Project Title: **Smart Aquaculture Quality Monitoring (AQM) System with Internet of Things (IoT)**

Background :

This project is focusing on enhancement of shrimp farm management through an embedment of multiple wireless communication technologies. The technologies of RFID, WSN, mobile application platform and IoT system will be embedded into one platform as an efficient solution for aquaculture quality monitoring (AQM). The proposed wireless system known as "Smart Aquaculture Monitoring with Internet of Things System (SAM-IoT)" is designed to collect data of pH level, dissolve oxygen (DO) and water temperature at shrimp ponds. The proposed active RFID tag will transmit the captured data to its reader which is also designed as an internet gateway. A low power consumption AVR microcontroller will be embed to both of proposed RFID tag and its reader for efficient power management. Fast rectification work regarding water quality of shrimp pond could be deployed through this feature. Therefore, the valuable captured data from this proposed SAM-IoT system can be accessed at anywhere on anytime as long as the internet bandwidth is available.

Targets:

To design portable Aquaculture Quality Monitoring (AQM) system namely as SAM-IoT system based on pH, DO and temperature measurement through IoT based system implementation by incorporating the active RFID tag into WSN platform, to allow continuous M2M communication between the IoT gateway and user's mobile device including the online monitoring mobile application through embedded circuit design.

To fabricate and implement the prototype of SAM-IoT system as a proof of concept on real-time aquaculture quality monitoring through internet bandwidth connection.

To analyze and characterize the proposed prototype system at real location by validating the energy analysis, data collision analysis, communication range analysis, pH measurement, DO measurement, temperature measurement, network latency and throughput evaluation.

To promote and create awareness of multiple technologies embedment based on IoT for smart aquaculture quality monitoring

Speaker: Prof. Dr. Widad Ismail (USM)

Voice recording:
https://drive.google.com/file/d/1AzQQeIdMfo0PY2ZAzXsyq5ckwlfAB5G7/view?usp=sharing

Project Title:

Project Members :

Leader : Widad Ismail, USM, Malaysia
Members:

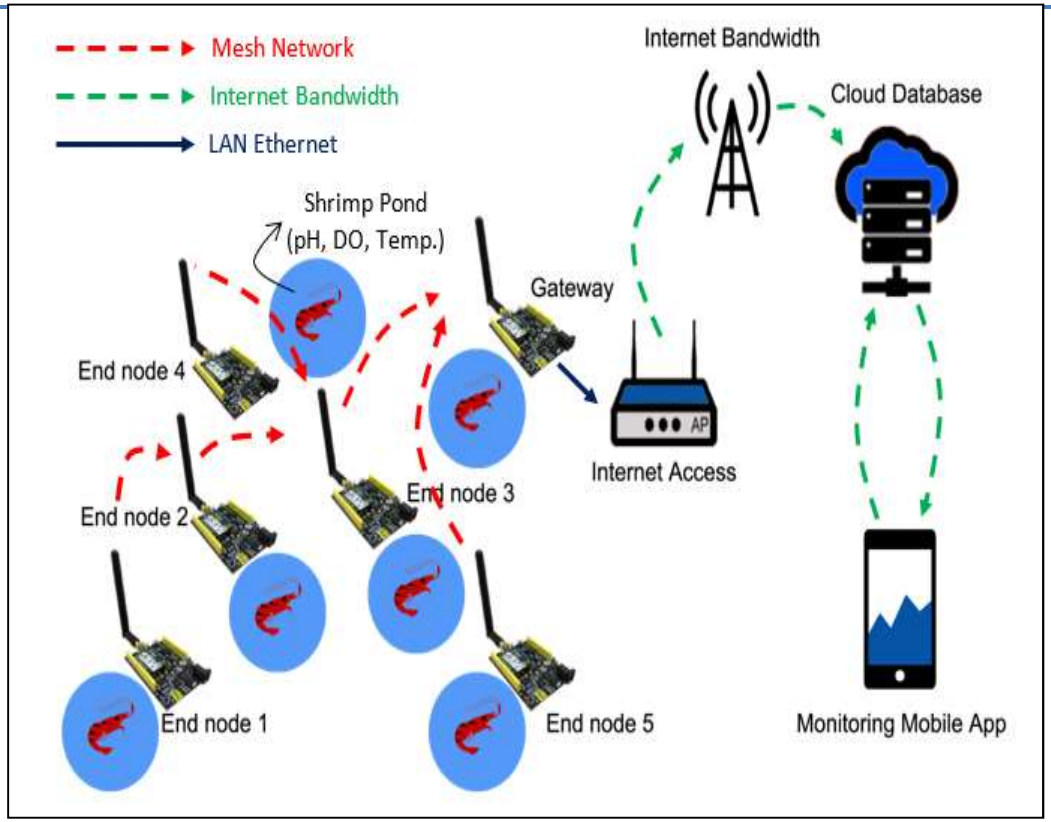
1) USM, Malaysia – Harsa Amylia Mat Sakim, Dzati Athiar Ramli, Nur Syazreen Ahmad, Chong Yung Wey
2) Kyoto Uni., Japan – Naoki Shinohara
3) UTM, Malaysia - Sevia Mahdaliza Idrus Sutan Nameh, Farid Zubir
4) RMUTSV, Thailand – Wasana Boonsong
5) UNISSULA, Indonesia – Suryani Alifah
6) MAMPU, Malaysia – Kamarul Hafiz Kamaludin
7) UTP, Malaysia – Toni Anwar, Savita K Sugathan

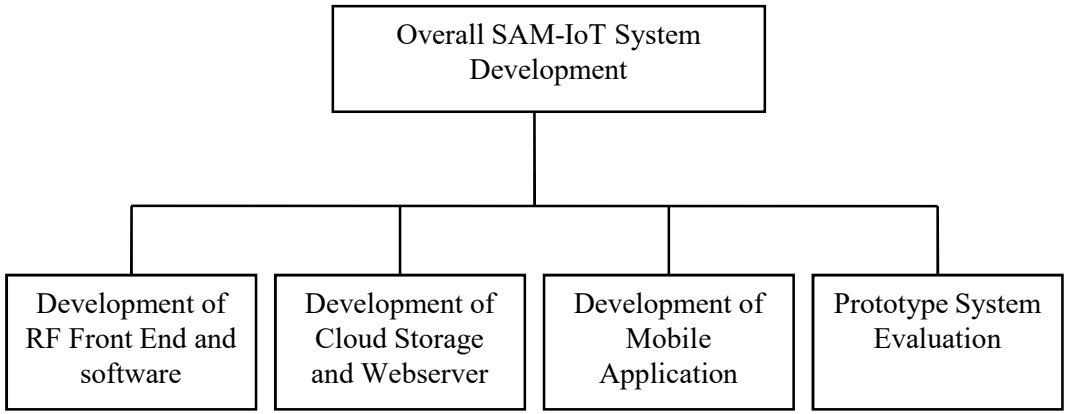
Project Duration :

2.5 years (6 months extension)

Project Budget:

USD 74,876





WORK SCOPES & RESPONSIBILITIES

NO	RESEARCHER	JOB DESCRIPTIONS
1	**Universiti Sains Malaysia (USM)** Address: Auto-ID Laboratory, School of Electrical & Electronic Engineering, Engineering Campus, 14300 Nibong Tebal, Pulau Pinang, Malaysia	
	a) Prof. Dr. Widad Ismail (Project Leader) E-mail: eewidad@usm.my / ismailwidad@gmail.com	- Monitoring the whole development of the prototype development including hardware, software and network design - Extra focus on the devlopement embedment of different RFID hardware developments with WSN for the proposed automated SAM-IoT - Preparing and supervise pilot plant for validation purposes.
	b) Associate Prof. Dr. Harsa Amylia Mat Sakim (Project Member) E-mail: amylia@usm.my	-Implement data mining techniques on transmitted data. - Analyse captured data using neural network techniques and propose predictions method to utilize potential information which shall be incorporated in the mobile application development.
	c): Dr. Nur Syazreen Ahmad (Project Member) Email: syazreen@usm.my	- Investigate and develop control mechanisms for the proposed SAM-IoT in prolonging the performance lifetime for sustainability and green technology - Modeling and evaluate feasibility of proposed control mechanism into the proposed system - Analysis on the accuracy of the data (eg: pH level, dissolved oxygen (DO) and water temperature), and improvement on the mechanisms to read the data.
	d) Associate Professor Dr. Dzati Athiar Ramli (Project Member) Email: dzati@usm.my	- Proposed study evaluation based on DOE and statistical approach in real environment for the prototype development - Signal processing of prototype performance for reliability approach in smart AQM implementation.
	e) Ms. Chong Yung Wey (Project Member) Email: chong@usm.my	- Software and network development to incorporate the mult-i platform mechanism to the prototype - Hybrid energy harvesting element development for the proposed prototype
2	**Kyoto University, Japan** Address: Research Institute for Sustainable Humanosphere (RISH) , Kyoto Universit , Uji 611-0011, Japan	
	Prof. Dr. Naoki Shinohara (Mainmember) Email: shino@rish.kyoto-u.ac.jp	- Focuses on development of Hybrid Energy Harvester and green technology embedment for SAM-IoT system - Testing of technical energy requirements for the proposed prototypes. - Knowledge and expert sharing on data analysis
3	**Universiti Teknologi Malaysia (UTM)** Address: Faculty of Electrical Engineering, Universiti Teknology Malaysia (UTM), 81310 UTM, Johor Bahru, Johor Darul Ta'zim, Malaysia	
	a) Prof. Dr. Sevia Mahdaliza Idrus Sutan Nameh (Main member) Email: sevia@utm.my	- Monitor the operation portal check out prototype testing and advice for any problems arise during implementation - Provide accessibility to communication lab at UTM for the RF equipment sharing and anechoic chamber testing. -Ensure the proposed system meet the standard and regulations to be used in ASEAN region.
	b) Dr. Farid Zubir (Project Member) Email: faridzubir@utm.my, farid@fke.utm.my	- Assist in the hardware development of the embedded RFID and WSN prototypes for the smart AQM system. - Focus on pilot development and testing of SAM-IoT system in Malaysia site.

4	**Rajamangala University of Technology Srivijaya (RMUTSV), Thailand** Address: Department of Electronic and Telecommunication Engineering, Faculty of Industrial Education and Technology, Rajamangala University of Technology Srivijaya (RMUTSV), No.1 Ratchadamnoen Nok, Bo Yang, Muang, Songkhla 90000, Thailand	
	Dr. Wasana Boonsong (Mainmember) Email: wasana.b@rmutsv.ac.th, boonsong.was@hotmail.com	- Develop the processor part of the hardware part of the prototype to suit the requirements for smart AQM system with IoT. - Embed and analyze the data acquisition system to the processor functionality. - Prepare Site for field test and implementation for proof of concept in thailand
5	**Universitas Islam Sultan Agung Semarang (UNISSULA), Indonesia** Address: Smart System Research Group of Unissula, JI RayaKaligawe KM. 04, Semarang 50012, Indonesia	
	Associate Professor Ir. Dr. Sury ani Alifah (Main member)	- Prepare Site for field test and implementation for proof of concept in Indonesia - Focus on communication data transfer and feedback survey of the field testing
6	**Malaysian Administration Modernization and Planning Unit (MAMPU), Malaysia** Address; Development Division of ICT Shared Service and Security, MAMPU, Prime Minister Office, Building MKN Embassy Tachzone, Block B, No. 3200, Jalan Teknokrat 2, 6300 Cyberjaya, Selangor, Malaysia	
	Mr. Kamarul Hafiz Kamaludin (Mainmember) Email: kamarulhafiz@mampu.gov.my, khafiz4g@gmail.com	- Internet and networking infrastructure for the whole development of the smart AQM system - Data comparison with aquaculture agencies and industries across ASEAN region
7	**Universiti Teknologi Petronas (UTP), Malaysia** Address: Computer and Information Sciences, Faculty Science and Information Technology, Universiti Teknologi Petronas, Jalan Desa Seri Iskandar, 32610 Bota, Perak, Malaysia	
	Associate Professor. Dr. Toni A nwar (Main member) Email: toni.anwar@utp.edu.my, toni_anwar@yahoo.com	- Validation on network infrastructure and integration of the proposed SAM-IoT - Prepare Site for field test and implementation for proof of concept in Peninsular Malaysia
	Dr. Savita K Sugathan (Project Member) Email: savitasugathan@utp.edu.my	- Knowledge Management expert and analysis - Promote Greener IT in supply chain management adoption for the smart AQM system for related aquaculture industries

MILESTONES & ACTIVITIES

NO	MILESTONE	ACTIVITIES	COMPLETION DATE
1	Milestone 1: **COMPLETION OF INTEGRATED SENSORS, RFID & ENERGY HARVESTING BASED INFRASTRUCTURE**	• Upscaling embedded sensors & RFID with AQM requirements • Capture data frame through proposed prototype • To embed energy harvesting for power management system • Verification of AQM data to sensors & RFID performance	Month 6
2	Milestone 2: **COMPLETION OF EMBEDDED CONTROL FUNCTION TO THE PROPOSED SYSTEM**	• Embedding developed hardware & software according to adaptive AQM system requirements on a single data acquisition platform • Testing & validation of data transfer within the proposed platform in controlling & monitoring focusing on the aspects of fault & data security	Month 12
3	Milestone 3: **COMPLETION OF INTELLIGENT SOFTWARE, NETWORK & MOBILE APPLICATION WITH STATISTICAL APPROACH**	• Integration of back-end & data management system using the developed hardware & software system. • To integrate the proposed SAM-IoT system to WSN and Cloud platform with real time internet and mesh networking infrastructure for the whole development of the system for pilot testing. • Data synchronization & security including the setup of mobile network system • Testing, evaluating and finalizing the application (software, hardware, network and mobile apps) based on statistical approach	Month 24
4	Milestone 4 **COMPLETION OF PILOT TESTING & IMPLEMENTATION**	• Site preparation and installation considering coverage area, samples type and test specifications • To setup the complete infrastructures & networking of proposed SAM-IoT system at specified location • To measure, optimize and characterize the performance of the SAM-IoT system with IoT according to design specification • To validate the whole system with acceptance from potential users and feedback on market survey/oppurtunities	Month 32

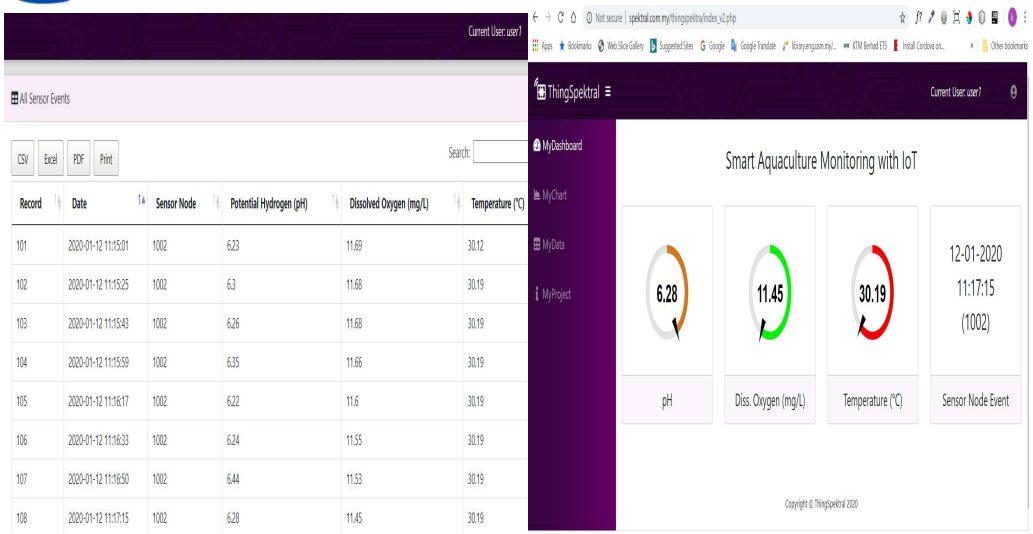
COMPLETED PROTOTYPE DEVELOPMENT

iSmartAqua Main Processing Unit

As Portable Unit iSmartAqua

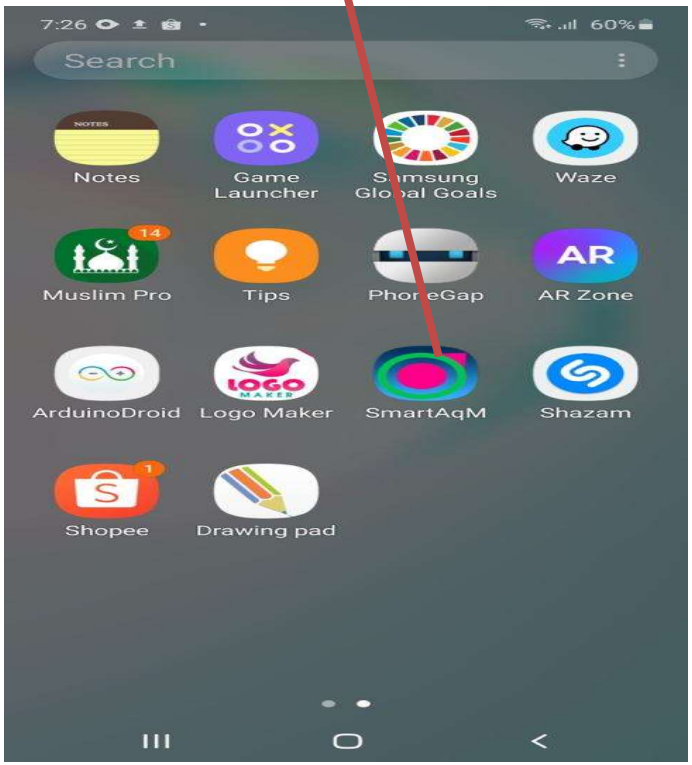
End node system

COMPLETED WEB & MOBILE APPS DEVELOPMENT

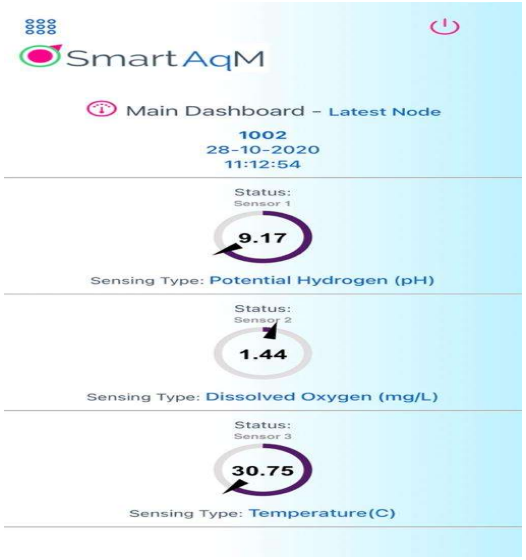


iSmartAqua web based system

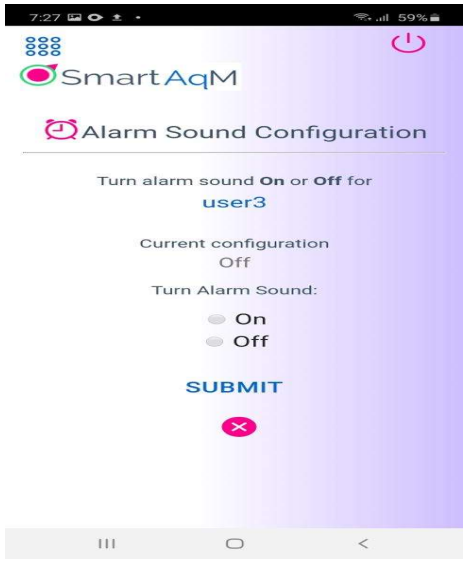
Mobile application at Google Playstore or iOS Application Store



Android and iOS based application



Main Dashboard Reading and Reporting

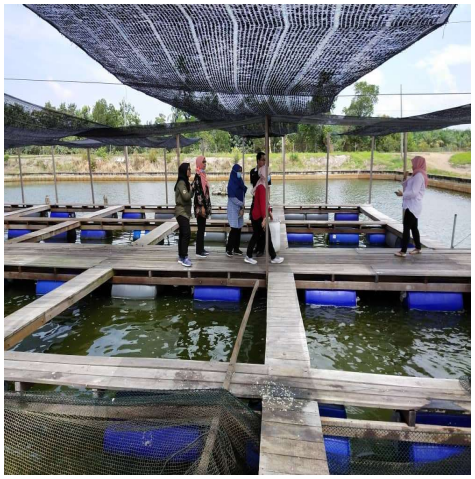


Alarm System Feature

MEETING, TRAINING AND KNOWLEDGE SHARING

Visit and meeting at iKerpan (integrated Kerpan), Arca Biru Sdn Bhd, a wholly owned subsidiary of Blue Archipelago Berhad, shrimp industry in Kedah on 12th. January 2020

Demo to NCIA, Malaysia at installed pond for potential commercial collaborations 15th October 2020



Visit with students to Fisheries Research Institute, Malaysia Fisheries Department, Johor, July 2020

Training at USM on 25th September 2020

PROTOTYPE AND SYSTEM INSTALLATIONS

Installation at DFJ Livestock Fish Pond, Bukit Selambau, Kedah, Malaysia, 15th. October 2020 (USM & MAMPU)

Installation at *Milkfish* Fish Pond in Kaliwungu, Kendal, Central Java, Indonesia on 26th October 2020 (UNISSULA)

Installation at RPH Pond, USM on 25th September 2020 (USM & MAMPU)

Installations at Lobster Pond in Kuala Kangsar, Perak, Malaysia on 25th October 2020 (UTP)

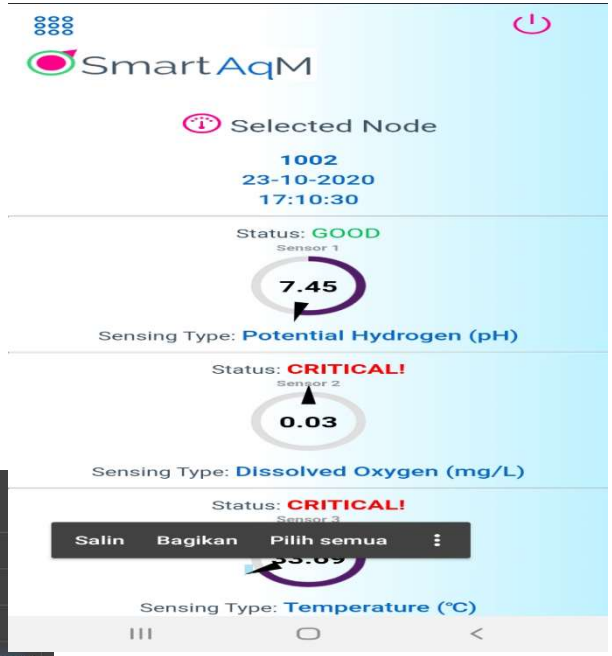
Installation at Fisheries Research Institute of Malaysia, Gelang Patah, Johor on 30th September 2020 (UTM)

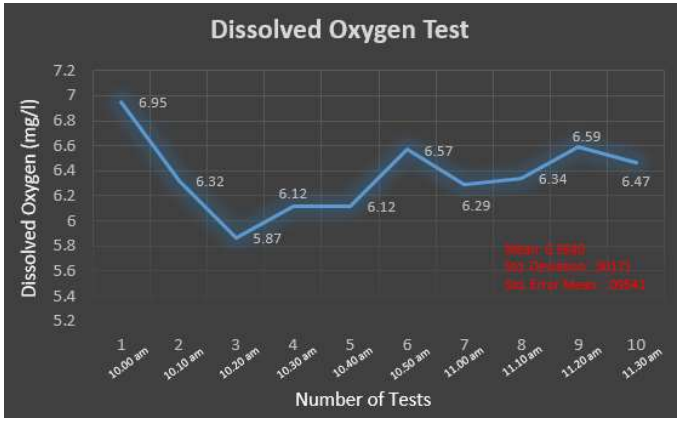
Installations Hatching Crab Culture Centre (Ban Hua-Khao), Singhanakorn, Songkhla, 26th. July 2019 (RUTS)

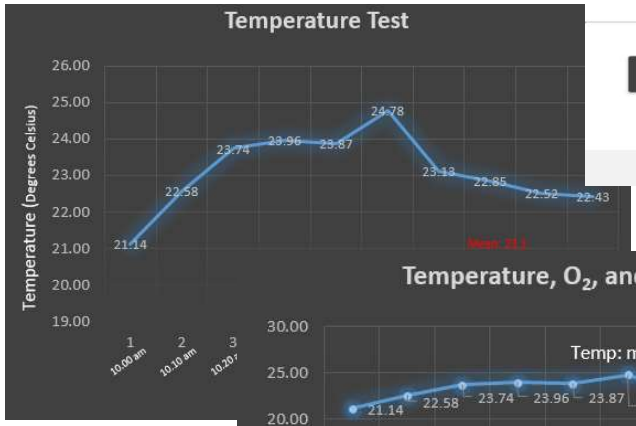
Results & Analysis

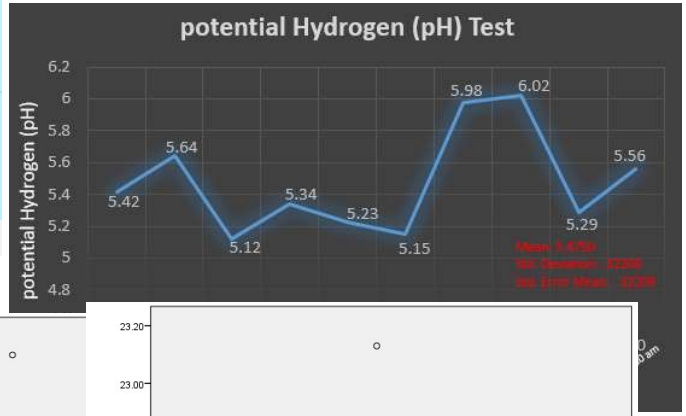
By UNISSULA, Indonesia

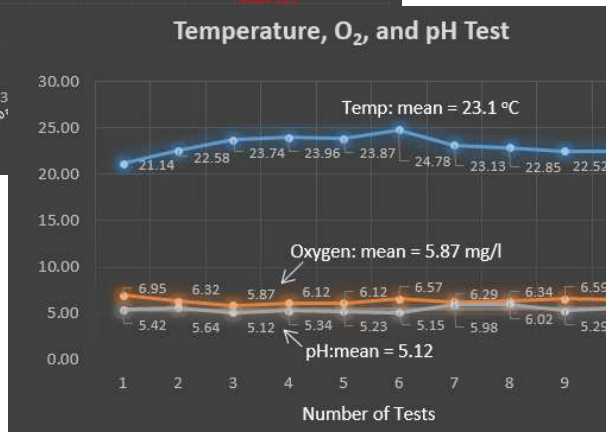
```
IP address: 192.168.43.32
OK
Initializing Iot Gateway to update cloud database...
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.69, pH:7.32, DO:0.49
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.69, pH:7.45, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.63, pH:8.21, DO:19.13
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.63, pH:6.94, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.50, pH:7.07, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.38, pH:7.17, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.25, pH:7.21, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.19, pH:7.14, DO:0.03
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.13, pH:8.14, DO:8.17
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.00, pH:8.21, DO:4.57
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):33.00, pH:8.24, DO:4.41
Authkey:L83wOuZ7D, SensorTag:1002, Temp(Celcius):32.75, pH:8.25, DO:8.65
```

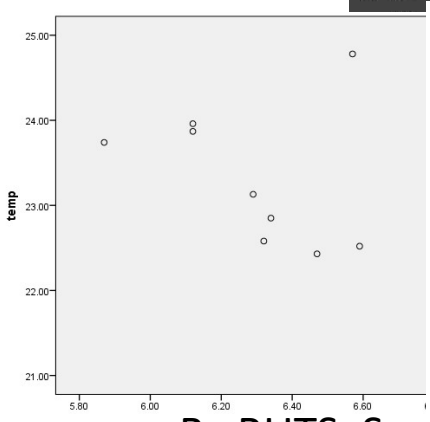


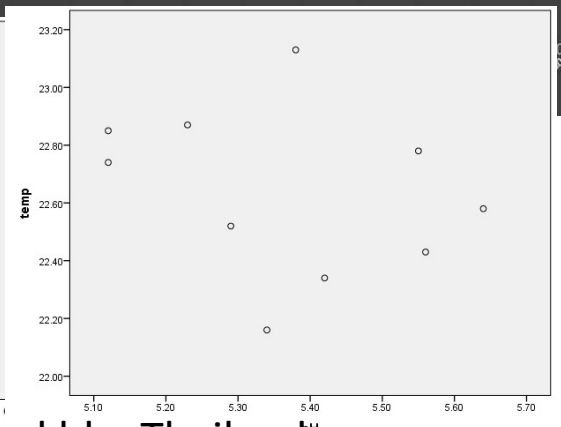






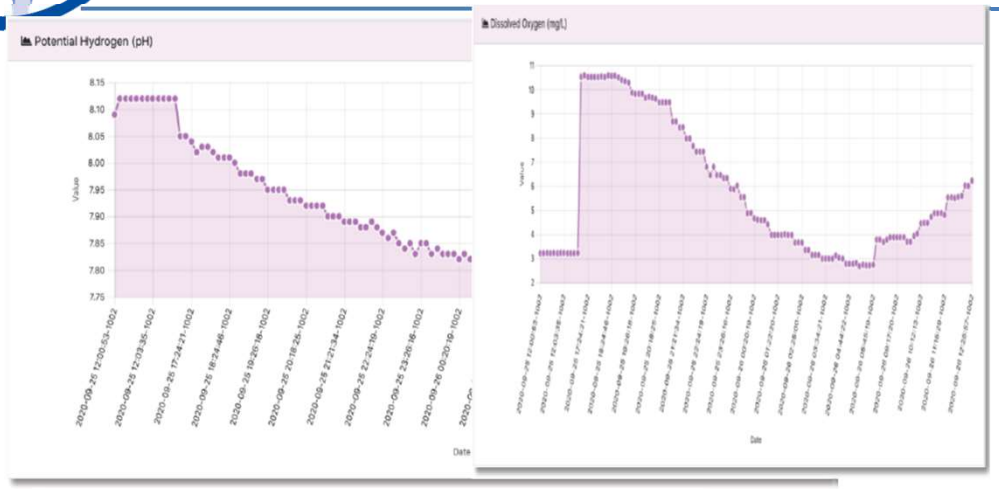


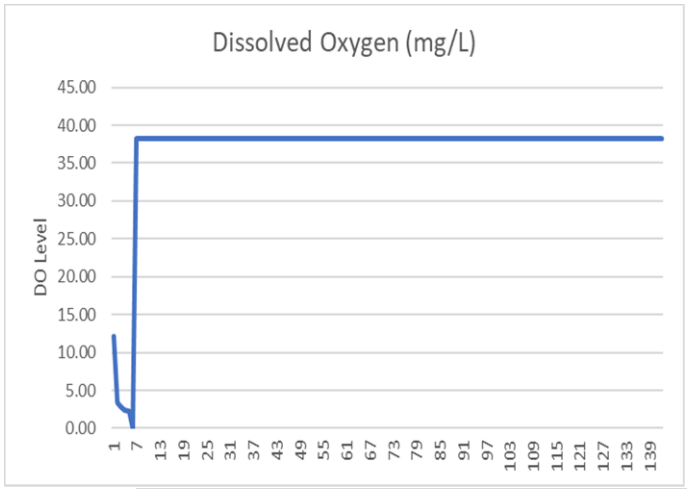


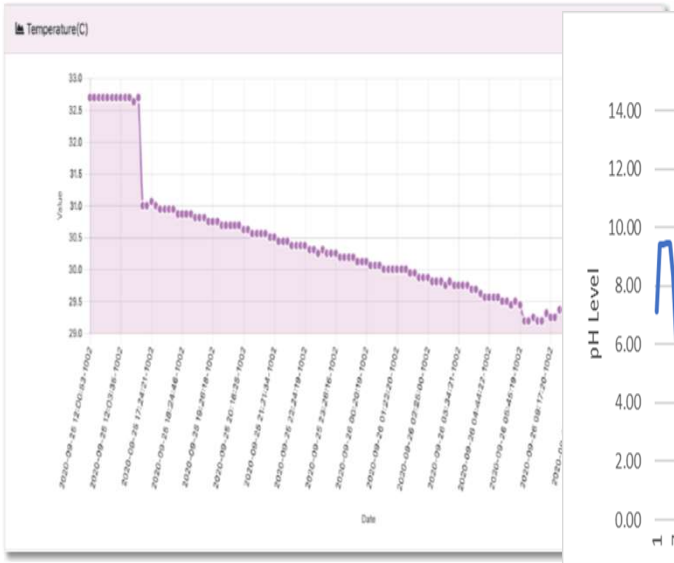


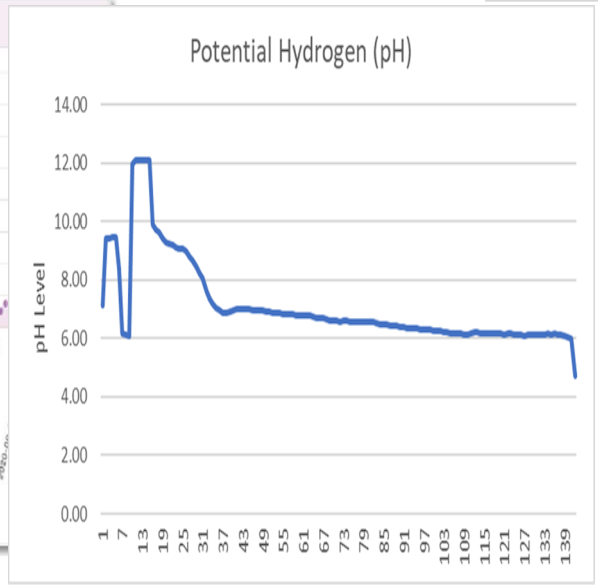
By RUTS, Songkhla, Thailand

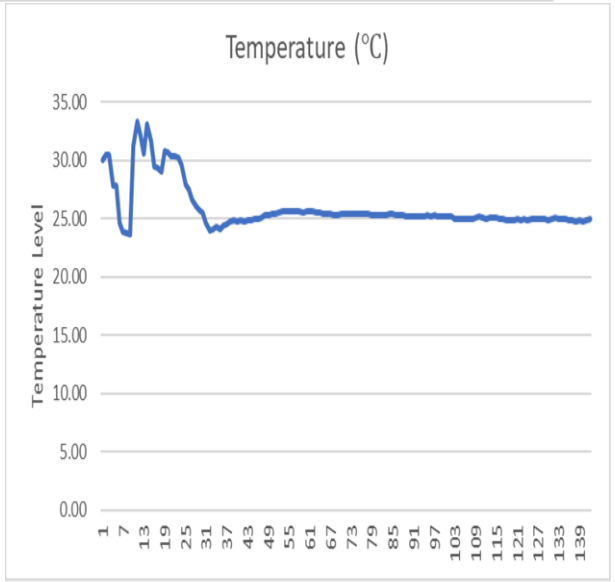
Results & Analysis











By USM, UTP, MAMPU & UTM (Malaysia)

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.	Smart Aquaculture Monitoring, Control and Predictive Analysis System with Internet of Things and Machine Learning	Toni Anwar	Universiti Teknologi Petronas	International Seminar Water and Environmental Management in Asia Challenges of Sustainable	23-28/03/20 , postponed to 2021	University of Sumatera Utara (USU), Kampus USU, Medan, 23-25 March 2020 and Parapat, Lake Toba 26-28 March (invited speaker)
2.	**Development of Smart Aquaculture Quality Monitoring (AQM) System with Internet of Things (IoT)**	*W. Ismail, Naoki Shinohara, Sevia Mahdaliza Idrus Sutan Nameh, Wasana Boonsong, Suryani Alifah, Kamarul Hafiz Kamaludin, Toni Anwar*	Universiti, Sains Malaysia, Kyoto University, Universiti Teknologi Malaysia, Rajamangala University Technology of Srivijaya, Universitas Islam Sultan Agung Semarang, Malaysian Administration Modernization and Planning Unit (MAMPU), Universiti Teknologi Petronas	2019 IEEE SYMPOSIUM ON ACOUSTIC, SPEECH AND SIGNAL PROCESSING (SASSP)	20/03/2019	Centre for Advanced and Professional Education (CAPE), Kuala Lumpur, Malaysia

Scientific Contribution:

The Published Journal Papers:

No:	Paper title:	Author names	Affiliation	Journal name:	The publisher of the Journal	The volume number and Pages
1.	REAL-TIME WATER QUALITY MONITORING OF AQUACULTURE POND USING WIRELESS SENSOR NETWORK AND INTERNET OF THINGS	WASANA BOONSONG, WIDAD ISMAIL , NAOKI SHINOHARA, SEVIA MAHDALIZA IDRUS SUTAN NAMEH , SURYANI ALIFAH, KAMARUL HAFIZ KAMALUDIN, TONI ANWAR	Rajamangala University Technology of Srivijaya, Universiti, Sains Malaysia, Kyoto University, Universiti Teknologi Malaysia, Universitas Islam Sultan Agung Semarang, Malaysian Administration Modernization and Planning Unit (MAMPU), Universiti Teknologi Petronas	Journal of Theoretical and Applied Information Technology	Journal of Theoretical and Applied Information Technology	Vol. 98

Innovation Award:

GOLD AWARD, "S-AQUA SMART AQUACULTURE CONTROLLING SYSTEM", INNOVATION, INVENTION & CREATION EXHIBITION 2019 (IICE 2019), UiTM PUNCAK ALAM, SELANGOR MALAYSIA, 7th. NOVEMBER 2019

Societal Impact:

IMPACT

1) Increase efficiency: **Percentage of aquaculture ponds being stopped or having downtime problem is reduced by at least 30 % due to automated monitoring transferred from the proposed technology**
2) Reduce process time: **Detection of aquatic health with alarming system through mobile application in real time to supervisors and workers at the pond**
3) Improve quality: **Improve monitoring of the aquatic pond in real time can prolong the aquatic lifetime thus improve the aquatic quality being delivered to end users.**
4) To increase revenue: **Percentage of aquatic productions per month is increased by at least 40%**
5) Reduce manpower: **Maintenance & operational cost reduction due to increase automation**

Conclusion:

Current findings:

1. **Scientific and technological** – Scientific knowledge on the aquaculture life sciences and cycle is very important to be matched to the requirements of the technological designs in solving the real problems by the aquaculture communities. All members studied on the different life sciences background at respective selected sites in each region. The iSmartAqua automation system enhanced with multi-platform to assist farmers and fishermen to monitor aquaculture productivity and quality and get resources to support the supply chain mechanism. This project underlies the improvement of aquaculture quality process, which is beneficial to economic development in community, society, and the country.
2. **Application (or system) development** – USM developed the Smart Aquaculture prototypes for the experiments and pilot testing according to the requirements by other members in the regions. The implementation of iSmartAqua at selected aquaculture farms in rural area promote and induces the benefits of broadband services and application services to people in rural areas and to underserved communities as part of Asean digital economy initiative.
3. **Experiments including field testing** – Prototype testing's have been conducted at 5 sites across 3 Asean countries with different aquatic lifes. Based on current observation, many agriculture and aquaculture industry players are capable to increase their mass production and ready to implement a high technology solution at their production site. However, current precision agriculture solution has limitation in their capabilities especially in their financial expenses for maintenance purpose. They need to allocate a huge sum of money either for the required product, training or manpower from solution provider. Therefore, a significant cost reduction is promising by adopting this innovation with local expertise support. We believe that their readiness in adopting this kind of high technology solutions of precision agriculture and aquaculture for better mass production is not doubtful.
4. **Aquaculture Community engagement** – The engagement involved non-profit and profitable organizations handling the production of sustainable aquaculture. IoT in aquaculture play a significant role in increasing the current aquaculture productivity to cater to the growing demand for food. Factors such as rise in global population, climate change effect and increase in demand for food across the globe have fueled the adoption of new technology to optimize the aquaculture production, this project are expected to boost the growth of the IoT in aquaculture market improve the farmers productivities.

Future prospects: Research Collaboration and Commercialization Activities

USM has signed collaboration for commercialization with iSmartUrus Sdn Bhd, a UTM Spin-off Company, while FRI Gelang Patah has issued letter of interest to acquire SmartAqua for the centre.

LETTER OF INTENT FOR CONSORTIUM COLLABORATION

Between

AUTO-ID LABORATORY, UNIVERSITI SAINS MALAYSIA

AND

ISMARTURUS SDN BHD

In line with the development of friendly collaboration in accordance with our interests in commercialization and business operation of '**Smart Aquaculture Water Monitoring System and Application (iSmartAqua)**' for the purpose of establishing a long term mutually beneficial association, **Auto-ID Laboratory, Universiti Sains Malaysia** and **iSmartUrus Sdn Bhd** (Co. no. 1057063A) an ICT solution and services company incorporated under the Companies Act 1965 in Malaysia, join in the following letter of intent. Both parties agree to deliver their best effort to develop the following form of cooperation:

1. **iSmartUrus Sdn Bhd** liaise with **Auto-ID Laboratory, USM** on matters pertaining to improve the iSmartUrus's water quality monitoring solution with the **Smart Aquaculture Water Monitoring System and Application** (a smart sensor system for monitoring aquaculture water quality) supported with Internet of Thing (IoT) platform and mobile application for efficient data management for iSmartUrus's clients.
2. Development, promotion, marketing and implementation of the SAWM system platform for commercial level execution with commitment value up to RM50,000.00 for the benefit of small and medium and large fishery farms in Malaysia and surrounding region. The sale and delivery will be under the memorandum of agreement (MOA) of iSmartUrus to Auto-ID Laboratory.
3. Promote mutual understanding on education, research, development and commercial collaboration in the area of sensor system, IoT and ICT solution between USM and iSmartUrus Sdn Bhd.

Both Auto-ID Laboratory and iSmartUrus Sdn Bhd are committed to working together to develop specific agreements on the points above. These agreements will provide logistical and management details appropriate to the successful process of the solution implementation and operation. These agreements will fulfil the spirit and purpose of this general letter of intent.

Signatories

SR MOHD SHAFIZAL ABDULLAH

24th July 2020
iSmartUrus Sdn Bhd
25 & 25A, Jalan Pulai Utama 26,
Taman Sri Pulai, Skudai,
81300, Johor Bahru, Johor, Malaysia.

PROF DR WIDAD ISMAIL

24th July 2020
Auto-ID Laboratory
School of Electrical & Electronic Engineering,
Engineering Campus, Universiti Sains Malaysia
14300, Nibong Tebal, Pulau Pinang, Malaysia.

JABATAN PERIKANAN MALAYSIA
KEMENTERIAN PERTANIAN DAN INDUSTRI MAKANAN
(Department of Fisheries Malaysia
Ministry of Agriculture and Food Industries)
BAHAGIAN PENYELIDIKAN AKUAKULTUR AIR PAYAU
(Brackish Water Aquaculture Research Division)
FRI GELANG PATAH
81550 GELANG PATAH
JOHOR DARUL TAKZIM

Telefon : 07-5101202
Faks : 07-5103015
Portal Rasmi : http://www.dof.gov.my
E-mel : pplap@dof.gov.my

Ruj. Kami : PRK.MAS(GP)100/19.JLD.2(1)
Tarikh : 26 Oktober 2020

Tuan Hj Mohd Shafizal Abdullah
Pengarah Urusan,
iSmartUrus Sdn. Bhd.
25 & 25A, Jalan Pulai 26,
Taman Pulai Utama, 81300,
Johor Bahru, Johor, Malaysia.

Assalamualaikum Tuan Haji,

Surat Tunjuk - Minat Pemasangan '*Smart Aquaculture Monitoring System Supported by IOT Platform (IoT-SAMS)*' : Produk Teknologi Usahasama iSmartUrus Sdn Bhd dengan Universiti Teknologi Malaysia dan Universiti Sains Malaysia Di Bahagian Penyelidikan Akuakultur Air Payau, FRI Gelang Patah, Johor.

Merujuk kepada sesi perbincangan dan demonstrasi pihak tuan yang dihadiri oleh Dr Najwa Abu Bakar, Pengarah Teknikal iSmartUrus bersama kumpulan penyelidik UTM pada 30 September 2020. Pihak kami bersetuju untuk menggunakan alat iOT-SAMS ini di empat kolam terpilih bagi tujuan kajian lapangan untuk meneliti kemampuan dan kecekapan alat bagi pelaksanaan di kolam-kolam lain.

2. Begitu juga merujuk kepada beberapa siri perbincangan dan pembentangan hasil kajian oleh Profesor Dr Sevia Mahdaliza Idrus dan pasukannya, kami sediamaklum produk IoT-SAMS ini adalah untuk memantau kualiti air kolam ikan dan udang secara jarak jauh dan automatik. Pihak kami yakin, cadangan menggunakan alat teknologi termaju seperti IoT-SAMS ini berpotensi untuk meningkatkan hasil keluaran penternakan ikan dan udang yang diusahakan secara moden.

3. Kami berbesarhati untuk berkerjasama dengan pihak tuan serta UTM dan USM dalam menyediakan kolam ternakan udang dan ikan untuk percubaan keberkesanan sistem tersebut bagi peningkatan kualiti ternakan ikan udang tempatan.

Sekian, terima kasih

" BERKHIDMAT UNTUK NEGARA "

Saya yang menjalankan amanah,

(AZMI BIN RANI)
Pengarah
Bahagian Penyelidikan Akuakultur Air Payau
FRI Gelang Patah

An interest for commercialization with Northern Corridor Implementation Authority (NCIA), Malaysia as Agri-business sector to accelerate economic growth in the four northern states of Peninsular Malaysia for collaboration with Ministry of Fisheries. Farmers from Indonesia also stated the interest for commercialization efforts.