IVO FORUM 2018, 26th - 29th November, Jakarta

A Scalable Distributed IoT Framework based on Mobile Robot Technology for High Performant Plants

NEC Solution Innovators, Ltd. (NES), Japan
NEC Vietnam Co Ltd. (NECVN), Vietnam
Hanoi University of Science and Technology (HUST), Vietnam
National Institute of Communication Technology (NICT), Japan and Singapore
Champasak University (CHAM), Lao

About **HUST**

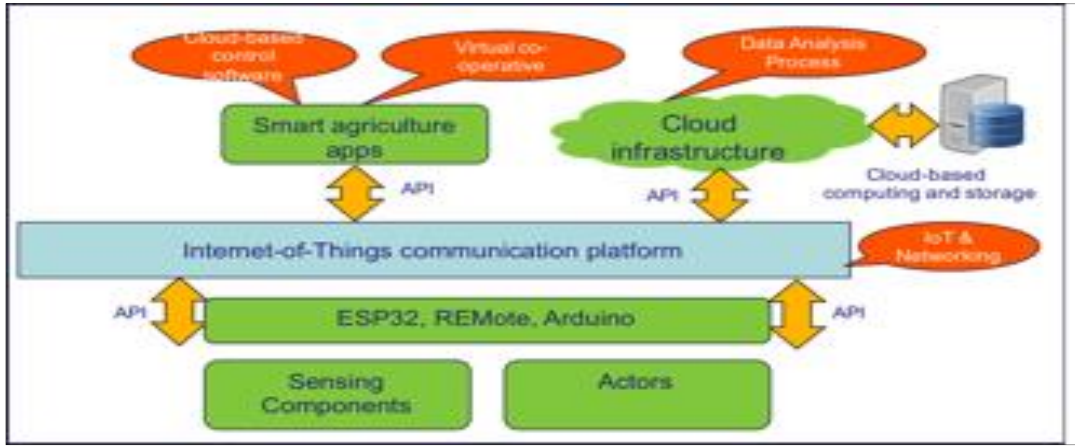
HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY

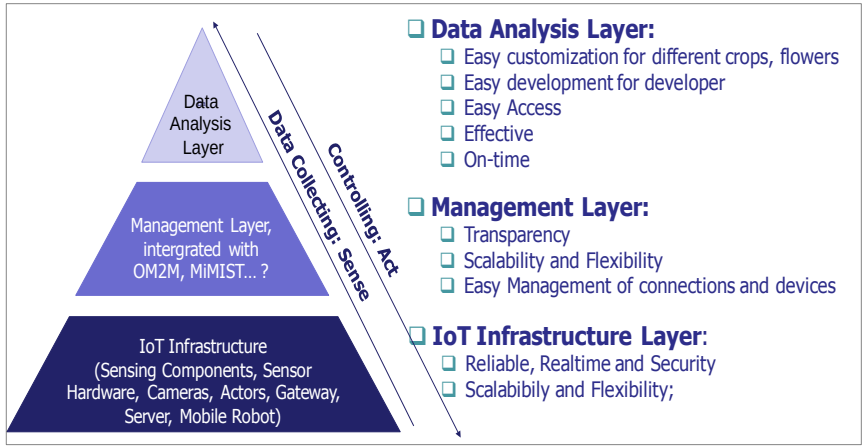
- Established in **1956**
- **45.000** students
- **2000** employees, including 1600 faculty members
- **27** schools and research institutes
- **One of the leading** technical universities in Vietnam

Project Title: Scalable Distributed IoT Framework based on Mobile Robot Technology for High Performance Greenhouse Plant

Introduction:

In this project, we aim to develop a Scalable and Distributed IoT Framework for Hydroponic Greenhouse in order to increase hydroponic production with following requirements: low cost, scalability, distributed, high performance and practical using. This 3-layers framework (data collect and control, management and data analysis) consists of following components: i) End-to-end IoT-based Infrastructure, integrated with a Mobile Robot (optional). ii) Transparent management component. iii) Cloud, Fog Computing and APIs. iv) Data Analysis.





Project Members:

- Thu Ngo-Quynh — Hanoi University of Science and Technology, HUST, Vietnam
- Tomoyuki KURODA — NEC Solution Innovators, NES, Japan
- Giang Nguyen-Linh — Hanoi University of Science and Technology, HUST, Vietnam
- Son Ngo-Hong — Hanoi University of Science and Technology, HUST, Vietnam
- Fumihide KOJIMA — National Institute of Information and Communications Technology, NICT, Japan
- Sonxay LUANGOUDON — Champasak University, CHA, Lao

Project's Overview (1)

- **Duration: 1st April 2018 - 30th September 2020**
- **Project's goal:**
  - Improving cultivating (hydroponic) production
  - Focus initially at Vietnam, then extend to other Asean (Lao…) countries
  - Bringing benefits for Vietnam and Asian farmers
- **For achieving this goal:**
  - Collaboration - important
  - Research – Development: also important
  - Considering the opportunity for commercialization
- **By developing ICT solution that is:**
  - **SCALABLE IoT FRAMEWORK,** associated possibly with **Mobile Robot Technology**
  - **DATA ANALYSIS PROCESSES**

Project's Kick-off Meeting – 1st Collaborate Activity

❑ July at Hanoi – 1st Collaborate Activity

- ❑ NES Japan, NEC Vietnam, HUST, NICT, Champasak University

→ Completing administrative formalities

→ **SURVEYING** (By Collaboration and Considering Commercialization)

→ **IMPLEMENTING** current testbed at HUST

(By Research and Development)

→ **CULTIVATING** crops at HUST (By Development)

→ **TRANSFERRING** testbed to LAO (By Collaboration)

→ **PUBLICATION** (By Research, Development and Collaboration)

CURRENT PROJECT'S STATUS - SURVEYING Vietnamese Market (1)

- **Researching Vietnam agriculture market:**
  - Market situation of greenhouse
  - Top the list of greenhouse cultivation (all/regional) → Targeting the crops for greenhouse cultivation
- **Researching IT solutions company in Vietnam**
  - The more widespread agriculture ICT
  - List of the agriculture venture with its business
- **Researching current issues of Vietnam agriculture**
  - Cultivation process
  - The issue of the current cultivation, and its solutions
- **Considering the possibility of commercialization of project**
  - Verifying the developed system for commercialization
  - Targeting the customers and considering sales strategy

CURRENT PROJECT'S STATUS - SURVEYING Vietnamese Market (2)

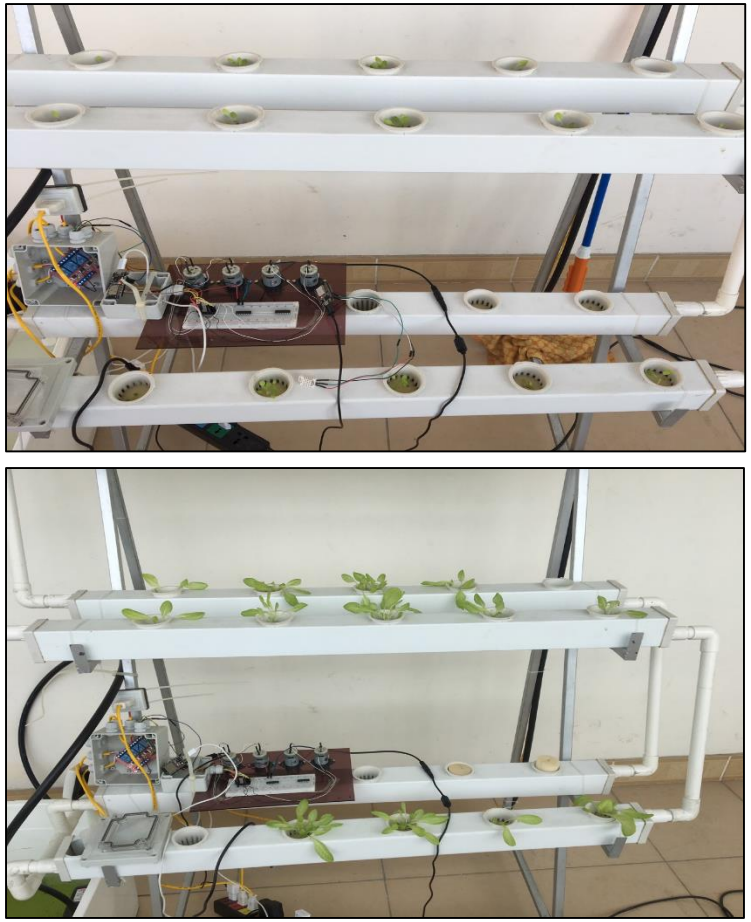
- **The issues of Vietnamese cultivation process:**
  - Surveying irrigation processes
  - Surveying nutrients/fertilization/bio-product processes
  - Surveying environment's monitoring processes
  - Surveying anomalies detecting processes
- **Then determining requirement of the system:**
  - **2nd Collaborate Activity: Meeting through TV Conference System at Hanoi on 1th November**

→ DECIDED TO FOCUS ON HOME CULTIVATION (HOME GARDEN)

→ CONTINUE TO DETERMINE REQUIREMENTS OF THIS SYSTEM

CURRENT PROJECT'S STATUS – CULTIVATION (1)

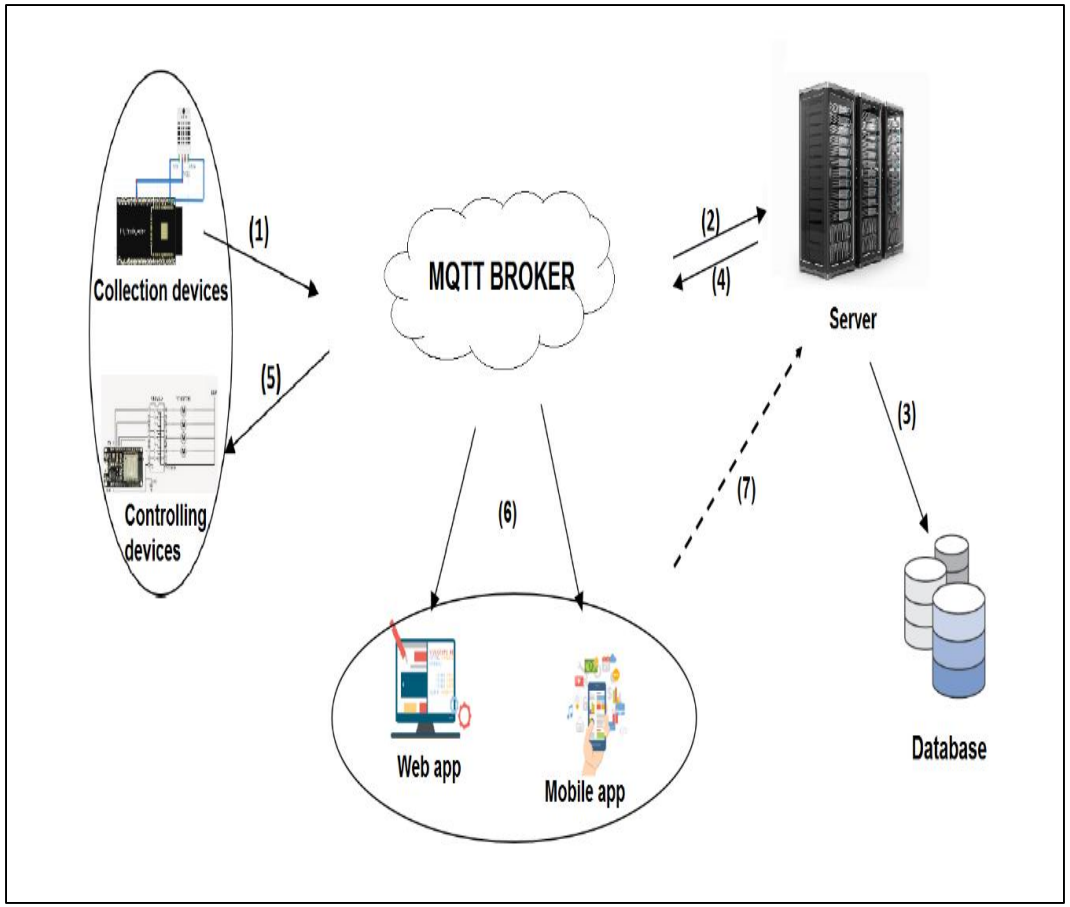
- **Dynamic Hydroponic Cultivation at HUST:**
  - → Selected crops: salad
  - → Current testbed implemented at B1-901 HUST
- **Salad requires following conditions:**
  - → Temperature: 15-18^{o}C
  - → pH: 6-6.5
  - → CO1: 1000→1500ppm
  - → Humidity: 65-75%
- **If unsatisfied environment's conditions:**
  - → pH>7 → leafs become yellow
  - → Temperature>22^{o}C → leafs become yellow
- **Future Cultivation: Static Hydroponic**



Cultivating Salad

CURRENT PROJECT'S STATUS – IMPLEMENTING TESTBED at HUST (1)

- **A Hydroponic Testbed**
- **Receive** pH, humidity, temperature
- **Automatically control** light, fan and irrigation systems
- **Integrated** also with Markov process for saving water
- **MQTT protocol utilizing publish/subscribe mechanism is selected**
- Collecting: MQTT, thus, reliable
- Contol: MQTT, thus, reliable
- Small size

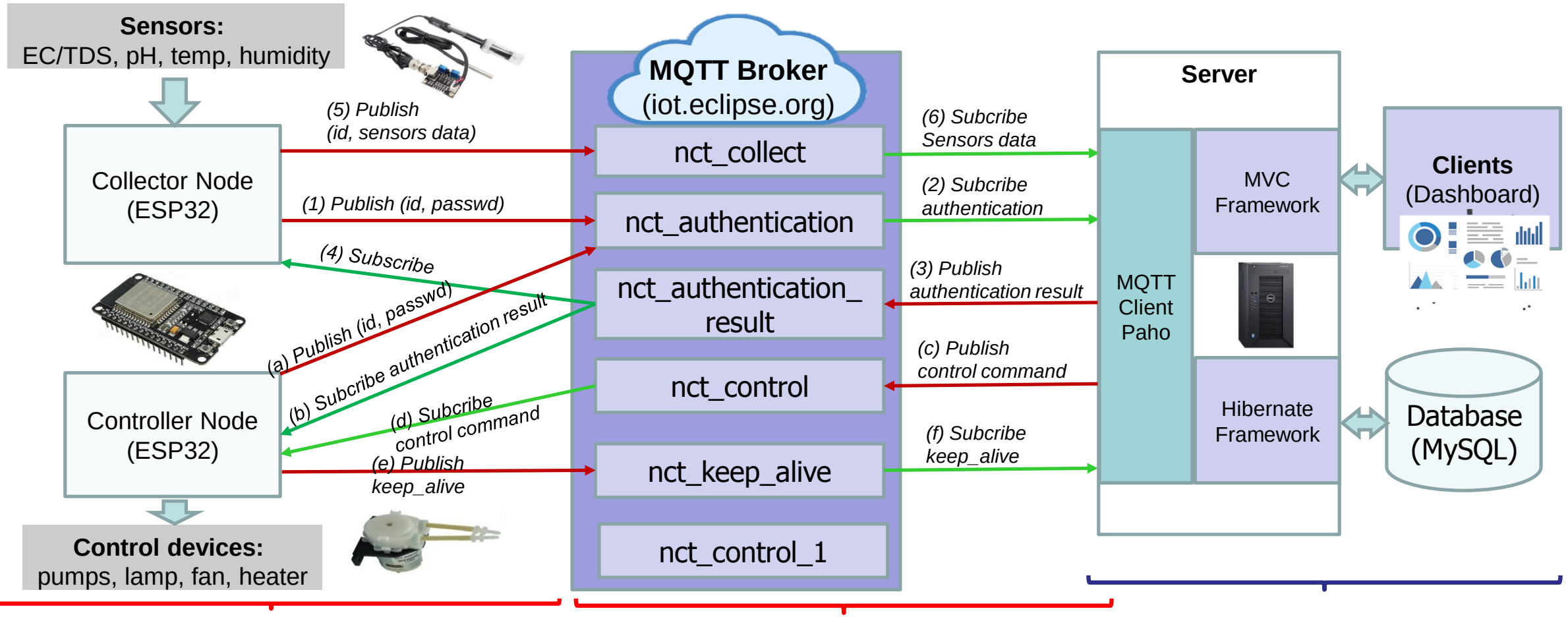


System's Architecture

CURRENT PROJECT'S STATUS – IMPLEMENTING TESTBED at HUST (2)

- **Testbed** implemented at HUST B1-901 consists of:
  - → Sensing components: pH, humidity, temperature, TDS/EC
  - → Collecting part: ESP32, Free RTOS
  - → Control part: ESP32
  - → Actor system: lights, fans, pump systems (4 drip small pumps) and one pump
- **MQTT protocol** for exchanging message
  - → In 2 directions (control and collecting)
  - → Publish/subscribe: 6 topics
  - → MQTT Broker: Paho Eclipse
  - → MQTT clients: MQTT Mosquito
- **Topics:**
  - → nct_authentiacation, nct_authentication_result
  - → nct_collect, nct_keep_alive
  - → nct_cpntrol, nct_control_1

CURRENT PROJECT'S STATUS – IMPLEMENTING TESTBED at HUST (3)



Part 1: Collector node, controller node:
- Firmwares worked, adding new sensors
- Prototyped hardware => need to design hardware pcb, box (for stable working)

Part 2: Mqtt broker – Server Communication:
- Need to re-design communication protocol/scenarios (keep stable in realtime)

Part 3: Web server app
- Storing, representing data (OK)
- Management
- Command (control)

CURRENT PROJECT'S STATUS – IMPLEMENTING TESTBED at HUST (4)

- **Part 1 - Collector node, controller node:**
  - → Firmwares worked, adding new sensors
  - → Prototyped hardware => need to design hardware pcb, box (for stable working)
- **Part 2: MQTT Broker – Server Communication:**
  - → Need to re-design communication protocol/scenarios
  - → Keep stable in real-time
- **Part 3 - Web server app**
  - → Storing, representing data (OK)
  - → Management
  - → Command (control)
- **Collecting data: reliable because of MQTT/TCP/IP/Wifi**
- **Control data: reliable only because of MQTT/TCP/IP/Wifi**

CURRENT PROJECT'S STATUS - Collaborating Activities (1)

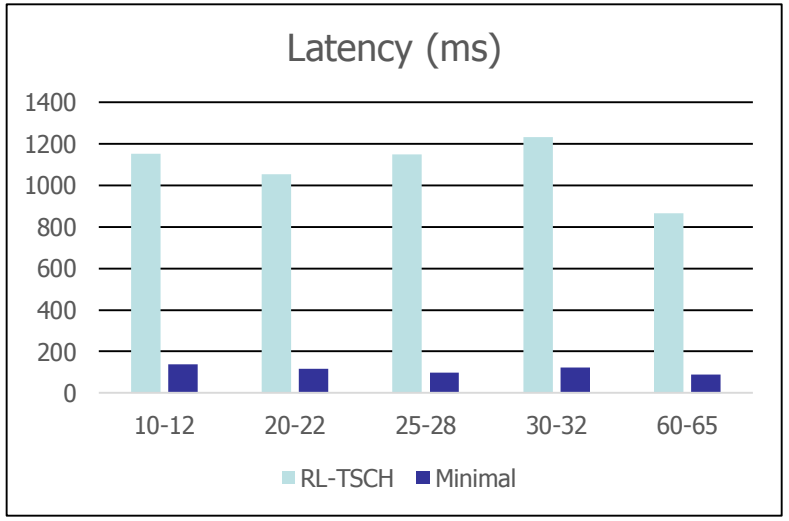
- **1st Activity - Kick-off Meeting, Hanoi**
- **2nd Activity - Meeting on 1st November, Hanoi**
- **3rd Associated Activity - Meeting on 25th-27th Sep, Hanoi**
  - → Associated with meeting of IVO Project - Open Innovation Platform at HUST
  - → Introduction on IoT Solutions, applied possible for Agriculture for Lao people
  - → Introduction on an IoT Open Innovation Platform for Lao people
- **4th Activity - Meeting on 24th Nov, Hanoi**
  - → Introduction of MQTT, MVC, SOA, Hibernate
  - → Introduction of Hydroponic Cultivation
  - → Implementation of System for Lao people
  - → Discussing on possible future implementation at Lao

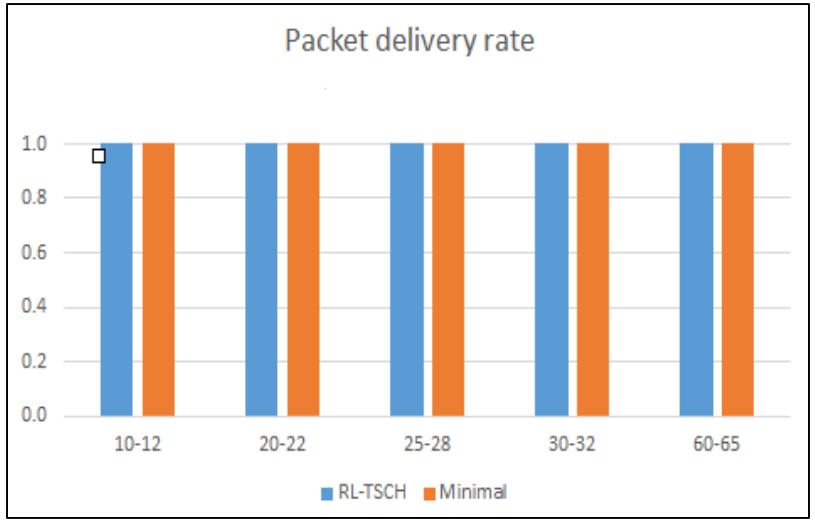
CURRENT PROJECT'S STATUS – Joint PUBLICATION (1)

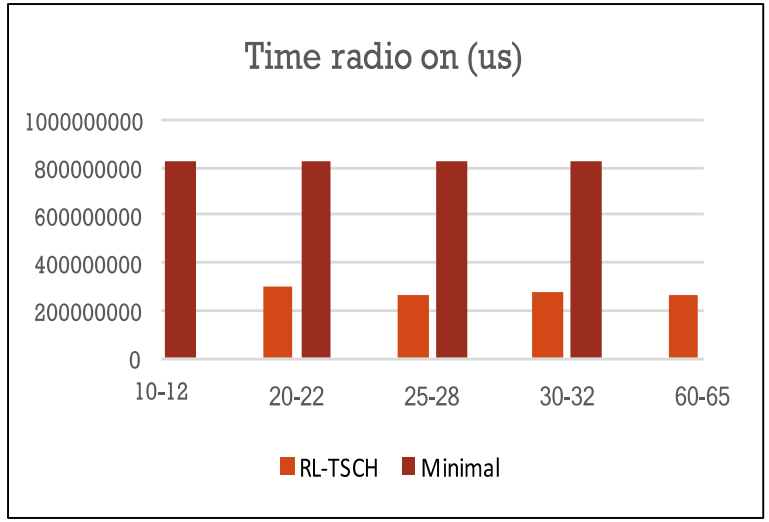
- **Current Testbed:** ESP32, 2 piece for collect/control separately of 1 hydroponic scaffold
- **For minimizing price** → future design: 1 ESP32 for collecting/control together
- **ESP32 needs to be** always ON for receiving control signal from server

→ Power Consumption is high

→ Design of Markov-based Machine Learning Algorithm for Low-Power Low Cost WSN (802.15.4e)

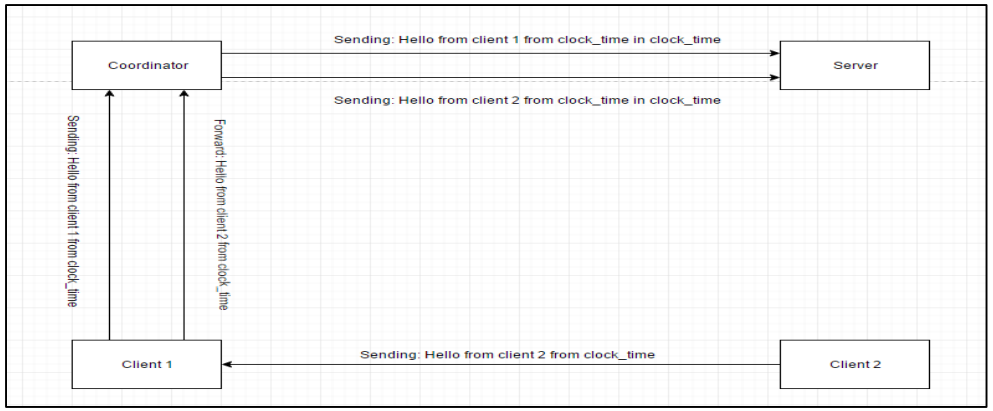


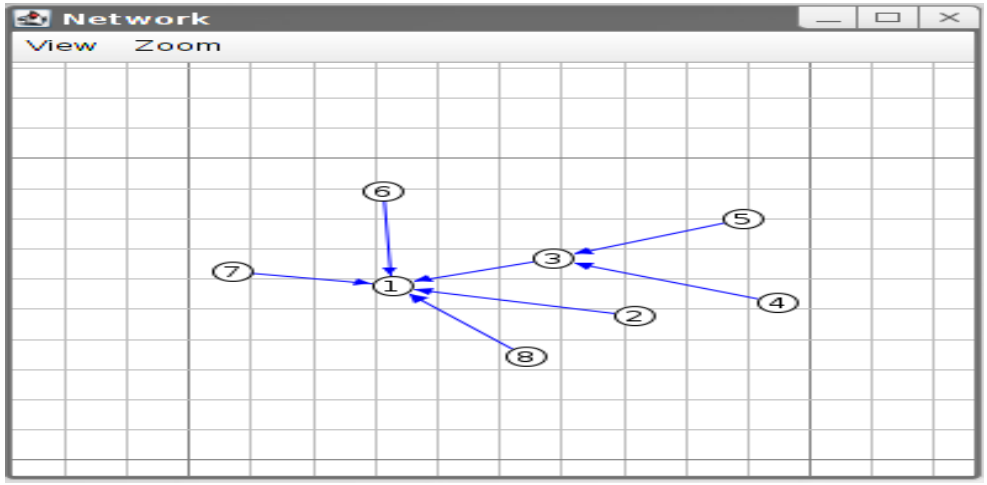




CURRENT PROJECT'S STATUS – Joint PUBLICATION (2)

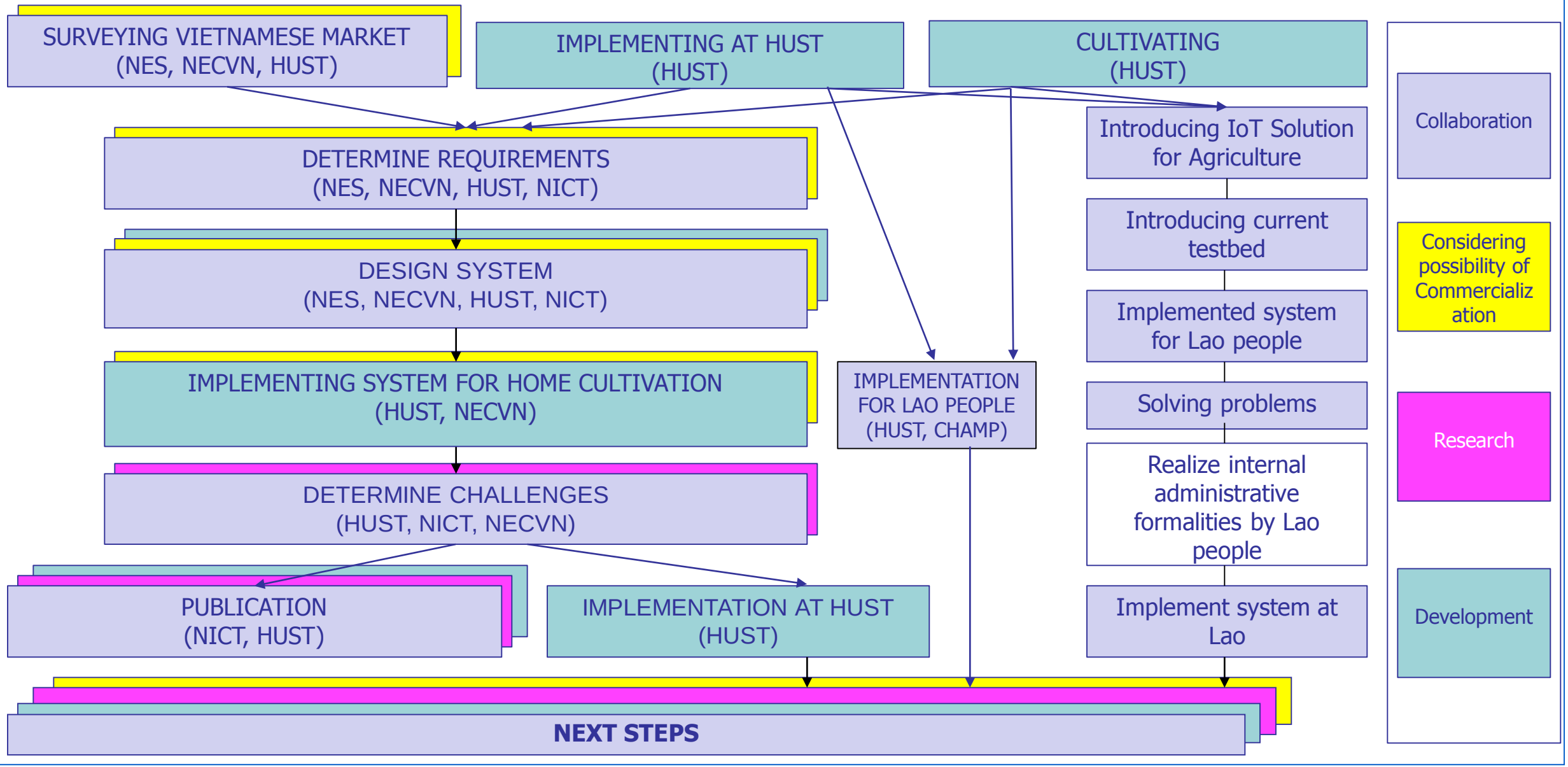
- **Minimizing:**
  - → Power Consumption, Providing reliability
  - → Adaptively to application's traffic
- **Based on** 802.15.4e and TSCH/Contiki
- **Zolertia RE-Mote**
- **Algorithm implemented:**
  - → Cooja/Contiki simulation
  - → Real RE-Mote nodes
- **FUTURE CHALLENGES:**
  - → Minimizing energy consumption for easy plug and play home cultivation
  - → Synchronization for Wireless Sensor Networks for implementing system in big farming area





Implementation with RE-Mote and Contiki/Cooja

PROJECT'S DIAGRAM – 1st Year



Thank you very much and any questions?