Relay Station Network Based on Low-power Wide-area Network (LPWAN) Technologies for Disaster Management

Background :

The loss of communication network is especially vital when the disasters are taking place because data under those situations are crucial either for analytics or strategic planning, such as rescue or evacuation. Thus, a backup telecommunication channel is mandatory in this case.

Targets:

We propose a relay station network as a solution to such situations. The relay station network consists of an array of relay stations that their only function is to forward the received data to the next station until the data reach the destination (base) station.

Speaker: Dr. Kanokvate Tungpimolrat
National Electronics and Computer Technology Center, Thailand

Relay Station Network Based on Low-power Wide-area Network (LPWAN) Technologies for Disaster Management

Project Members :

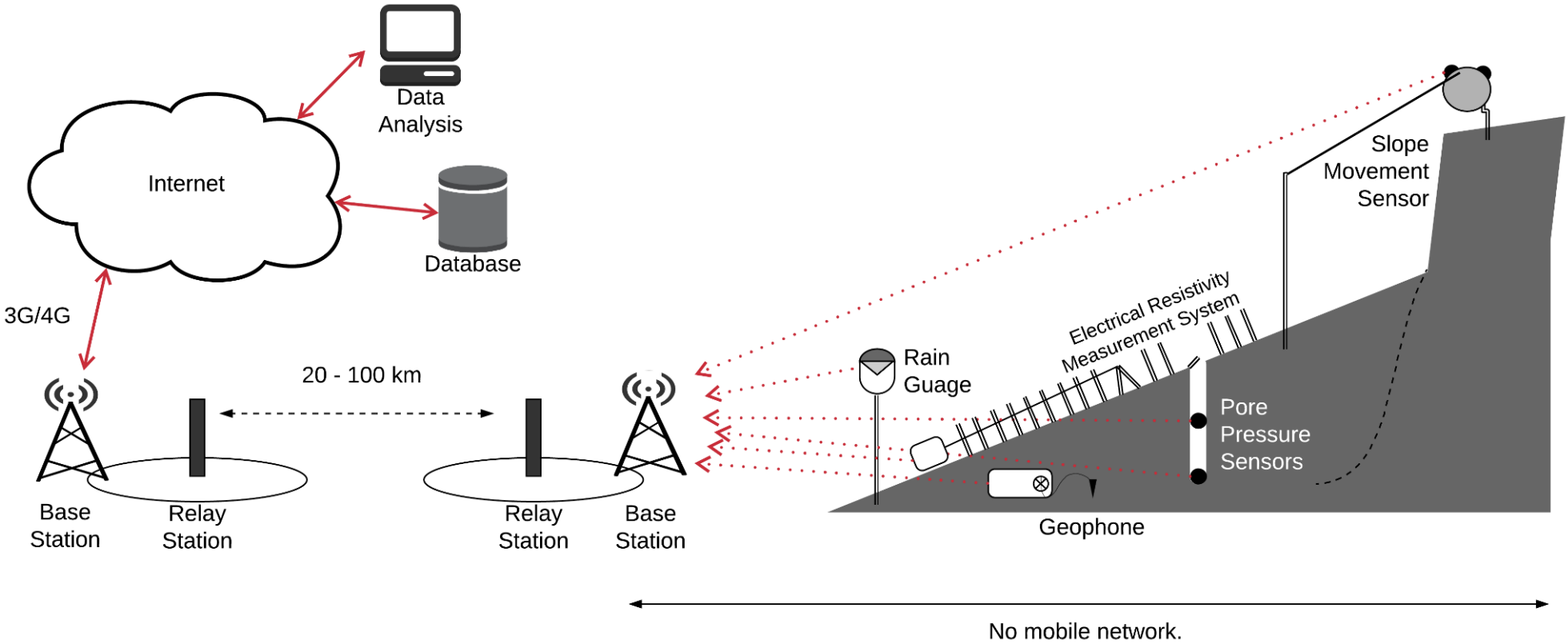
National Electronics and Computer Technology Center (NECTEC)
Chiang Mai Governor's Office
National Institute of Information and Communications Technology (NICT)
Universiti Teknology Brunei (UTB)
Mapua University
Advanced Science and Technology Institute (ASTI)
National University of Laos (NUoL)
Technology Computer and Electronics Institute (TCEI)
University of Computer Studies, Yangon (UCSY)
King Mongkut's Institute of Technology, Ladkrabang (KMITL) **(New Member)**
Ready Affiliate Japan **(New Member)**

Project Duration : 2 years (Jun 2019 – **May 2022**) (Request for 1-year extension)

Project Budget: 80,000 USD

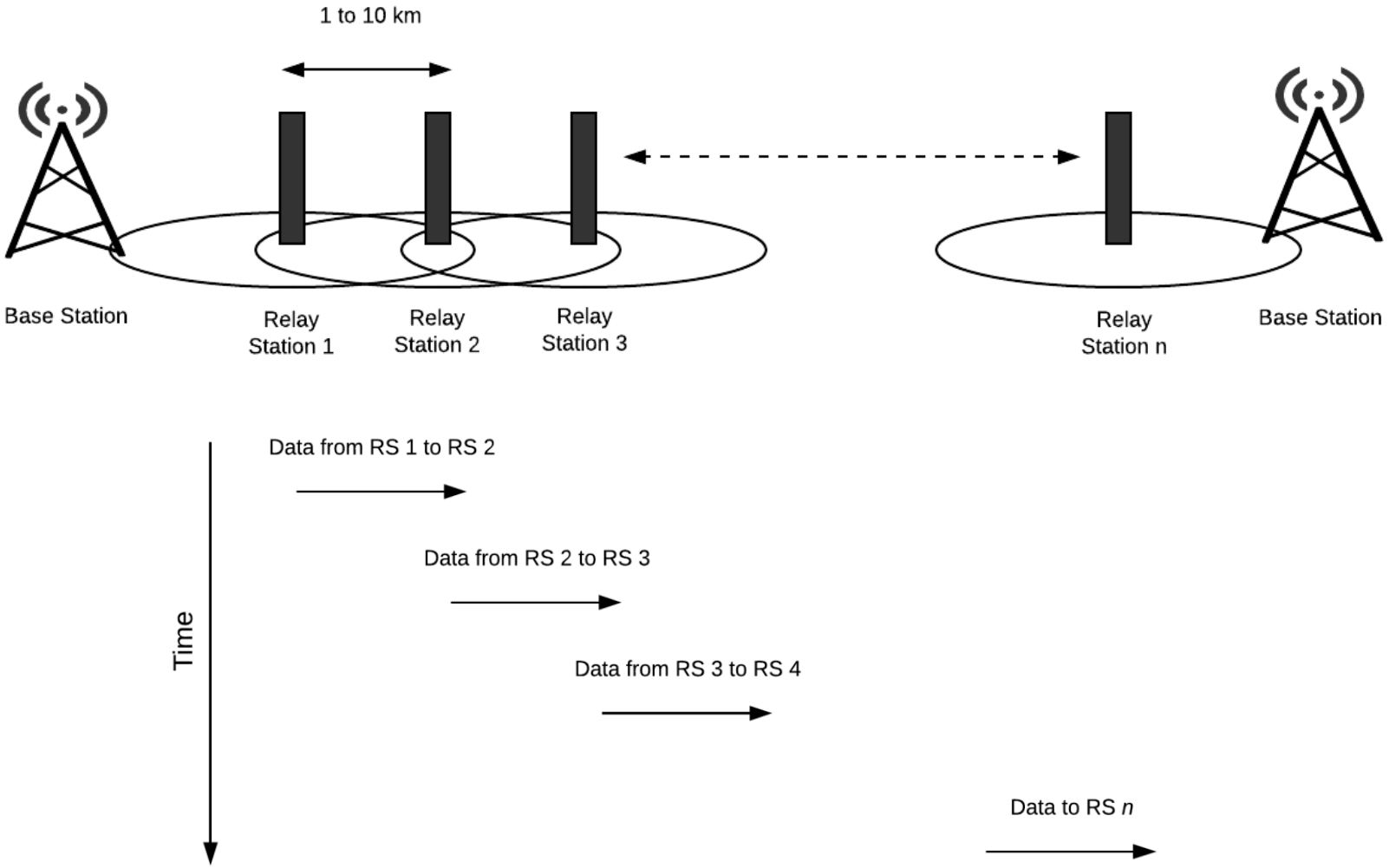
Project Activities

System Overview



Project Activities

System Overview



Project Activities

2019

- Kick-off Meeting
  - 31 July – 1 Aug 2019, @USCY & Thaton Computer University, Myanmar

2020

- 2nd Meeting
  - 6 – 7 Jan 2020, @Holiday Inn Chiang Mai & Doi Pui Village, Thailand
- 3rd Meeting (WebEx)
  - 8 Apr 2020
- Experiments in Thailand
  - Implementation and test of a simple relay function, @TSC & TU, Thailand
- Meeting with DDPM
  - 26 Oct 2020, @DDPM office, Chiang Mai, Thailand
- Manuscript preparation (by UCSY team, ASTI team, and UTB-NECTEC team)
- Development of an LoRa-based networks for Off-grid emergency communications (by ASTI team)
- Meeting and field survey in Lao PDR (by NOUL team)

2021

- Field survey and testing in Thailand
- Development of the relay stations

Project Activities

2nd Meeting

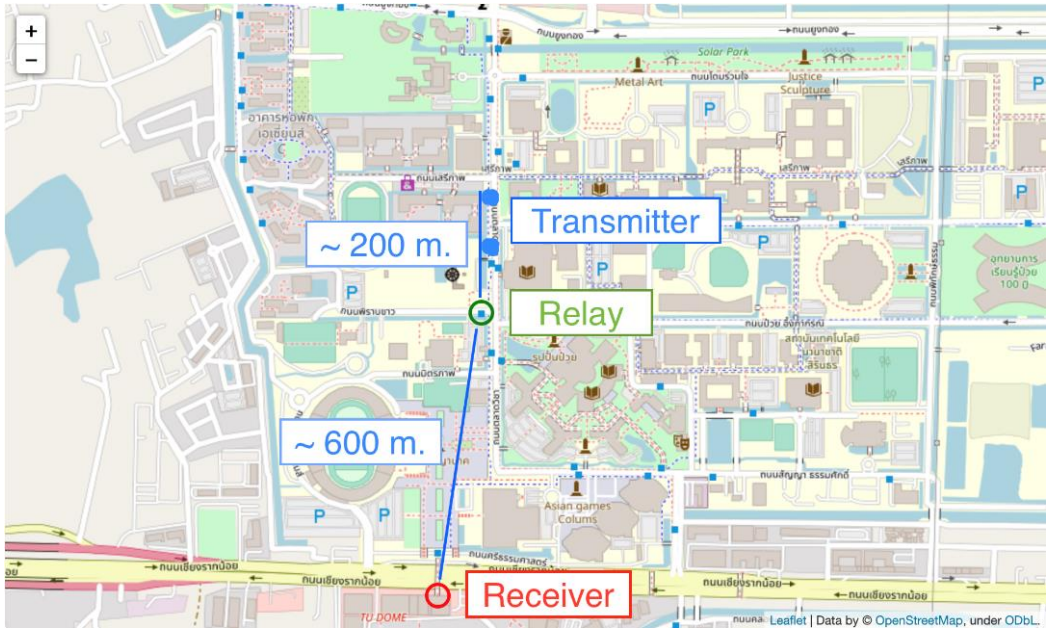
- Introducing DDPM & DMR
- Visiting the experiment site of the ASEAN COSTI's project
- Prototype demonstration

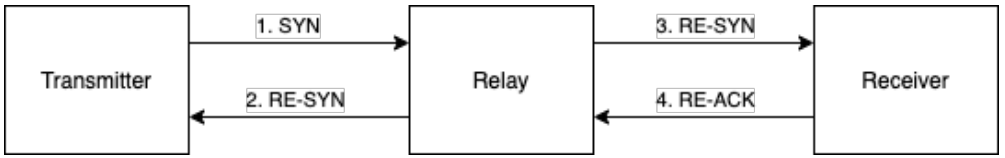
3rd Meeting (WebEx)

- Updating project progress and COVID-19-related situations
- Finalizing CRDA
- Budget re-allocation
- Testing plan for NICT's LoRa module

Project Activities

Experiments in Thailand We conducted experiments on a simple relay function.



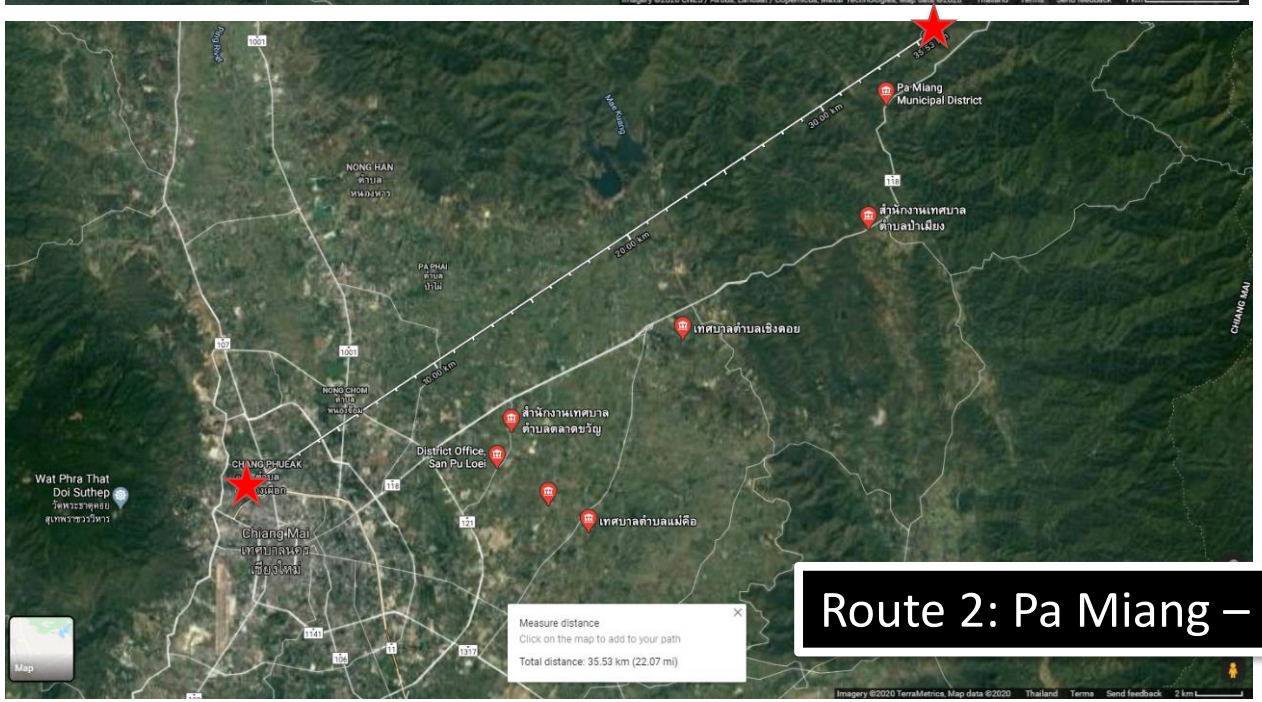


No. of relays	PRR	Corrupted data
0	0.994	0
1	0.795	0
2	0.678	0

Meeting with DDPM It aims to finalize the locations of relay stations.

Project Activities: Route Plan

Route 1: Doi Pui – DDPM (10 km)

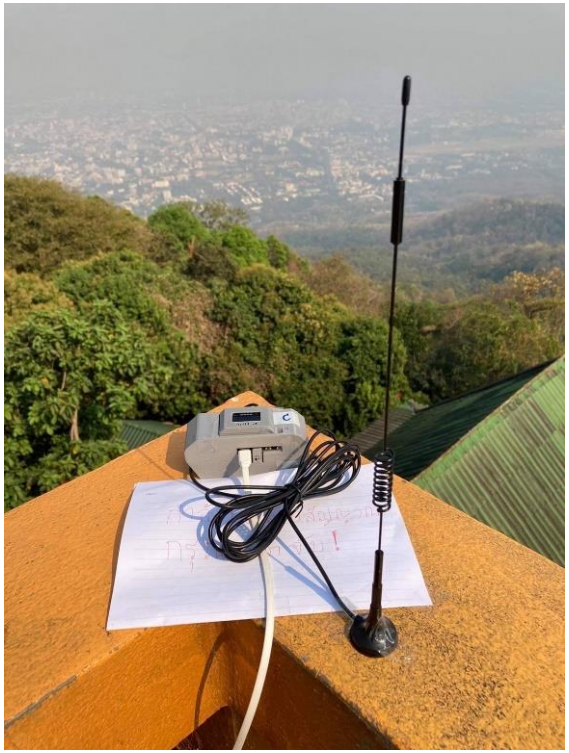


Route 2: Pa Miang – DDPM (35 km)

Project Activities: Field Survey and signal testing

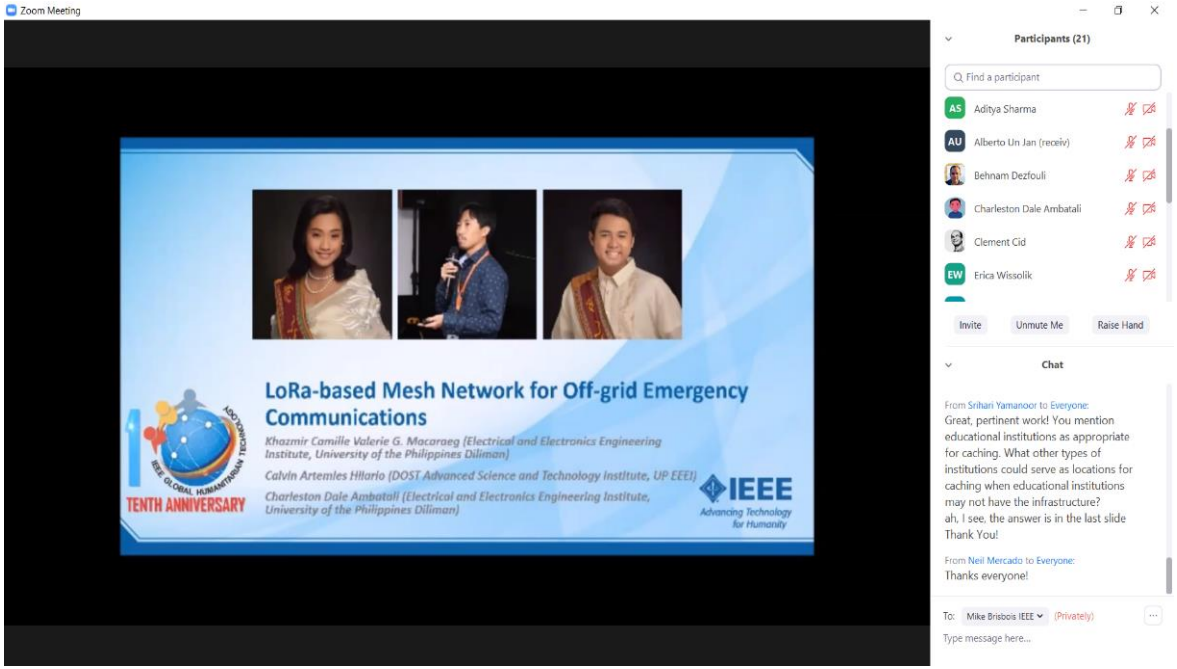
Project Activities in 2021

Field Survey

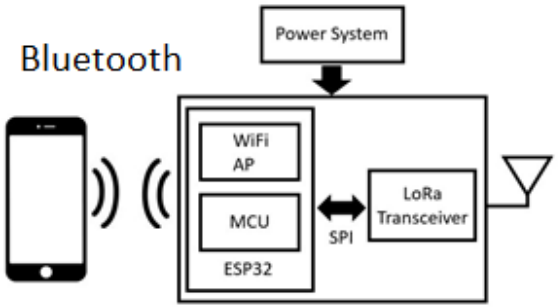


Tower Installation

Project Activities in the Philippines



Paper presentation in 2020 IEEE Global Humanitarian Technology Conference held virtually



Node prototype of the LoRa-based Mesh Network

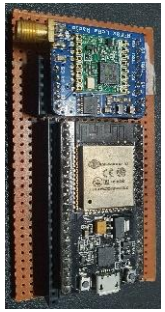
Development of an LoRa-based networks for Off-grid emergency communications

- Node prototype development using commercial-off-the-shelf modules
- Implementation of RSSI-based modified ad hoc on-demand distance vector (ADOV) routing algorithm in LoRa to enable mesh networks
- Simple and controlled experiments to characterize the performance of the system

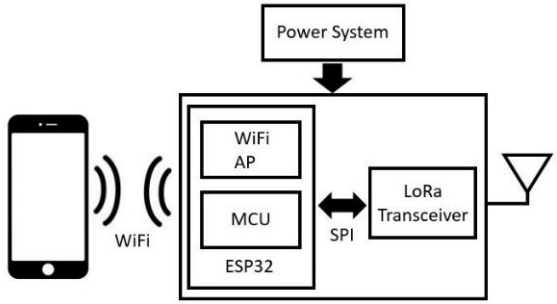
Other activities

- Researched on appropriate hardware/modules and reviewed datasheet and technical documents
- Coordination with local suppliers for the procurement of hardware components for the LoRa relay station prototype
- Literature review and initial simulation for planned research paper on reinforcement learning-based routing for LoRa mesh networks

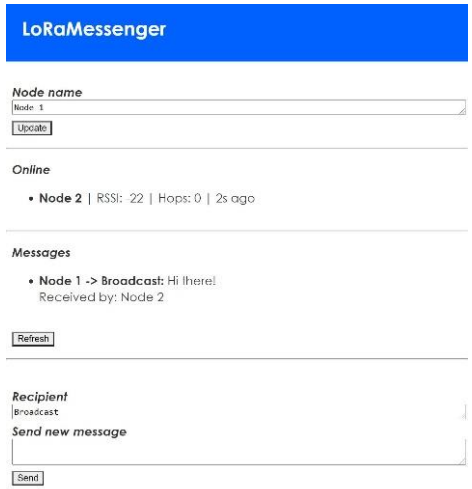
Project Activities in the Philippines



LoRa node

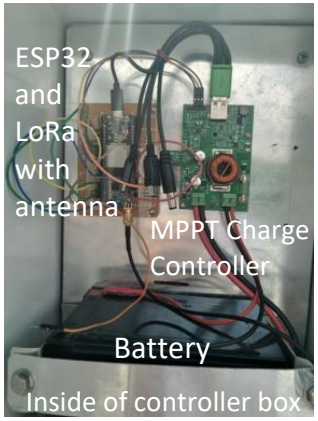


Phone access to LoRa node via ESP32 WiFi AP



Open-Source LoRaMessenger UI and lab testing

Field test of send/receive functions in rural setting



Development of a LoRa-based networks for Off-Grid emergency SMS-style communications

- Uses WiFi AP of ESP32 instead of Bluetooth to utilize advantages for this type of application
- Off-grid implementation using photovoltaic supply and charge controller
- Testing of open-source LoRaMessenger App for setting Tx parameters, node discovery, broadcast mode or set specific node recipient, basic send/receive functions in lab setting
- Implementation of off-grid lora node using photovoltaic supply and testing of communications from node to node
- Field testing of LoRa node and LoRaMessenger in rural area in PH to test functions in rural setting where environment and spectrum may be different

Future activities and plans:

- Pursue works on exploring algorithm used and optimization on routing algorithm best for this type of application
- Implementation of mesh setup and stress test on power, capacity, speed, and range on simulated emergency situations (and possible publications)
- Possible project proposal (subject to funding from sources including ASEAN-IVO to implement personal versions of the off-grid LoRa node to that can function as a relay, as well as a personal locator, beacon, and emergency communicator in case of emergencies similar to projects like Meshtastic[1] and Disaster-Radio[2]

[1] https://github.com/meshtastic
[2] https://github.com/sudomesh/disaster-radio

Project Activities in Lao PDR

Date	Location	Work	Person in charge
17/01/2022	Luangprabang Province	Travelling to site	Assoc.Prof.Dr.Khampasith Thammathevo, Dr.phoummixay Siharath, Dr.Phetnakhone Xaixongdeth, Ms. Malivanh Vongsalasinh
18/01/2022	Luangprabang Province	Meeting and discuss with local authorities	Assoc.Prof.Dr.Khampasith Thammathevo, Dr.phoummixay Siharath, Dr.Phetnakhone Xaixongdeth, Ms. Malivanh Vongsalasinh
19/01/2022	Luangprabang Province	Site investigation and survey	Assoc.Prof.Dr.Khampasith Thammathevo, Dr.phoummixay Siharath, Dr.Phetnakhone Xaixongdeth, Ms. Malivanh Vongsalasinh
20/01/2022	Luangprabang Province	Site investigation and survey	Assoc.Prof.Dr.Khampasith Thammathevo, Dr.phoummixay Siharath, Dr.Phetnakhone Xaixongdeth, Ms. Malivanh Vongsalasinh
21/01/2022	Luangprabang Province	Site investigation and survey a nd back to Vientiane	Assoc.Prof.Dr.Khampasith Thammathevo, Dr.phoummixay Siharath, Dr.Phetnakhone Xaixongdeth, Ms. Malivanh Vongsalasinh

- To discuss with the local authorities on how importance of the real time system.
- To survey the site to design and plan on the next proposal for setting up the water quality system by using wireless system to send and receive the signal through wireless to the centralized system.
- To identify the appropriate location for setting up water quality system.

Scientific Contribution:

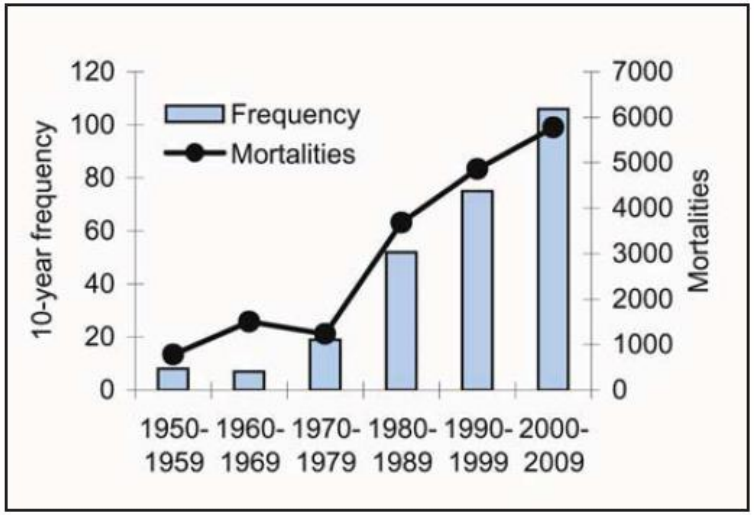
Presentations at International Conferences:

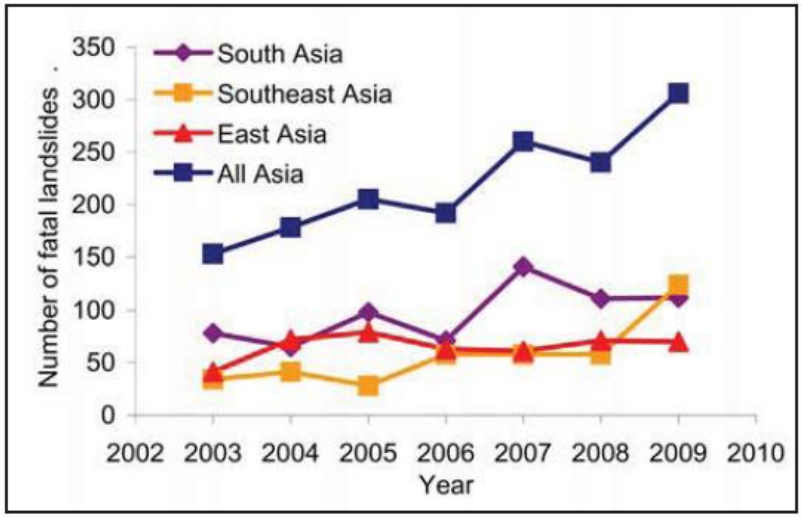
No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1.	Real-Time Monitoring and Early Warning System for Landslide Preventing in Myanmar	Thin Lai Lai Thein, Myint Myint Sein, Ken T. Murata, Kanokvate Tungpimolrut	[1]University of Computer Studies, Yangon, Myanmar, [2]University of Computer Studies, Yangon, Myanmar, [3]National Institute of Information and Communications Technology & NICT, Japan, [4]National Electronics and Computer Technology Center, Thailand	2020 IEEE 9th Global Conference on Consumer Electronics (GCCE), Kobe, Japan	13-16 October, 2020	Kobe, Japan
2.	LoRa-based Mesh Network for Off-grid Emergency Communications	Khazmir Camille Valerie G. Macaraeg[1], Calvin Artemies G. Hilario[1,2], and Charleston Dale C. Ambatali[1]	[1]Electrical and Electronics Engineering Institute, University of the Philippines - Diliman [2]Advanced Science and Technology Institute, Department of Science and Technology Quezon City, Philippines	2020 IEEE Global Humanitarian Technology Conference	29 October – 1 November, 2020	Seattle, Washington, USA (virtual)
3.	Experiments on LoRa Communication Used in a Relay Station Network for Disaster Management	K. Sangrit[1,2], K. Tungpimolrut[1], U. Lewlomphaisarl[1], M. Chatpoj[1], J. Karnjana[1], Ken T. Murata[3], Wida Susanty Haji Suhaili[4], Jennifer Dela Cruz[5], Fredmar Asarias[6], Phoumixay Siharath[7], Daoheung Bouangeune[8], and Thin Lai Lai Thein[9]	[1]National Electronics and Computer Technology Center, [2]Sirindhorn International Institute of Technology, [3]National Institute of Information and Communication Technology, [4]Universiti Teknology Brunei, [5]Mapua University, [6]Advanced Science and Technology Institute, [7]National University of Laos, [8]Technology Computer and Electronics Institute, [9]University of Computer Studies, Yangon	The 4th International Conference on Computational Intelligence in Information System (CIIS 2020)	25-27 January 2021	UTB, Brunei Darussalam

Societal Impact:

A direct social impact of this project has two folds.

- When we want to monitor environmental parameters in very rural areas where 3G/4G networks are not available and where electricity transmission via powerlines is out of reach, especially when the parameters could be triggers for disasters, a low-power-and-long-range communication channel is required. In such a case, the benefit of the proposed relay station network is crystal clear because, in order to send data from one station to another, each relay station is expected to operate by using only solar power.
- As it is known that under disaster situations (such as earthquakes or landslides) there is a high chance of losing the 3G/4G networks, and they are out of service in the areas where the disasters take place.





Conclusion:

Activities that have been done so far in 2021 are summarized as follows.

- **Meetings**: 3 meetings, which are 2nd Meeting, 3rd Meeting, Meeting with DDPM
  - Meetings with government offices for tower station installation
- **Experiments**
  - LORA-based relay function
  - Field survey and gathering requirement for solar system implementation
  - Field survey for installation locations
  - Field test and data collection
- **Publications**: 3 conference papers
- **Human resource development**: 1 Master's degree student (Mr. Kittikom Sangrit)

Future Works

- Tower installation and data collection
- Data analysis

Activities	2021		2022				
	Nov	Dec	Jan	Feb	Mar	Apr	May
Conference							
Journal							
Field tests							
Purchase							