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 (Project Leader), Jessada Karnjana (Speaker)
National Electronics and Computer Technology Center, Thailand

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

Project Members :

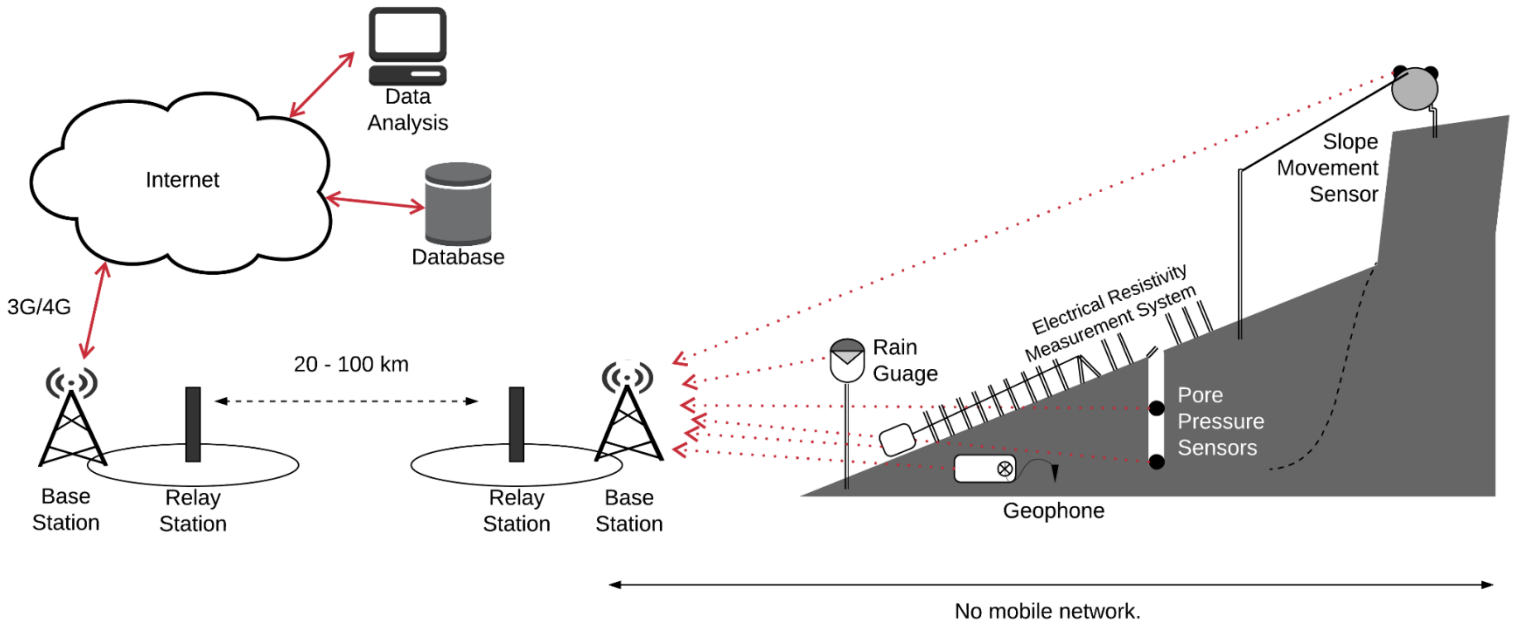
National Electronics and Computer Technology Center (NECTEC)
Chiang Mai Governor's Office
National Institute of Information and Communications Technology (NICT)
Universiti Teknology Brunei (UTB)
Mapua University
Advanced Science and Technology Institute (ASTI)
National University of Laos (NUoL)
Technology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

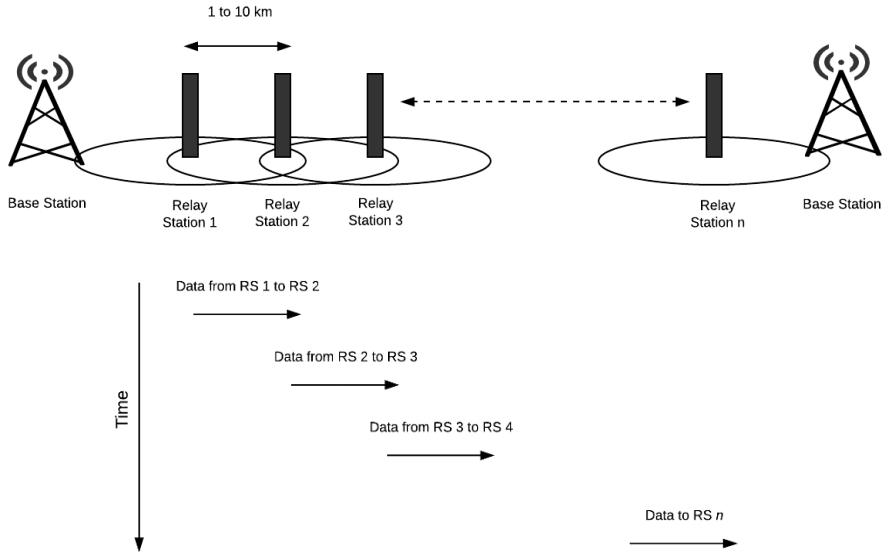
Project Duration : 2 years (Jun 2019 – **May 2022**) (Request for 1-year extension)

Project Budget: 80,000 USD

Project Activities

System Overview





Project Activities

Myanmar

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
- Tower construction

2022

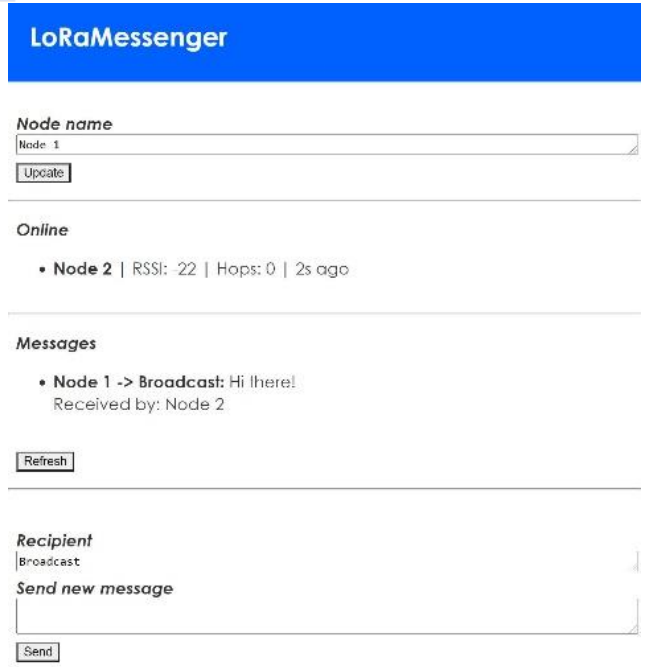
- System installation
- Testing

Project Activities in Japan

Field Survey and Meeting at Chikuma-City Experimental Site

- Dr. Murata will try invite OOI denki to join the project, and we should start from the OOI denki system, as a one candidate.
- OOI denki is interested in our intelligent solar charger controller. Thus, we may negotiate with OOI denki.

Project Activities in Philippines

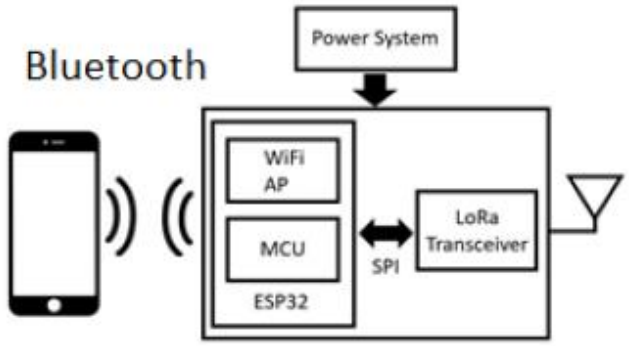


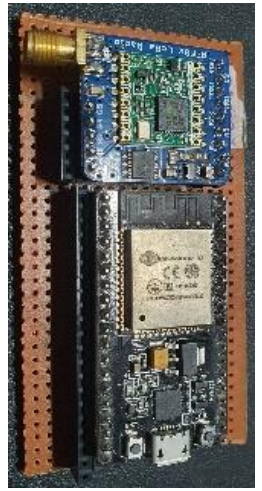
Open-Source LoRa Messenger UI and lab testing

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 LoRa Messenger 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 LoRa Messenger in rural area in PH to test functions in rural setting where environment and spectrum may be different



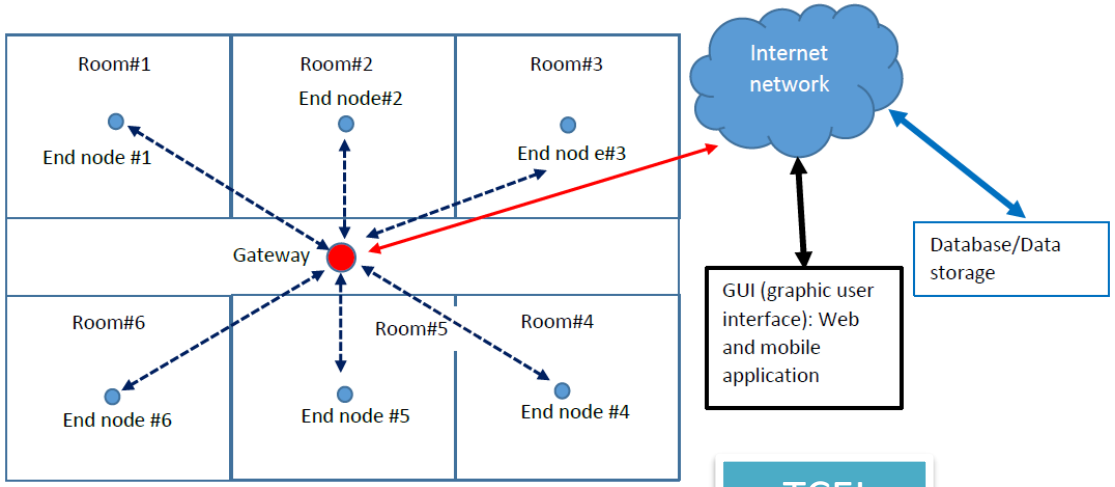


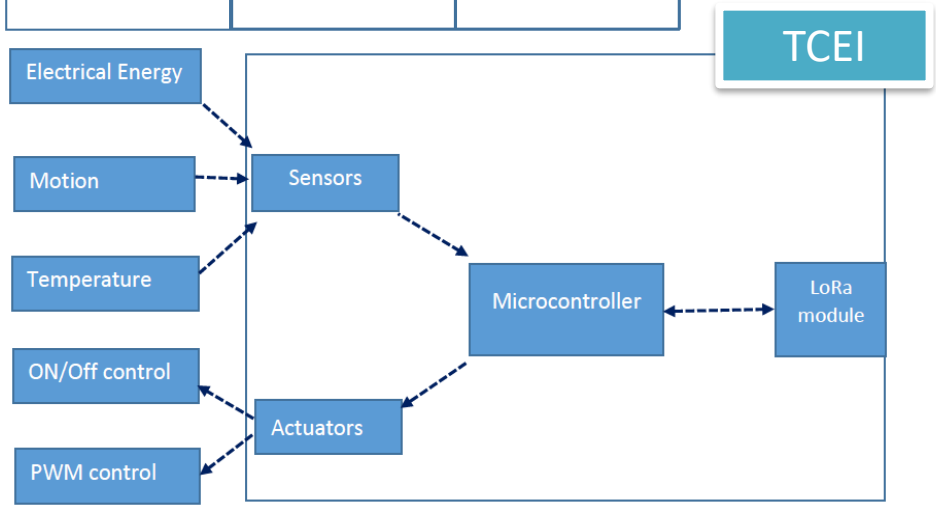
Node prototype of the LoRa-based Mesh Network

Project Activities in Lao PDR

Date	Location	Work
17/01/2022	Luangprabang Province	Travelling to site
18/01/2022	Luangprabang Province	Meeting and discuss with local authorities
19/01/2022	Luangprabang Province	Site investigation and survey
20/01/2022	Luangprabang Province	Site investigation and survey
21/01/2022	Luangprabang Province	Site investigation and survey a nd back to Vientiane

NUOL

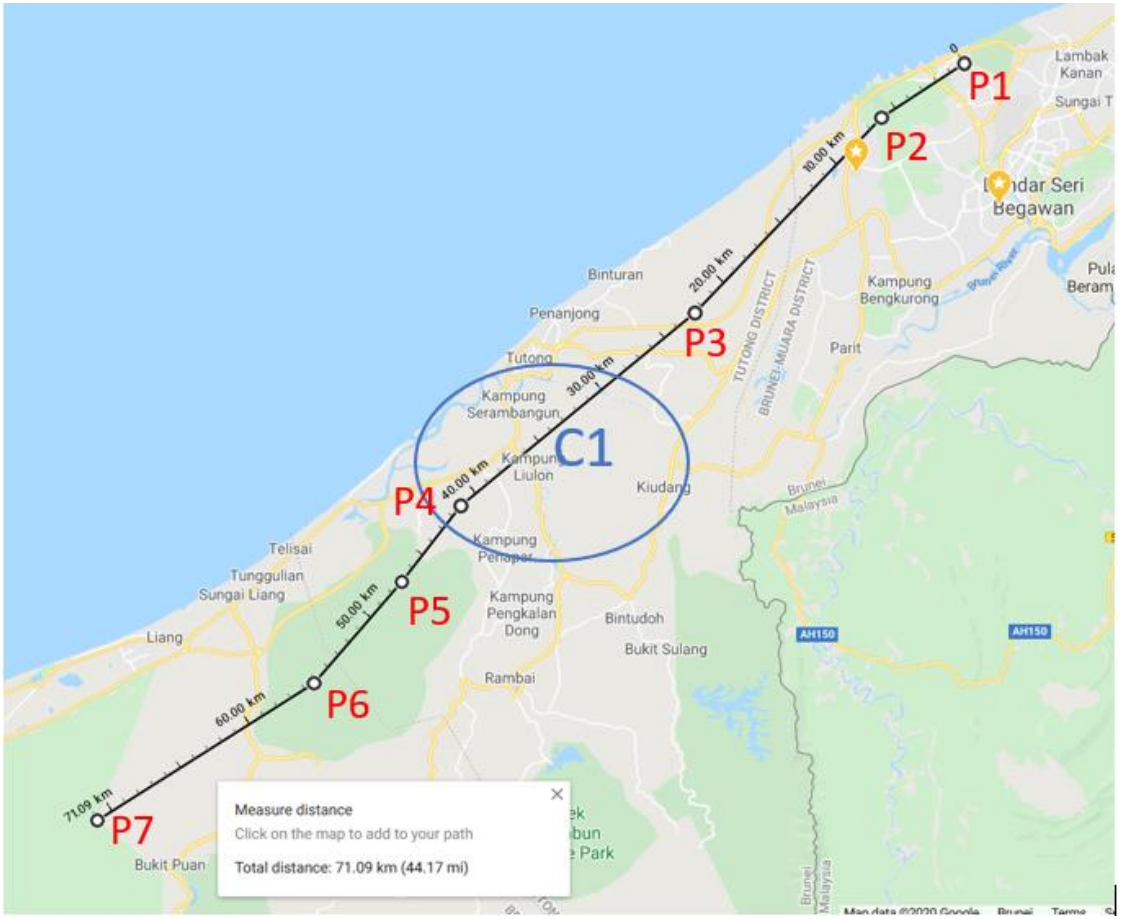




- To discuss with the local authorities on how importance of the real time system.
- To survey the site to design and plan on the next proposal for setting up the water quality system by using wireless system to send and receive the signal through wireless to the centralized system.
- To identify the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

Project Activities in Brunei

Brunei Darussalam is similar to other countries within ASEAN to experience some form of natural disaster such as forest fire, floods and some cases of mild landslide. Forest fire is one of the disaster that UTB is addressing. LoRa is an unlicensed frequency. NAPC is one of the ASEAN IVO 2018 projects, where the deployment of LoRa is adopted. Currently there are 5 Lora gateways deployed by one of the lead industries ANIAN in Brunei and another 20 will be soon be deployed by them. Plus another lead industry Imagine will soon embark on deploying more Lora to test its connectivity. With ANIAN, two of these gateways are within the coastal highway one in UTB and another in Massutera Sg Bera. In-house testing is currently done to test on connectivity to the cloud. The distance covered from P7, Badas, Massutera building,to P1, UTB is around 71.09 km. Within this distance, the terrain consists of a high level land area where connectivity might be disrupted which is identified within the C1 region. The height can reach up to 30m. Other points where placement of the beacon can be placed are P2, P3, P4, P5 and P6.



Point	Region / Area	Distance from UTB	Height above sea level
P1	UTB	~ 0km	41m – 60m
P2	Bukit Shahbandar	~ 6.07km	59m – 81m
P3	Near Muara-Tutong Highway	~ 22.63km	60m – 84m
P4	Kampong Bukit Beruang	~ 41.22km	52m – 64m
P5	Kampong Bukit Beruang	~ 47.12	80m – 104m
P6	Andulau Forest Reserve	~ 55.35km	72m – 85m
P7	Badas	~ 71.09km	14m – 25m

Project Activities in Thailand

2nd Meeting

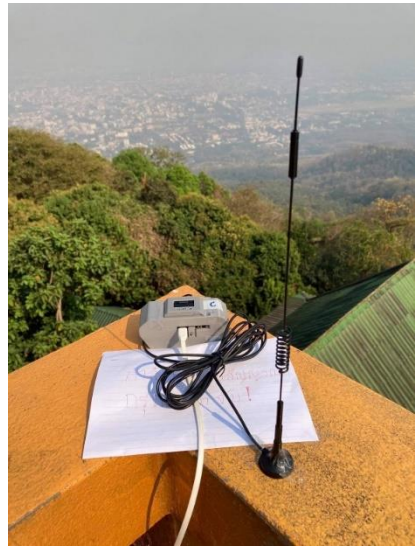
- Introducing DDPM & DMR
- Visiting the experiment site of the ASEAN COSTI's project
- Prototype demonstration

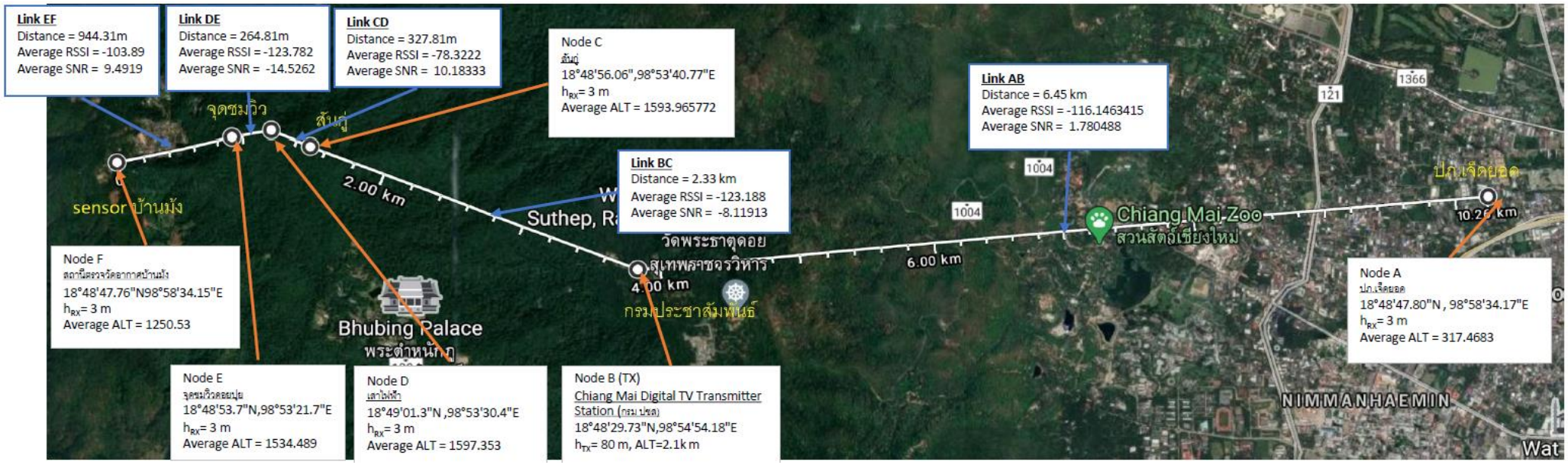
3rd Meeting (WebEx)

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

Project Activities in Thailand

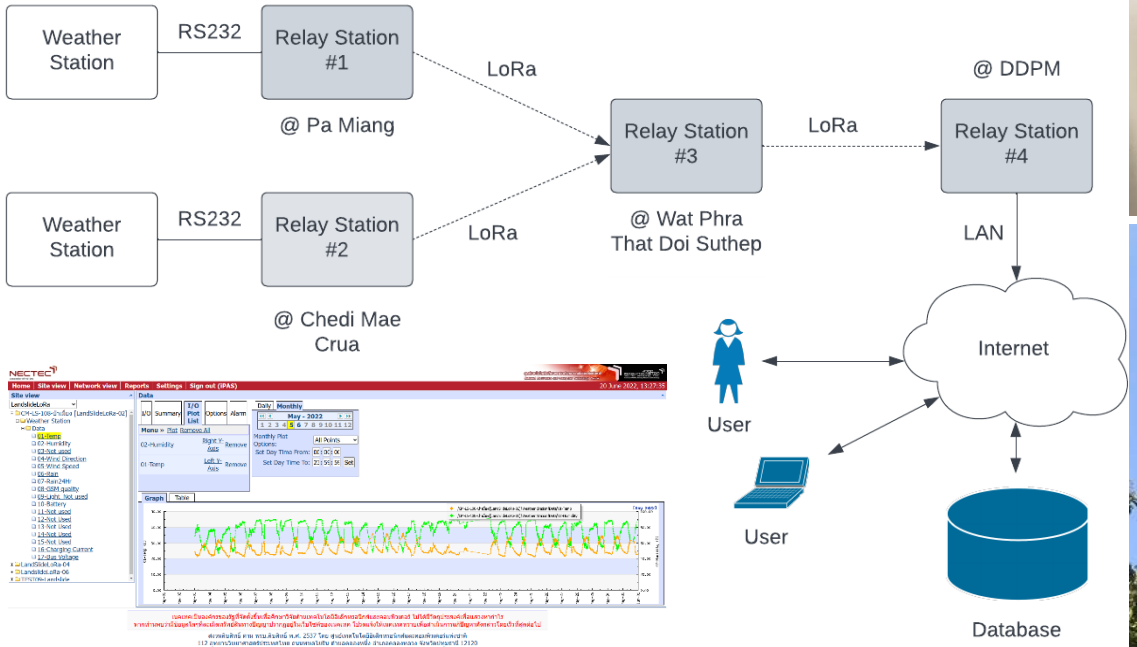
Field Survey, Signal Testing, Construction, Installation

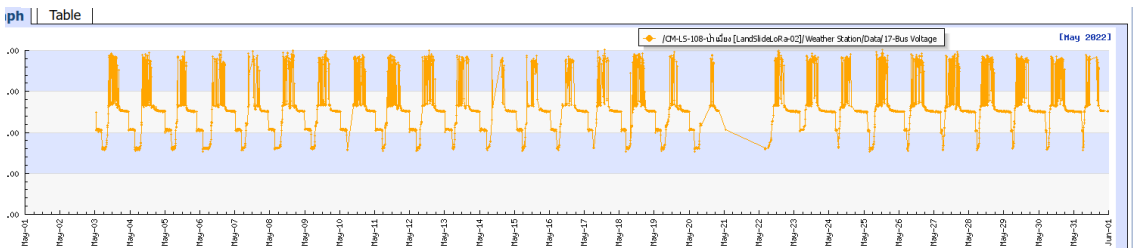


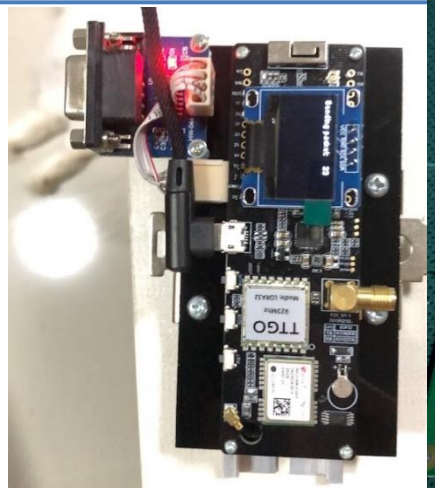


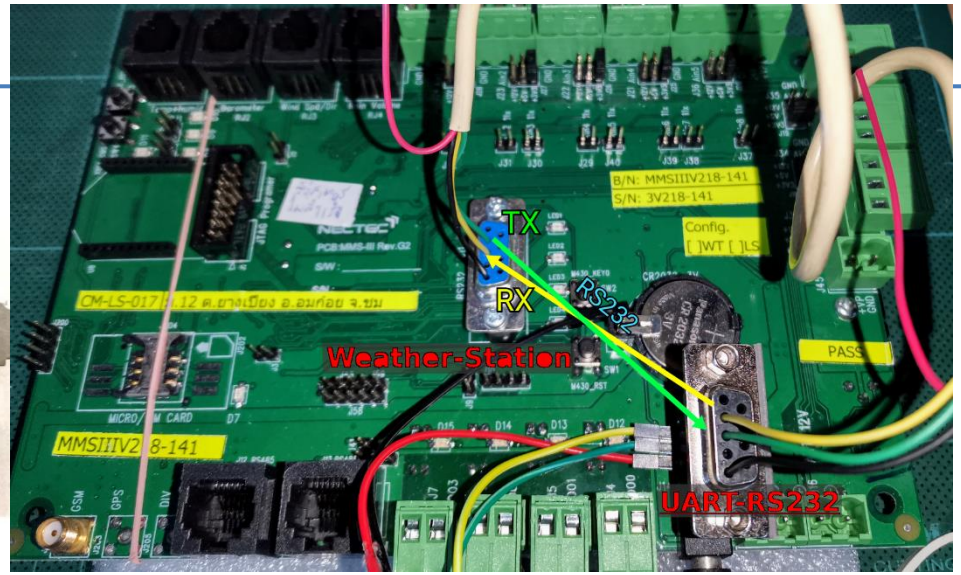
R&D results

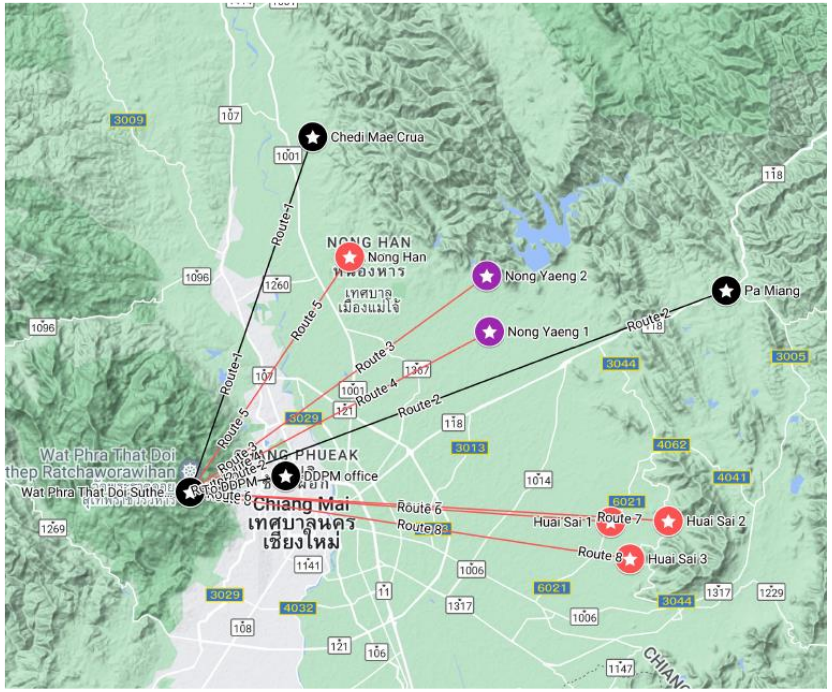
- Field prototype of the Relay Stations
- Field prototype of the LoRa-based network
- Data











Scientific Contribution

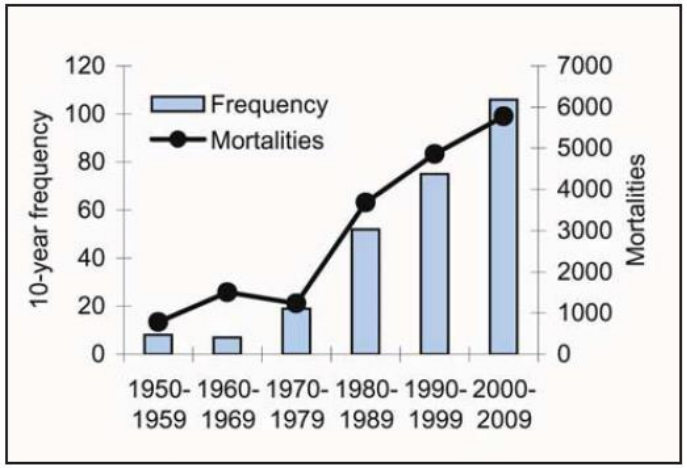
Presentations at International Conferences:

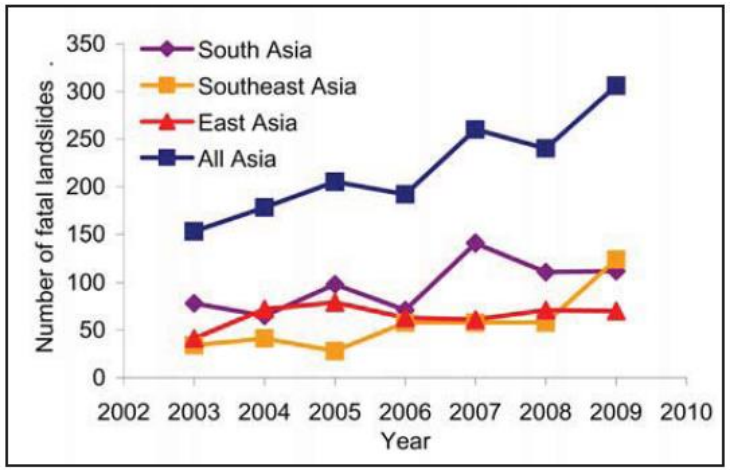
No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1.	Real-Time Monitoring and Early Warning System for Landslide Preventing in Myanmar	Thin Lai Lai Thein, Myint Myint Sein, Ken T. Murata, Kanokvate Tungpimolrut	[1]University of Computer 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.





Typhoon Noru & Landslide Awareness
(Doi Pui, Thailand, 4 Oct 2022)

Conclusion

Findings and Outcomes

To test the developed relay station network, we installed 3 relay station towers (at Pa Miang, Chedi Mae Crua, and DDPM) and 1 hub relay station at Wat Phra That Doi Suthep, Chiang Mai Thailand. The system has been tested for 3 months since May 2022. During the testing period, we found that the relay station could forward data (multiple hops) from a node at the longest distance of about 34.5 km, with only solar power. The system could operate continuously for months.

Collaboration

- Kick-off meeting at UCSY, Myanmar
- 2nd meeting in Thailand
- 3rd online meeting (due to COVID-19),
- Meetings with local authorities in Thailand
- Field surveys in Myanmar, Chikuma City, Japan, and Chiang Mai, Thailand
- Experiments in Chiang Mai, Thailand, and the Philippines

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. … **DONE**