TV White Space (TVWS) Experimental for Application in Remote Area

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Presentation Outline

- Background
- Project Implementation Schedule
  - Chini Lake, Malaysia
  - USC and Surigao, Philippines
- Project Contribution
  - Radio Propagation Study at both side
  - WiSUN and LoRa (sub-GHz) Experiment at Chini Lake for Hydrological Monitoring Application
  - Surigao: Philippines Experiment for Emergency Communications using TV White Space (IEEE 802.11af)
- Future Development
- Summary

Background

Project Overview

- Project title:
  - TV White Space (TVWS) Experimental for Application in Remote Area
- Project theme:
  - Social Renovation in Rural Areas and/or Urban Areas
  - **To develop solution for hydrological quality monitoring in rural area and emergency network in urban area**
- Project members:
  - NICT, Japan
  - MIMOS & UKM, Malaysia
  - University of San Carlos, Philippines
- Amount:
  - USD 29,900
- Duration:
  - 21 months (Jul 2016 – March 2018)

Project Impacts

- This project enables connectivity for multiple sensors in rural area
- Two potential experimental sites have been identified with the following benefits;
  - as hydrological monitoring system to avoid **Chini Lake (Malaysia)**
  - as emergency wireless networking at **Surigao (Philippines)**
- These applications are very critical for natural disaster management
- These applications are useful for people in rural areas as their daily life will be affected by any problem related to environmental pollution and natural disaster
- The implemented system provides ICT solutions to protect the environment and saves human lives

Project Implementation Schedule

Project Schedule (Malaysia)

Activities	2016						2017												2018		
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Discussion with regulator and stakeholders	X	X	X	X	X	X	X	X													
Site visit and experimental work at Chini Lake	X			X		X			X			X		X				X		X	
Theoretical study and path loss simulation	X	X	X	X																	
Conduct TVWS spectrum measurement					X	X	X	X													
WiSUN equipment transfer from NICT									X	X	X										
WiSUN and LoRa installation and experiment at Chini Lake												X	X	X							
Prepare and present research findings															X	X	X				
Further data collection and analysis																		X	X	X	
End of project report																					X
Face-to-face meeting and discussion					X				X			X						X			

Project Schedule (Philippines)

Project Activities	2016						2017												2018		
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Topographical profiling of USC Talamban and site visit to Bogo	X		X																		
TVWS license application (NTC)			X	X	X																
MOA with DICT-Cebu on TVWS					X	X	X														
Transfer and arrival of NICT TVWS equipment to USC						X	X														
Experimental work for NICT IEEE 802.11af devices for fixed location							X	X	X												
Multihop deployment of NICT IEEE 802.11af in USC Talamban									X	X	X										
Procurement, installation and integration of equipment											X	X									
Experimental work for NICT IEEE 802.11af for multi-floored												X	X	X							
TVWS deployment for disaster response at Surigao														X	X	X	X				
Publish research findings and end of project report																		X	X	X	X

Face to Face Meeting

Meeting	Date	Venue	Purpose
#1 Meeting	22 Nov 2016	NICT, Tokyo, JAPAN	• Project Kickoff Meeting
#2 Meeting	29-30 Mar 2017	Le Meridien Hotel, Kuala Lumpur Tasik Chini, Pahang, MALAYSIA	• Project Site Inspection • Project Progress Meeting
#3 Meeting	Dec 17-20, 2017	Royal Ambarrukmo Hotel, Yogyakarta, INDONESIA	• Paper presentation in WPMC2017, • Project Progress Meeting
#4 Meeting	28 Feb – 2 Mar 2018	NICT, Tokyo, JAPAN	• Paper presentation in IEICE RCS Technical Workshop • Project Completion Meeting

F2F Meeting #1: KickOff Meeting (Japan)

- F2F meeting in Japan on 22 Nov 2016.

F2F Meeting #2

- Progress Update : 29-30 Mar 2017 in Malaysia
- The main objectives are as follow:
  - Conducted site visit to Chini Lake which is the location of the implementation site for this project. This was 1-day trip using a chartered coach and the travelling time is about 3.5 to 4 hours (one way)
  - Presented project progress update from each project members
  - Discussion on the project implementation plan, timeline, finalize budget and equipment list and discuss outstanding issues

F2F Meeting in March 2017 *(Discussion & Site Visit to Chini Lake)*

F2F Meeting #3: Progress Update

- **Date: Dec 17-20, 2017**
- Venue: WPMC Conference, at Yogyakarta, Indonesia
- **Activities:**
  - Conducted face-to-face meeting and discussion and understand deploy ment issue at Chini Lake and Surigao
    - To discuss project progress and update from project members (implementati on plan, timeline and budget)
    - To establish continuous water quality monitoring station from Jemberau Stati on to PPTC.
  - Presented project output in the form of TWO conference papers at the 2 0th International Symposium on Wireless Personal Multimedia Communi cations (WPMC), Jogyakarta, Indonesia.
    - Paper #1 entitled “Implementation of a Multihop Network at the University C ampus Using an IEEE 802.11af Compliant Network”.
    - Paper #2 entitled "The World-First Deployment of Narrowband IoT for Rural Hydrological Monitoring in UNESCO Biosphere Environment

Project Closure Meeting:

- Date: F2F Meeting at NICT on 28 Feb to 2 March, 2018
- Venue: NICT@YRP, Japan

Activities:

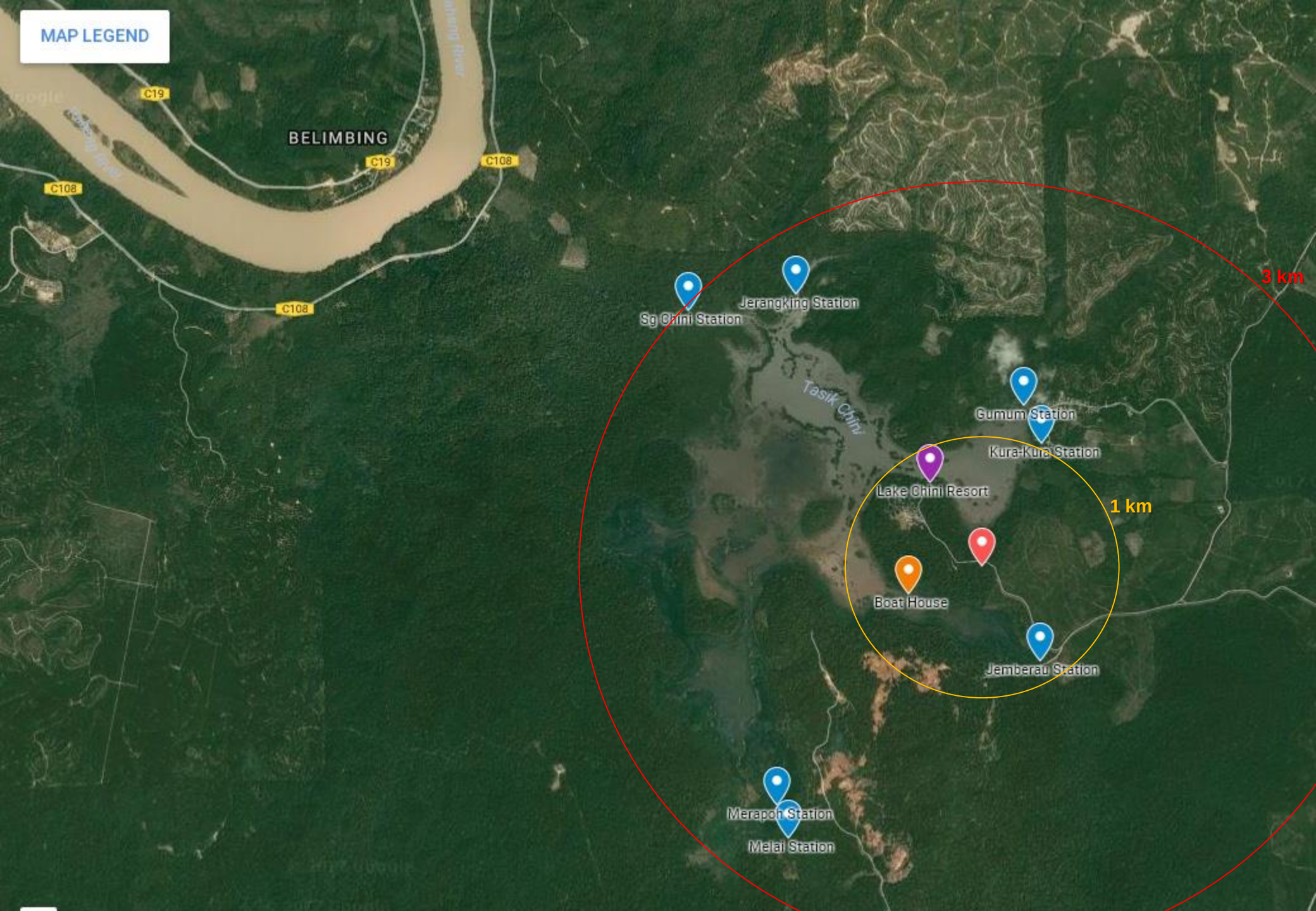
- Discussed and presented project outputs at the IEICE TC RCS, Yokosuka , Japan (**Feb 28, 2018**)
  - Discussion on research output, general discussion and interactions with rese arch community in Japan.
  - Presentation entitled “IEEE 802.11af-based Multihop Experiment in the Philip pines under the ASEAN-IVO Project on TV White Space for Social Deployme nt”. Authors are project members from USC and NICT.
  - Presentation entitled "Internet of Things for Water Quality Monitoring Applicati on". Authors are project members from MIMOS, NICT and UKM.
- Final face-to-face meeting and discussion related to deployment at Chini Lake and Surigao (**Mar 1-2, 2018**)
  - To discuss project progress and final update from project members
  - To conduct workshop for final documentation and project closing report

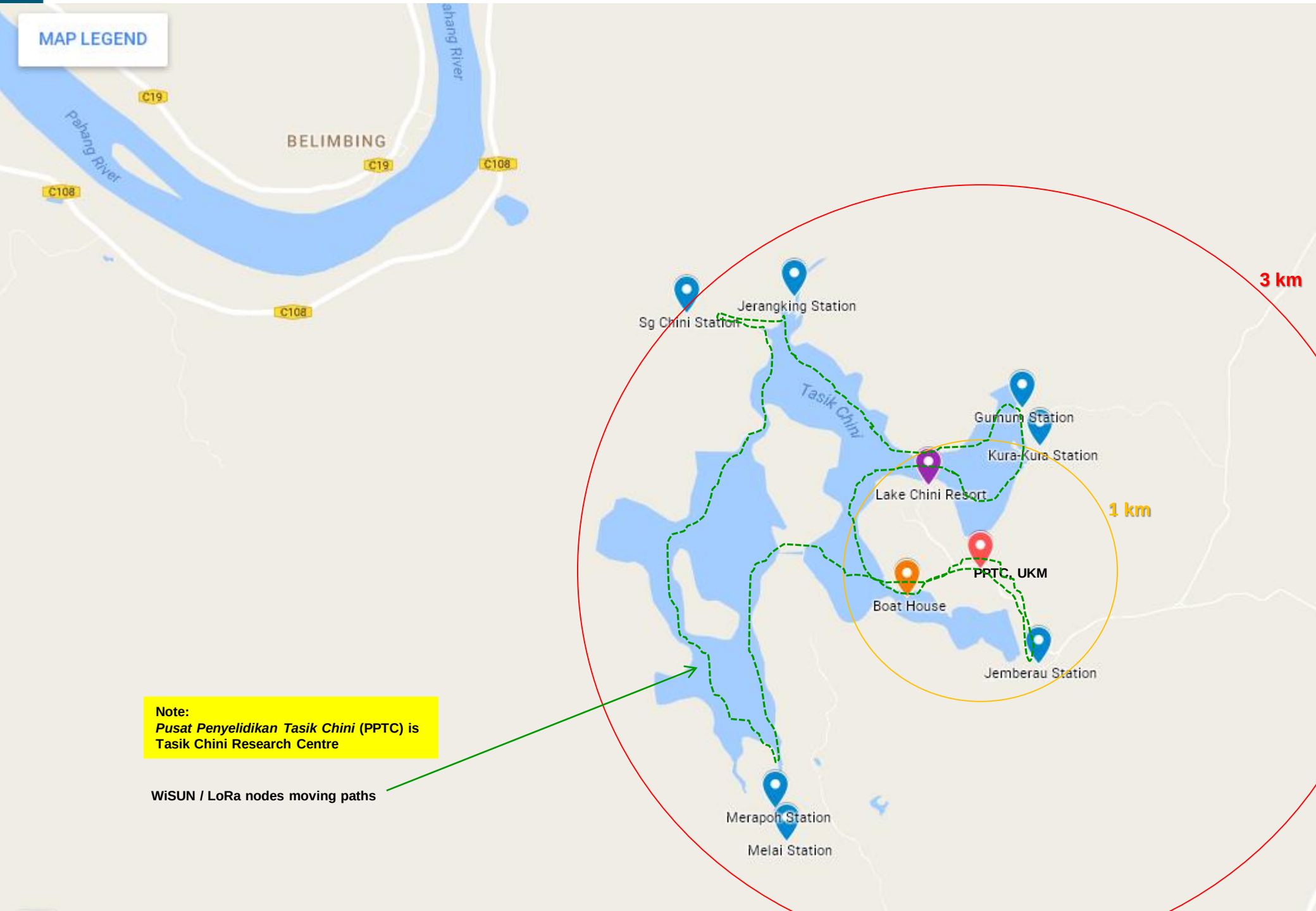
FINDINGS AND OUTCOMES

Findings and Outcomes

- We have conducted radio propagation study and comprehensive spectrum measurement at Chini Lake.
- We have successfully conducted experimental work at
  - Surigao: Philippines Experiment for Emergency Communications using TV White Space (IEEE 802.11af)
  - WiSUN and LoRa (sub-GHz) Experiment at Chini Lake for Hydrological Monitoring Application.

RADIO PROPAGATION STUDY AND COMPREHENSIVE SPECTRUM MEASUREMENT AT CHINI LAKE.


MAP LEGEND
BELIMBING
C19
C108
Sg Chini Station
Jerangking Station
Tasik Chini
Gumum Station
Kura-Kura Station
Lake Chini Resort
Boat House
Jemberau Station
Merapoh Station
Melai Station
3 km
1 km


MAP LEGEND
BELIMBING
Pahang River
C19
C108
3 km
1 km
Sg Chini Station
Jerangking Station
Tasik Chini
Gumum Station
Kura-Kura Station
Lake Chini Resort
PPTC, UKM
Boat House
Jemberau Station
Merapoh Station
Melai Station
Note:
Pusat Penyelidikan Tasik Chini (PPTC) is Tasik Chini Research Centre
WiSUN / LoRa nodes moving paths

Objectives

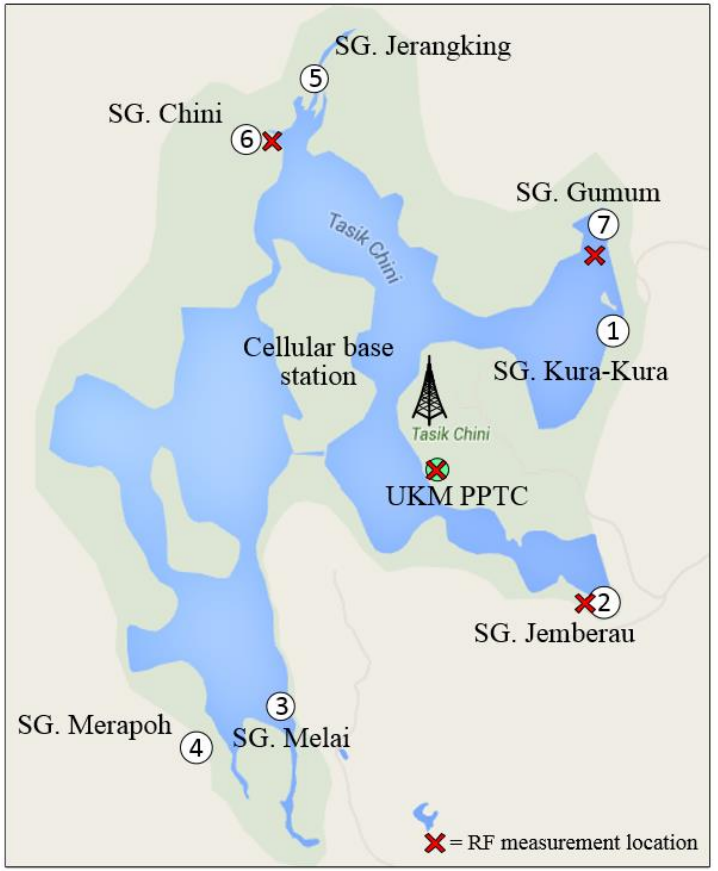
- To measure the spectrum availability in the area of Tasik Chini, Pahang
- The spectrum span of approximately 100 MHz was chosen as it enabled easy UHF spectrum band measurement as:
  - 400-496 (400 MHz band)
  - 500-596 (500 MHz band)

Total of four (4) RF measurement location & the location of the water stations

Date of measurement:
October 14th to 15th 2016

Methodology:
Measurement on the fly for the region of interest (400 – 600MHz)

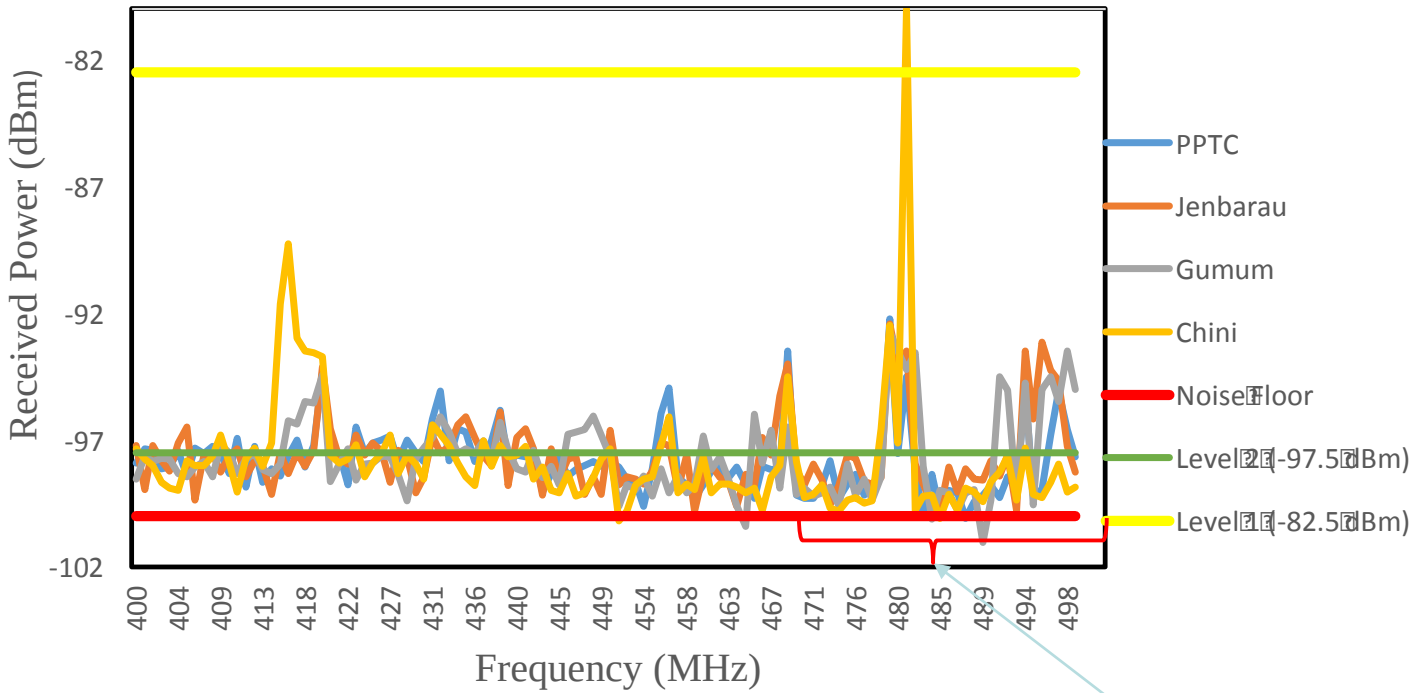
Tools:
RF Explorer



Indicator from the figure:

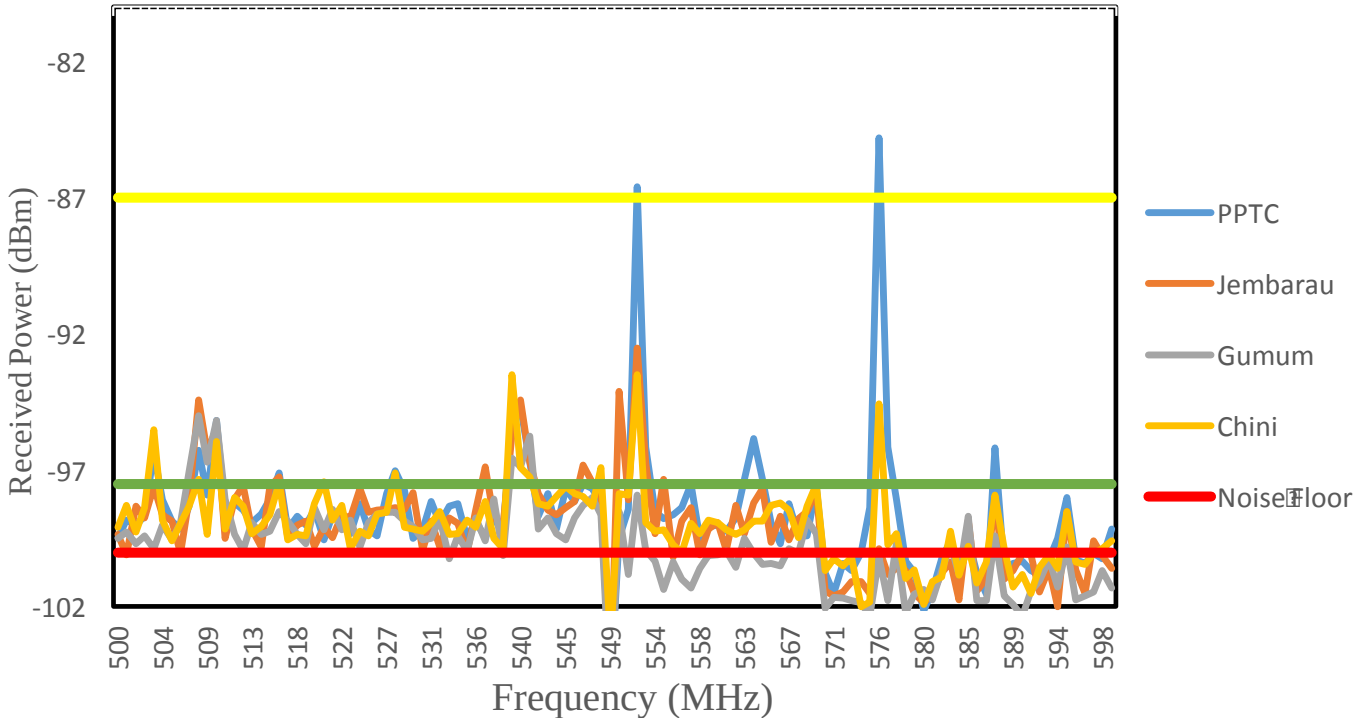
- Above Level 1: ‘high’
- Below Level 1 but above Level 2: ‘low’
- Below Level 2: noise floor
- Observation:
  - Values with strength below Level 2 are considered the noise floor they are below the receiver sensitivity of most radios and well beyond the level required for adequate decoding of a TV signal.
  - Therefore, signals below Level 2 are considered as TV White Spaces.

Measurement from 400MHz to 499MHz



Area of interest

Measurement from 500MHz to 599MHz



Observation:

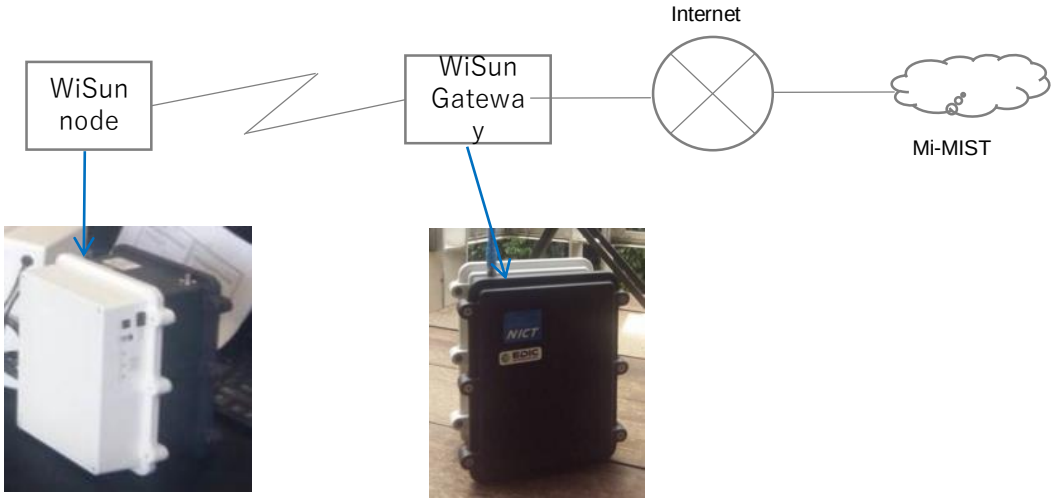
- Our trial program is focusing on spectrum 470 - 600MHz
- Thus, based on the measurement, it is recommend the following UHF channel that available for the TVWS transmission in the area of Tasik Chini.

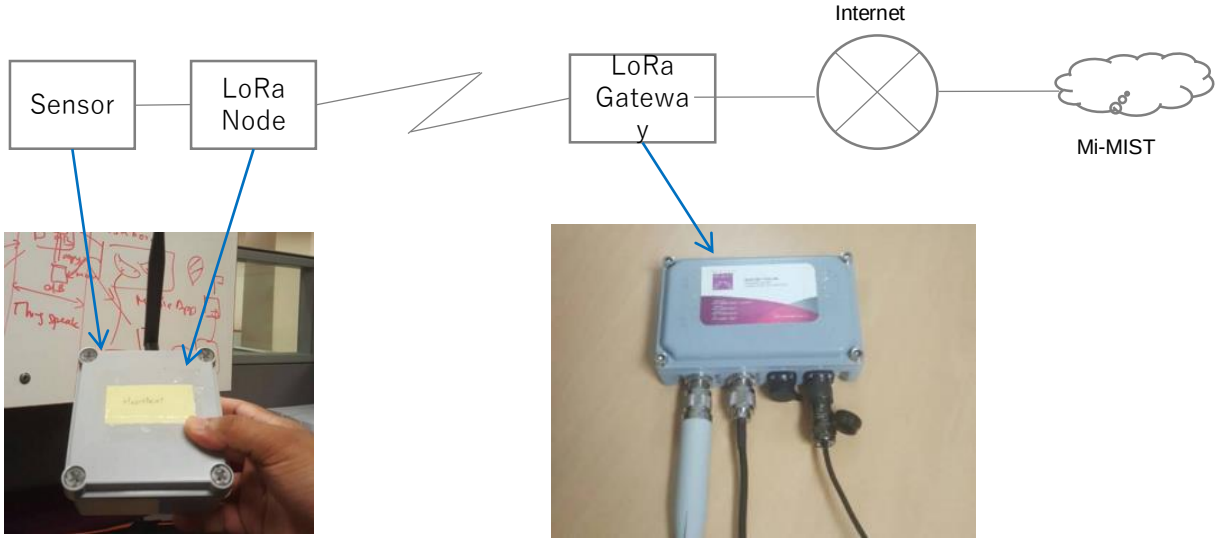
Table 1: Recommendation of available UHF channels surrounding Tasik Chini

Frequency Range (MHz)	Avg RSS	Avail. frequency	TV Channel No
400-500	-98 dBm	470MHz – 478MHz	Channel 21
500-600	-98 dBm	510MHz – 518MHz	Channel 26
	-99 dBm	518MHz – 526MHz	Channel 27
	-99 dBm	526MHz – 534MHz	Channel 28

WISUN AND LORA (SUB-GHZ) EXPERIMENT AT CHINI LAKE FOR HYDROLOGICAL MONITORING APPLICATION

WiSUN and LoRa Setup

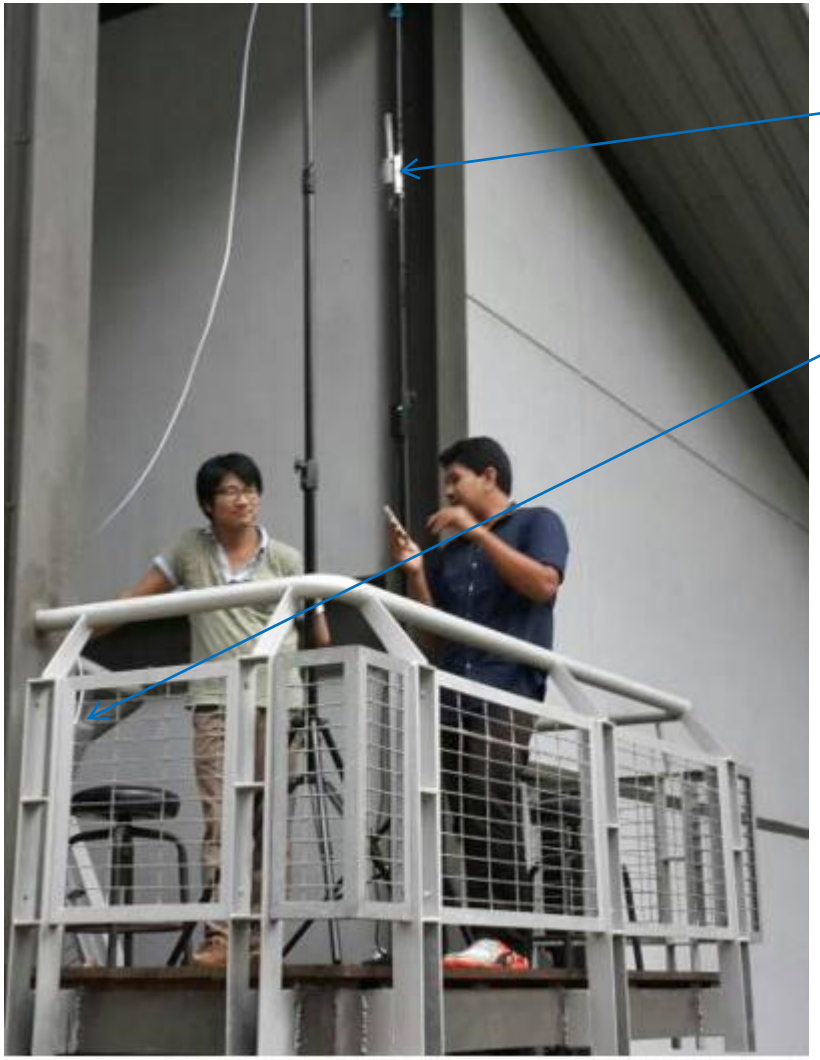




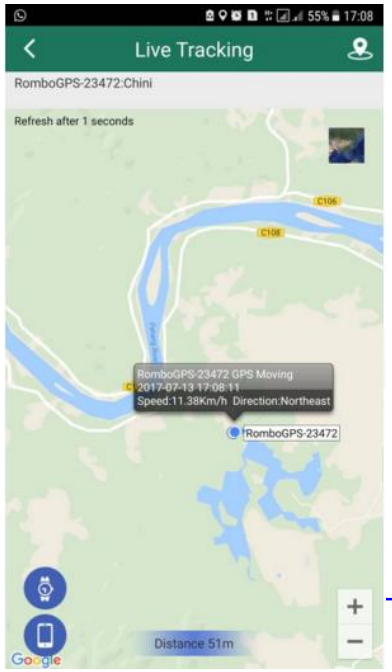
WiSUN Multihop Setup

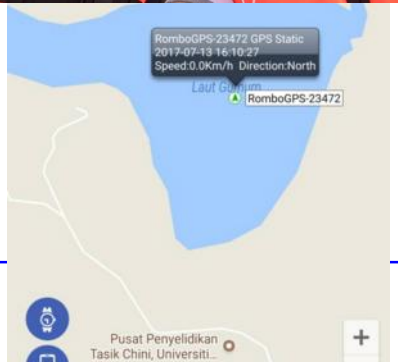
Set no	Location	Note
1	BS at Research Centre, UE1 at Jemberau station	1 hop experiment, on land
2	BS at Research Centre, UE1 on the boat (position of the boat is 500m from BS, toward the Kura-Kura Stn)	1 hop experiment, on water
3	BS and UE1 as in set 2, UE2 at Kura-Kura Station	2 hop experiment, on water
4	BS and UE1 as in set 2, UE2 at Gumum Station	2 hop experiment, further distance
4.1	BS, UE1, UE2 as in set 3, UE3 at Gumum Station	3 hop experiment, if Set 4 is not working
5	Other experiment to cover Merapoh/Melai Station	3 hop experiment, further distance
6	Other experiment to cover Jerangking/Sg Chini station	3 hop experiment, cover all stations

WiSUN and LoRa Gateway at Control Centre (PPTC)



WiSUN/LoRa Nodes – *move around lake & water station*





Snapshot of transmitted data and RSSI

Data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":216,"payload_raw":"JSOq","payload_fields":{"Humidity":35,"Temperature":37},"metadata":{"time":"2017-07-13T05:04:52.870596071Z","frequency":922.6,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":3204406036,"time":"2017-07-13T05:04:52.148291Z","channel":4,"rssi":-99,"snr":11.5,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

now

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":250,"payload_raw":"IyWq","payload_fields":{"Humidity":37,"Temperature":35},"metadata":{"time":"2017-07-13T05:10:40.091981231Z","frequency":922.2,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":3551848676,"time":"2017-07-13T05:10:39.59364Z","channel":2,"rssi":-95,"snr":10,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

1 second

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":17,"payload_raw":"HTqq","payload_fields":{"Humidity":58,"Temperature":29},"metadata":{"time":"2017-07-13T07:04:41.704040096Z","frequency":922.2,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":1803443804,"time":"2017-07-13T07:04:41.126014Z","channel":2,"rssi":-89,"snr":9.2,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

now

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":130,"payload_raw":"GRmq","payload_fields":{"Humidity":25,"Temperature":25},"metadata":{"time":"2017-07-13T07:23:56.36705607Z","frequency":922,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":2958219292,"time":"2017-07-13T07:23:55.901033Z","channel":7,"rssi":-121,"snr":-8.8,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

now

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":130,"payload_raw":"GRmq","payload_fields":{"Humidity":25,"Temperature":25},"metadata":{"time":"2017-07-13T07:23:56.36705607Z","frequency":922,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":2958219292,"time":"2017-07-13T07:23:55.901033Z","channel":7,"rssi":-121,"snr":-8.8,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

now

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":24,"payload_raw":"HEaq","payload_fields":{"Humidity":70,"Temperature":28},"metadata":{"time":"2017-07-13T09:38:14.860974795Z","frequency":923.4,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":2886679244,"time":"2017-07-13T09:38:14.116025Z","channel":1,"rssi":-122,"snr":-12.5,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

now

Data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":166,"payload_raw":"HT2q","payload_fields":{"Humidity":61,"Temperature":29},"metadata":{"time":"2017-07-13T07:30:04.525669636Z","frequency":922.2,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":3326100988,"time":"2017-07-13T07:30:03.78467Z","channel":2,"rssi":-120,"snr":0.5,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

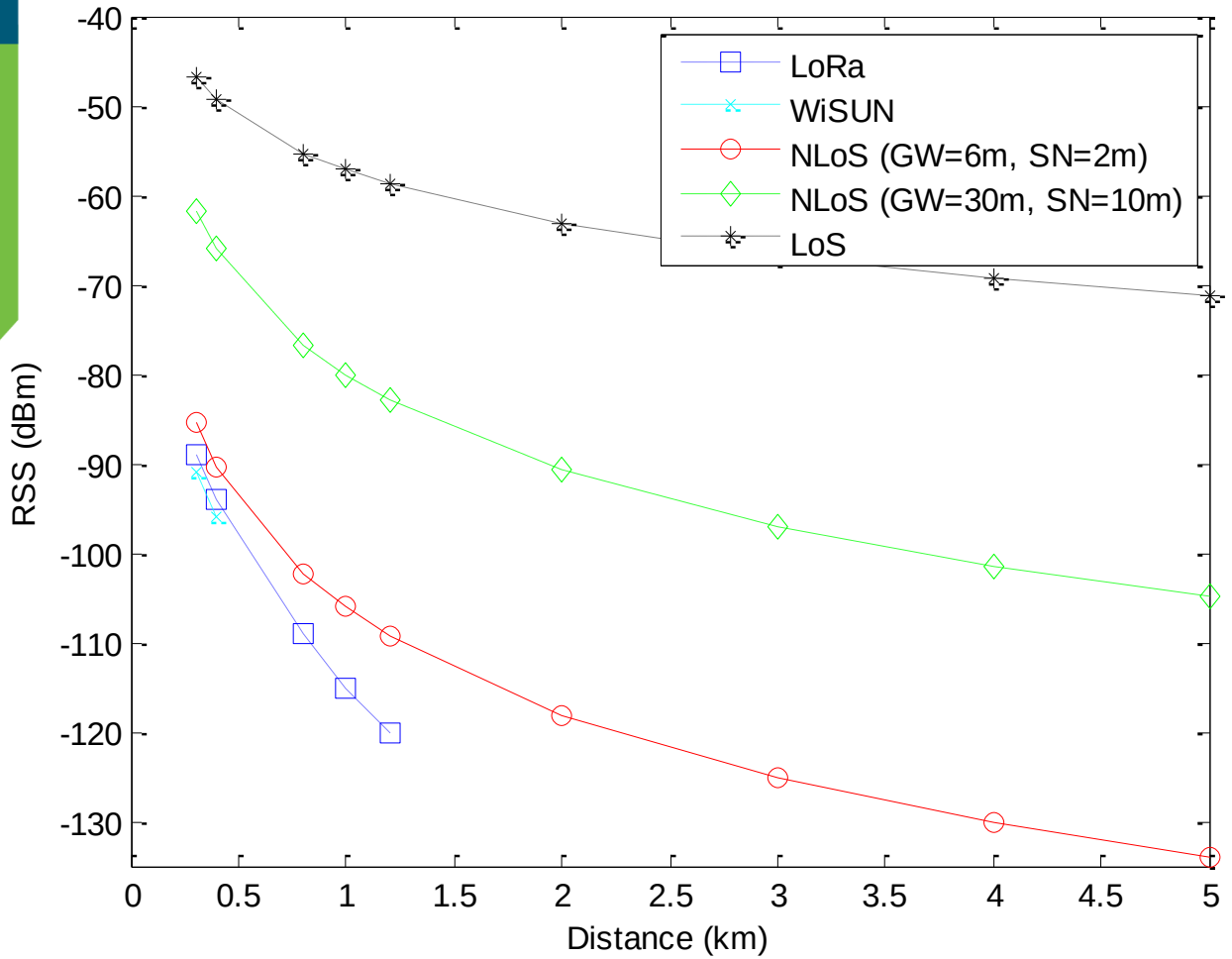
23 minutes

data

{"app_id":"arduino_temp_humid","dev_id":"rn2903_dht11_1","hardware_serial":"00FCF75E95727811","port":30,"counter":274,"payload_raw":"JSKq","payload_fields":{"Humidity":34,"Temperature":37},"metadata":{"time":"2017-07-13T05:14:45.351315739Z","frequency":922,"modulation":"LORA","data_rate":"SF10BW125","coding_rate":"4/5","gateways":[{"gtw_id":"eui-b827ebfffef21991","timestamp":3797111012,"time":"2017-07-13T05:14:44.856111Z","channel":7,"rssi":-97,"snr":7.8,"rf_chain":1,"latitude":3.04636,"longitude":101.69601,"altitude":10}]}}

59 seconds

WiSUN/LoRa and Friis/Hata Models



RSS at different Tx-Rx separation distance based on LoS/NLoS models in comparison with actual WiSUN/LoRa implementation

The Friis LoS model represents an ideal propagation condition, whereby there is no obstruction between the node and gateway. NLoS model based on Hata model is plotted for different transmitter (SN) and receiver (GW) height. From our WiSUN/LoRa implementation work, it is observed that the actual measurement around Tasik Chini is worse than NLoS Hata model for GW = 6m & SN = 2m.

Green diamond markers and red square markers represent the simulated configuration for GW = 30m & SN = 10m, and GW = 6m & SN = 2m, respectively. From the simulated results, the signal propagates better for high transmitter and receiver placements, whereby an improvement of around 25dBm could be achieved if the GW height is increased from 6m to 30m, while the SN height is increased from 2m to 10m.

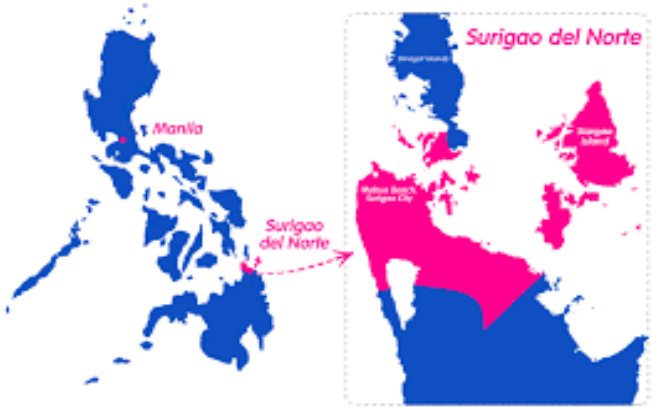
Results and Findings

- WiSUN and LoRa gateways were installed at PPTC (refer photo)
- Field study and RSSI evaluation
  - Signal could reach Gumum (1.3km), Kura-kura (1.1km), Jemberau (0.8km) stations
  - Signal could not reach Sg Chini (3km), Melai (2.5km) and other water stations due to challenging propagation environment
  - Comparison of LOS/NLOS model and measurement is shown in previous slide. Height of the gateway and antenna gain are important for ubiquitous coverage around the lake
- Sensor nodes and WiSUN/LoRa gateway operates successfully within the stipulated regulation guidelines and we manage to setup a private WiSUN/LoRa network. WiSUN/LoRa nodes transmit sensor data every 10 seconds.

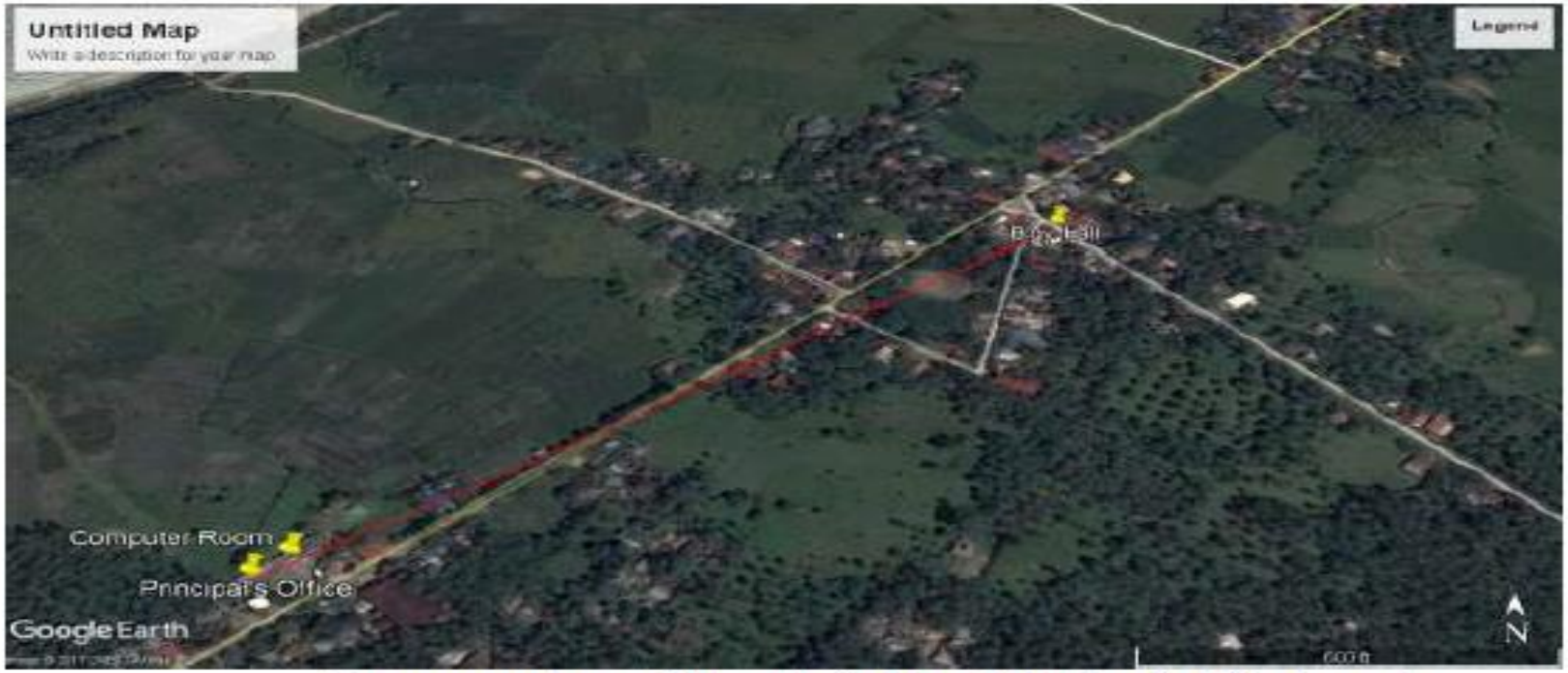
SURIGAO: PHILIPPINES EXPERIMENT FOR EMERGENCY COMMUNICATIONS USING TV WHITE SPACE (IEEE 802.11AF)

Overview: TVWS implementation

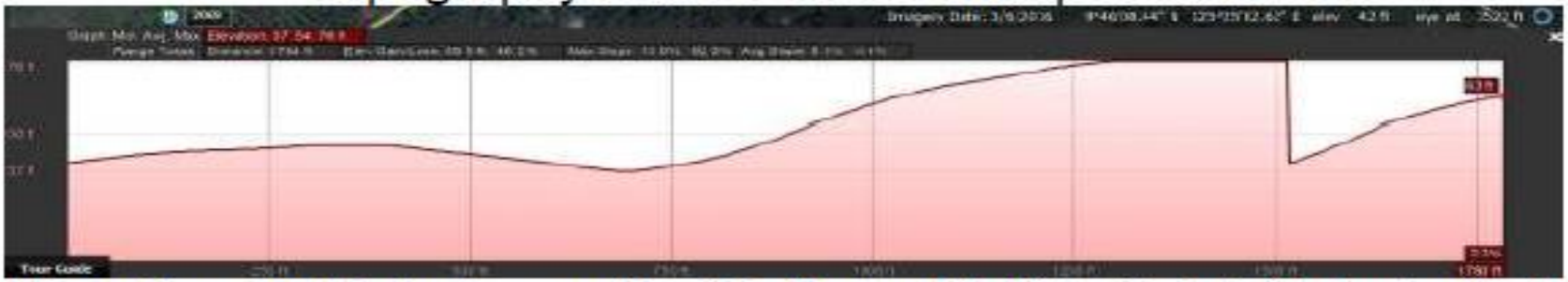
- Objective:
  - To perform tests and measurements that will demonstrate the capability of TVWS technology (IEEE 802.22af) to provide internet connectivity to remote area and as an emergency network during disasters
- Project Site:
  - Bgy. Diaz Elementary School and other premises of San Francisco, Surigao del Norte



Use Case #1: Point to Multipoint



Topography of the Point-to-Multipoint Network



Elevation Profile between the AP (Brgy. Hall) to STA1 (Principal's Office)

Use Case #1: Point to Multipoint

ACCESS POINT at BGY HALL

STATIONS 1 and 2 at the
Diaz Elementary School

Use Case #1: PtMP Throughput Performance

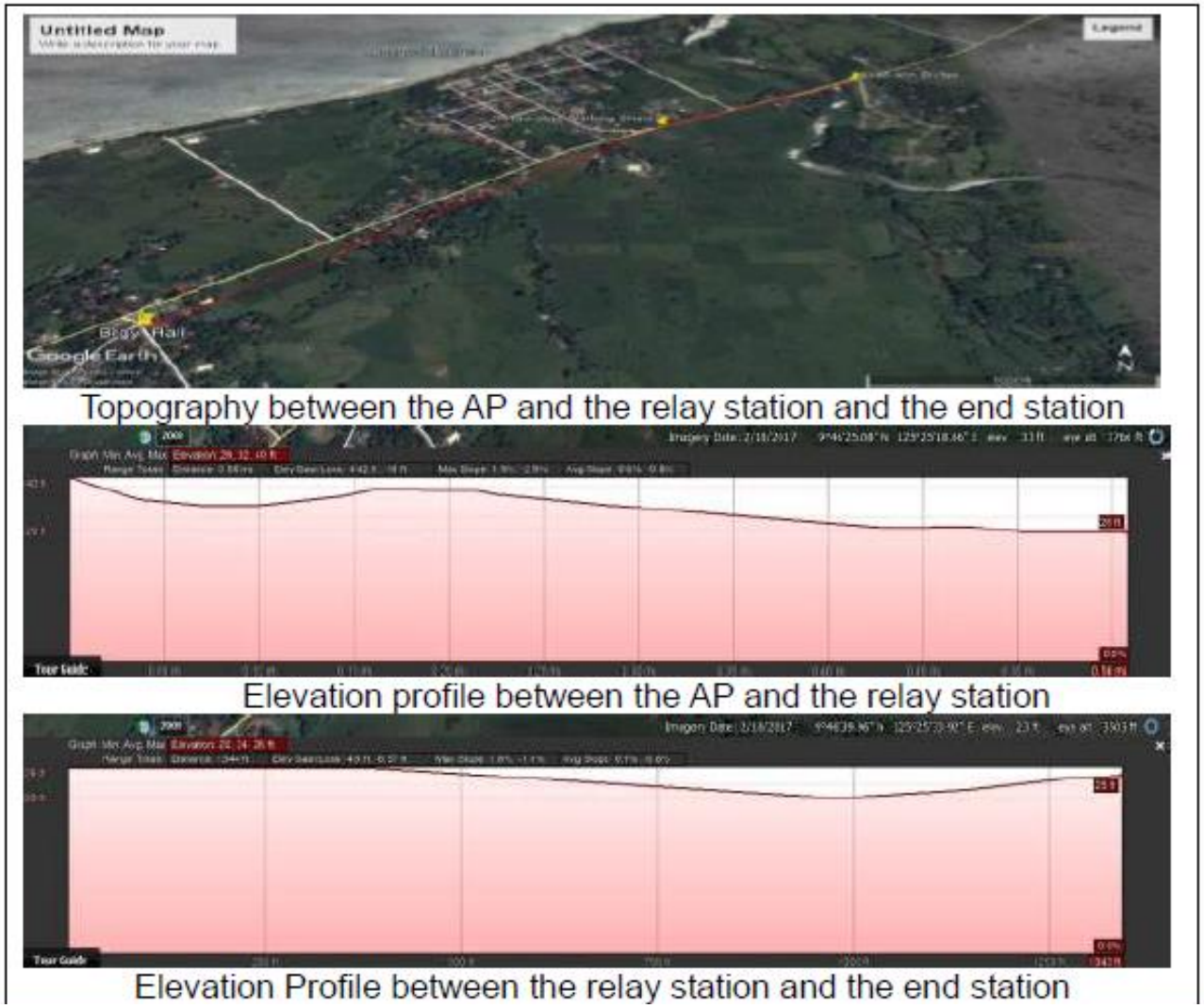
Station 1: Principal's Office				
Antenna: 3-element				
Tx Power (dBm)	MCS	RSSI (dBm)	Downlink (Mbps)	Uplink (Mbps)
20	0	-87	1.46	1.27
15	0	-92	0	0
20	3	-89	3.43	3.38
15	3	-91	0	0
20	5	-87	0	0
Station 2: Computer Room				
Antenna: 3-element				
Tx Power (dBm)	MCS	RSSI (dBm)	Downlink (dBm)	Uplink (dBm)
20	0	-88	1.22	0.764
15	0	-91	0	0
20	3	-89	3.56	0.235
15	3	-91	0	0
20	5	-89	0	0

Use Case #1: PtMP Application

Figure Showing connectivity between AP (Bgy. Hall) and STA1 (Principal's Office)

Figure 6. Learning with the aid of internet connectivity

Use Case #2: Multihop TVWS



Use Case #2: Multihop TVWS

Use Case #2: Multihop Throughput Performance

Tx Power (dBm)	MCS	Hop 1(~800m from AP)			Hop 2(~400m from Relay Station)			Total Downlink (Mbps)	Total Uplink (Mbps)
		RSSI (dBm)	Downlink (Mbps)	Uplink (Mbps)	RSSI (dBm)	Downlink (Mbps)	Uplink (Mbps)		
20	0	-86	1.36	1.31	-72	1.41	1.36	1.36	1.31
20	3	-86	3.25	3.16	-72	3.66	3.55	3.25	3.16
20	5	-86	1.07	0	-72	4.92	4.61	1.07	0
15	0	-89	1.21	0.706	-76	1.39	1.35	1.21	0.706
15	3	-89	2.89	0.376	-76	3.6	3.36	2.89	0.376
15	5	-89	0	0	-77	0.47	0.423	0	0
10	0	-93	0.095	0.118	-85	1.43	1.32	0.095	0.118
10	3	-93	0	0	-85	3.5	3.55	0	0
10	5	no connection			-85	2.69	1.41	0	0
5	0	no connection			-88	1.36	0.811	0	0
5	3	no connection			-88	3.46	1.92	0	0
5	5	no connection			-89	0	0	0	0
0	0	no connection			-91	0.388	0.106	0	0
0	3	no connection			-92	0.188	0	0	0
0	5	no connection			-92	0	0	0	0

Findings: 802.11af (TVWS)

- Internet connection can be established between an access point and multi-points or stations in a remote area utilizing TVWS technology
  - Maximum throughput of 3.43 Mbps (downlink) and 3.38 Mbps (uplink) at a maximum power of 20 dBm with MCS 3
- In the case of point to multipoint network, utilizing a single frequency can cause co-channel interference affecting uplink throughput
- An internet connection coverage can be extended via a multi-hop network using an IEEE 802.11af devices
  - Maximum throughput is 3.25 Mbps (downlink) and 3.16 Mbps (uplink) at a maximum power of 20 dBm with MCS 3
- To avoid co-channel and adjacent channel interference, two distinct frequencies are employed for each hop: 659 MHz and 593 MHz for hop 1 and hop 2, respectively

Summary

Achievements

- We have conducted successfully the TVWS deployment in two venue
  - Chini Lake, Malaysia
  - USC and Surigao, Philippines
- This project has also created awareness for stakeholders in Malaysia and the Phillipines about the benefit of TVWS for applications in rural areas, whereby the aim of this project is to enable positive social impact specifically focusing on environmental preservation and disaster communications.
- Publications: 4

Achievements & Findings (1/3)

- The main achievements for this project for in 2016 are as follow;
  - Conducted radio propagation study at Chini (Malaysia) and Bogo (the Philippines), as well as completed comprehensive spectrum measurement at Chini Lake.
  - In 2017, this project has achieved major accomplishment by conducting the following experiments successfully; Surigao, Philippines Experiment for Emergency Communications using TV White Space (IEEE 802.11af) as well as WiSUN and LoRa (sub-GHz) Experiment at Chini Lake for Hydrological Monitoring Application.
  - This project has utilized TVWS transceiver equipment as well as WiSUN node and gateway which were design and build by NICT Japan. The devices were deployed in the Philippines and Malaysia.

Achievements & Findings (2/3)

- In the Philippines, the TV white space technology (IEEE 802.11af) has so far been tested successfully in providing internet connectivity through multihopping
  - (1) in a hilly terrain covering a distance of about 600 meters obtaining a maximum throughput of 4.81 Mbps and 4.93 Mbps for uplink and downlink, respectively; and
  - (2) in a relatively flat terrain that further extends distance coverage to a total of about 1200 meters with a maximum downlink throughput of 3.25 Mbps and 3.16 Mbps for uplink.
- The success has so far encouraged further deployment and testing of the prototypes to applications in vehicle-to-vehicle communications, besides emergency applications for disaster communications. The results of the study have so far been disseminated in a form or oral presentations both in and outside the Philippines.

Achievements & Findings (3/3)

- Based on our experience in this project in Malaysia, we found that the main challenges are to address the thick foliage and various terrain profile that obstruct the propagation of the EM waves in the remote jungle area.
- These challenges limit the penetration and coverage to reach the water sampling stations that scattered across the lake area. In other words, higher elevation is the key to solve variable terrains & tall trees in rural wireless communications. The next plan is to increase the tower height or be innovative such as to experiment the use of the unmanned aerial vehicle (UAV), or drones.

Research Publications

- R. Nordin, H. Mohamad, M. Behjati, A. Kelechi, N. Ramli, K. Ishizu, F. Kojima, M. Ismail & M. Idris, “The World-First Deployment of Narrowband IoT for Rural Hydrological Monitoring in UNESCO Biosphere Environment,” International Conference on Smart Instrumentation, Measurement and Application 2017 (ICSIMA), Nov 2017
- A.S. Bañacia & A. Montejo, “Implementation of a Multihop Network at the University Campus Using an IEEE 802.11af Compliant Network,” International Symposium on Wireless Personal Multimedia Communications (WPMC), Dec 2017
- R. Nordin, H. Mohamad, M. Behjati, A. Kelechi, N. Ramli, K. Ishizu, F. Kojima, M. Ismail & M. Idris, "Internet of Things for Rural Hydrological Monitoring in UNESCO Biosphere Environment," International Symposium on Wireless Personal Multimedia Communications (WPMC), Dec 2017
- R. Nordin, H. Mohamad, N. Ramli, K. Ishizu, F. Kojima, M. Ismail & M. Idris, “Internet of Things for Water Quality Monitoring Application,” IEICE Tech. Rep., vol. 117, no. 457, SR2017-116, pp. 31-34, Feb. 2018.

Future Development

- In the Philippines, the TVWS has been tested successfully in providing internet connectivity with multihopping.
- In Malaysia, due to challenging propagation condition, the next plan is to experiments the use of the unmanned aerial vehicle (UAV), or drones.

Project Title: TV White Space (TVWS) Experimental for Application in Remote Area

ASEAN IVO Final Report

Project Leader: Hafizal Mohamad, MIMOS Berhad (Malaysia)
Project members: Dr. Nordin Ramli (MIMOS), Alberto S. Bañacia (USC), Dr. Rosdiadee Nordin (UKM), Dr. Mahamod Ismail (UKM), Dr. Kentaro Ishizu (NICT), Dr. Takeshi Matsumura (NICT), Dr. Fumihide Kojima (NICT) Budget: USD 29,900 Duration: 21 months (Jul 2016 – Mar 2018)

Target of this project: This project aims to demonstrate the effectiveness of TVWS experimentation for the following applications; hydrological quality monitoring in rural area and natural disaster emergency network. This project has utilized TVWS transceiver equipment as well as WiSUN node and gateway which were design and build by NICT Japan. The devices were deployed in the Philippines and Malaysia.

Findings and Outcomes: We have conducted radio propagation study and comprehensive spectrum measurement at Chini Lake. We have successfully conducted experimental work at Surigao: Philippines Experiment for Emergency Communications using TV White Space (IEEE 802.11af) as well as WiSUN and LoRa (sub-GHz) Experiment at Chini Lake for Hydrological Monitoring Application.

Collaborations: NICT has developed prototype hardware for TVWS communications. Philippine government has strong interest in TVWS and an TVWS experimental has be deployed in Surigao. This IVO project enables researchers from MIMOS and UKM to discuss TVWS with Malaysia stakeholders. WiSUN transceivers were deployed for water quality experiment work at Lake Chini.

Broader Impact and Future Developments: In the Philippines, the TVWS has been tested successfully in providing internet connectivity with multihopping. In Malaysia, due to challenging propagation condition, the next plan is to experiments the use of the unmanned aerial vehicle (UAV), or drones.

Social Contribution: This project has produced four (4) academic papers presented at international conference. This project has also created awareness in Malaysia and the Philippines about the benefit of TVWS for applications in rural areas, focusing on environmental preservation and disaster comms.


Thank You!

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