A mesh-topological, low-power wireless network platform for a smart watering system

Background :

The plant watering system lies at the heart of agriculture since it directly affects product yields, as well as the quality of products. Therefore, controlling when plants should be watered and determining how much water the plants need concerning the current environmental conditions are crucial for the plant growth.

Targets :

- Developing weather stations, sensor nodes, valve-control nodes, and a controller node
- Developing a smart watering system based on a mesh-topological WSN
- Developing a smart watering system based on a NerveNet-LoRa WSN

Speaker : Udom Lewlompaisarl
National Electronics and Computer Technology Center, Thailand

A mesh-topological, low-power wireless network platform for a smart watering system

Project Members :

National Electronics and Computer Technology Center (NECTEC)
National Institute of Information and Communications Technology (NICT)
Universiti Teknology Brunei (UTB)
Department of Agriculture and Agrifood (DAA)
University of Computer Studies, Yangon (UCSY)
Universiti Teknology Malaysia (UTM)

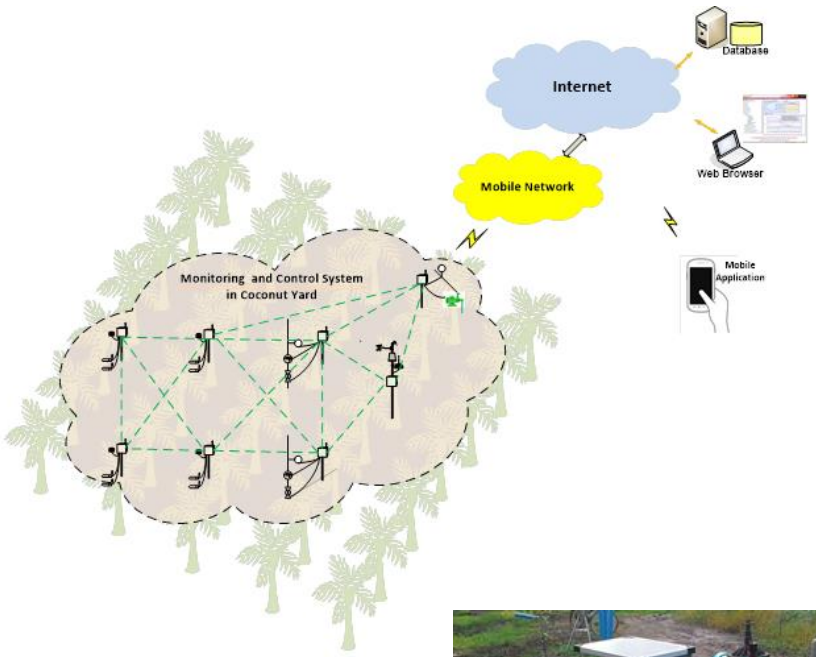
Project Duration : 3 years (Jun 2018 – **May 2022**) (Request for 1-year extension)

Project Budget: 116,000 USD

Project Activities

System Overview

Experiments at Kehakaset Coconut Farm, Pathum Thani, Thailand



Project Activities

2018

- Kick-off meeting at NICT, Japan (Jul 2018)
- NECTEC-NICT technical meeting on NerveNet application at NECTEC, Thailand (Aug 2018)
- A draft of CRDA
- Experiment with NerveNet/LoRa at NECTEC, Thailand (Sep 2018)
- Visiting Brunei's site by Thanika-san (Nov 2018)

2019

- 2nd Meeting at UTB, Brunei (Jan 2019)
- System implementation and testing for UTB (Feb – Oct 2019)
- Special meeting with Dr Jennifer's team (ET-based Irrigation) for research idea exchange and collaboration in Bangkok (Mar 2019)
- 3rd Meeting at UCSY, Myanmar (Jul 2019)
- CRDA issues!

Project Activities

2020

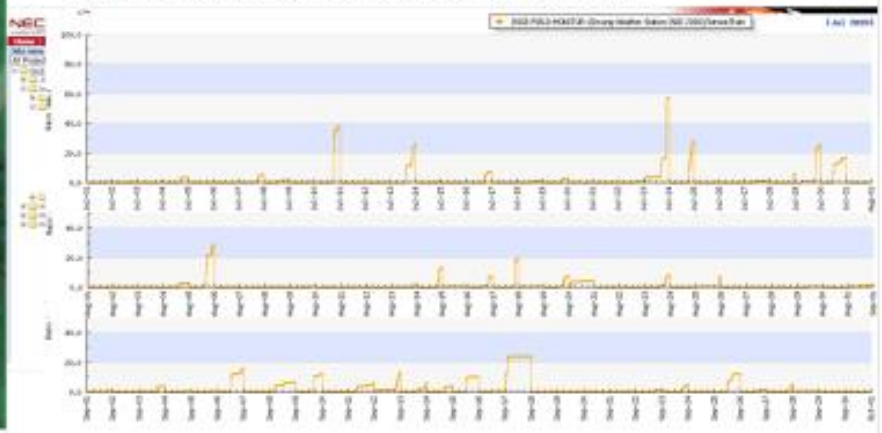
- Completion of CRDA
- 4th Meeting (WebEx) on April 8, 2020
- Equipment purchase & system installation in Brunei
- System requirement for the experimental site in Myanmar

Project Activities in Brunei Darussalam

Weather station at Imang Dam

Imang Dam – Weather station

Data collected real-time: Daily and monthly view



Project Activities in Brunei Darussalam

New location of the paddy site

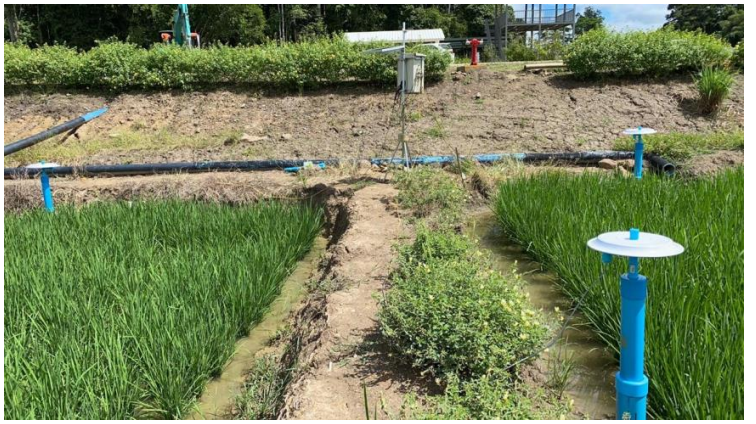
- IBTE Agro 7.7km from Imang Dam
- Wasan office – IBTE 5km

Project Activities in Brunei Darussalam

IBTE Agro: First trial 2020 (Jul – Sep Season)





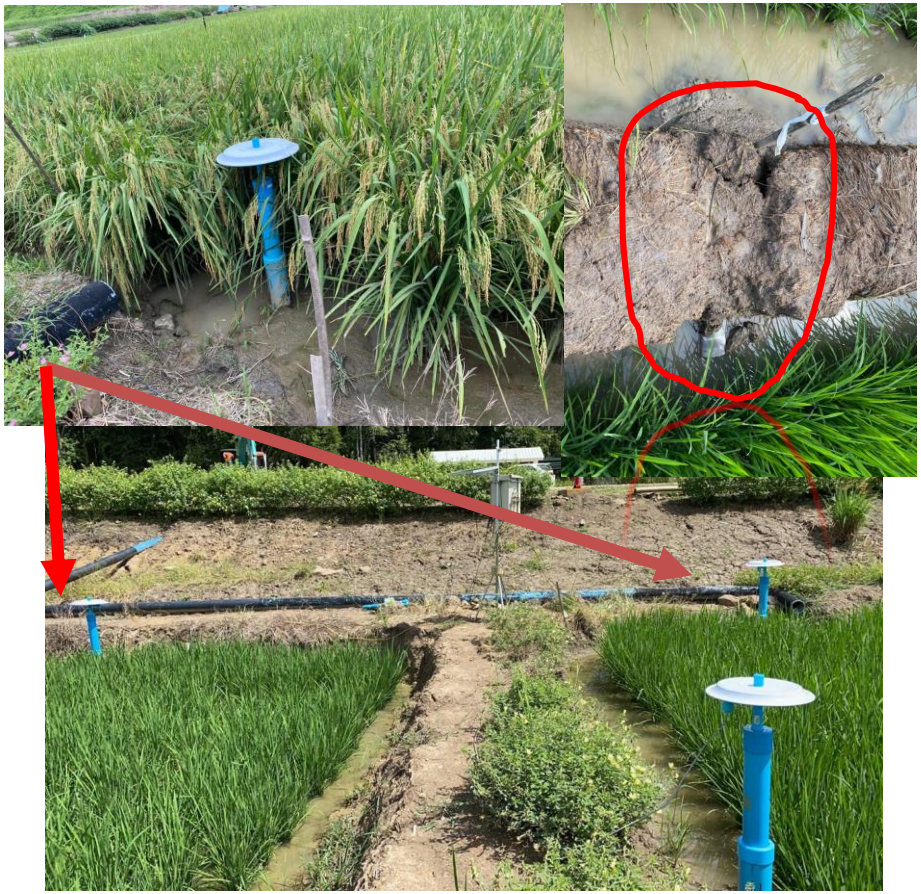



Project Activities in Brunei Darussalam

Next step: To improve current setting to the new plot

- **Wasan** – Plot irrigation collected via canal

- **IBTE** – Plot irrigation direct via pipe



- Need to work on the water-gate

Project Activities in Myanmar

Meeting @UCSY



Green House Site @UCSY


Mango Farm site @on the way to Kungyangon


Meeting @Tawku Village


Paddy Field site @Khalauktayar Village


Project Activities in Malaysia

Paddy Field Water Quality Data Analysis Using ANOVA Approach

One-way ANOVA Table

Variance source	Sum of squares *SS*	Degrees of freedom *df*	Mean square *MS*	*F*-statistic	Tail area above *F*
Between	*SSC*	$k-1$	*MSC*	*MSC/MSE*	*p*-value
Within	*SSE*	$N-k$	*MSE*	—	—
Total	*SST*	$N-1$	—	—	—

$$SST = \sum_{i=1}^{k}\sum_{j=1}^{n_i}(x_{ij} - \bar{x})^2$$

$$SSE = \sum_{i=1}^{k}\sum_{j=1}^{n_i}(x_{ij} - \bar{x}_i)^2 = \sum_{i=1}^{k}(n_i - 1)\bullet s_i^{\,2}$$

$$SSC = \sum_{i=1}^{k}\sum_{j=1}^{n_i}(\bar{x}_i - \bar{x})^2 = \sum_{i=1}^{k} n_i \bullet (\bar{x}_i - \bar{x})^2$$

$$SST = SSE + SSC$$

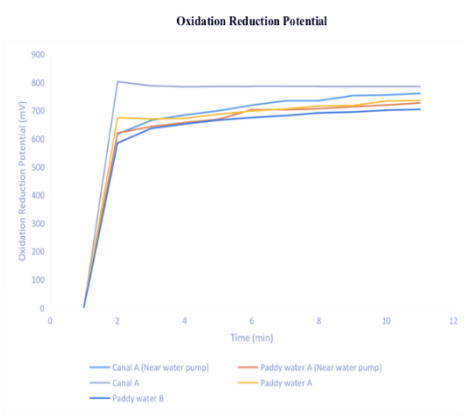
$$MST = \frac{SST}{df(SST)} = \frac{SST}{N-1},$$

$$MSE = \frac{SSE}{df(SSE)} = \frac{SSE}{N-k},$$

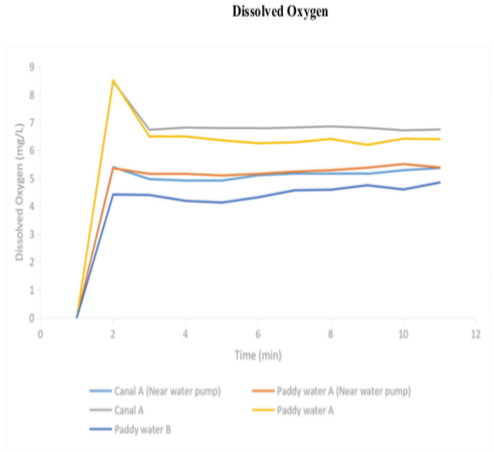
$$MSC = \frac{SSC}{df(SSC)} = \frac{SSC}{k-1}$$

Project Activities in Malaysia

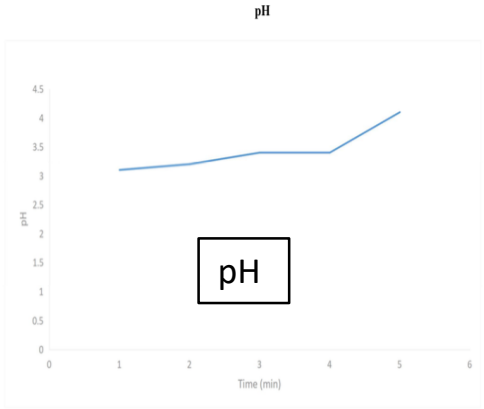
Paddy Field Water Quality Data Analysis Using ANOVA Approach



Oxidation Reduction Potential



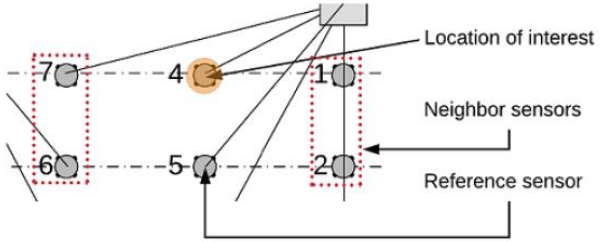
Dissolved Oxygen

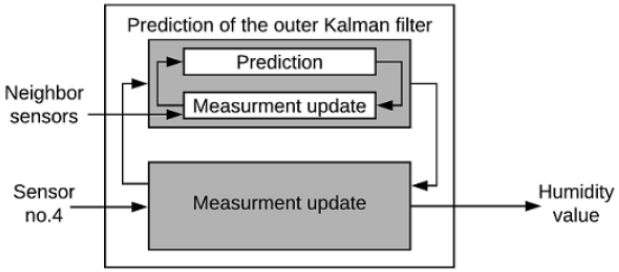


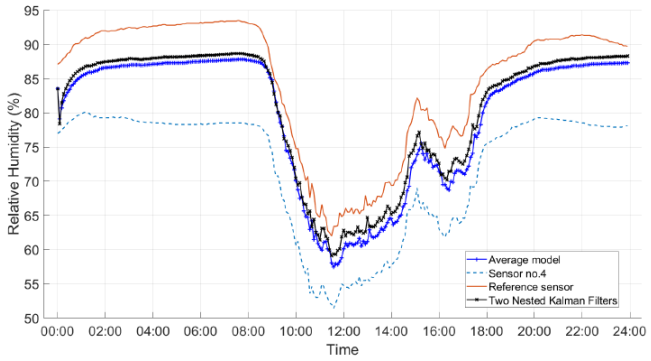
pH

Experiments with data collected from the system

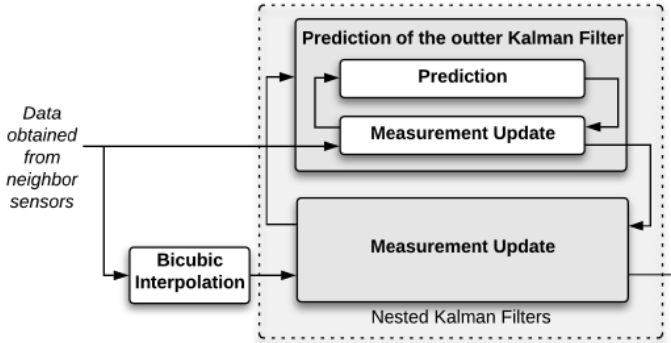
- Humidity sensor accuracy improvement based on two nested Kalman filters (2NKF)

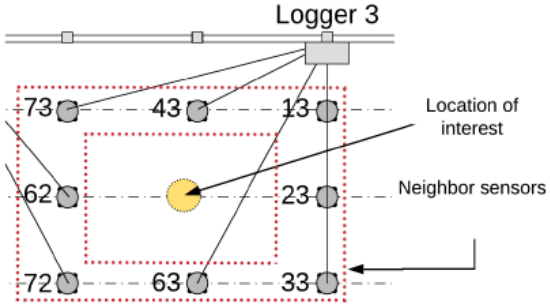


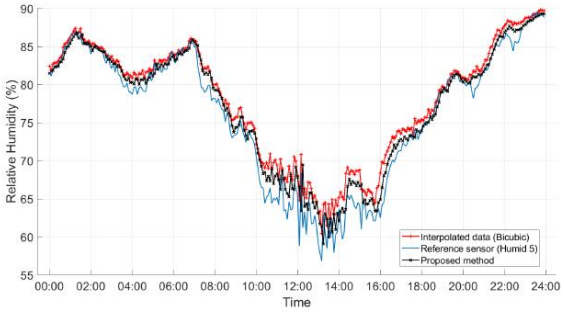




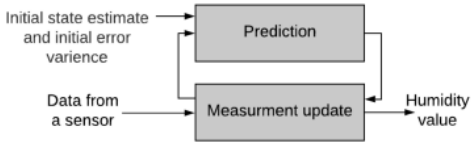
- Relative humidity estimation based on 2NKF with bi-cubic interpolation

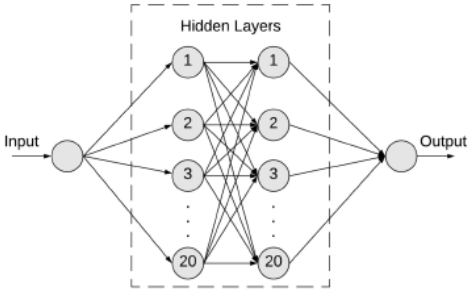


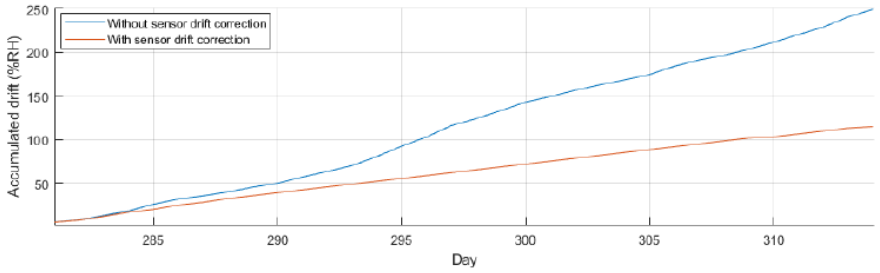




- Humidity sensor drift detection and correction based on ANN and KF







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.	A Design for IoT Based Smart Watering System Using LoRa	Khin Than Mya[1], Myint Myint Sein[1], Thi Thi Soe Nyunt[1], Udom Lewlompaisarl[2], and Yasunori Owada[3]	[1]University of Computer Studies, Yangon, [2]National Electronics and Computer Technology Center, [3]National Institute of Information and Communications Technology	2020 IEEE 9th Global Conference on Consumer Electronics (GCCE 2020)	13-16 October 2020	Online
2.	Humidity Sensor Accuracy Improvement Based on Two Nested Kalman Filters for Commercial Cultivation of Tropical Orchids	P. Dangsakul[1], N. Siripool[1,2], K. Sirisanwannakul[1,2], R. Keinprasit[1], K. Rungprateeptavorn[1], S. Keerativittayanun[1], and J. Karnjana[1]	[1]National Electronics and Computer Technology Center, [2]Sirindhorn International Institute of Technology	The 27th International Conference on Neural Information Processing	18-22 November 2020	Online
3.	Relative Humidity Estimation Based on Two Nested Kalman Filters with Bicubic Interpolation for Commercial Cultivation of Tropical Orchids	N. Siripool[1,2], K. Sirisanwannakul[1,2], W. Kongprawechnon[2], P. Dangsakul[1], A. Leelayuttho[1], S. Chokrung[1], J. Intha[1], S. Keerativittayanun[1], and J. Karnjana[1]	[1]National Electronics and Computer Technology Center, [2]Sirindhorn International Institute of Technology	International Symposium on Integrated Uncertainty in Knowledge Modelling and Decision Making	11-13 November 2020	Online
4.	Humidity Sensor Drift Detection and Correction Based on a Kalman Filter with an Artificial Neural Network for Commercial Cultivation of Tropical Orchids	K. Sirisanwannakul[1,2], N. Siripool[1,2], W. Kongprawechnon[2], P. Dangsakul[1], U. Lewlompaisarl[1], S. Sartsatit[1], T. Duangtanoo[1], S. Keerativittayanun[1], Wida Susanty Haji Suhaili[3], Y. Owada[4], Khin Than Mya[5], Sharifah Hafizah Syed Ariffin[6], and J. Karnjana[1]	[1]National Electronics and Computer Technology Center, [2]Sirindhorn International Institute of Technology, [3]Universiti Teknologi, [4]National Institute of Information and Communications Technology, [5]University of Computer Studies, Yangon, [6]Universiti Teknologi Malaysia	The 4th International Conference on Computational Intelligence in Information System (CIIS 2020)	25-27 January 2021	UTB, Brunei Darussalam & Online

Societal Impact:

- A direct social impact of the proposed system is straightforward; that is, it improves farming productivity both in quality and quantity. Therefore, it can be an answer to the world's food shortage crisis. Furthermore, it has many impacts on various applications that share the same technological infrastructure. Since this work aims to study and implement, as well as to experiment with, a stable and reliable wireless platform with low-power consumption, the studied platform can be applied in other domains, such as environmental/earth sensing, area monitoring, and healthcare monitoring.

Conclusion:

Activities that have been done so far in 2020 are summarized as follows.

- **Meetings**: 4th Meeting (WebEx)
- **Experiments**
  - System installation in Brunei
  - System requirements in Myanmar
  - Data analysis
- **Publications**: 4 conference papers

Targets

- Developing weather stations, sensor nodes, valve-control nodes, and a controller node … **DONE**
- Developing a smart watering system based on a mesh-topological WSN … **DONE**
- Developing a smart watering system based on a NerveNet-LoRa WSN … **ONGOING**

Budget Plan

- Budget used: approx. **43,000** USD (as of October 15, 2020)
- Budget allocation plan (**72,510** USD)

	NECTEC	UTB	UTM	UCSY
Conference	330		500	
Journal		3,500	1,690	
Field tests				
Equipment		33,245		33,245

Future works:

- System installation in Myanmar
- NerveNet/LoRa-based system (Target: Thailand)
- Data collection and analysis
- Publications

Activities	2020		2021												2022
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
Conference															
Journal															
Field tests															
Purchase															