of information and its challenges about natural disasters. The researchers also identified the list of hardware components to be used in creating the prototype. A block diagram was the basis of the researchers' dissemination of information along with its flowchart. The researchers also presented the circuit design of the prototype and the setup design of the system. After determining the planning and designing the hardware part, the researchers then focused on the software part. The researchers presented the list of software materials, list of components of GUI, and flowcharts.

C. Creation of the Mobile Application

The mobile application is the input and output devices of the system. This section presents the actual graphical user interface of the mobile application. Using the MIT App Inventor, the researchers first create the frame of the mobile application, then apply the conde blocks to create its functionality.

D. Programming of the System

After information gathering, planning and designing, and creation of the mobile application, the researchers then now create the program of the connection of all the hardware and software components. This section presents different functions of transmission of data.

E. Assembly of the Prototype

This section details the assembly of the prototype. The components were seamlessly integrated, and the wirings were carefully secured to prevent any malfunctions.

F. Testing and Evaluation of the System

This section identifies the user evaluation of the system's wireless dissemination of information about natural disasters. Additionally, the interaction and compatibility of wireless communication without using the internet are thoroughly evaluated in different scenarios. The researchers conducted a questionnaire for the acceptability of the system to the MDRRMO and Barangay Officials.

Chapter IV

RESULTS AND DISCUSSION

This chapter presents the system overview, tables, flowchart, Graphical User Interface (GUI), and the materials used in the development. It also deals with the tabulation of the data gathering and their discussions and analysis.

System Overview

LoRa Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication, disseminate information around the community through wireless communication and without using or relying on the internet. This system alerts both senders and receivers about natural disaster preparedness and response.

The system comprises different nodes: a Master Node and multiple Slave Nodes. The process starts and ends with a mobile phone, where data is input and decoded. Each node contains a main box with electronic components, including an ESP32 and a LoRa module, to broadcast data from the mobile phone,

Data transmission occurs through these nodes, with the Master Node and Slave Nodes capable of sending and receiving messages between each other. To amplify the message from the mobile application, a horn speaker is connected using an audio cable.

The main box connects to the mobile phone via peer-to-peer connection through the ESP32. Once connected, the user opens the mobile application and inputs their message. The ESP32 receives the data and sends it to the LoRa module, which transmits it to the LoRa modules of other nodes. The data then passes through the ESP32 of the receiving node to the mobile application on the other end. The same process applies for responses back to the Master Node.

This combination of LoRa of mobile application and LoRa technology significantly enhances communication for natural disaster response and preparedness. The system enables quick coordination among rescue teams and helps communities prepare for natural disasters, improving emergency response and making neighborhoods safer.

Technical Description

This section covered the detailed system function and the gathered ideas that support the construction of the system, such as the planning and designing, and the system's process flow. The concept of the system is also shown in a block diagram and a flow chart. These are the few aspects that are included used to develop the LoRa alert system for remote natural disaster response to enhance disaster preparedness and communication.

Information Gathering

The researchers started exploring the types of natural disasters by researching the website of the Department of Science and Technology - Philippine Atmospheric Geophysical and Astronomical Services Administration (DOST-PAGASA) and interviewing experts and authorities of the Municipal Disaster Risk Reduction Management Office (MDRRMO) about the existing dissemination of information in the community about natural disasters.

The researchers interviewed and researched what is the information to be disseminated. Table 2, shows the different types of natural disasters. This information is from the MDRRMO and DOST-PAGASA website. An island or remote community is the basis of what natural disasters should disseminate.

Table 2. Type of Natural Disasters that are disseminated on Research Locale

Types of Natural Disaster	Information to Disseminate
Earthquake Alert	**ANNOUNCEMENT:** All the residents, especially near the seashore, need to go to highland. Bring all the necessary materials, food, and a first aid kit. The highlands that the residents can evacuate include, Mountain Roads of Brgy. Busdak, Sinintan and Tapol, and Senior High School buildings.
Gale Warning	**WIND SPEED:** 31 mph (50 km/h) minimum and 63 mph (102 km/h) maximum. **WARNING:** Ocean transportation (passenger boats) is prohibited.
Rainfall Advisory	**YELLOW RAINFALL ADVISORY** **RAIN THREAT:** 7.5 to 15 mm

	WARNING LEAD TIME: Observed for 1 hour and expected to persist for the next 2 hours. **WARNING**: Flooding may occur. Please keep an eye on weather conditions.
	ORANGE RAINFALL ADVISORY **RAIN THREAT:** 15 to 30 mm **WARNING LEAD TIME**: Observed for 1 hour and expected to persist for the next 2 hours. **WARNING**: Flooding poses a threat. Prepare for potential evacuation.
	RED RAINFALL ADVISORY **RAIN THREAT:** More than 30 mm **WARNING LEAD TIME**: Observed for 1 hour and expected to persist for the next 2 hours. **WARNING**: Severe flooding is anticipated in low-lying areas. Evacuation is necessary.
Tropical Cyclone	**Signal # 1** **WIND THREAT:** 39-61 km/h (22-33 kt, 10.8-17.1 m/s) **WARNING LEAD TIME:** 36 hours **POTENTIAL IMPACTS:** ● Poorly constructed homes, such as those with bamboo, wood frames, or improvised constructions, as well as older, light-colored buildings, will sustain little to no damage. Wind may cause little tree twigs to swing and banana plants to tilt. Damage to rice crops is possible, particularly during the blooming and ripening periods. There will not be much of an impact on public transit.
	Signal # 2 **WIND THREAT:** 62-88 km/h (34-47 kt, 17.2-24.4 m/s) **WARNING LEAD TIME:** 24 hours **POTENTIAL IMPACTS:** ● Older or lighter structures, as well as poorly constructed homes, may sustain minor to major damage. Lightweight objects that are not secured might fly away and cause more damage. There is a chance that some electrical lines will fall, causing power outages and perhaps disrupting public transit. Rice and related crops that are in the blossoming and ripening stages are likely to sustain substantial damage, while banana plants and small trees may tilt or collapse, shattering limbs.
	Signal # 3 **WIND THREAT:** 89-117 km/h (48-63 kt, 24.5-32.6 m/s)

	WARNING LEAD TIME: 18 hours **POTENTIAL IMPACTS:** ● Older, flimsy, or light-material buildings might sustain major damage, while ordinary or impoverished homes could sustain major wall, window, and roof damage. Even well-built homes might have some roof damage. Industrial buildings and warehouses may sustain mild to major damage. Unsecured outdoor objects have the risk of becoming projectiles and inflicting extra harm or injury. There will probably be power disruptions, but the water and communications supplies won't be severely affected. Significant disruptions to public transit are possible. Rice and related crops in the blossoming and ripening stages may sustain significant damage from small trees, the majority of banana plants, and some large trees falling.
	Signal # 4 **WIND THREAT:** 118-184 km/h (64-99 kt, 32.7-51.2 m/s) **WARNING LEAD TIME:** 12 hours **POTENTIAL IMPACTS:** ● Older and temporary buildings are likely to sustain severe damage, while ordinary or impoverished homes may experience significant wall and roof collapses. While industrial buildings may experience roof failures, well-built homes may have mild to moderate roof damage. There may be glass that blows out in high-rise offices. Debris in the air might hurt people. There will be significant disruptions to the water, power, and telecommunications networks. There will be substantial damage to crops, trees, and banana plants, as well as disruptions to public transit.
	Signal # 5 **WIND THREAT:** 185 km/h or higher (100 kt or higher, 51.3 m/s or higher) **WARNING LEAD TIME:** 12 hours **POTENTIAL IMPACTS:** ● Poorly built homes and light-material structures may expect severe to catastrophic damage, with substantial devastation in industrial buildings. Windows in high-rise workplaces may blow away, and there may be mild structural damage. Significant threats are posed by airborne debris, and protracted outages in telecommunications, water, and power will result from infrastructure failures. Most trees and plants will likely sustain significant damage, and there will be significant disruptions to public transit.

Table 2, shows the different types of natural disasters, which are Earthquake, Gale Warning, Rainfall, and Tropical Cyclone. Rainfall Warnings has three different categories that include yellow, orange, and red advisories. Also, Tropical Cyclones have different number levels which are signal numbers 1 to 5. In addition, the table provides the potential impacts and actions of the residents when the authority announces a certain natural disaster.

In addition, the MDRRMO also added that there are some unexpected things that happen during natural disasters. They also need to announce the condition of the barangay during a natural disaster, for example, during a typhoon. They announce blocked roads due to fallen trees, power interruption, sea levels in the coastal areas, and other conditions that the residents are unaware of because they are not allowed to go outside their houses or evacuation centers. There are some instances where the evacuation center is destroyed, and they need to announce another evacuation center. There are also some residents who do not listen and take action regarding the weather announcements, so they need to mention specific areas in the barangay.

Planning and Designing

From the information gathered, the researchers plan and design the needs for the development of the software and hardware of the system. The researchers determined the system's block diagram and flowchart, which was the foundation for assembling the system. Additionally, to answer the objectives of planning and designing wireless dissemination of information of the alert systems, the researchers identify the needs when it comes to the warning alert and applying wireless communication.

Table 3, shows the existing way of disseminating the information and its related actions to plan the system. It shows the conversion of traditional disseminating information to the researcher’s study.

Table 3. Conversion of Traditional/Existing Dissemination of Information to Related Actions of the System

Traditional / Existing Dissemination of Information	Related Actions of the System
The MDRRMO or Barangay Officials write and record their voice message.	There is already a prepared message in the mobile phone and just select it.
The MDRRMO or Barangay Officials ride in a vehicle to disseminate the information.	The dissemination of information will use wireless communication.
The MDRRMO or Barangay Officials use a megaphone to announce the information.	There is a horn speaker in a respective area in the barangay.
The residents of the barangay go to the MDRRMO or to the Office of the Barangay to inform the officials that they need help or any other things requested by the residents.	The resident can send their needs or requests through the use of their mobile phone.

Table 3 shows the list of traditional dissemination of information about natural disasters and the related actions of the researcher to create the alert system. From the manual recording and writing the announcement of the MDRRMO, the researchers will provide a default or prepared messages about natural disasters that are ready for dissemination. The officials need to ride in a vehicle and patrol around the community to disseminate the information. To lessen this effort, the researcher's action is to create a dissemination of information through wireless. The officials have a single megaphone and cannot be heard in a wide range. To improve, a provided horn speaker in the respective area in the barangay so that even the residents living far from the main road will be informed. For the request of the residents, they need to go to the office of the Officials. To also lessen this effort, they can use their mobile phone to inform the authorities.

There are some difficulties that the Officials and the residents encounter in times of Natural Disaster. Table 4 shows the difficulties of the dissemination of information.

Table 4. Challenges of Dissemination of Information about Natural Disasters

Difficulties	Related Actions of the System
Power Interruption	The prototype will still operate the system even if blacked out and used a backup power supply.
Not all the residents were informed because they do not live in the main area of the barangay.	There will be different nodes in the barangay.
During natural disasters, there is no internet connection and no cellular signal and they cannot send SMS or call through mobile phones.	The researchers will use a technology or modules of communication that relies on the frequency signal.

Table 4, shows the list of difficulties and the related actions of the researchers. The first problem is the power interruption. It can be solved through the use of a backup power supply that can still operate the alert system. Since the locale is a remote area, some residents live far from the main town and they do not inform the Officials. The researchers assigned different nodes in the barangays. The node was the communication point where the information was disseminated.

Hardware Materials

After the researchers gathered information about the dissemination of information about natural disasters, this section details the list of the hardware components and materials to create the prototype of the system. The hardware components are considered based on their availability and capability that can be used to transmit data.

Table 5 lists all the major hardware components to create the prototype. It involves a comprehensive overview of the essential electronic components required for the construction of the wireless alert system. These are the main components used to create the transmission of data.

Table 5. Major Hardware Components/Materials

Materials	Product Name	Basic Specification	Function
	ESP32	NodeMCU-ESP32, 512 KB SRAM, 4MB flash memory, 21 pins	A microcontroller that connects the LoRa module and the mobile phone.
	LoRa module	AS32 433 Mhz, 100 milliwatt	Transmit data between Master Node and Slave Nodes through wireless communication without the use of the internet.
	LoRa Antenna	SMA F-MALE Connector 433Mhz	Lower the Received Signal Strength Indicator (RSSI) of the LoRa modules.
	Horn Speaker	H - 5X8 50 Watts 8 Ohms	Output the audio
	Amplifier	TPA3118 DC 8 to 24v PBTL 60W MONO AUDIO AMP	Amplify the sound of the horn speaker

In Table 5, the ESP32 microcontroller is a versatile component boasting 512 KB SRAM and 4 MB flash memory, offering ample storage and processing power. With 21 pins, it provides flexibility for connecting peripherals and sensors. Its primary function lies in bridging the communication between the LoRa module and the mobile phone, facilitating data exchange between these devices. The LoRa AS32 module operates at 433 MHz with a power output of 100 milliwatts, designed specifically for long-range communication without relying on the internet. Paired with a LoRa antenna equipped with a gain ranging from 5 dBi to 12 dBi and a 60 cm cable, it enhances signal reception and extends communication range. The horn speaker, rated at 50 Watts, serves as an audio output device for broadcasting alerts or announcements, amplified by a 60 Watts amplifier for clarity in noisy environments.

Table 6 lists all the minor hardware components to create the prototype. It involves a comprehensive overview of the essential electronic components required for the construction of the wireless alert system. These are the supporting components to power and support the main components.

Table 6. Minor Hardware Components/Materials

Materials	Product Name	Basic Specification	Function
	Battery	L-ION 12V 20K MA	Power supply backup to operate the prototype
	Regulator	Mini 360 DC - DC 5 Volts	Outputting an adjustable DC voltage
	Power Switch	Pack Mini 2 Pins ON and OFF Toggle Power Switch SPST Metal Rocker up to 6A 125V AC or DC Latching Panel Mount Switches ON-OFF	To power ON or OFF the main box/prototype.
	Charger	SMS Power Supply (Charger) AC 220V / 12V 5A	Convert the power from the source into the correct format and voltage
	Audio Cable	A30 0.5 meter	Used to connect the sound of the mobile phone to the amplifier with a horn speaker.

In Table 6, shows the minor components such as regulator, power switch, charger and audio cable. To connect the amplifier to the mobile phone, it uses an audio cable that transmits sound going to the horn speaker. Power is supplied by a battery operating within a voltage range of 6 Volts to 24 Volts, ensuring system functionality when disconnected from a fixed power source. There is a power switch for turning ON or OFF the prototype. In case of a blackout, the prototype used a voltage regulator and a charger that can charge the battery and also operate the alert system even without an electricity supply.

To calculate the number of hours that the battery can be used, we can use the formula of Bogna Szyk last updated on May 24, 2024, in which the Battery Life equals the quotient of Capacity (mAh) and Consumption (mAh). The Capacity (mAh) is the capacity of the battery, while Consumption (mA) is the load current or power consumption of all the components connected to the battery.

Battery Life = $Capacity\ (mAh)$ / $Consumption\ (mA)$

Battery Life = 20,000 mAh / (23.73 mA + 0.04 mA + 83.33 mA + 69.17 mA)

Battery Life = 113.46 hours

The 6 L-ION batteries are connected in a series and their capacity is 12V 20k mAh. The average power consumption of ESP32 is 78.32 mW with 3.3 V equivalent to 23.73 mA. The load current of the LoRa module is 0.04 mA from its power of 100 mW and an input voltage of 2.5 V. The wattage of the amplifier is 60 W and its voltage is 24. Its equivalent load current in milliamps is 2,500 mA. The horn speaker that is connected to the amplifier is 50 W and it consumes 69.17 mA power. The value of each component is based on its datasheet. The battery will last until 113.46 hours since the amplifier and a horn speaker will only operate to play the audio with only a 1-minute range or less.

Block Diagram

The following figure presents the block diagram illustrating the interconnections among the input, the process, and the output needed in the construction of the LoRa alert system for remote natural disaster response to enhance disaster preparedness and communication.

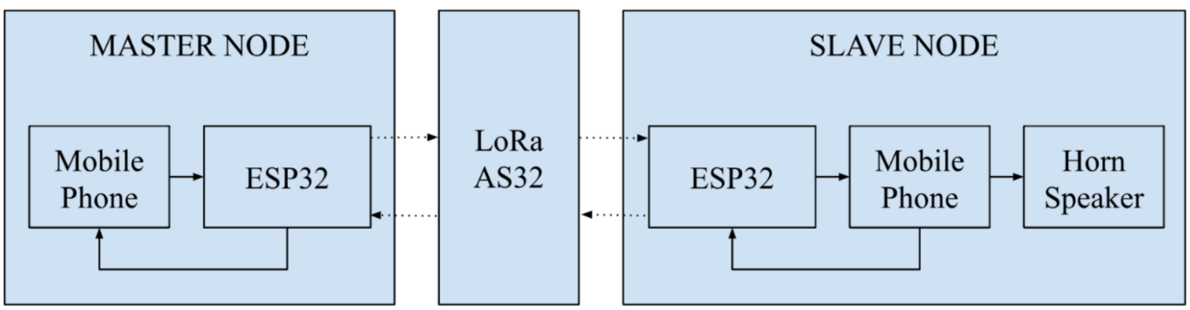

Figure 2. Block Diagram of Wireless Alert System

Figure 2 shows where the input becomes output, and the output can also serve as input. The data passes through the microcontroller and communication module, which then broadcasts it. A mobile application is used to input and decode the data. A horn speaker serves as an extension output for amplifying the output display.

Flowchart

The researchers planned the flowchart of the system. It outlines the starting point of the dissemination of information, the paths it follows, and how it ends.

This flowchart shows the alert system. It shows the process of dissemination of information using the mobile phone and the system.

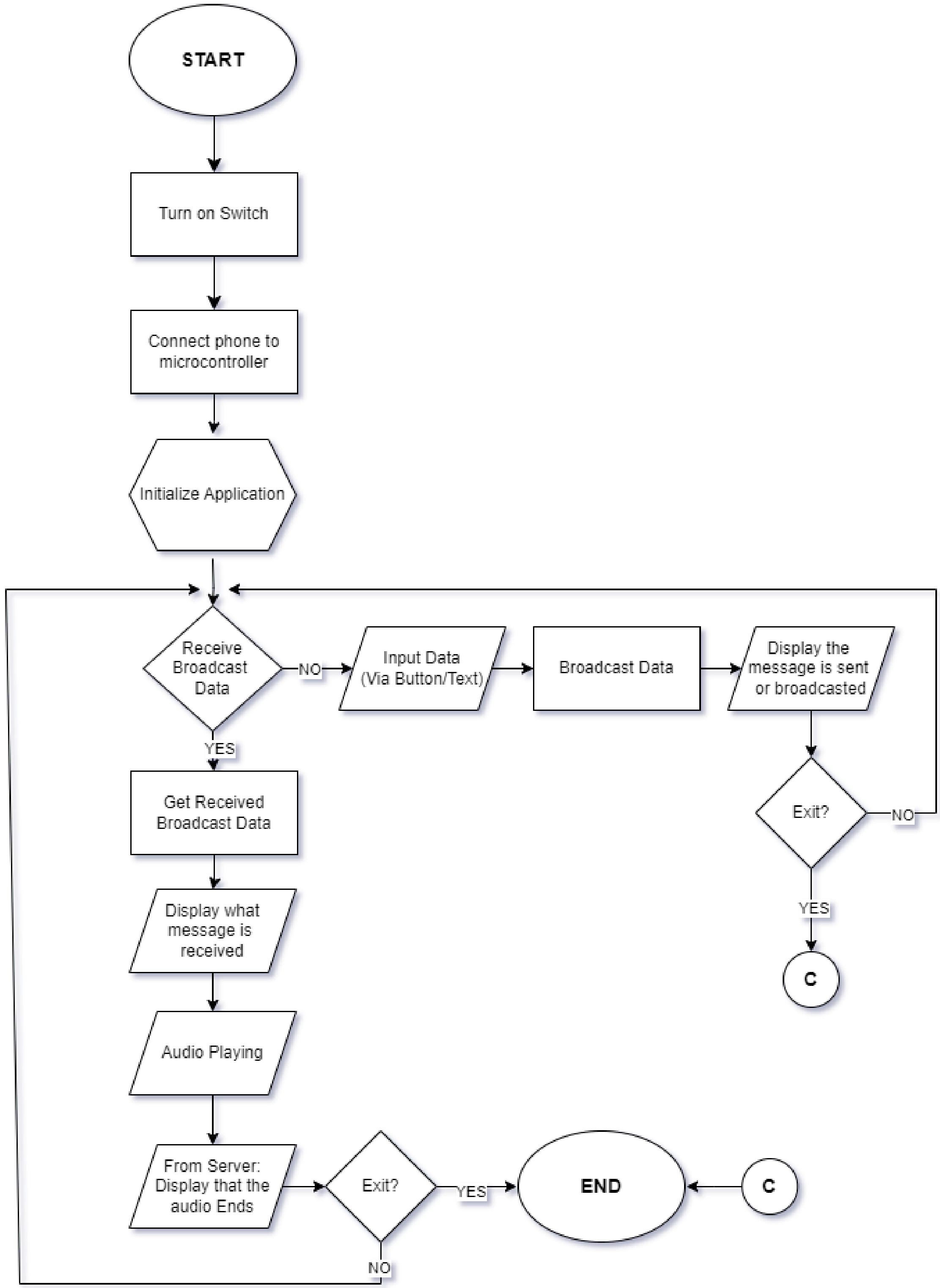

Figure 3. System Flowchart

The Figure 3 flowchart shows the process of how the system works. It starts with turning on the switch of the devices and connecting the mobile phone to the microcontroller. The mobile phone has an application where the user has the privilege to send messages to each node. The received data or messages is broadcasted to the other nodes. In the main device's mobile application, a message indicating that the data has been sent or broadcast is displayed. Meanwhile, the receiver devices receive the broadcast data, retrieve it , and display the received message. The message is then played as audio. Once the audio ends, their own application displays a message indicating that the audio has ended.

Circuit Design

The researchers proceeded to construct the pin configuration after determining the needed materials and/or electronic components for the development of the prototype. The pins and connections are shown in the following figures:

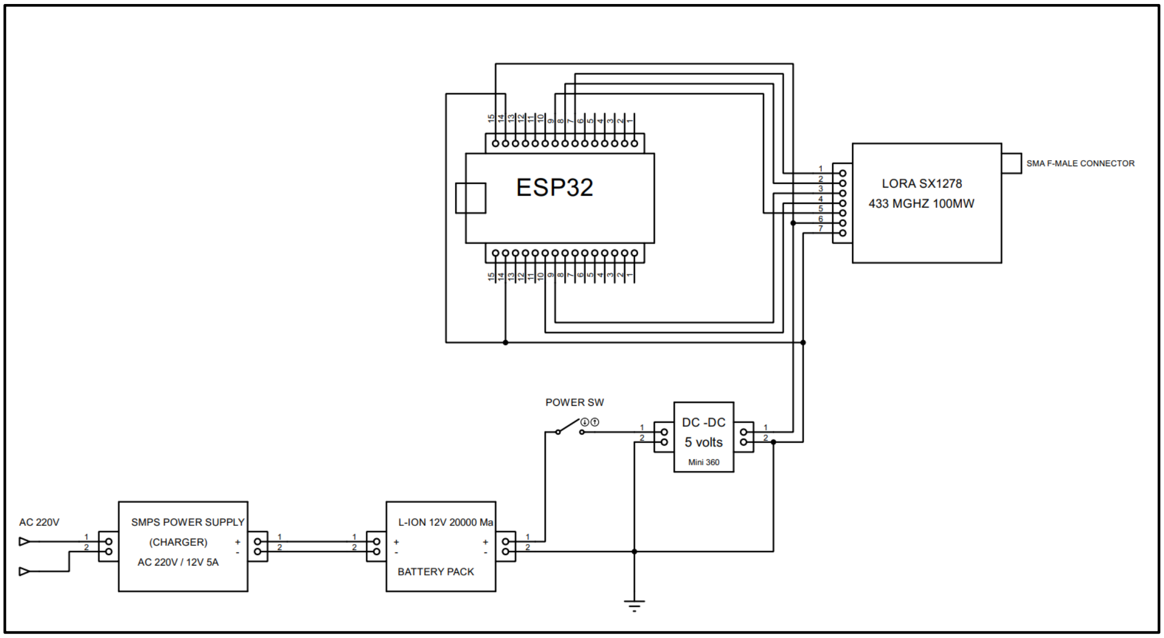

Figure 4. Schematic Diagram of the Main Prototype

Figure 4 shows the connection of all the components inside and outside the main box of the Main Prototype. The input voltage of the SMS power supply is 220V and it is regulated to 12V and 5A as an output and to supply the battery. The battery has a maximum voltage of 12V connected to Mini 360 that will supply to all the electronic components. For the supply, the VCC pin of LoRa AS32 connects to the 3.3V pin of ESP32 as well as its GND pin. The communication of LoRa and ESP32 is connected by UART. In transmitting and receiving data, the TXD pin of LoRa AS32 is connected to the RX pin of ESP32, while the RXD pin of LoRa AS32 is connected to the TX pin of ESP32. An antenna for LoRa AS32 is connected through the use of SMA F-MALE connector.

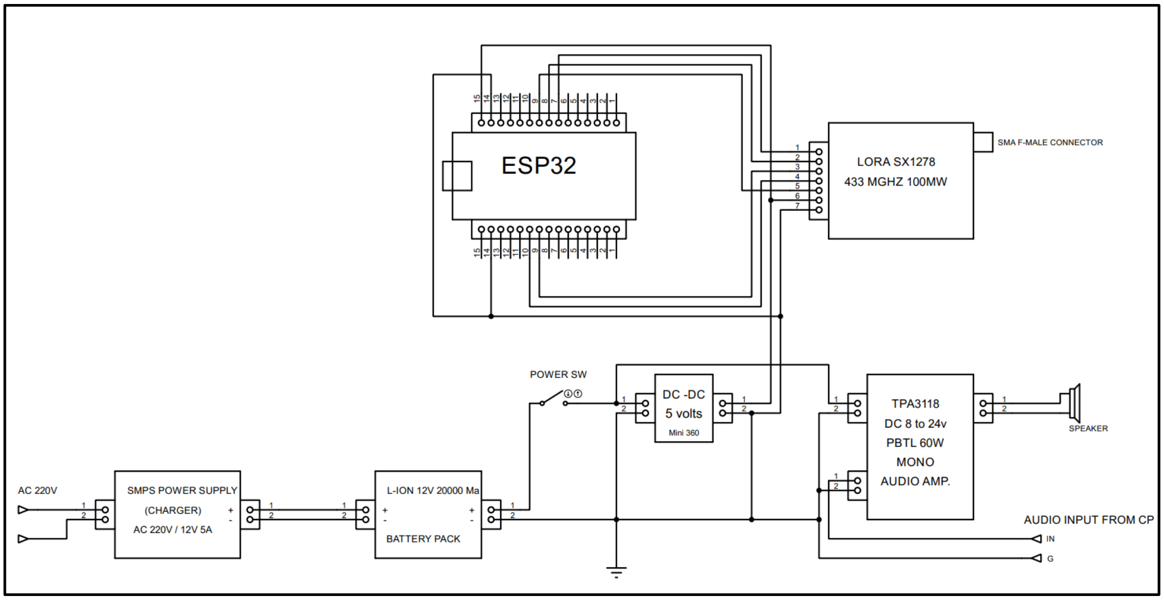

Figure 5. Schematic Diagram of the Sub Prototype

Figure 5 shows the schematic diagram of the sub prototype having different electronic components. The connection of the power supply, ESP32, and LoRa module are the same with the main box of the Master Node. In Slave Nodes there is an amplifier and a horn speaker. The battery supplies charge to the power pins of the amplifier. Another two pins are connected to the positive and negative terminal of the horn speaker. Mobile phones are also connected to the amplifier for audio input.

Prototype/Node Design

The figure below shows the physical design of the system. The researchers came up with a two-way communication that uses different nodes to send and receive messages. However, the horn speaker is outside the casing because of its size and also for the sound capability. The antenna is also outside of the casing for the capability of detecting signals.

In Figure 6, the researchers design the setup of different nodes that will disseminate or broadcast the information. This figure is for better presentation of the prototype with its connected device and electronic components in each node.

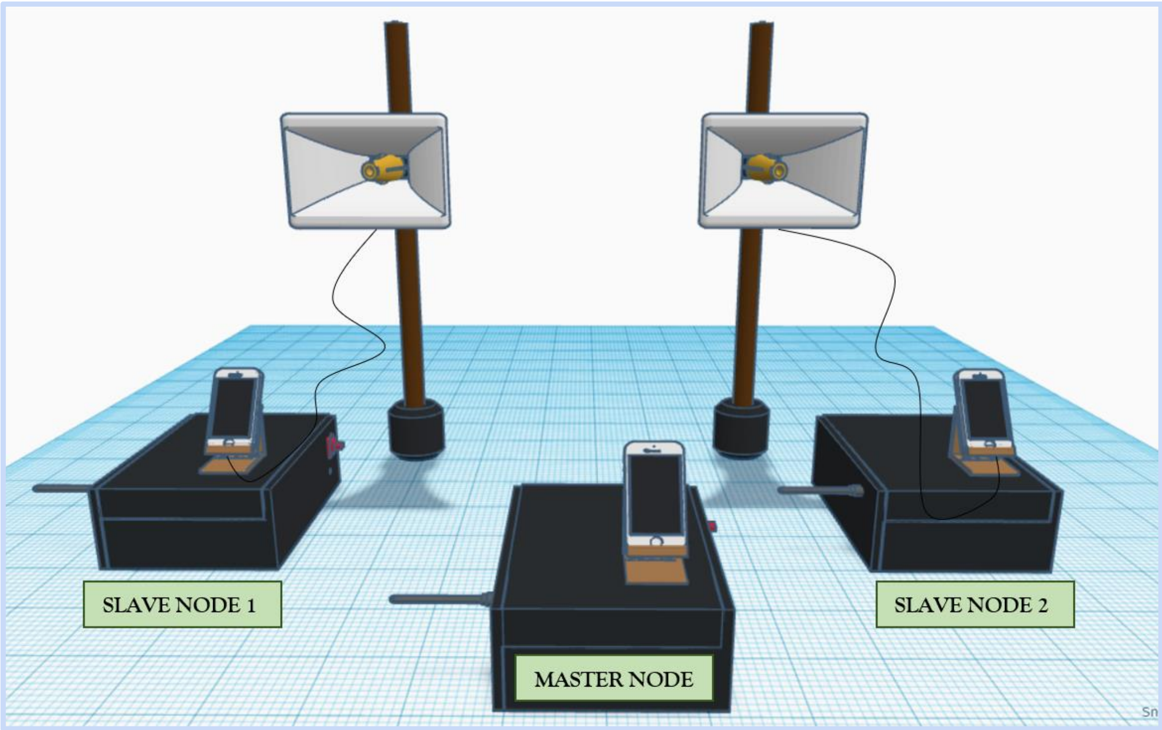

Figure 6 Setup of the Master Node and Slave Nodes

Figure 6 shows three nodes: a single Master Node and two Slave Nodes. A mobile phone is wirelessly connected to the Master Node. Each Slave Node is equipped with a horn speaker and a mobile phone. Additionally, there is an antenna in each node. Both the horn speaker and the antenna are adjustable depending on their sound capability and signal strength. The Master Node is positioned in the MDRRMO and Barangay Office, while the Slave Nodes are placed in their respective areas in the community based on where the officials have assigned them.

There is a main box shown in Figure 6. Figure 7 shows the designation of the electronic components inside the box. I also include the measurement of the box and how the components fit inside.

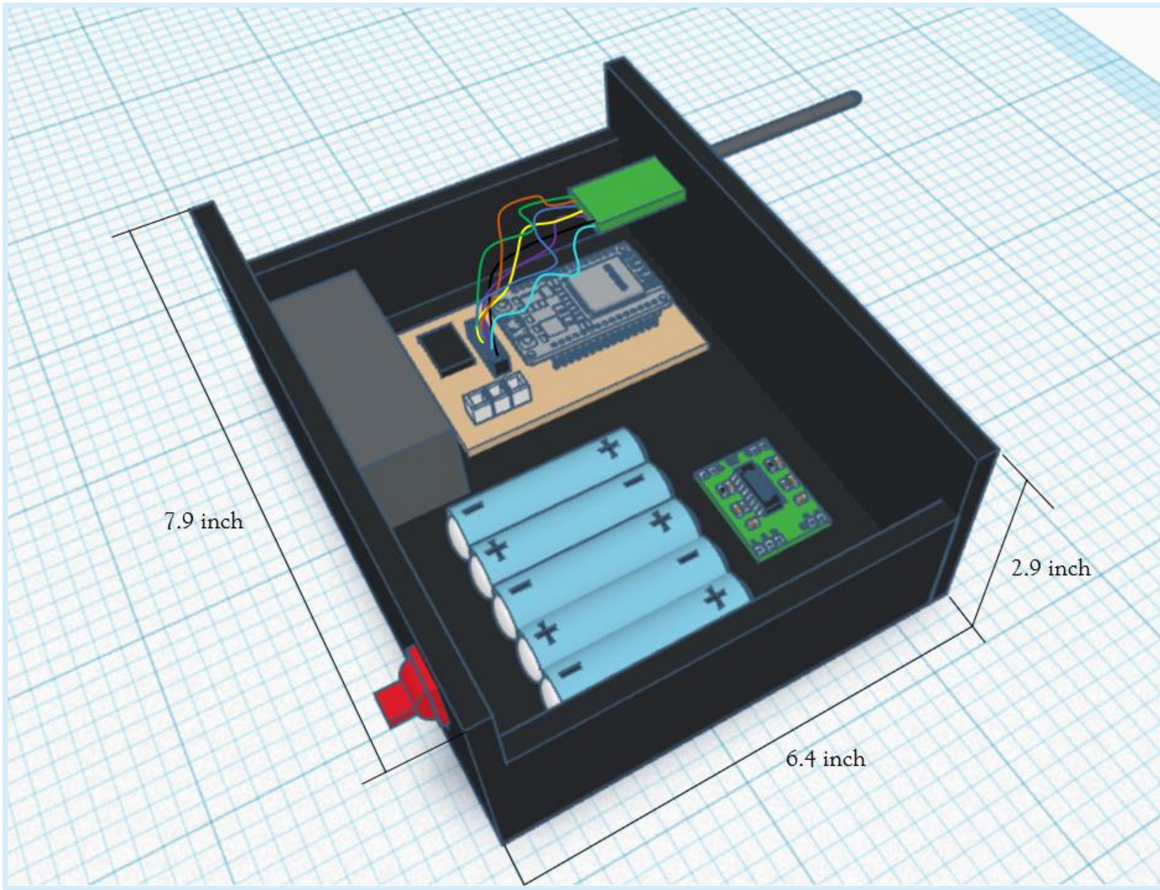

Figure 7 Designation placement of the components

Figure 7, shows the designation placement of the components inside the casing. The case is rectangular in shape and it is 2.9 inches high, 6.4 inches width, and 7.9 inches length. The main box includes the components like LoRa module, microcontroller, battery, amplifier, and a voltage regulator fit together. Each mobile phone is connected in each main box using peer-to-peer connection. The horn speaker and antenna have an extension wires/cable to connect in the main box to position it outdoors.

The position of each node is assigned to the respective areas in the barangays by the authority of the MDRRMO and the Barangay Officials. The positioning is based on the testing conducted by the researchers to ensure the system is effective and efficient. It is found under Project Evaluation.

Components of Mobile Application

After planning and designing how the dissemination of information and what information to disseminate, the researchers then now plan what are the components and elements to be used in the GUI of the mobile application.

Table 7 shows the list of components/elements to be used in creating the mobile application. It is based on the information gathered in Table 2.

Table 7 List of the Components in Creating the GUI of the Mobile Application

Components/Elements		Functions
Button	Send	To send user input messages.
	Earthquake Alert	To send data for earthquake warnings.
	Gale Alert	To send data for gale warning.
	Yellow Rainfall	To send data for yellow rainfall warning.
	Orange Rainfall	To send data for the orange rainfall warning.
	Red Rainfall	To send data for red rainfall warning.
	Signal No. 1	To send data for signal no. 1 warning.
	Signal No. 2	To send data for signal no. 2 warning.
	Signal No. 3	To send data for signal no. 3 warning.
	Signal No. 4	To send data for signal no. 4 warning.
	Signal No. 5	To send data for signal no. 5 warning.
	Close/Exit	To exit the application.
Text box	Text box	For an input text message.
Labels	Earthquake Warning	To display label text for earthquake warning.
	Gale Warning	To display label text for gale warning.
	Rainfall Warning	To display label text for rainfall warning.
	Typhoon Signal Warning	To display label text for typhoon signal warning.
	Message Notification	To display label text for message notifications.
Image	Title of the application	To display the name of the application through a logo image.
	Close/Exit	To show that the icon is for exiting the application.
	Battery	Serves as the icon container for displaying the battery percentage.

In Table 7, the list of components/elements are the buttons, text box, labels, and images. For buttons, there are twelve buttons with specific functions to send data from the main application to another mobile phone's application. For textbox, each mobile application has it for the user to input text messages. Labels, meanwhile, indicate what the buttons are for. Images display the logo of the applications, exits, and battery.

Software Materials

After planning and designing the hardware of the system, this section presents the planning of the software. It details how the dissemination of information occurs within the software of the alert system.

The table below shows the list of IDEs and programming languages necessary to build the controller of the prototype and to create the mobile application. The essence of this table is to present the function of each.

Table 8. Software Material Used in Developing LoRa Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication

Application/Programming Language	Definition	Function
	Arduino IDE	It will serve to establish a connection with the ESP32, LoRa module, and mobile application, enabling the uploading of programs and communication with it.
	MIT App Inventor	It will be used to create the mobile application including its GUI and functionalities.
	C++	The programming language used in Arduino IDE to establish the general instructions for the software components.

In Table 8, the connection between ESP32, LoRa module, and the UI of the mobile application is programmed using the Arduino IDE. The transmission of data is programmed depending on the sending and receiving data between different nodes. To write a program using the Arduino IDE, C++ language is used. It will define the set of instructions for the microcontroller. In addition, the MIT app inventor is used to create the design of the GUI and the blocks of the functionality of the UI of the mobile application. These software materials integrate the task and uses of the overall system to satisfy the transmission of data in each prototype.

Mobile Application's Flow Chart

After planning the flow of dissemination of information through hardware materials and components, the researchers then now plan the transmission of data using the mobile applications.

The two following flowcharts show the process of using the mobile application in different Nodes. The mobile application is used for inputting and decoding messages in dissemination of information.

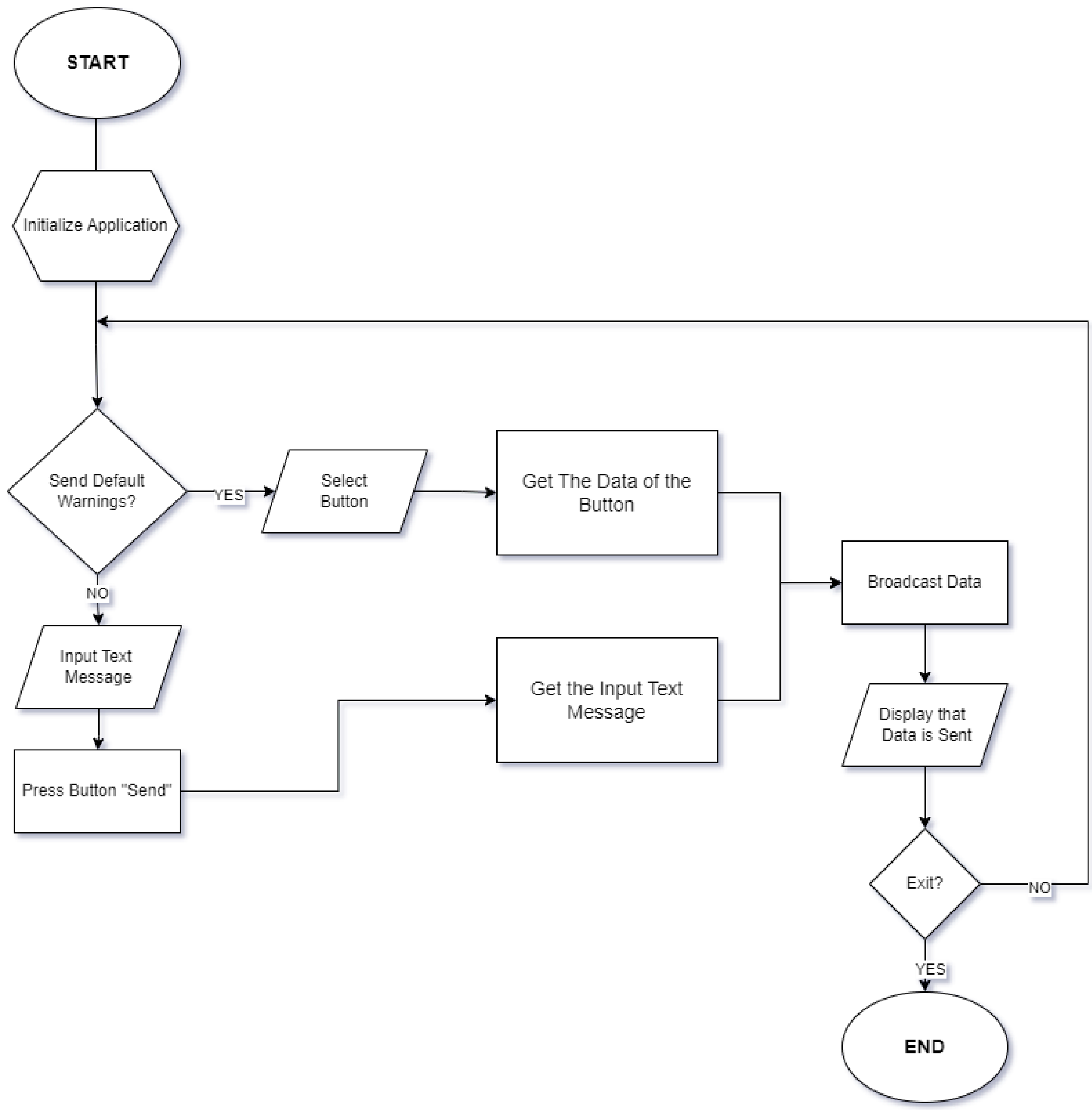

Figure 8. Main Node's Mobile Application Flowchart

The above flowchart, Figure 8, illustrates the process of user navigation within the application. This application is overseen by an authorized individual in either the MDRRMO office or a barangay office. Upon initiating the application, various buttons are presented, each categorized accordingly. These categories include earthquake warnings, gale warnings, rainfall warnings, typhoon signal warnings, and a siren alert. Should the user wish to send a customized message, they simply type the message and click the send button. Conversely, if the user prefers to send a default message for earthquake, gale, or typhoon signal warnings, they can do so by selecting and clicking the appropriate button for the specific warning. The data associated with the button will then be sent to broadcast. Once the broadcast ends, it would display that the message is sent and end, indicating that the process already ends and is now waiting for another input.

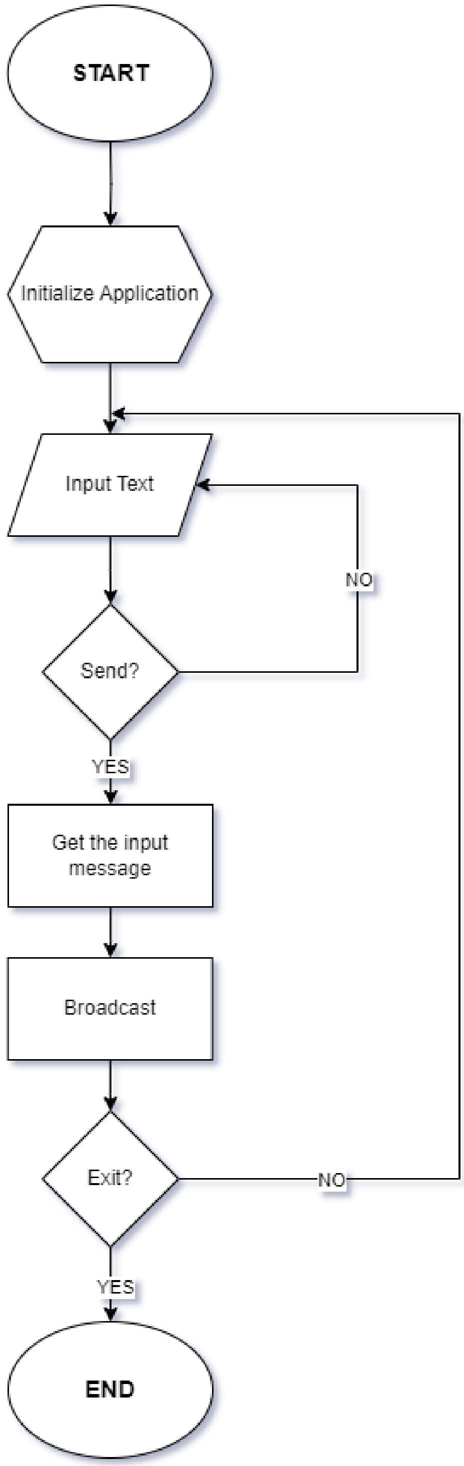

Figure 9. Sub Node’s Mobile Application Flowchart

The receiver devices of the system also have mobile applications. These applications allow the assigned resident to know when a message is sent by an authorized official. The application's features include sending text messages to the main device. As seen in the flowchart above, Figure 9, the user inputs a message, then by clicking the send button, it is processed and sent to broadcast in the main device's mobile application.

Project Structure and Organization

This section shows the process of how the system was developed, including the creation of the mobile application and the program for the connection of the alert system. It also involves the connection of the system and assembling the components. Once the entire system was developed, the researchers tested it for potential errors and subsequently evaluated its performance.

Actual GUI of Mobile Applications

After planning and designing the dissemination of information of the alert system, the researchers created a mobile application for sending and receiving information. The mobile phone serves as the input and output device of the alert system. There is a separate mobile application for the Master Node and Slave Nodes. The GUI of the mobile application is created in MIT App Inventor. The components are dragged into the frame and customized for design and layout.

Figure 10 shows the user interface of the Master Node's mobile application, where the default messages and text are input. The default messages/buttons are based on gathered data in Table 7. It used to send and receive messages from/to the Slave Nodes.

Figure 10. Master Node's Mobile Application

Figure 10 shows the graphical user interface (GUI) of the Master Node's mobile application. The interface consists of the application's logo, a text-to-speech input box, and buttons for pre-recorded announcements. These buttons are categorized by warning type: earthquake, gale, rainfall, and typhoon signal. The earthquake warning category features an "earthquake alert" button. Similarly, the gale warning category offers a "gale alert" button. The rainfall warning category includes three buttons for different severity levels: "yellow" "orange" and "red". Finally, the typhoon signal warning category provides buttons for "signal no. 1" to "no. 5". Additionally, there are buttons for a siren alert, an exit button, and a battery indicator.

Figure 11 shows the user interface of the Slave Nodes, where text is input and the message is displayed. It is used to send and receive messages from/to the Master Node.

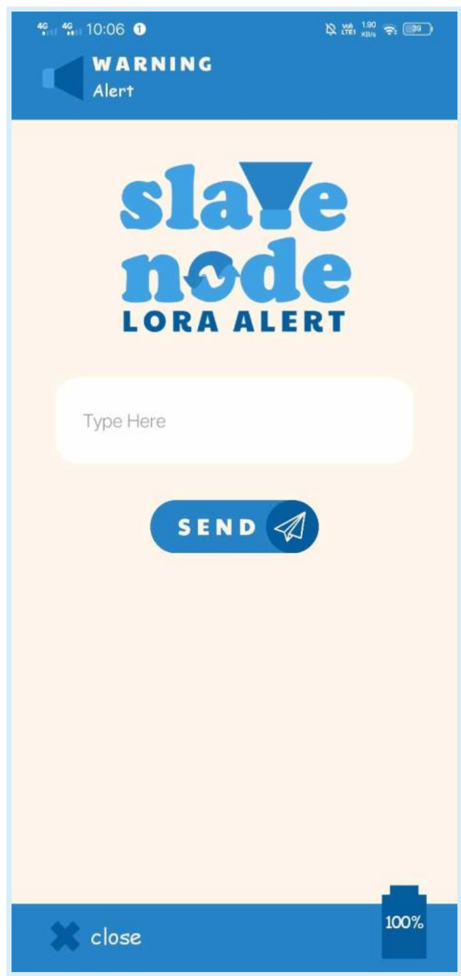

Figure 11. Slave Node's Mobile Application

Figure 11 shows the graphical user interface (GUI) of the Slave Node’s mobile application. The interface consists of the application's logo, a text-to-speech input box, an exit button, and a battery indicator.

Code Blocks of Mobile Applications

This section shows the code blocks of the mobile applications. It is based on the planning and design outlined in Table 8 and Figure 10 and 11. The code for the mobile application is created using MIT App Inventor. Pre-provided components are available for the user to drag into the frame and then create functions using the code blocks.

a. Master Node

The following figure shows the necessary code blocks of the Master Node. The functions of the code blocks are based on the GUI that is displayed in the frame of the Master Node’s mobile application.

The user of the mobile application can input text messages for custom messages. The button has a textbox for inputting the text-to-speech text, and a send button for sending this text.

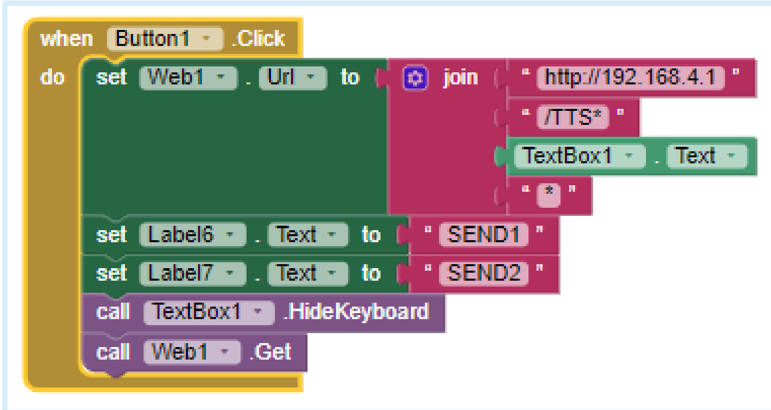

Figure 12 Blocks to Get the Text-to-Speech Text Input

Figure 12 shows the code for sending the inputted Text-to-speech content. When the button1 or the send button is clicked. The web URL is set to http://192.168.4.1, which is the address of the node. The next code then shows that the text of textbox1 is retrieved. Then it sets the labels text as send, and the corresponding number of the slave nodes. Lastly, it calls the web1 component.

The user can view the status of the messages that are sent/received. The master node has a notification label, to show the progress of the message.

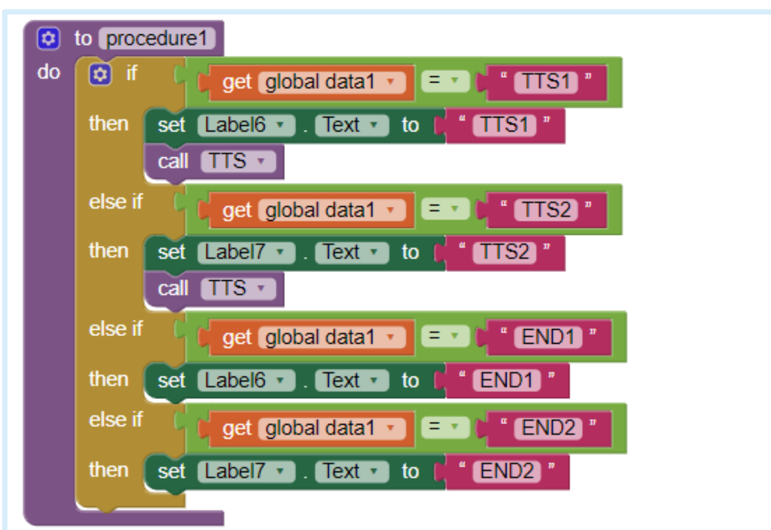

Figure 13 Blocks to Display Text-to-Speech Notification

Figure 13 shows the start and the content of the procedure1, it uses an if-else if statement. If data1 contains TTS, it then changes the Labels to TTS and its corresponding slave node number. It then calls the TTS code block procedure. But if data1 contains END, it changes the Labels to END, and similarly to its corresponding slave node number.

To convert the text into audio, the master node has code to enable the Text-To-Speech function.

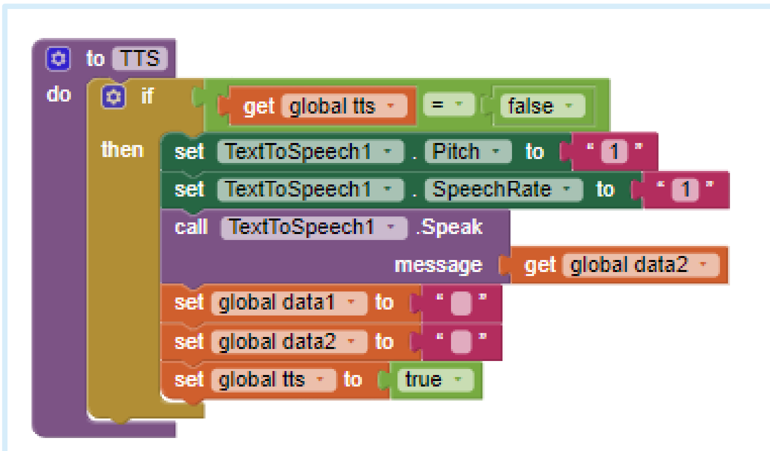

Figure 14 Blocks to Control Text-to-Speech Function

Figure 14 shows the start and the content of the TTS function, it uses an if statement. This code block works if the global variable tts is false, and the pitch and speech rate for the TestToSpeech component are set. The Speak method of the TextToSpeech component is called, passing the value of data2 as the message to speak. Lastly, the data1, data2, and tts, are given new values.

The user of the master node’s mobile application can see if the audio is finished in the receivers. The master node has code when the Text-To-Speech Audio is done.

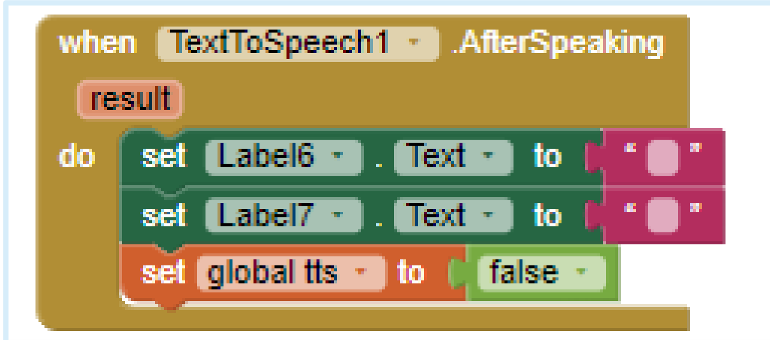

Figure 15 Blocks to Set the Text after the Text-to-Speech Audio

Figure 15 shows the start and the content of the TTS function, it uses an if statement. The AfterSpeaking method of the TextToSpeech component is called, it then sets the text for the labels, and false for the tts.

To present the different types of natural disasters, the researchers used buttons. The master node has different buttons corresponding to different alerts for different warnings separated into earthquake, gale warning, rainfall, and tropical cyclone.

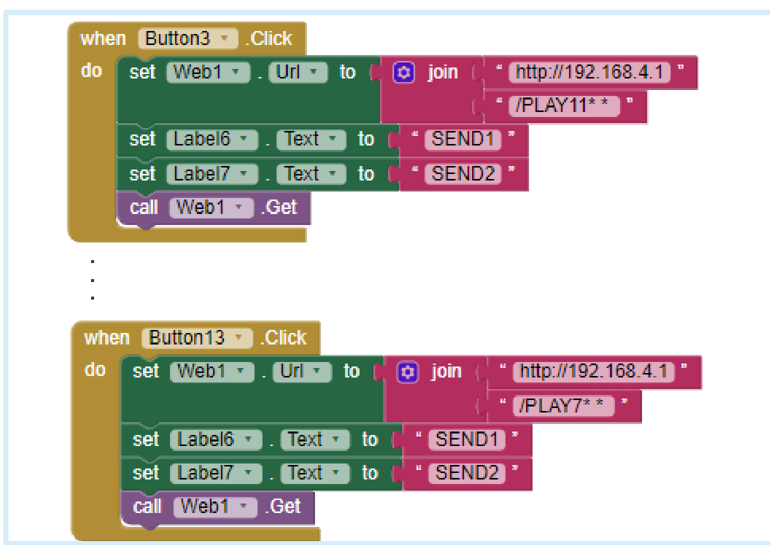

Figure 16 Blocks to Play the Corresponding Audio

Figure 16 shows the code blocks for each alert button. When the corresponding button is clicked, its corresponding audio is then played, and it sets the text for each slave node's label, as sent. Lastly, it calls the Web1 component.

b. Slave Nodes

The following figure shows some code blocks of the Slave Node. The functions of the code blocks are based on the GUI displayed in the frame of the Slave Node's mobile application.

The following figures are the blocks of codes that show how the text is displayed in the mobile application. On the slave node part, there is an indicator that helps the user to know what is the message or audio that is playing.

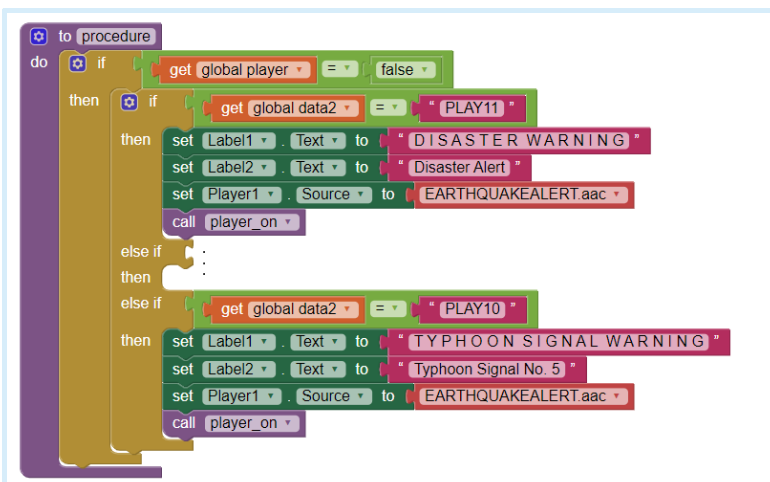

Figure 17 Blocks to Display the Name of the Audio

Figure 17 shows the block of code for displaying the title of the message that is currently playing on the mobile application. There is an if statement that if the user selects a button in the master node, its corresponding text label will display. This block also included the source of the audio file of the button.

The master node's applications display when the audio on the slave nodes is done playing.

Figure 18 Blocks of Code for Displaying When the Audio "END"

Figure 18 shows the block of code for displaying the word "END" on the mobile app of the Master Node, once the player completes in the Slave Nodes. This is a sample for Slave Node 1. The IP address of the Slave Node is joined to know which nodes finished playing the audio

c. Similar Code Blocks for All Nodes

There are six code blocks in Figure 19. Each code block uses global variables, which are initialized.

Figure 19 Blocks to Initialize Global Variables

The figure 19 shows blocks for initialization of global variables such as data1, data2, data3, and data4. Other global variables are initialized like global variable player and tts, which are both initialized to false.

Each node has an IP address that ensures each prototype has its own unique address. This IP address is used to identify the sender and determine where the message should be sent.

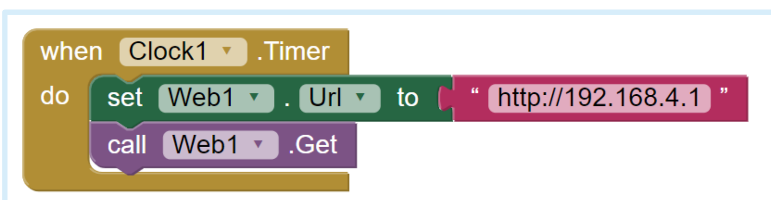

Figure 20 Blocks to Load the Node's Address

The figure 20 shows the blocks that set the Web1 URL to a specific IP address. The next block then retrieves this address from the Web1.

The node has a battery indicator that shows the current percent of the node's battery. This battery indicator presents the battery of the prototype not the battery of the mobile phone.

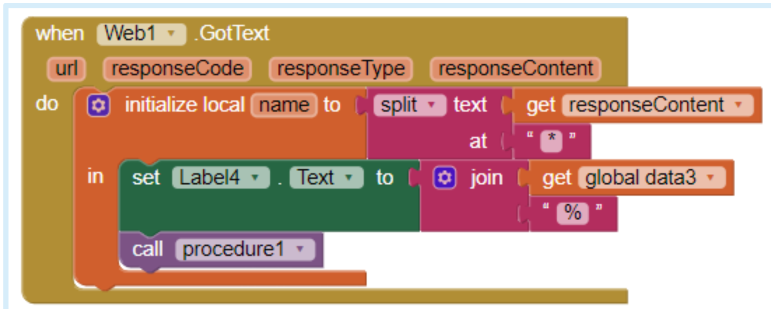

Figure 21 Blocks to Display the Battery Percentage

Figure 21 shows code blocks for processing text from the Web1 component. A web request was sent to Web1 and successfully got text data as the response. The text data is then split into lists. The split text list is then combined with the value from data3. The result is then used to change the text of Label 4. The procedure1 is then called.

The nodes' application has a button for exiting the application. It is provided in case the user does not use the back button on their mobile phone.

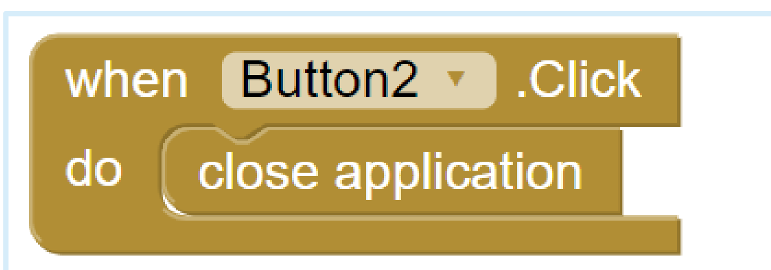

Figure 22 Block to Close the Application

The figure 22 shows the code blocks to close the application. When the button is clicked, it closes the application.

Program of the System

This section details the programming and structured a program code using Arduino IDE to establish the connection of ESP32 microcontrollers on how the data transfer between the LoRa module and mobile phone. It is composed of two codes for Master Node and Slave Node. It shows the program connection of all the components of the alert system.

The code of the Master Node is programmed to send and receive data from/to Slave Nodes. The data is input and output in the mobile application.

```
// Connect to Wi-Fi network with SSID and password
Serial.print("Setting AP (Access Point)…");
WiFi.softAP(Ssid, Password);
IPAddress myIP = WiFi.softAPIP();
Serial.print("AP IP address: ");
Serial.println(myIP);
server.begin();
delay(1000);
}
```

Figure 23 Function to Connect the Mobile Phone to ESP32

Figure 23 presents the function of how the mobile phone connects to the ESP32. The code sets a password to pair before it connects. WiFi.softAP(Ssid, Password) configures the Wi-Fi module to create an access point with the specified network name and password. IPAddress myIP = WiFi.softAPIP() retrieves the IP address assigned to the access point. When the connection is successful, it indicates that the access point setup process is starting.

The Master Node can receive messages from the Slave Nodes. The data is processed and decoded to output the message.

```
void get_S2data(){
  if (Serial2.available()) {
  while (!Serial2.available()) {
  delay(2); /// 1
  }
  Srxdata =  Serial2.readStringUntil('\r');  //\n
  Serial.println(Srxdata); // r
  sel_string();
  }
  }
```

Figure 24 Function for Receiving Data from LoRa module to ESP32 in Master Node

Figure 24 shows the program on how the data is read using the LoRa module and process by ESP32. The function get_S2data() reads data from Serial2, which is used for communication with another device connected to the microcontroller. The loop while (!Serial2.available()), waits until there is data available to be read from Serial2. Srxdata = Serial2.readStringUntil('\r'), reads the data from Serial2 until it encounters a carriage return character ('\r'). The data read is stored in the variable Srxdata.

Besides from the Master Node that can receive data, it can also transmit data to the other nodes. It gets the input of the user and processes the string or a value to send.

```
void    sel_data(){
        int   ctdex;
        int   ctdexe;
        String Crx1;
        String Crx2;
        String Crx3;
        Crx1  =  serialinput.substring(ctdex,ctdexe);
        ctdex++;
        Crx2   =  serialinput.substring(ctdex,ctdexe);
        serialinput = "";
        Serial.println(Crx1);
        Serial.println(Crx2);
        if (Crx1 == "TTS"){
        tts_data = Crx2;
        send_tts1();
        }else if(Crx1 == "PLAY1"){
        send_play1();
        .
        .
        .
        }else if(Crx1 == "PLAY11"){
        send_play11();
        }
        }
```

Figure 25 Function for Transmitting Data from ESP32 to LoRA module in Master Node

Figure 25 shows the program code used for selecting which data would be sent. If the “Crx1” is “TTS”, then it saves the content of “Crx2” as text-to-speech data. Then it calls the function “send_tts1()”. But if the “Crx1” is “PLAY#”, then it calls the function “send_play#”.

```
void send_tts1(){
     Serial2.print("TTS1*");
     Serial2.print(tts_data);
     Serial2.println("* ");
     delay(2000);  /////
     Serial2.print("TTS2*");
     Serial2.print(tts_data);
     Serial2.println("* ");
     }
```

Figure 26 Function for Sending String from Master Node to Slave Nodes

Figure 26 shows the transmission of data input using the mobile application and process by the ESP 32 and passed through the LoRa module. This function is called from the function sel_data(). The function send_tts1() is responsible for sending data via Serial2 to another LoRa module. It sends data to the serial connection "TTS1" and "TTS2". The tts_data is a variable containing the data to be sent, this function sends "TTS1" followed by the content of tts_data, then waits for 2 seconds, and finally sends "TTS2" followed by tts_data again.

The Master node has a default warning message. This default warning message is shown as a button. If the button is pressed, there is a corresponding data that will be sent to play the default warning message.

```
void send_play1(){
     Serial2.println("PLAYER1*PLAY1* ");
     delay(2000);
     Serial2.println("PLAYER2*PLAY1* ");
     }
     .
     .
     .
void send_play11(){
     Serial2.println("PLAYER1*PLAY11* ");
     delay(2000);
     Serial2.println("PLAYER2*PLAY11* ");
     }
```

Figure 27 Function for Sending Default Messages from Master Node to Slave Nodes

Figure 27 shows the functions of sending default warning messages. This function is called from the function sel_data(). There are eleven buttons that represent different default warning messages. The commands are structured as "PLAYER1PLAYx" and "PLAYER2PLAYer", where "x" is the track number. There is a delay of 2 seconds as the Slave Nodes receive the data.

The battery is also programmed to have a battery indicator in the GUI of the mobile application. The user monitors the status of the battery if the prototype is unplugged from the external supply.

```
void get_voltage(){
  int data_in6  = 0;
  uint32_t data_in6_ = 0; /// int
  float avg_volt = 0;
  for (int i=0; i < 100; i++) {
  data_in6 = analogRead(vbat_input); //
  data_in6_ = data_in6_ + data_in6;
  }
  data_in6 = data_in6_ / 100;
  avg_volt = data_in6 *(3.3 / 4095.0);
  volt_val  = avg_volt / (R2/(R1+R2));
  volt_val = volt_val + 2;

  bat_level = map(volt_val,0,12,0,100);

  if (bat_level > 100){
  bat_level = 100;
  data3 = bat_level; // convert to string
  }
  }
```

Figure 28 Function for Battery Indicator

Figure 28 shows the function of the battery indicator in the mobile application. This function appears to read and process voltage data from an analog input, compute the average voltage, and then map it to a battery level percentage. The voltage conversion using the variable avg_volt converts the averaged analog value to a voltage. The formula 3.3 / 4095.0 converts the raw ADC value to a voltage assuming a 12-bit ADC with a reference voltage of 3.3V. In the variable bat_level the battery percentage does not exceed 100. The data3 variable is used to store the value of bat_level and convert it into string.

Furthermore, the functions of the Slave Nodes are the same with the Master Node, except for the buttons for default warning messages. The following codes are the program where the data is received and sent from/to the Master Node.

```
void get_data(){
  WiFiClient client = server.available();
while (!client.available()) { // Wait until the client sends some data
delay(1);
}
String req = client.readStringUntil('\r');
req = req.substring(req.indexOf("/") + 1, req.indexOf("HTTP") - 1);
client.print ("HTTP/1.1 200 OK\n\n"+String(Sdata));
client.flush();
data1 =  " ";
data2 =  " ";
data3 = bat_level; // convert to string
data4 =  " ";

if (req != 0){
serialinput = (req); // do command
Serial.println(serialinput);///////////////////
url.urlcode = serialinput;
url.urldecode();
String decoded = url.strcode;
Serial.println(decoded);///////////////////
Serial2.println(serialinput);
}
delay(5);
}
```

Figure 29 Function for Receiving Data from LoRa module to ESP32 in Slave Nodes

Figure 29 shows the code for handling incoming data received by the ESP32 microcontroller from the LoRa module of the Slave Node. The HTTP functionality indicates that this function serves as the handler for incoming data to the microcontroller. It waits and checks for the incoming data, when data is available, the microcontroller processes, decodes the data, and sends it out to the mobile phone via the serial ‘Serial2’ interface.

The code for sending text has the same function as the Master Node, but in this case, there are no buttons that are used for default warning messages.

```
void    sel_data(){
        int   ctdex;
        int   ctdexe;
        String Crx1;
        String Crx2;
        String Crx3;
        Crx1  =  serialinput.substring(ctdex,ctdexe);
        ctdex++;
        Crx2   =  serialinput.substring(ctdex,ctdexe);
        serialinput = "";
        Serial.println(Crx1);
        Serial.println(Crx2);
        }
```

Figure 30 Function for Sending String from Slave Nodes to Master Nodes

Figure 30 shows the function for processing the string received by the microcontroller from the mobile application. It parses the received string, extracting specific substrings or segments, and prepares them for transmission via LoRa to the Master Node. This parsing process involves breaking down the received string into individual characters for the LoRa to easily transmit them to the Master Node.

Assembly of the Prototype

In this section, the researchers assemble and build the prototype of the LoRa alert system. All the components are properly assembled and all the wirings are properly connected to operate the whole prototype. The assembly of the prototype is divided into two parts which are the Slave Nodes and Master Node. Shown below are the connections of all the components inside and outside the main box.

The Slave Nodes used a rectangular shape of the case that fits its main components, which are LoRa AS32 with antenna, ESP32, horn speaker with amplifier, battery, and a voltage regulator.

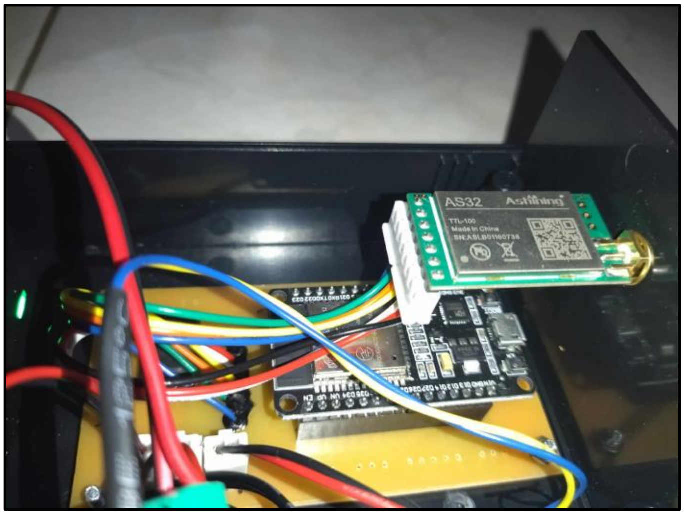

Figure 31 Connections of ESP32 and LoRa AS32

Figure 31 shows the connection of the microcontroller ESP32 and a LoRa module with a specification of AS32. Using the seven pins of LoRa AS32, it configures and programs in the code of ESP32. The pins of the LoRa module are determined using the RX and TX depending on its function, whether to send or receive data.

The LoRa module has a built-in antenna to send and receive signals from other LoRa modules. But the researchers also used an extended antenna to have a low value of RSI.

Figure 32 Connections of Antenna for LoRa AS32

Figure 32 shows two different antennas used for LoRa AS32. The antenna and LoRa module have the same value of frequency which is 433 Mhz. The position of the antenna is in an open area. So, the antenna needs an extended cable that can adjust its position. The researchers used an antenna that can easily plug out or plug in if there are any changes of the type of antenna.

The researchers first tested if the LoRa modules communicate using the ESP32. Once it transmits and receives data, the researcher can now assemble how the data will output in the mobile application and use a horn speaker with an amplifier. The book written by Bob Cordel in 2019, an amplifier is used for speakers to create sophisticated audiophiles.

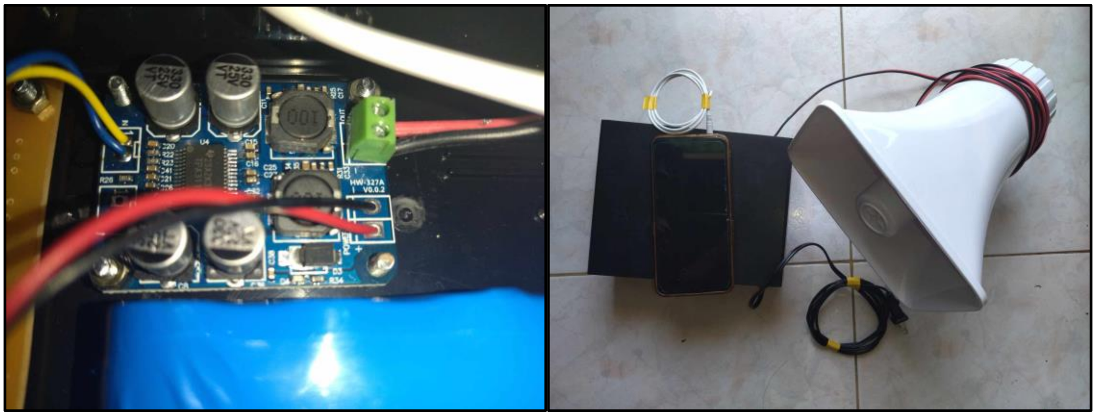

Figure 33 Connections of Amplifier and horn speaker

Figure 33 shows the connection of a 60 Watts amplifier and a 50 Watts horn speaker. By the given ports in the amplifier, it is also connected to the audio cable that is connected to the mobile phone. The amplifier is also connected to the battery to have a power supply. In this section, it is used as the extended output of the mobile phone to loudspeaker the audio.

However, based on the assembly in Figure 31 and Figure 33, those components need a voltage supply to operate. Since the power supply from the first testing of communication between LoRa modules is only dependent on the supply from the laptop, the researchers used a voltage regulator that is directly connected to the AC supply and a battery as a backup.

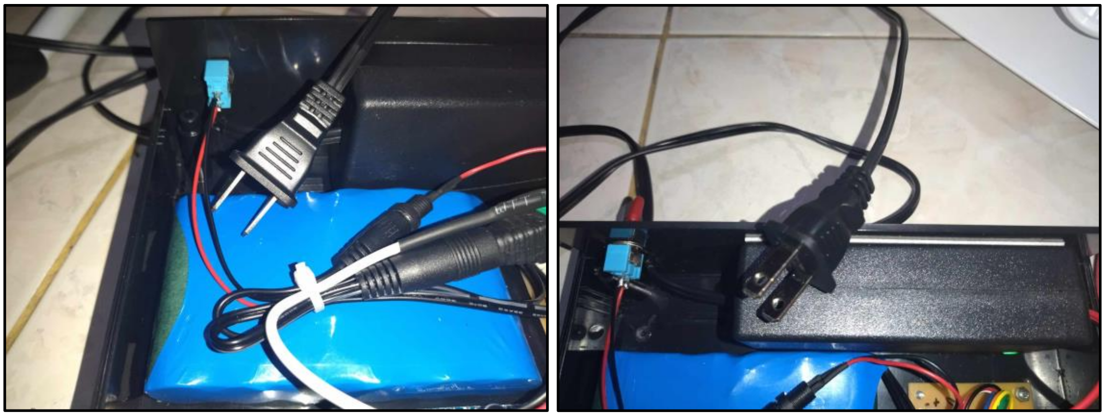

Figure 34 Connections of Voltage Regulator and a Battery

Figure 34 shows the connection of the voltage regulator and a battery. The researchers used a Mini 360 DC type of regulator and a 6 to 24 volts battery. The male plug is plugged in the socket which is the input supply for the voltage regulator. The regulated voltage then now passes through the battery that holds the power supply and will operate the whole prototype. The battery is connected to the supply port with other components. There is also a power switch to control whether the prototype needs to turn ON or OFF.

The assembly of the components of the Master Node is also the same with the Slave Nodes, except for the horn speaker. The researchers do not use a horn speaker since the message doesn't need to speak louder. So the researchers plan is that the audio is enough to play on the mobile phone.

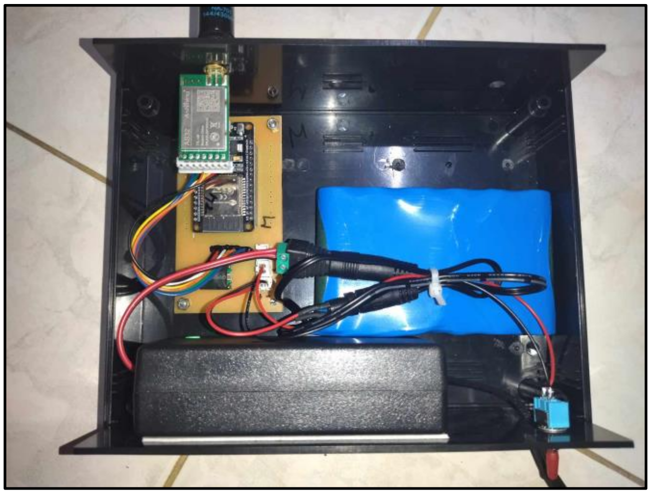

Figure 35 Assembly of the Master Node

Figure 35 shows the whole assembly of the components of the Master Node. The researchers used a rectangular shape of case that fits all the components. The main components used in Master Node are LoRa AS32 with antenna, ESP32, battery and a voltage regulator.

Project Evaluation

The system has undergone testing and evaluation in order to achieve the fourth objective of the study. Testing of effectiveness/efficiency and users' evaluation are shown below.

The researchers test the range of signals and height of the antenna that can transmit and receive data between the Master Node and Slave Node. The researchers chose a starting distance of 100 meters for testing, as it is the standard range for effective signal transmission and reception.

Table 11 shows the testing of the system in an obstructed environment. The walls and other structural obstructions are unavoidable and may affect the dissemination of information in distant nodes with obstruction. The researchers test in which the antenna is positioned higher. The height of the antenna changes in each trial with the distance between each node. It tests which height of the antenna is efficient for transmitting messages over a longer range.

Table 9. Height of the Antenna and its Range to Transmit Messages

Height of an Antenna (meters)	Range (meters)	Trials										Frequency	Percentage
		1	2	3	4	5	6	7	8	9	10		
2	100	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	200	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	300	✔	x	✔	x	✔	x	x	x	x	x	3/10	30%
4	250	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	300	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	400	x	x	✔	x	x	x	x	x	x	x	1/10	10%
6	350	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	400	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	500	✔	✔	x	x	x	✔	x	x	✔	x	4/10	40%
8	450	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	500	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	1/10	100%
	600	x	x	x	x	x	✔	✔	x	x	x	2/10	20%
10	550	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	500	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	600	x	x	x	x	x	x	✔	✔	✔	x	3/10	30%
12	550	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	600	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	700	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	800	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
	900	✔	✔	✔	✔	✔	✔	x	✔	x	✔	8/10	80%

Table 9 shows different columns that provide data on testing the efficiency of the antenna height. The first column is the height of the antenna. The second column shows the range of each node in meters. The column for trials includes ten trials. The column for frequency records how many times the transmission of messages was successful over ten trials. The last column converts the frequency data into a percentage. As shown in the table, the maximum height of the antenna tested by the researchers is 12 meters. At this height, the maximum range of each node is 800 meters. There were two unsuccessful transmissions of messages in the 7th and 9th trials. The researchers have no capability to increase further the height of the antenna.

After the researchers tested the efficient height of the antenna and the range of the transmission of messages, the researchers then now test its effectiveness without using a SIM card in the mobile phone and a fully covered antenna.

The researchers test the transmission of data by removing the SIM card in the mobile phone. The researchers want to know if the alert system is effective even if there is no cellular signal in their mobile phone. The mobile phone can only connect to the IP address of ESP32. The researchers test using the maximum height of the antenna in Table 9, which is 12 meters.

Table 10. Transmission of Messages by removing the SIM Card of the Mobile Phone

Trial	Transmit Data	Remarks
1	✔	*Excellent*
2	✔	*Excellent*
3	✔	*Excellent*
4	✔	*Excellent*
5	✔	*Excellent*
6	✔	*Excellent*
7	✔	*Excellent*
8	✔	*Excellent*
9	✔	*Excellent*
10	✔	*Excellent*

Table 10 shows the transmission and reception of data using a mobile phone without its SIM card. The remarks for all the trials are excellent, with the mobile phone successfully sending and receiving data. The tests of the nodes were conducted nearby.

Based on Table 9 with its maximum height, the researchers covered the antenna. In Table 11 the test was conducted by positioning the prototype in a covered room. It tests the transmission of data that passes through the wall and other blockings or barriers. It will test the effectiveness of the antenna even if it is fully covered with barriers. In this testing, the researchers also test at a given height of the antenna at 12 meters.

Table 11. Transmission of Messages where the Antenna is Fully Covered

Range (meters)	Trials										Frequency	Percentage
	1	2	3	4	5	6	7	8	9	10		
500	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
550	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
600	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
650	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
700	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
750	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	10/10	100%
800	✔	x	x	x	x	✔	✔	x	x	x	3/10	30%

Table 11 presents the testing of message transmission with the antenna at a height of 12 meters, but fully covered. The researchers started the distance of each node at 500 meters and added 50 meters in each trial. Compared to Table 9, the maximum range in Table 11 is 750 meters, which is 80 meters less than the 800-meter range in Table 9. At 800 meters, the researchers only achieved 30% transmission success. Therefore, they chose 750 meters as the maximum range to transmit messages with the antenna at a height of 12 meters.

A survey was conducted of ten barangay officials who evaluated the usage of mobile applications, the results are shown in Table 12. The survey's goal was to assess the design, functionality, and the ease of use of the mobile application and the alert system.

Table 12. Results of Users Evaluation of the Mobile Application

Statement	WM	DR
Design		
1. The mobile application is presentable. *(Ang mobile application ay presentable ng tingnan.)*	**4.70**	Strongly Agree
2. The design of the mobile application is user-friendly. *(Ang mobile application ay madaling gamitin.)*	**4.70**	Strongly Agree
Functionality		
3. The mobile application is reliable in delivering alerts. *(Ang mobile application ay nakakapag send ng message nang maayos.)*	**4.50**	Strongly Agree
4. The Slave Nodes' application displays what audio messages received. *(Nakikita ko kung anong klaseng mensahe ang ipinadala galing sa awtoridad.)*	**4.70**	Strongly Agree
5. The features of the mobile application fulfill the purpose of disseminating warnings regarding natural disasters. *(Nagagampanan ng mobile application ang mga mensahe patungkol sa natural disaster na dapat ay maipahiwatig.)*	**4.80**	Strongly Agree
6. The mobile application is user-friendly. *(Ang mobile application ay madaling gamitin.)*	**4.70**	Strongly Agree
Ease of Use		
7. The mobile application is easy to navigate. *(Ang mobile application ay madaling gamitin.)*	**4.50**	Strongly Agree
8. I have not encountered any technical issues while using the mobile application. *(Wala akong na anomang technical issues sa mobile application.)*	**4.00**	Agree
Total Average Weighted Mean	**4.58**	Strongly Agree

Table 12, survey results regarding the users' evaluation of using the mobile application revealed respondents were satisfied. In summary, the results indicated high positive feedback. Users found the mobile application presentable, easy to navigate, and features are working properly.

A survey was conducted to ten barangay officials who evaluated the usage of the prototype, the results are shown in Table 13. The survey's goal was to assess the overall efficiency of the prototype, node's ability to send and receive messages from/to other nodes, text-to-speech conversion, and ease of use.

Table 13. Results of Users' Evaluation of the Wireless Alert System

Statement	WM	DR
Functionality		
1. The Master Node sends and receives messages from/to Slave Nodes. *(Nakakapag send at receive ang Master Node ng mensahe papunta at galing sa Slave Nodes.)*	**4.70**	Strongly Agree
2. The Slave Nodes send and receive messages from/to the Master Node. *(Nakakapag send at receive ang Slave Nodes ng mensahe papunta at galing sa Master Node.)*	**4.80**	Strongly Agree
3. The horn speaker outputs sound clearly and loudly. *(Malinaw at malakas ang tunog ng horn speaker.)*	**4.50**	Strongly Agree
4. The text is properly converted into speech for receivers of messages. *(Tama at maayos na napapalitan ng tunog ang ipinasa na salita.)*	**4.60**	Strongly Agree
Ease of Use		
5. The mobile phone is easy to connect to the prototype. *(Madali lang ikonekta ang mobile phone sa prototype.)*	**4.40**	Strongly Agree
6. The prototype was easy to learn and use. *(Madaling maintindihan at gamitin ang prototype.)*	**4.60**	Strongly Agree
Total Average Weighted Mean	**4.60**	Strongly Agree

Table 13, survey results regarding the efficiency of the prototype revealed respondents were satisfied. In summary, the results indicated high positive feedback. Users found the prototype easy to use, components working properly, and able to send and receive messages.

Project Limitations and Capabilities

After the project evaluation, the researchers found out the capabilities and limitations of the system based on the results of the testing.

The mobile phone has the capability to connect to the microcontroller using a peer-to-peer connection. Multiple users can connect to the microcontroller, but it cannot send simultaneously. However, the user cannot easily connect if they do not have access or do not know the password of the microcontroller.

Moreover, the proposed design of the communication of LoRa modules is a two-way communication and it is called Master Node and Slave Nodes. Slave Node cannot send and receive messages from/to its fellow Slave Node. Each node has the capability to communicate wireless even without the internet or any cellular signal.

Furthermore, the user sends either through buttons with default warning messages or through text-to-speech. If the user presses the button multiple times, it will only send the message once. It only accepts the user's first input until the message is finished. When it comes to the feature of text-to-speech, the user can only input English words. If a Tagalog word is input, the pronunciation is not clear.

Through several testing of systems where the minimum and maximum range are tested and delay is also considered, the position of the Nodes in the community depends on the maximum range considering observed factors. The frequency of LoRa modules and an antenna is 433 Mhz, then the horn speaker is 50 Watts and the amplifier is 60 Watts. Therefore, the range of communication and the sounds of the audio have its limitations depending on the frequency and the decibel.

For the power supply of the prototype, the battery only supplies the main box to operate. The mobile phone cannot charge and also does not consume power in the prototype.

Chapter V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This chapter presents the summarized, the conclusions and the recommendations resulting from the study of the research work conducted. The chapter includes the research findings, including the analysis, observations, interpretation of the results, and explores how these results align with the study objectives.

Summary

The research emphasizes the development of the wireless communication alert system utilizing LoRa modules and mobile applications. This system is used to disseminate important alerts or warnings regarding natural disasters without the use of internet and cellular networks connection. With the use of the mobile application which is connected to the device, the authorized official can conveniently select the default warnings and broadcast it to the slave nodes. Likewise, the residents can send responses. The communication in each node informs everyone about natural disaster updates even without physical interactions.

The height and the environment that the antenna of the devices affects the range coverage that the system communicates. The higher the antenna and they are in line-of-sight, the better communication. Ensuring optimal antenna placement can significantly enhance the reliability and efficiency of the alert system.

To construct the system the applied research design is used in that it involves developing a device that addresses the problems presented, and providing solutions to these problems. The Lora-Based Alert System was eventually developed for remote natural disasters response to enhance disaster preparedness and communication.

The researchers used MIT app inventor to create the mobile applications. ESP32 was the microcontroller used by the researchers, and LoRa AS32 were used for the communication of the devices, and they are programmed using the C++ languages. The microcontroller is a program for the connection of the mobile applications to the LoRa.

Findings

The study focuses on constructing a system for natural disaster response and preparedness, utilizing both mobile applications and LoRa modules. The following findings are based on the research accomplished during the study and through the testing and evaluation of the system and considering the objectives of the study.

The researchers were able to plan and design the wireless communication process using the mobile application and different nodes. The MDRRMO or Barangay Officials used a mobile application to send messages about natural disasters. The MDRRMO or Barangay Officials used the Master Node to send information to the Slave Nodes and these are connected using the LoRa modules. The residents can send requests of information back to the authority using the Slave Node. Using these technologies it satisfies the alert system in dissemination of information about natural disasters.

To be able to create the mobile application, the researchers gathered different types of natural disasters. The researchers used buttons representing different types of natural disasters to send information. It can also receive responses via text input and display notifications to alert the user. The researchers used MIT App Inventor to create the GUI and the functions of the mobile applications.

In creating the program of the wireless connection of the alert system, the researchers considered the microcontroller and model of the LoRa module. It is better to use and program the ESP32 to establish the connection of mobile phones through IP addresses and different LoRa modules. It defines a set of instructions and libraries to connect the pins of the LoRa module. Through testing and debugging, the researchers encounter difficulties in the transmission of data. It found out that it has limitations on how large the bit/byte of data is going to transfer. It is fine to send data of a button and a string, but cannot transmit an audio file.

The researchers discovered, through testing and evaluation of the mobile application and wireless alert system, that the height of the antenna and the range of each LoRa module affect data transmission. They found that it is better to position the antenna in an open area or at a higher altitude. The efficient height of the antenna is 12 meters at a range of transmission in 800 meters, but with obstructions it only ranges at 750 meters.

This indicates that the transmission of data wirelessly is not always controllable due to unexpected barriers in the air or environment.

Overall, the study can develop a system for natural disaster response and preparedness that utilizes both the mobile application and LoRa modules.

Conclusions

The researchers developed the LoRa alert system for natural disaster response and preparedness, particularly in rural areas, by enabling officials to send warnings to residents and receive responses using mobile applications without requiring community patrols, achieving high efficiency for using the system.

Recommendation

After thorough analyzing the results of the study, the researchers recommend the following for the improvement of the system:

1. In the future, if a microcontroller and LoRa module becomes available with the capability to decode and handle larger amounts of data, it could significantly enhance the system's performance and functionality of transceiving data.

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APPENDICES

APPENDIX A
(User Manual)

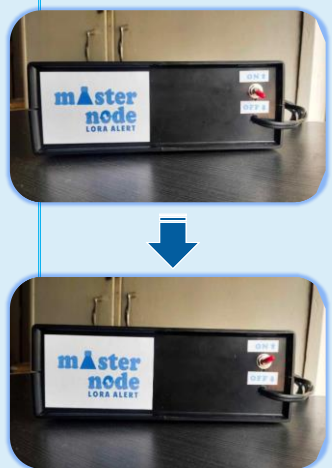
USER MANUAL

BOLO,
Lyza April P.

CARREOS,
Clarice Mae G.

CORPUZ,
Reimarc G..

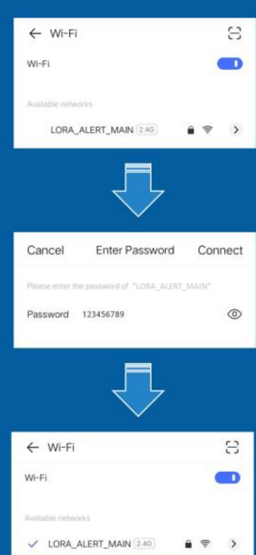
01



Turn on the prototype

02

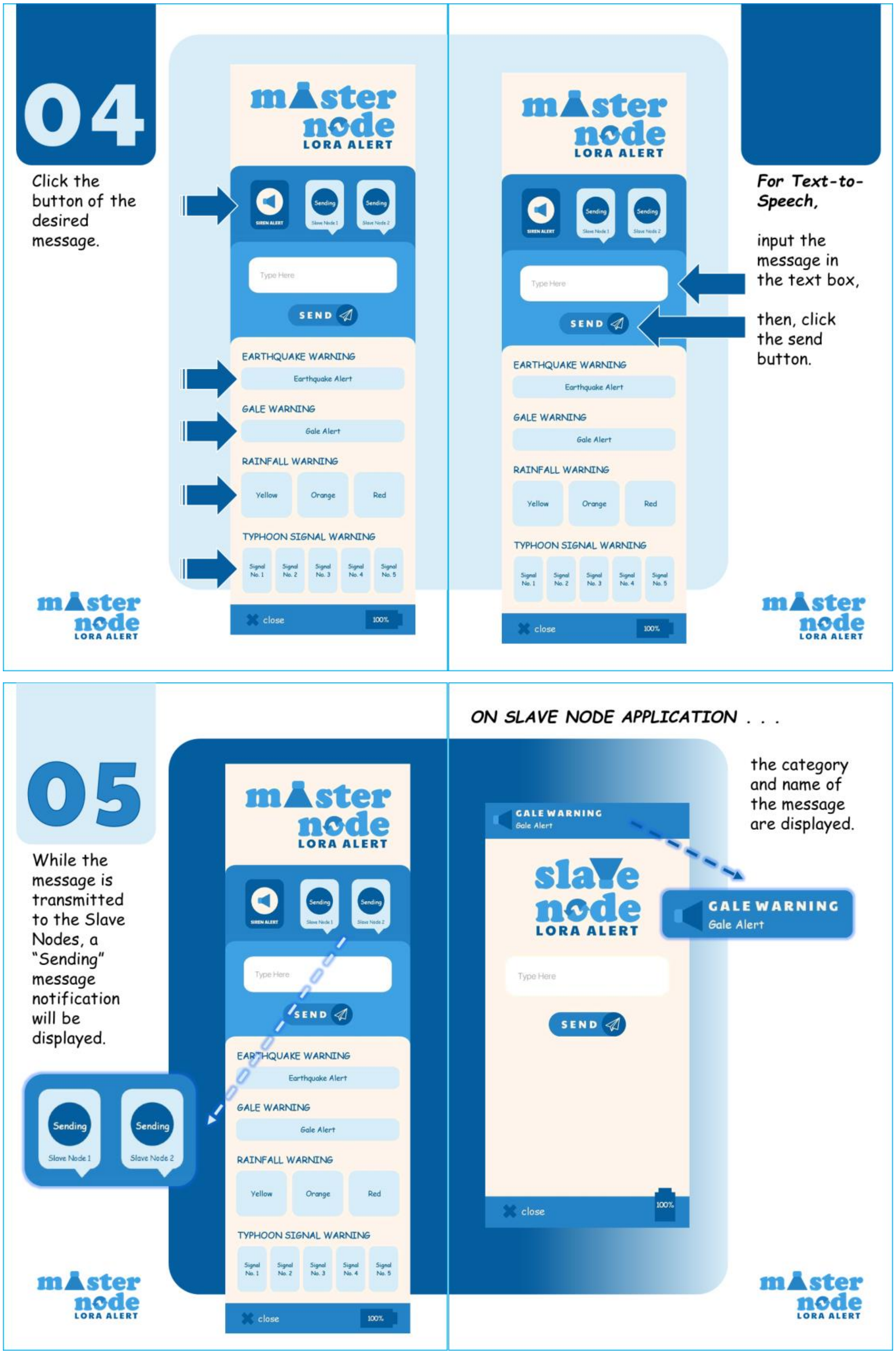
Connect the mobile phone to the same network as the prototype.



03

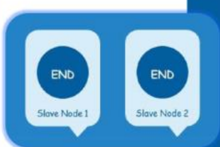
Open the installed mobile application on your phone.

Master Node


04
Click the button of the desired message.
master node LORA ALERT
SIREN ALERT
Sending
Slave Node 1
Slave Node 2
Type Here
SEND
EARTHQUAKE WARNING
Earthquake Alert
GALE WARNING
Gale Alert
RAINFALL WARNING
Yellow
Orange
Red
TYPHOON SIGNAL WARNING
Signal No. 1
Signal No. 2
Signal No. 3
Signal No. 4
Signal No. 5
close
100%
For Text-to-Speech,
input the message in the text box,
then, click the send button.
05
While the message is transmitted to the Slave Nodes, a "Sending" message notification will be displayed.
ON SLAVE NODE APPLICATION . . .
the category and name of the message are displayed.
GALE WARNING
Gale Alert
slave node LORA ALERT

06

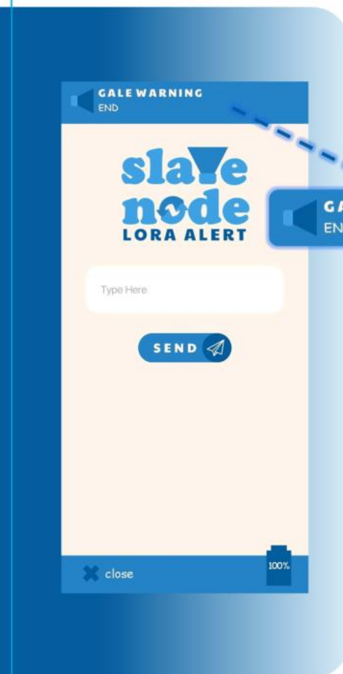
Upon successful transmission to the Slave Nodes, an "END" message will be displayed.



master node LORA ALERT

ON SLAVE NODE APPLICATION . . .

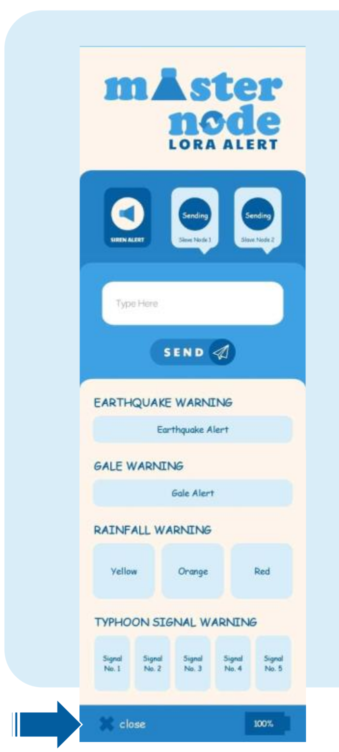
the category of the message and an "END" are displayed.



master node LORA ALERT

07

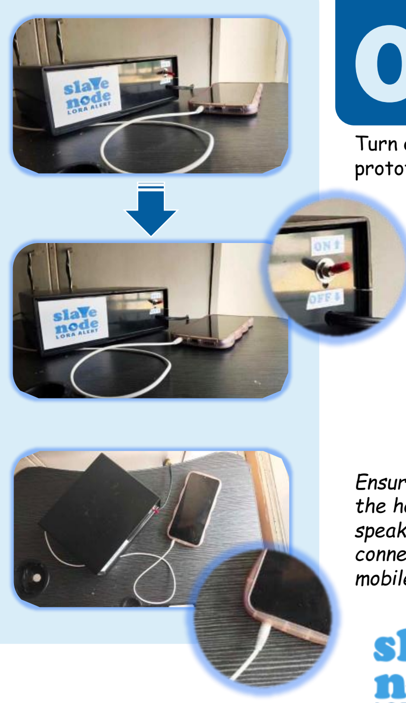
Click the "close" button to exit the application.



master node LORA ALERT

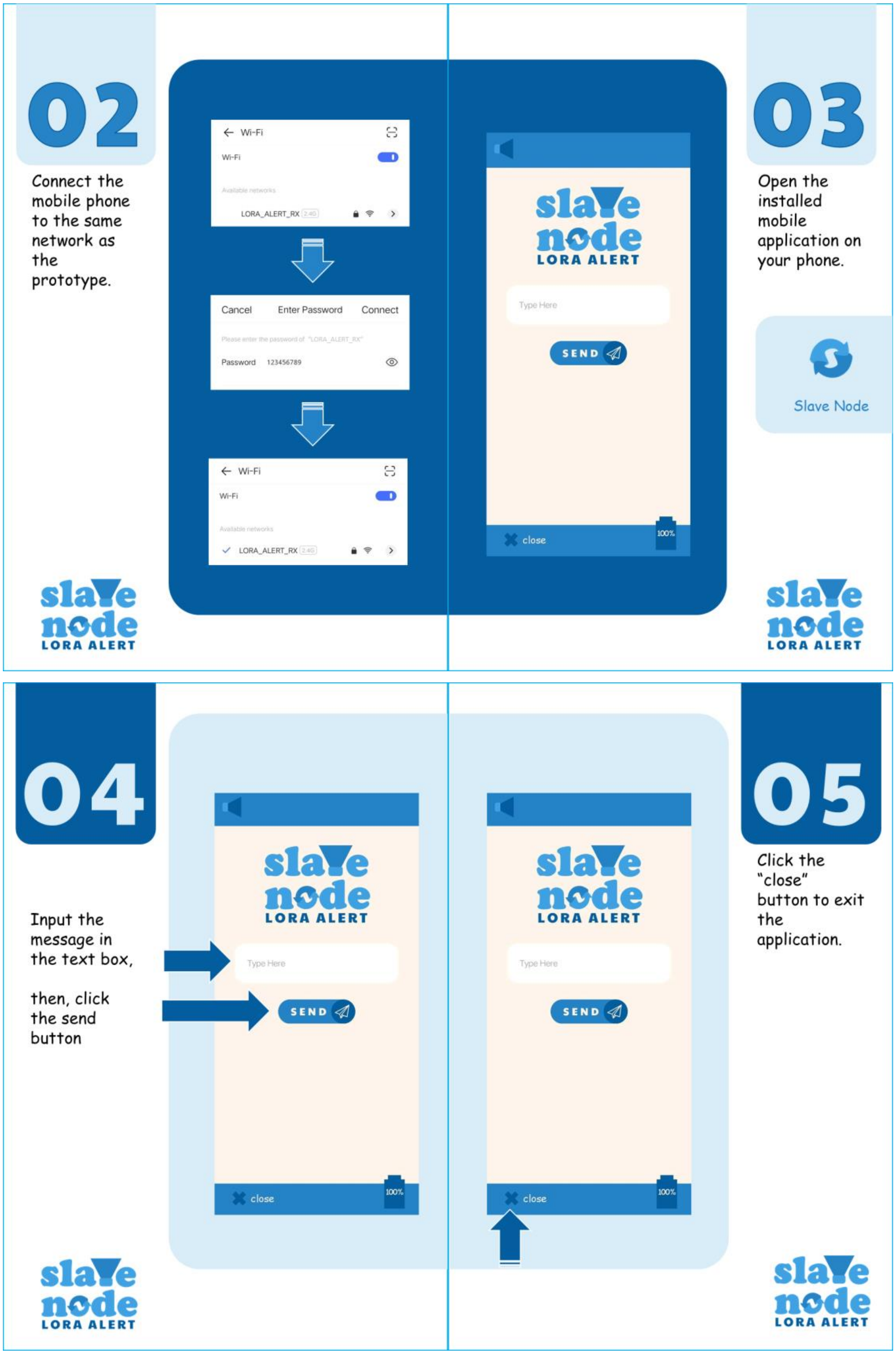
01

Turn on the prototype



Ensure that the horn speaker is connected to mobile phone

slave node LORA ALERT


02
Connect the mobile phone to the same network as the prototype.
Wi-Fi
LORA_ALERT_RX
Cancel
Enter Password
Connect
Password 123456789
Wi-Fi
LORA_ALERT_RX
slave node
LORA ALERT
03
Open the installed mobile application on your phone.
Slave Node
Type Here
SEND
close
100%
04
Input the message in the text box,
then, click the send button
05
Click the "close" button to exit the application.

APPENDIX B

(Survey Questionnaire)

LORA BASED ALERT SYSTEM FOR REMOTE NATURAL DISASTER RESPONSE TO ENHANCE DISASTER PREPAREDNESS AND COMMUNICATION

Name (Optional): ___________________________________

Directions: Please indicate your level of agreement and disagreement with each of these statements regarding the efficiency of the mobile application and the alert system itself. Please check (✓) and rate how much you personally agree or disagree with these statements, using the following scales:

5 - Strongly Agree
4 - Agree
3 - Neutral
2 - Disagree
1 - Strongly Disagree

I. Evaluation of the Mobile Application

Statement	5	4	3	2	1
Design					
1. The mobile application is presentable. *(Ang mobile application ay presentable ng tingnan.)*					
2. The design of the mobile application is user-friendly. *(Ang mobile application ay madaling gamitin.)*					
Functionality					
3. The mobile application is reliable in delivering alerts. *(Ang mobile application ay nakakapag send ng message nang maayos.)*					
4. The Slave Nodes' application displays what audio messages received. *(Nakikita ko kung anong klaseng mensahe ang ipinadala galing sa awtoridad.)*					
5. The features of the mobile application fulfill the purpose of disseminating warnings regarding natural disasters. *(Nagagampanan ng mobile application ang mga mensahe patungkol sa natural disaster na dapat ay maipahiwatig.)*					
6. The mobile application is user-friendly. *(Ang mobile application ay madaling gamitin.)*					
Ease of Use					
7. The mobile application is easy to navigate. *(Ang mobile application ay madaling gamitin.)*					
8. I have not encountered any technical issues while using the mobile application. *(Wala akong na anomang technical issues sa mobile application.)*					

II. Evaluation of the Wireless Alert System

Statement	5	4	3	2	1
Functionality					
1. The Master Node sends and receives messages from/to Slave Nodes. *(Nakakapag send at receive ang Master Node ng mensahe papunta at galing sa Slave Nodes.)*					
2. The Slave Nodes send and receive messages from/to the Master Node. *(Nakakapag send at receive ang Slave Nodes ng mensahe papunta at galing sa Master Node.)*					
3. The horn speaker outputs sound clearly and loudly. *(Malinaw at malakas ang tunog ng horn speaker.)*					
4. The text is properly converted into speech for receivers of messages. *(Tama at maayos na napapalitan ng tunog ang ipinasa na salita.)*					
Ease of Use					
5. The mobile phone is easy to connect to the prototype. *(Madali lang ikonekta ang mobile phone sa prototype.)*					
6. The prototype was easy to learn and use. *(Madaling maintindihan at gamitin ang prototype.)*					

APPENDIX C

(Code of the Prototype)

Code for Main Node

```
#include "Arduino.h"
#include <WiFi.h>
#include <URLCode.h>

// Define URL Object
URLCode url;

WiFiServer server(80);
const char *Ssid = "LORA_ALERT_MAIN";
const char *Password = "123456789";
String serialinput;
String Sdata = " * * ";


int  pulse_counter = 0;
int  test_counter  = 0;

/// SERIAL2
const int M0  = 33;
const int M1  = 25;
const int AUX = 26;
String    Srxdata;

String    tts_data;

String    data1 = " ";
String    data2 = " ";
String    data3 = " ";
String    data4 = " ";

/// SENSORS OUTPUT
float   volt_val  = 0;
int     bat_level = 0;
// VOM
float R1 = 100000.0;
float R2 = 10000.0;
const int vbat_input = 34;
```

```
unsigned long time_now = 0; /// time delay millis
void setup() {
 Serial.begin(115200);
 delay(500);
 Serial.println("LORA_ALERT_MAIN");
 delay(100);
 delay(1000);
 Serial2.begin(9600);
 delay(100);
 Serial2.println(" Serial2 begin");


 // Connect to Wi-Fi network with SSID and password
 Serial.print("Setting AP (Access Point)…");
 WiFi.softAP(Ssid, Password);
 IPAddress myIP = WiFi.softAPIP();
 Serial.print("AP IP address: ");
 Serial.println(myIP);
 server.begin();
 delay(1000);
 }

void loop(){
    if(millis() > time_now + 1000){ ////
    time_now = millis();
    get_voltage();
    }
    get_S2data();
    get_data();
    }

void get_S2data(){
 if (Serial2.available()) {
 while (!Serial2.available()) {
 delay(2); /// 1
 }
 Srxdata =  Serial2.readStringUntil('\r');  //\n
 Serial.println(Srxdata); // r
 sel_string();
```

```
 }
 }
void sel_string(){
     int  stdex;
     int  stdexe;
     String Srx1;
     String Srx2;
     String Srx3;
     Srx1  =  Srxdata.substring(stdex,stdexe);
     stdex++;
     stdexe =  Srxdata.indexOf("*",stdex);
     Srx2   =  Srxdata.substring(stdex,stdexe);
     stdex++;
     Srx3   =  Srxdata.substring(stdex,stdexe);
     Srxdata = "";
     Serial.println(Srx1);
     Serial.println(Srx2);
     Serial.println(Srx3);
     data1 = Srx1;
     data2 = Srx2;
    // data3 = Srx3;
     data3 = bat_level; // convert to string
     data4 = " ";
     }



 void get_data(){
   WiFiClient client = server.available();

 // Wait until the client sends some data
 while (!client.available()) {
 delay(1);
 }
 String req = client.readStringUntil('\r');
 req = req.substring(req.indexOf("/") + 1, req.indexOf("HTTP") - 1);
 client.print ("HTTP/1.1 200 OK\n\n"+String(Sdata));
 client.flush();
 data1 =  " ";
 data2 =  " ";
```

```
  data3 = bat_level; // convert to string
 // data3 =  " ";
  data4 =  " ";

  if (req != 0){
  serialinput = (req); // do command
  Serial.println(serialinput);///////////////////
  url.urlcode = serialinput;
  url.urldecode();
  String decoded = url.strcode;
  Serial.println(decoded);///////////////////
//  Serial2.println(serialinput);
  sel_data();
  }
  delay(5);
  }

void   sel_data(){
       int   ctdex;
       int   ctdexe;
       String Crx1;
       String Crx2;
       String Crx3;
       Crx1  =  serialinput.substring(ctdex,ctdexe);
       ctdex++;
       Crx2   =  serialinput.substring(ctdex,ctdexe);
       serialinput = "";
       Serial.println(Crx1);
       Serial.println(Crx2);
       if (Crx1 == "TTS"){
       tts_data = Crx2;
       send_tts1();
       }else if(Crx1 == "PLAY1"){
       send_play1();
       }else if(Crx1 == "PLAY2"){
       send_play2();
       }else if(Crx1 == "PLAY3"){
       send_play3();
       }else if(Crx1 == "PLAY4"){
       send_play4();
```

```
 }else if(Crx1 == "PLAY5"){
 send_play5();
 }else if(Crx1 == "PLAY6"){
 send_play6();
 }else if(Crx1 == "PLAY7"){
 send_play7();
 }else if(Crx1 == "PLAY8"){
 send_play8();
 }else if(Crx1 == "PLAY9"){
 send_play9();
 }else if(Crx1 == "PLAY10"){
 send_play10();
 }else if(Crx1 == "PLAY11"){
 send_play11();
 }
 }

void send_tts1(){
    Serial2.print("TTS1*");
    Serial2.print(tts_data);
    Serial2.println("* ");
    delay(2000);  /////
    Serial2.print("TTS2*");
    Serial2.print(tts_data);
    Serial2.println("* ");
    }

void send_play1(){
    Serial2.println("PLAYER1*PLAY1* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY1* ");
    }
void send_play2(){
    Serial2.println("PLAYER1*PLAY2* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY2* ");
    }
void send_play3(){
    Serial2.println("PLAYER1*PLAY3* ");
    delay(2000);
```

```
    Serial2.println("PLAYER2*PLAY3* ");
    }
void send_play4(){
    Serial2.println("PLAYER1*PLAY4* ");
    delay(1000);
    Serial2.println("PLAYER2*PLAY4* ");
    }
void send_play5(){
    Serial2.println("PLAYER1*PLAY5* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY5* ");
    }
void send_play6(){
    Serial2.println("PLAYER1*PLAY6* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY6* ");
    }
void send_play7(){
    Serial2.println("PLAYER1*PLAY7* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY7* ");
    }
void send_play8(){
    Serial2.println("PLAYER1*PLAY8* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY8* ");
    }
void send_play9(){
    Serial2.println("PLAYER1*PLAY9* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY9* ");
    }
void send_play10(){
    Serial2.println("PLAYER1*PLAY10* ");
    delay(2000);
    Serial2.println("PLAYER2*PLAY10* ");
    }
void send_play11(){
    Serial2.println("PLAYER1*PLAY11* ");
    delay(2000);
```

```
    Serial2.println("PLAYER2*PLAY11* ");
    }


void get_voltage(){
  int data_in6  = 0;
  uint32_t data_in6_ = 0; /// int
  float avg_volt = 0;
  for (int i=0; i < 100; i++) {
  data_in6 = analogRead(vbat_input); //
  data_in6_ = data_in6_ + data_in6;
  }
  data_in6 = data_in6_ / 100;
  avg_volt = data_in6 *(3.3 / 4095.0);
  volt_val  = avg_volt / (R2/(R1+R2));
  volt_val = volt_val + 2;
 // Serial.print("volt_val: ");
 // Serial.println(volt_val);

  bat_level = map(volt_val,0,12,0,100);
 // Serial.print("bat_level: ");
 // Serial.println(bat_level);

  if (bat_level > 100){
  bat_level = 100;
  data3 = bat_level; // convert to string
  }

  }
```

Code for Slave Node

```
#include "Arduino.h"
#include <WiFi.h>
#include <URLCode.h>

// Define URL Object
URLCode url;

WiFiServer server(80);
const char *Ssid = "LORA_ALERT_RX";
const char *Password = "123456789";
String serialinput;
String Sdata = " * * ";


int  pulse_counter = 0;
int  test_counter  = 0;

/// SERIAL2
const int M0  = 33;
const int M1  = 25;
const int AUX = 26;
String    Srxdata;

String    data1 = " ";
String    data2 = " ";
String    data3 = " ";
String    data4 = " ";

/// SENSORS OUTPUT
float   volt_val  = 0;
int     bat_level = 0;
// VOM
float R1 = 100000.0;
float R2 = 10000.0;
const int vbat_input = 34;


 unsigned long time_now = 0; /// time delay millis
```

```
void setup() {
 Serial.begin(115200);
 delay(500);
 Serial.println("LORA_ALERT_RX");
 delay(100);
 delay(1000);
 Serial2.begin(9600);
 delay(100);
 Serial2.println(" Serial2 begin");


 // Connect to Wi-Fi network with SSID and password
 Serial.print("Setting AP (Access Point)…");
 WiFi.softAP(Ssid, Password);
 IPAddress myIP = WiFi.softAPIP();
 Serial.print("AP IP address: ");
 Serial.println(myIP);
 server.begin();
 delay(1000);
 }



void loop(){
   if(millis() > time_now + 1000){ ////
   time_now = millis();
   get_voltage();
   }
   get_S2data();
   get_data();
   }

void get_S2data(){
 if (Serial2.available()) {
 while (!Serial2.available()) {
 delay(2); /// 1
 }
 Srxdata =  Serial2.readStringUntil('\r');  //\n
 Serial.println(Srxdata); // r
 sel_string();
```

```
 }
 }

void sel_string(){
      int  stdex;
      int  stdexe;
      String Srx1;
      String Srx2;
      String Srx3;
      stdex =  Srxdata.indexOf("*");
      Srx1  =  Srxdata.substring(stdex,stdexe);
      stdex++;
      stdexe =  Srxdata.indexOf("*",stdex);
      Srx2   =  Srxdata.substring(stdex,stdexe);
      stdex++;
      stdexe =  Srxdata.indexOf("*",stdex);
      Srx3   =  Srxdata.substring(stdex,stdexe);
      Srxdata = "";
      Serial.println(Srx1);
      Serial.println(Srx2);
      Serial.println(Srx3);
      data1 = Srx1;
      data2 = Srx2;
     // data3 = Srx3;
      data3 = bat_level; // convert to string
      data4 = " ";
      }


 void get_data(){
   WiFiClient client = server.available();
   // Wait until the client sends some data
 while (!client.available()) {
 delay(1);
 }
 String req = client.readStringUntil('\r');
 req = req.substring(req.indexOf("/") + 1, req.indexOf("HTTP") - 1);
 client.print ("HTTP/1.1 200 OK\n\n"+String(Sdata));
 client.flush();
 data1 =  " ";
```

```
  data2 =  " ";
  data3 = bat_level; // convert to string
 // data3 =  " ";
  data4 =  " ";

  if (req != 0){
  serialinput = (req); // do command
  Serial.println(serialinput);///////////////////
  url.urlcode = serialinput;
  url.urldecode();
  String decoded = url.strcode;
  Serial.println(decoded);///////////////////
  Serial2.println(serialinput);
//  sel_data();
  }
  delay(5);
  }

void   sel_data(){
      int   ctdex;
      int   ctdexe;
      String Crx1;
      String Crx2;
      String Crx3;
      Crx1  =  serialinput.substring(ctdex,ctdexe);
      ctdex++;
      Crx2   =  serialinput.substring(ctdex,ctdexe);
      serialinput = "";
      Serial.println(Crx1);
      Serial.println(Crx2);
      }

void get_voltage(){
  int data_in6  = 0;
  uint32_t data_in6_ = 0; /// int
  float avg_volt = 0;
  for (int i=0; i < 100; i++) {
  data_in6 = analogRead(vbat_input); //
  data_in6_ = data_in6_ + data_in6;
  }
```

```
 data_in6 = data_in6_ / 100;
 avg_volt = data_in6 *(3.3 / 4095.0);
 volt_val  = avg_volt / (R2/(R1+R2));
 volt_val = volt_val + 2;
// Serial.print("volt_val: ");
// Serial.println(volt_val);

 bat_level = map(volt_val,0,12,0,100);
// Serial.print("bat_level: ");
// Serial.println(bat_level);
 if (bat_level > 100){
 bat_level = 100;
 data3 = bat_level; // convert to string
 }
 }
```

APPENDIX D

(Code of the Mobile Applications)

Code for Master Node:


```
{
 "$components": [{
  "$Name": "Screen1",
  "$Type": "Form",
  "$Version": "31",
  "AccentColor": "&HFF2683C6",
  "ActionBar": "True",
  "AppName": "Master Node -",
  "BackgroundColor": "&HFFFFF6E9",
  "Icon": "master-icon.png",
  "PrimaryColor": "&HFF40A2E3",
  "PrimaryColorDark": "&HFF2683C6",
  "ScreenOrientation": "portrait",
  "Title": "Screen1",
  "TitleVisible": "False",
  "Uuid": "0",
  "$Components": [{
   "$Name": "VerticalScrollArrangement1",
   "$Type": "VerticalScrollArrangement",
   "$Version": "2",
   "AlignHorizontal": "3",
   "BackgroundColor": "&H00FFFFFF",
   "Height": "-2",
   "Width": "-2",
   "Uuid": "-1163224522",
   "$Components": [{
    "$Name": "VerticalArrangement4",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "Height": "-1003",
    "Width": "-2",
    "Uuid": "333724764"
   }, {
    "$Name": "VerticalArrangement1",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "AlignHorizontal": "3",
    "AlignVertical": "2",
```

```
  "BackgroundColor": "&H00FFFFFF",
  "Height": "-1020",
  "Width": "-2",
  "Uuid": "-969879380",
  "$Components": [{
    "$Name": "Image1",
    "$Type": "Image",
    "$Version": "6",
    "Width": "-2",
    "Picture": "master-node.png",
    "Uuid": "-634026621"
  }]
}, {
  "$Name": "VerticalArrangement12",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Height": "-1002",
  "Width": "-2",
  "Uuid": "264551659"
}, {
  "$Name": "VerticalArrangement2",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "BackgroundColor": "&H00FFFFFF",
  "Height": "-1004",
  "Width": "-2",
  "Image": "bg-up-dark.png",
  "Uuid": "-1397381528"
}, {
  "$Name": "HorizontalArrangement6",
  "$Type": "HorizontalArrangement",
  "$Version": "4",
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "BackgroundColor": "&HFF2683C6",
  "Height": "-1016",
  "Width": "-2",
  "Uuid": "4980263",
  "$Components": [{
    "$Name": "VerticalArrangement22",
```

```
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Width": "-1006",
  "Uuid": "-585532939"
},{
  "$Name": "VerticalArrangement27",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "Height": "-2",
  "Width": "-1021",
  "Uuid": "-356048254",
  "$Components": [{
    "$Name": "Button3",
    "$Type": "Button",
    "$Version": "7",
    "Height": "-2",
    "Width": "-2",
    "Image": "btn-siren-alert.png",
    "Uuid": "-581525504"
  }]
},{
  "$Name": "VerticalArrangement30",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Width": "-1009",
  "Uuid": "212376179"
},{
  "$Name": "VerticalArrangement28",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "Height": "-2",
  "Width": "-1021",
  "Image": "btn-sl1.png",
  "Uuid": "1701339302",
  "$Components": [{
    "$Name": "Label6",
```

```
    "$Type": "Label",
    "$Version": "5",
    "FontBold": "True",
    "FontSize": "18",
    "FontTypeface": "comic.ttf",
    "HasMargins": "False",
    "TextAlignment": "1",
    "TextColor": "&HFFFFF6E9",
    "Uuid": "-958020926"
   }, {
    "$Name": "HorizontalArrangement8",
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "Height": "-1001",
    "Uuid": "-445994735"
   }]
  }, {
   "$Name": "VerticalArrangement32",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "Width": "-1007",
   "Uuid": "432519694"
  }, {
   "$Name": "VerticalArrangement31",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "AlignHorizontal": "3",
   "AlignVertical": "2",
   "Height": "-2",
   "Width": "-1021",
   "Image": "btn-sl2.png",
   "Uuid": "-779696412",
   "$Components": [{
    "$Name": "Label7",
    "$Type": "Label",
    "$Version": "5",
    "FontBold": "True",
    "FontSize": "18",
    "FontTypeface": "comic.ttf",
    "HasMargins": "False",
```

```
      "TextAlignment": "1",
      "TextColor": "&HFFFFF6E9",
      "Uuid": "1500982266"
    }, {
      "$Name": "HorizontalArrangement9",
      "$Type": "HorizontalArrangement",
      "$Version": "4",
      "Height": "-1001",
      "Uuid": "1291169288"
    }]
  }, {
    "$Name": "VerticalArrangement29",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "Width": "-1006",
    "Uuid": "1130790367"
  }]
}, {
  "$Name": "VerticalArrangement5",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "BackgroundColor": "&H00FFFFFF",
  "Height": "-1004",
  "Width": "-2",
  "Image": "bg-up-dark-to-light.png",
  "Uuid": "472601758"
}, {
  "$Name": "VerticalArrangement6",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "BackgroundColor": "&HFF40A2E3",
  "Width": "-2",
  "Uuid": "1751643707",
  "$Components": [{
    "$Name": "VerticalArrangement9",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "BackgroundColor": "&H00FFFFFF",
```

"Height": "-1002",
"Width": "-2",
"Uuid": "-1517671524"
}, {
"$Name": "VerticalArrangement7",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1002",
"Width": "-1080",
"Image": "border-up.png",
"Uuid": "1864013008"
}, {
"$Name": "HorizontalArrangement3",
"$Type": "HorizontalArrangement",
"$Version": "4",
"AlignHorizontal": "3",
"AlignVertical": "2",
"BackgroundColor": "&HFFFFFFFF",
"Width": "-1080",
"Uuid": "497199439",
"$Components": [{
"$Name": "TextBox1",
"$Type": "TextBox",
"$Version": "14",
"BackgroundColor": "&HFFFFFFFF",
"FontSize": "18.0",
"Width": "-1070",
"Hint": "Type Here",
"MultiLine": "True",
"Uuid": "-1490126764"
}]
}, {
"$Name": "VerticalArrangement3",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1002",
"Width": "-1080",
"Image": "border-down.png",

```
    "Uuid": "-442046025"
   }, {
    "$Name": "VerticalArrangement10",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "BackgroundColor": "&H00FFFFFF",
    "Height": "-1003",
    "Width": "-2",
    "Uuid": "-774167351"
   }, {
    "$Name": "HorizontalArrangement2",
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "AlignHorizontal": "3",
    "Height": "-1006",
    "Width": "-2",
    "Uuid": "2035856975",
    "$Components": [{
     "$Name": "Button1",
     "$Type": "Button",
     "$Version": "7",
     "Width": "-1038",
     "Image": "btn-send-.png",
     "Uuid": "1723668355"
    }]
   }, {
    "$Name": "VerticalArrangement11",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "BackgroundColor": "&H00FFFFFF",
    "Height": "-1001",
    "Width": "-2",
    "Uuid": "144517942"
   }]
  }, {
   "$Name": "VerticalArrangement8",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "BackgroundColor": "&H00FFFFFF",
   "Height": "-1004",
```

"Width": "-2",
"Image": "bg-up-light-to-cream.png",
"Uuid": "1956326227"
}, {
"$Name": "VerticalArrangement20",
"$Type": "VerticalArrangement",
"$Version": "4",
"Height": "-1001",
"Width": "-2",
"Uuid": "1358491962"
}, {
"$Name": "HorizontalArrangement10",
"$Type": "HorizontalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-2",
"Uuid": "222493504",
"$Components": [{
"$Name": "VerticalArrangement33",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1006",
"Uuid": "1894651261"
}, {
"$Name": "VerticalArrangement34",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-2",
"Uuid": "-1269779786",
"$Components": [{
"$Name": "VerticalArrangement36",
"$Type": "VerticalArrangement",
"$Version": "4",
"Width": "-2",
"Uuid": "357461939",

"$Components": [{
"$Name": "Label8",
"$Type": "Label",
"$Version": "5",
"FontBold": "True",
"FontSize": "22",
"FontTypeface": "comic.ttf",
"Text": "EARTHQUAKE WARNING",
"TextColor": "&HFF035D9F",
"Uuid": "-305381186"
}, {
"$Name": "VerticalArrangement25",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1001",
"Width": "-2",
"Uuid": "-195397450"
}, {
"$Name": "Button4",
"$Type": "Button",
"$Version": "7",
"FontSize": "18",
"FontTypeface": "comic.ttf",
"Height": "-1006",
"Width": "-2",
"Image": "bg-btn-light-blue.png",
"Text": "Earthquake Alert",
"TextColor": "&HFF035D9F",
"Uuid": "884757125"
}, {
"$Name": "VerticalArrangement24",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1003",
"Width": "-2",
"Uuid": "1587855973"
}]
}, {

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"$Name": "VerticalArrangement37",
"$Type": "VerticalArrangement",
"$Version": "4",
"Width": "-2",
"Uuid": "-1398383296",
"$Components": [{
 "$Name": "Label9",
 "$Type": "Label",
 "$Version": "5",
 "FontBold": "True",
 "FontSize": "22",
 "FontTypeface": "comic.ttf",
 "Text": "GALE WARNING",
 "TextColor": "&HFF035D9F",
 "Uuid": "1375145927"
}, {
 "$Name": "VerticalArrangement26",
 "$Type": "VerticalArrangement",
 "$Version": "4",
 "BackgroundColor": "&H00FFFFFF",
 "Height": "-1001",
 "Width": "-2",
 "Uuid": "1527388236"
}, {
 "$Name": "Button5",
 "$Type": "Button",
 "$Version": "7",
 "FontSize": "18",
 "FontTypeface": "comic.ttf",
 "Height": "-1006",
 "Width": "-2",
 "Image": "bg-btn-light-blue.png",
 "Text": "Gale Alert",
 "TextColor": "&HFF035D9F",
 "Uuid": "1769686983"
}, {
 "$Name": "VerticalArrangement38",
 "$Type": "VerticalArrangement",
 "$Version": "4",
 "BackgroundColor": "&H00FFFFFF",
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"Height": "-1003",
"Width": "-2",
"Uuid": "194014579"
}]
}, {
"$Name": "VerticalArrangement39",
"$Type": "VerticalArrangement",
"$Version": "4",
"Width": "-2",
"Uuid": "1858233622",
"$Components": [{
"$Name": "Label10",
"$Type": "Label",
"$Version": "5",
"FontBold": "True",
"FontSize": "22",
"FontTypeface": "comic.ttf",
"Text": "RAINFALL WARNING",
"TextColor": "&HFF035D9F",
"Uuid": "790221788"
}, {
"$Name": "VerticalArrangement40",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1001",
"Width": "-2",
"Uuid": "-1978679657"
}, {
"$Name": "HorizontalArrangement11",
"$Type": "HorizontalArrangement",
"$Version": "4",
"AlignHorizontal": "3",
"AlignVertical": "2",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1012",
"Width": "-2",
"Uuid": "432324625",
"$Components": [{
"$Name": "Button6",

"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontSize": "18",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1028",
"Image": "bg-btn-blue.png",
"Text": "Yellow",
"TextColor": "&HFF035D9F",
"Uuid": "1638834313"
}, {
"$Name": "VerticalArrangement44",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1003",
"Uuid": "-1856261097"
}, {
"$Name": "Button7",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontSize": "18",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1028",
"Image": "bg-btn-blue.png",
"Text": "Orange",
"TextColor": "&HFF035D9F",
"Uuid": "1746602166"
}, {
"$Name": "VerticalArrangement43",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1003",
"Uuid": "1424344625"

```
    }, {
      "$Name": "Button8",
      "$Type": "Button",
      "$Version": "7",
      "BackgroundColor": "&H00FFFFFF",
      "FontSize": "18",
      "FontTypeface": "comic.ttf",
      "Height": "-1012",
      "Width": "-1028",
      "Image": "bg-btn-blue.png",
      "Text": "Red",
      "TextColor": "&HFF035D9F",
      "Uuid": "26607406"
    }]
  }, {
    "$Name": "VerticalArrangement41",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "BackgroundColor": "&H00FFFFFF",
    "Height": "-1003",
    "Width": "-2",
    "Uuid": "-1326860874"
  }]
}, {
  "$Name": "VerticalArrangement42",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Width": "-2",
  "Uuid": "528928115",
  "$Components": [{
    "$Name": "Label11",
    "$Type": "Label",
    "$Version": "5",
    "FontBold": "True",
    "FontSize": "22",
    "FontTypeface": "comic.ttf",
    "Text": "TYPHOON SIGNAL WARNING",
    "TextColor": "&HFF035D9F",
    "Uuid": "869817757"
  }, {
```

"$Name": "VerticalArrangement45",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1001",
"Width": "-2",
"Uuid": "821760313"
}, {
"$Name": "HorizontalArrangement12",
"$Type": "HorizontalArrangement",
"$Version": "4",
"AlignHorizontal": "3",
"AlignVertical": "2",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1012",
"Width": "-2",
"Uuid": "1095559044",
"$Components": [{
"$Name": "Button11",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontBold": "True",
"FontSize": "14",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1016",
"Image": "bg-btn-thin-light-blue.png",
"Text": "Signal No. 1",
"TextColor": "&HFF035D9F",
"Uuid": "385341772"
}, {
"$Name": "VerticalArrangement50",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1002",
"Uuid": "518393902"
}, {

"$Name": "Button13",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontBold": "True",
"FontSize": "14",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1016",
"Image": "bg-btn-thin-light-blue.png",
"Text": "Signal No. 2",
"TextColor": "&HFF035D9F",
"Uuid": "1660119659"
}, {
"$Name": "VerticalArrangement46",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1002",
"Uuid": "-854102628"
}, {
"$Name": "Button9",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontBold": "True",
"FontSize": "14",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1016",
"Image": "bg-btn-thin-light-blue.png",
"Text": "Signal No. 3",
"TextColor": "&HFF035D9F",
"Uuid": "-1033127321"
}, {
"$Name": "VerticalArrangement47",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",

"Height": "-2",
"Width": "-1002",
"Uuid": "-1736005989"
}, {
"$Name": "Button12",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontBold": "True",
"FontSize": "14",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1016",
"Image": "bg-btn-thin-light-blue.png",
"Text": "Signal No. 4",
"TextColor": "&HFF035D9F",
"Uuid": "-910034921"
}, {
"$Name": "VerticalArrangement49",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-2",
"Width": "-1002",
"Uuid": "381170942"
}, {
"$Name": "Button10",
"$Type": "Button",
"$Version": "7",
"BackgroundColor": "&H00FFFFFF",
"FontBold": "True",
"FontSize": "14",
"FontTypeface": "comic.ttf",
"Height": "-1012",
"Width": "-1016",
"Image": "bg-btn-thin-light-blue.png",
"Text": "Signal No. 5",
"TextColor": "&HFF035D9F",
"Uuid": "-416184317"
}]

```
        }, {
          "$Name": "VerticalArrangement48",
          "$Type": "VerticalArrangement",
          "$Version": "4",
          "BackgroundColor": "&H00FFFFFF",
          "Height": "-1003",
          "Width": "-2",
          "Uuid": "-387490572"
        }]
      }]
    }, {
      "$Name": "VerticalArrangement35",
      "$Type": "VerticalArrangement",
      "$Version": "4",
      "BackgroundColor": "&H00FFFFFF",
      "Height": "-2",
      "Width": "-1006",
      "Uuid": "1067395624"
    }]
  }]
}, {
  "$Name": "HorizontalArrangement5",
  "$Type": "HorizontalArrangement",
  "$Version": "4",
  "AlignVertical": "2",
  "BackgroundColor": "&HFF2683C6",
  "Height": "-1008",
  "Width": "-2",
  "Uuid": "1769888176",
  "$Components": [{
    "$Name": "VerticalArrangement15",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "Width": "-1007",
    "Uuid": "-1075323316"
  }, {
    "$Name": "VerticalArrangement18",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "AlignVertical": "2",
```

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  "Height": "-2",
  "Width": "-1010",
  "Uuid": "887818108",
  "$Components": [{
   "$Name": "Button2",
   "$Type": "Button",
   "$Version": "7",
   "Height": "-1005",
   "Width": "-1010",
   "Image": "close-icon.png",
   "Uuid": "1461412366"
  }]
 }, {
  "$Name": "VerticalArrangement21",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Width": "-1001",
  "Uuid": "519725967"
 }, {
  "$Name": "VerticalArrangement23",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "AlignVertical": "2",
  "Height": "-2",
  "Uuid": "-1482486339",
  "$Components": [{
   "$Name": "Label5",
   "$Type": "Label",
   "$Version": "5",
   "FontSize": "22",
   "FontTypeface": "comic.ttf",
   "HasMargins": "False",
   "Text": "close",
   "TextColor": "&HFFFFF6E9",
   "Uuid": "1502190013"
  }]
 }, {
  "$Name": "VerticalArrangement19",
  "$Type": "VerticalArrangement",
  "$Version": "4",
```

```
    "Width": "-2",
    "Uuid": "-1306973329"
   }, {
    "$Name": "HorizontalArrangement7",
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "Uuid": "600427930",
    "$Components": [{
     "$Name": "VerticalArrangement16",
     "$Type": "VerticalArrangement",
     "$Version": "4",
     "AlignVertical": "2",
     "Height": "-1005",
     "Width": "-1020",
     "Image": "battery-icon-horizontal.png",
     "Uuid": "1026871632",
     "$Components": [{
      "$Name": "Label4",
      "$Type": "Label",
      "$Version": "5",
      "FontSize": "16",
      "FontTypeface": "comic.ttf",
      "HasMargins": "False",
      "Text": "    100%",
      "TextColor": "&HFFFFF6E9",
      "Uuid": "-1131798972"
     }]
    }]
   }, {
    "$Name": "VerticalArrangement17",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "Width": "-1007",
    "Uuid": "-1919538436"
   }]
  }, {
   "$Name": "Player1",
   "$Type": "Player",
   "$Version": "6",
   "Source": "EARTHQUAKEALERT.aac",
```

"Uuid": "-2096813570"
}, {
"$Name": "Player2",
"$Type": "Player",
"$Version": "6",
"Source": "GALEWARNING.aac",
"Uuid": "-2087766903"
}, {
"$Name": "Player3",
"$Type": "Player",
"$Version": "6",
"Source": "YELLOWRAINFALL.aac",
"Uuid": "2119674729"
}, {
"$Name": "Player4",
"$Type": "Player",
"$Version": "6",
"Source": "ORANGERAINFALL.aac",
"Uuid": "-153884319"
}, {
"$Name": "Player5",
"$Type": "Player",
"$Version": "6",
"Source": "REDRAINFALL.aac",
"Uuid": "-212692229"
}, {
"$Name": "Player6",
"$Type": "Player",
"$Version": "6",
"Source": "SIGNALNO.1.aac",
"Uuid": "1294292977"
}, {
"$Name": "Player7",
"$Type": "Player",
"$Version": "6",
"Source": "TWO.aac",
"Uuid": "501780322"
}, {
"$Name": "Player8",
"$Type": "Player",

"$Version": "6",
"Source": "THREE.aac",
"Uuid": "-1737568981"
}, {
"$Name": "Player9",
"$Type": "Player",
"$Version": "6",
"Source": "FOUR.aac",
"Uuid": "9500052"
}, {
"$Name": "Player10",
"$Type": "Player",
"$Version": "6",
"Source": "FIVE.aac",
"Uuid": "-1880411225"
}, {
"$Name": "Player11",
"$Type": "Player",
"$Version": "6",
"Source": "emergency-siren-distant-mechanical-wave-1-00-32.mp3",
"Uuid": "1171620943",
"Volume": "200"
}, {
"$Name": "TextToSpeech1",
"$Type": "TextToSpeech",
"$Version": "6",
"Pitch": "5",
"SpeechRate": "0.8",
"Uuid": "1392338530"
}, {
"$Name": "Web1",
"$Type": "Web",
"$Version": "9",
"Uuid": "-838094918"
}, {
"$Name": "Clock1",
"$Type": "Clock",
"$Version": "4",
"Uuid": "-1519753126"
}]

}],

Code for Slave Node:


```
{
 "$components": [{
  "$Name": "Screen1",
  "$Type": "Form",
  "$Version": "31",
  "AccentColor": "&HFF2683C6",
  "ActionBar": "True",
  "AppName": "Slave Node -",
  "BackgroundColor": "&HFFFFF6E9",
  "Icon": "slave-icon.png",
  "PrimaryColor": "&HFF40A2E3",
  "PrimaryColorDark": "&HFF2683C6",
  "ScreenOrientation": "portrait",
  "Title": "Screen1",
  "TitleVisible": "False",
  "Uuid": "0",
  "$Components": [{
   "$Name": "VerticalArrangement13",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "AlignHorizontal": "3",
   "BackgroundColor": "&HFF2683C6",
   "Height": "-1008",
   "Width": "-2",
   "Uuid": "1682157139",
   "$Components": [{
    "$Name": "HorizontalArrangement4",
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "AlignVertical": "3",
    "BackgroundColor": "&H00FFFFFF",
    "Height": "-1006",
    "Width": "-2",
    "Uuid": "1424683063",
    "$Components": [{
     "$Name": "VerticalArrangement10",
     "$Type": "VerticalArrangement",
     "$Version": "4",
```

"Width": "-1004",
"Uuid": "-1121474317"
}, {
"$Name": "VerticalArrangement14",
"$Type": "VerticalArrangement",
"$Version": "4",
"AlignHorizontal": "3",
"AlignVertical": "3",
"Height": "-2",
"Uuid": "-61382489",
"$Components": [{
"$Name": "Image2",
"$Type": "Image",
"$Version": "6",
"Height": "-2",
"Picture": "sound-icon.png",
"Uuid": "-96409710"
}]
}, {
"$Name": "VerticalArrangement12",
"$Type": "VerticalArrangement",
"$Version": "4",
"Width": "-1002",
"Uuid": "971625041"
}, {
"$Name": "VerticalArrangement9",
"$Type": "VerticalArrangement",
"$Version": "4",
"AlignVertical": "2",
"Width": "-2",
"Uuid": "226700100",
"$Components": [{
"$Name": "Label1",
"$Type": "Label",
"$Version": "5",
"FontSize": "20",
"FontTypeface": "PaytoneOne-Regular.ttf",
"HasMargins": "False",
"Text": "W A R N I N G",
"TextColor": "&HFFFFF6E9",

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        "Uuid": "-1260157932"
       }, {
        "$Name": "Label2",
        "$Type": "Label",
        "$Version": "5",
        "FontSize": "17",
        "FontTypeface": "comic.ttf",
        "HasMargins": "False",
        "Text": "Alert",
        "TextColor": "&HFFFFF6E9",
        "Uuid": "-1088961926"
       }]
      }, {
       "$Name": "VerticalArrangement11",
       "$Type": "VerticalArrangement",
       "$Version": "4",
       "Width": "-1004",
       "Uuid": "1000746852"
      }]
     }]
    }, {
     "$Name": "VerticalScrollArrangement1",
     "$Type": "VerticalScrollArrangement",
     "$Version": "2",
     "AlignHorizontal": "3",
     "BackgroundColor": "&H00FFFFFF",
     "Height": "-2",
     "Width": "-2",
     "Uuid": "-1163224522",
     "$Components": [{
      "$Name": "VerticalArrangement4",
      "$Type": "VerticalArrangement",
      "$Version": "4",
      "Height": "-1004",
      "Width": "-2",
      "Uuid": "333724764"
     }, {
      "$Name": "VerticalArrangement1",
      "$Type": "VerticalArrangement",
      "$Version": "4",
```

```
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "BackgroundColor": "&H00FFFFFF",
  "Height": "-1020",
  "Width": "-2",
  "Uuid": "-969879380",
  "$Components": [{
   "$Name": "Image1",
   "$Type": "Image",
   "$Version": "6",
   "Width": "-2",
   "Picture": "slave-node.png",
   "Uuid": "-634026621"
  }]
 }, {
  "$Name": "VerticalArrangement2",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "Height": "-1004",
  "Width": "-2",
  "Uuid": "-1397381528"
 }, {
  "$Name": "VerticalArrangement6",
  "$Type": "VerticalArrangement",
  "$Version": "4",
  "AlignHorizontal": "3",
  "AlignVertical": "2",
  "Width": "-1080",
  "Uuid": "1751643707",
  "$Components": [{
   "$Name": "VerticalArrangement7",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "BackgroundColor": "&H00FFFFFF",
   "Height": "-1002",
   "Width": "-2",
   "Image": "border-up.png",
   "Uuid": "1864013008"
  }, {
   "$Name": "HorizontalArrangement3",
```

```
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "AlignHorizontal": "3",
    "AlignVertical": "2",
    "BackgroundColor": "&HFFFFFFFF",
    "Width": "-2",
    "Uuid": "497199439",
    "$Components": [{
     "$Name": "TextBox1",
     "$Type": "TextBox",
     "$Version": "14",
     "BackgroundColor": "&HFFFFFFFF",
     "FontSize": "18.0",
     "Width": "-1070",
     "Hint": "Type Here",
     "MultiLine": "True",
     "Uuid": "-1490126764"
    }]
   }, {
    "$Name": "VerticalArrangement3",
    "$Type": "VerticalArrangement",
    "$Version": "4",
    "BackgroundColor": "&H00FFFFFF",
    "Height": "-1002",
    "Width": "-2",
    "Image": "border-down.png",
    "Uuid": "-442046025"
   }]
  }, {
   "$Name": "VerticalArrangement8",
   "$Type": "VerticalArrangement",
   "$Version": "4",
   "Height": "-1004",
   "Width": "-2",
   "Uuid": "1956326227"
  }, {
   "$Name": "HorizontalArrangement2",
   "$Type": "HorizontalArrangement",
   "$Version": "4",
   "AlignHorizontal": "3",
```

```
      "Height": "-1006",
      "Width": "-2",
      "Uuid": "252559942",
      "$Components": [{
        "$Name": "Button1",
        "$Type": "Button",
        "$Version": "7",
        "Width": "-1038",
        "Image": "btn-send-.png",
        "Uuid": "-343013664"
      }]
    }, {
      "$Name": "VerticalArrangement20",
      "$Type": "VerticalArrangement",
      "$Version": "4",
      "Height": "-1002",
      "Width": "-2",
      "Uuid": "1358491962"
    }]
  }, {
    "$Name": "HorizontalArrangement5",
    "$Type": "HorizontalArrangement",
    "$Version": "4",
    "AlignVertical": "2",
    "Height": "-1011",
    "Width": "-2",
    "Image": "bg-down.png",
    "Uuid": "1769888176",
    "$Components": [{
      "$Name": "VerticalArrangement15",
      "$Type": "VerticalArrangement",
      "$Version": "4",
      "Width": "-1007",
      "Uuid": "-1075323316"
    }, {
      "$Name": "VerticalArrangement18",
      "$Type": "VerticalArrangement",
      "$Version": "4",
      "AlignVertical": "2",
      "Height": "-2",
```

"Width": "-1010",
"Uuid": "887818108",
"$Components": [{
"$Name": "VerticalArrangement22",
"$Type": "VerticalArrangement",
"$Version": "4",
"BackgroundColor": "&H00FFFFFF",
"Height": "-1003",
"Width": "-2",
"Uuid": "1723109256"
}, {
"$Name": "Button2",
"$Type": "Button",
"$Version": "7",
"Height": "-1005",
"Width": "-1010",
"Image": "close-icon.png",
"Uuid": "1461412366"
}]
}, {
"$Name": "VerticalArrangement21",
"$Type": "VerticalArrangement",
"$Version": "4",
"Width": "-1001",
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}, {
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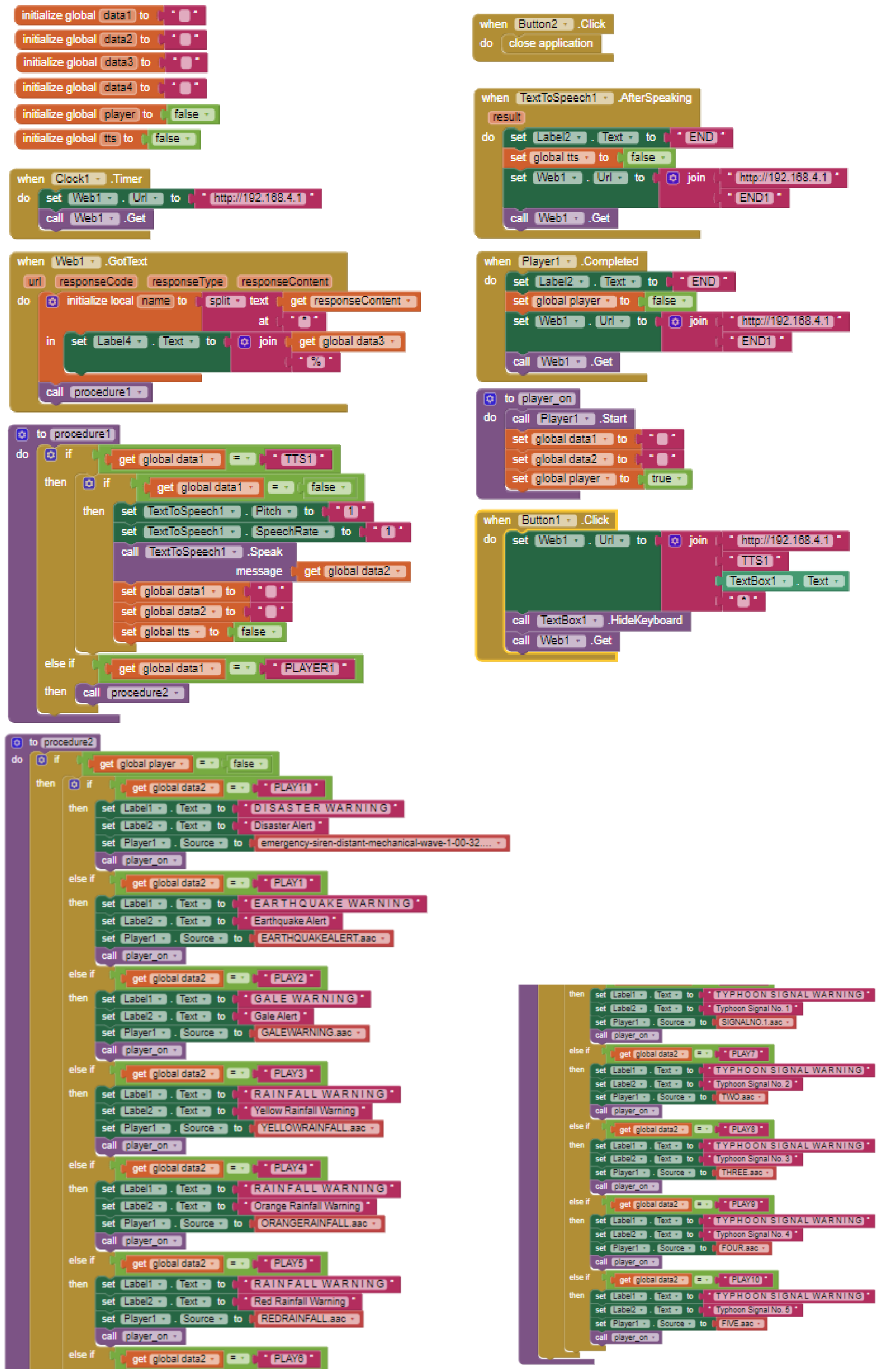
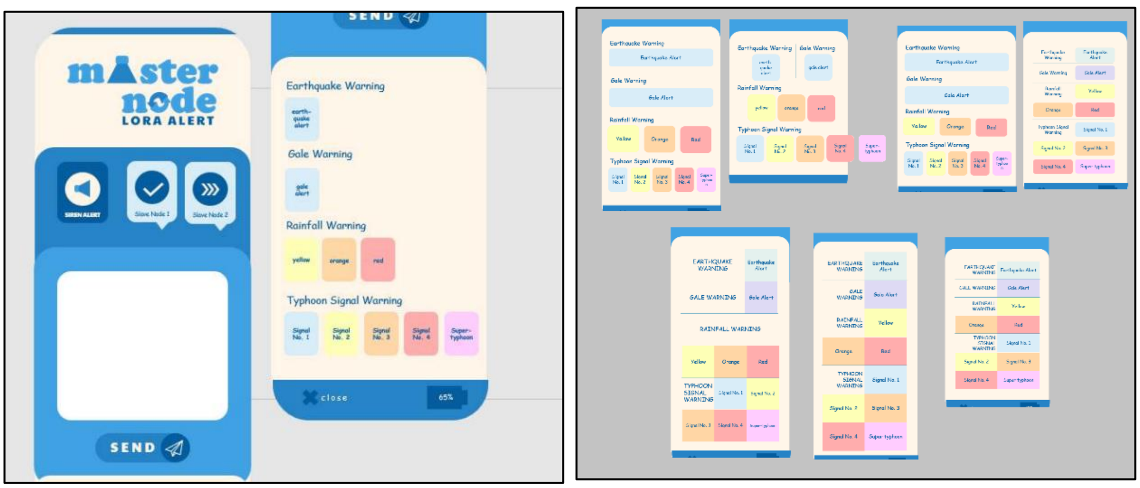
}],

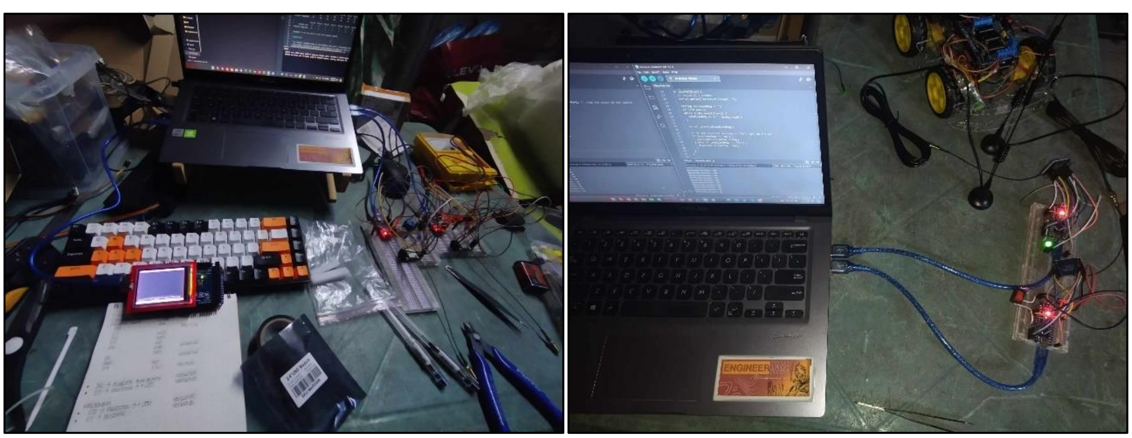

initialize global data1 to
initialize global data2 to
initialize global data3 to
initialize global data4 to
initialize global player to false
initialize global tts to false
when Clock1 .Timer
do set Web1 . Url to "http://192.168.4.1"
call Web1 .Get
when Web1 .GotText
url responseCode responseType responseContent
do initialize local name to split text get responseContent
at ""
in set Label4 . Text to join get global data3
"%"
call procedure1
to procedure1
do if get global data1 = "TTS1"
then if get global data1 = false
then set TextToSpeech1 . Pitch to "1"
set TextToSpeech1 . SpeechRate to "1"
call TextToSpeech1 .Speak
message get global data2
set global data1 to ""
set global data2 to ""
set global tts to false
else if get global data1 = "PLAYER1"
then call procedure2
to procedure2
do if get global player = false
then if get global data2 = "PLAY11"
then set Label1 . Text to "DISASTER WARNING"
set Label2 . Text to "Disaster Alert"
set Player1 . Source to emergency-siren-distant-mechanical-wave-1-00-32....
call player_on
else if get global data2 = "PLAY1"
then set Label1 . Text to "EARTHQUAKE WARNING"
set Label2 . Text to "Earthquake Alert"
set Player1 . Source to EARTHQUAKEALERT.aac
call player_on
else if get global data2 = "PLAY2"
then set Label1 . Text to "GALE WARNING"
set Label2 . Text to "Gale Alert"
set Player1 . Source to GALEWARNING.aac
call player_on
else if get global data2 = "PLAY3"
then set Label1 . Text to "RAINFALL WARNING"
set Label2 . Text to "Yellow Rainfall Warning"
set Player1 . Source to YELLOWRAINFALL.aac
call player_on
else if get global data2 = "PLAY4"
then set Label1 . Text to "RAINFALL WARNING"
set Label2 . Text to "Orange Rainfall Warning"
set Player1 . Source to ORANGERAINFALL.aac
call player_on
else if get global data2 = "PLAY5"
then set Label1 . Text to "RAINFALL WARNING"
set Label2 . Text to "Red Rainfall Warning"
set Player1 . Source to REDRAINFALL.aac
call player_on
else if get global data2 = "PLAY6"
then set Label1 . Text to "TYPHOON SIGNAL WARNING"
set Label2 . Text to "Typhoon Signal No. 1"
set Player1 . Source to SIGNALNO.1.aac
call player_on
else if get global data2 = "PLAY7"
then set Label1 . Text to "TYPHOON SIGNAL WARNING"
set Label2 . Text to "Typhoon Signal No. 2"
set Player1 . Source to TWO.aac
call player_on
else if get global data2 = "PLAY8"
then set Label1 . Text to "TYPHOON SIGNAL WARNING"
set Label2 . Text to "Typhoon Signal No. 3"
set Player1 . Source to THREE.aac
call player_on
else if get global data2 = "PLAY9"
then set Label1 . Text to "TYPHOON SIGNAL WARNING"
set Label2 . Text to "Typhoon Signal No. 4"
set Player1 . Source to FOUR.aac
call player_on
else if get global data2 = "PLAY10"
then set Label1 . Text to "TYPHOON SIGNAL WARNING"
set Label2 . Text to "Typhoon Signal No. 5"
set Player1 . Source to FIVE.aac
call player_on
when Button2 .Click
do close application
when TextToSpeech1 .AfterSpeaking
result
do set Label2 . Text to "END"
set global tts to false
set Web1 . Url to join "http://192.168.4.1"
"END1"
call Web1 .Get
when Player1 .Completed
do set Label2 . Text to "END"
set global player to false
set Web1 . Url to join "http://192.168.4.1"
"END1"
call Web1 .Get
to player_on
do call Player1 .Start
set global data1 to ""
set global data2 to ""
set global player to true
when Button1 .Click
do set Web1 . Url to join "http://192.168.4.1"
"TTS1"
TextBox1 . Text
"*"
call TextBox1 .HideKeyboard
call Web1 .Get

APPENDIX E
(Documentation)

Planning and Designing



Creating Mobile Application



Programming

Assembly

Testing and Evaluation

APPENDIX F
(Project Cost)

Materials	Quantity	Cost	Total
ESP32: NodeMCU-ESP32, 512 KB SRAM, 4MB flash memory, 21 pins	3	349	1,047
LoRa module: AS32 433 Mhz, 100 milliwatt	3	1,457	4,371
LoRa Antenna	3	120	360
Horn Speaker: H - 5X8 50 Watts 8 Ohms	2	699	1,398
Amplifier: TPA3118 DC 8 to 24v PBTL 60W, MONO AUDIO AMP	3	197	591
Battery Pack: L-ION 12V 20K MA	3	699	2,097
Regulator: Mini 360 DC - 5 Volts	3	55	165
Power Switch: Pack Mini 2 Pins ON and OFF Toggle Power Switch SPST Metal Rocker up to 6A 125V AC or DC Latching Panel Mount Switches ON-OFF	3	15.	45
Charger: SMS Power Supply (Charger) AC 220V / 12V 5A	3	159	477
Audio Cable: A30 0.5 meter	2	100	200
Case	3	300	900
Other Components: Jumping wires, PCB, connectors, etc…		700	700
		GRAND TOTAL:	**12,351**

APPENDIX G
(English Critique Certification)

CERTIFICATION FROM ENGLISH CRITIC

CERTIFICATION

This is to certify that the study entitled "LoRa Based Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication" by Lyza April P. Bolo, Clarice Mae G. Carreos, and Reimarc G. Corpuz has been edited and consulted for English language critiquing and formatting.

ELAINE C. SALAYO, LPT
English Language Critique

APPENDIX H
(Certificate of Manuscript Originality)

SLSU ITSSO

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CERTIFICATE OF MANUSCRIPT ORIGINALITY

This is to certify that the research paper entitled, **"Lora Based Alert System for Remote Natural Disaster Response to Enhance Disaster Preparedness and Communication"**

Title of the Manuscript

submitted by **Lyza April P. Bolo, Clarice Mae G. Carreos** *and* **Reimarc G. Corpuz**

Faculty / **Student-Author/s**

of the **College of Engineering**

College / Unit

program under the **Bachelor of Science in Computer Engineering**

Course / Program

is an outcome of an independent and original work. The manuscript received a text similarity / plagiarism score of **8%** with Turnitin Paper ID **oid:29310:61225455** which is an acceptable originality score based on our school policies. Furthermore, the work has also not been submitted elsewhere for publication.

NONA D. NAGARES, PhD

Director, ITSSO

Email: itsso.slsu@gmail.com
itsso@slsu.edu.ph

Telephone No.: 540 8506
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APPENDIX I

(Similarity Report)

Similarity Report

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