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

Background :

1. The transition from traditional agriculture economy to the **knowledge-based, information agriculture economy,** bases on **intellectual capital** and focus on rapid evolution, innovation, high efficiency and global scope!
2. **Information and knowledge** are **the core of many difficult controlling problems with high value** that all vietnamese (and possibly also asean) farmers now still cannot solve at their farms!

Targets:

1. For bringing benefit to Vietnamese farmers, designing controlling solutions, integrated easily for all farmers.
2. And by **collaborating, researching/developing** and **considering the opportunity for commercialization** in order to apply many new core technologies of Big Data, IoT, AI and Agriculture areas at the same time
3. Focus initially at Vietnam, then extend to other Asean countries

Speaker:

Project's Leader: Assoc. Prof. Thu Ngo-Quynh, thunq@soict.hust.edu.vn, +84 - 912528824
School of Information and Communication Technologies (SoICT)
Hanoi University of Science and Technology, Vietnam (HUST)

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

Project Members :

1. **NEC Solution Innovators, Ltd., (NES) Japan, members:**
   a. Mr. Tomoyuki Kuroda (TK) and colleagues
   b. NEC Vietnam Co Ltd., (NECVN), Vietnam:
      I. Members: Mr. Luyen Xuan-Tien (LXT) and colleagues
2. **HUST/SoICT, Vietnam:**
   a. Assoc. Professor Thu Ngo-Quynh and students
   b. Dr. Linh Dang-Tuan and Dr. Toan Nguyen-Duc and other
3. **CHAMP, Lao, members:**
   a. Sonxay Loungoudon and colleagues
4. **NICT, Japan:**
   a. Mr. Fumihide Kojima
   b. Mr. Hiroshi EMOTO

Project Duration:

From April 2018 to September 2020

Project Budget:

96.000 USD

Project Activities: 1st year

1. HUST/SoICT and NES and NECVN surveyed Vietnamese agriculture market:
   a. It is important to classify different types of vietnamese farmers
   b. It is also important to repeat this survey continuously many times during project's period
2. Then, HUST/SoICT and NES and NECVN focused on the 1st type (Home Cultivation at Vietnamese big cities):
   a. HUST/SoICT and NES and NECVN surveyed and considered the opportunity of commercialization of control solutions for Home Cultivation clients at Hanoi
   b. HUST/SoICT develop mechanisms and NICT comments on Markov-based Machine Learning Algorithm for Low-Power Low Cost WSN (802.15.4e) in order to minimize power consumption and to improve reliability adaptively to traffic. **This cannot applied to the real application because of unreliable property of protocol stack. Names of CHAMP were added as co-author without any contribution.**
   c. HUST/SoICT developed under NES's orientation: using ESP32 board with FreeRTOS operating system, MQTT/TCP/IP/802.11 for designing a low-cost and simple algorithm for controlling pH, EC levels in order to reach to target.
3. HUST/SoICT transferred the 1st version of Home Cultivation system to CHAMP November 2018

Project Activities: 1st year

1. Then, HUST/SoICT and NES and NECVN switched to the all rest types of Vietnamese farmers and continued to survey:
   - ✓ Vietnamese farmers do not know how to control at their greenhouses and open-field
   - ✓ Vietnamese farmers have to ask/buy this knowledge with high cost of technology transfer
   - ✓ But because of the diversity, complexity and heterogeneity of this control knowledge, this control knowledge still cannot work and provide appropriate production to farmers

Project Activities: 1st year (1)

2. HUST/SoICT and NES and NECVN: in order to overcome the diversity, complexity and heterogeneity of this control knowledge of all farmers:

- ✓ Then it is important to select appropriate greenhouse where data collected can be used for developing control solution
- ✓ Then it is important to collect data as much as possible precisely at this greenhouse
- ✓ Then it is important to analyze growth of plants
- ✓ Based on data collected, then it is important to design the control solution, applicable for all farmers at greenhouse
- ✓ By applying new core technologies of IoT/Agriculture/AI/Big Data at the same time
- ✓ So that:
  - ✓ Our control solutions can help to overcome the difficulties of all farmers while controlling at their greenhouses
  - ✓ Our control solutions can be integrated easily to current systems of farmers

R&D results: 1st year – Achievement (2)

1. HUST/SoICT developed mechanisms and NICT comments on Markov-based Machine Learning Algorithm for Low-Power Low Cost WSN (802.15.4e) in order to minimize power consumption and to improve reliability adaptively to traffic. Names of CHAMP were added as co-author without any contribution.

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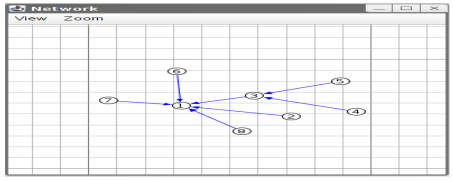
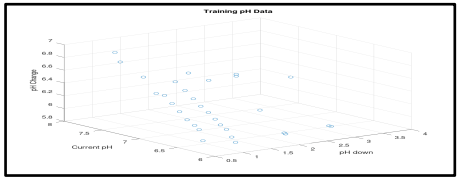
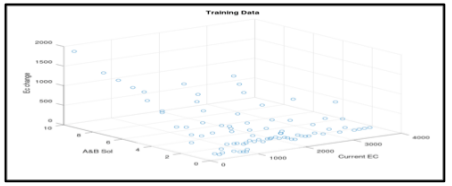
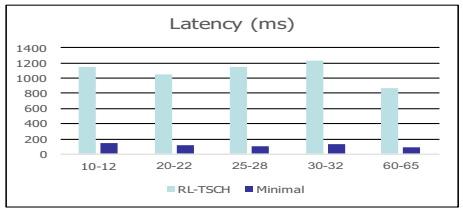
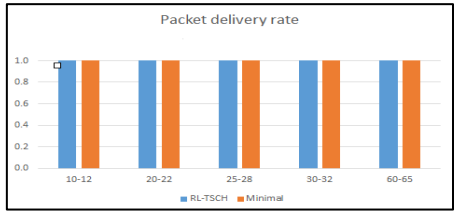
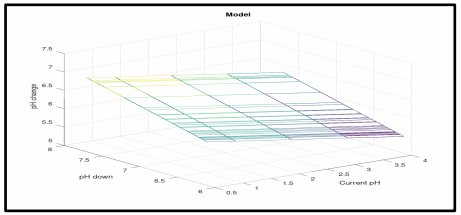


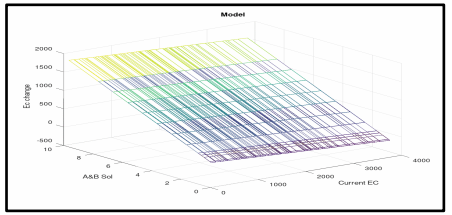




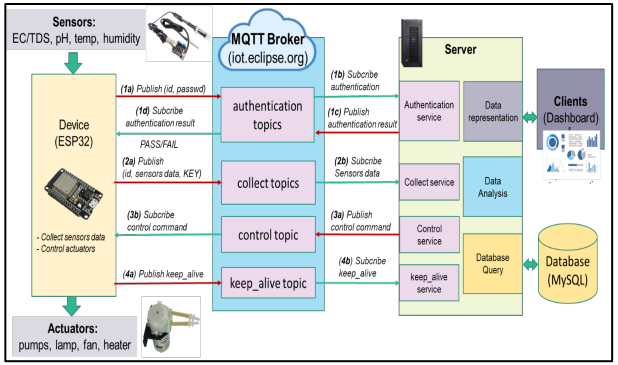


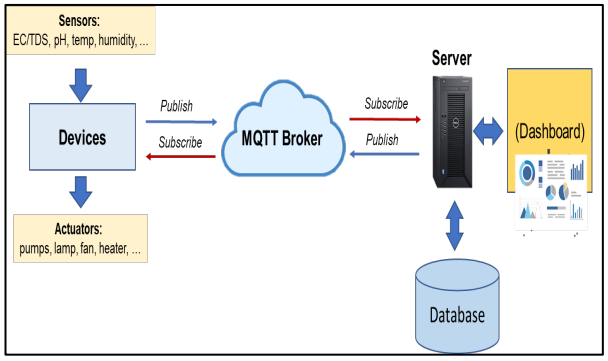


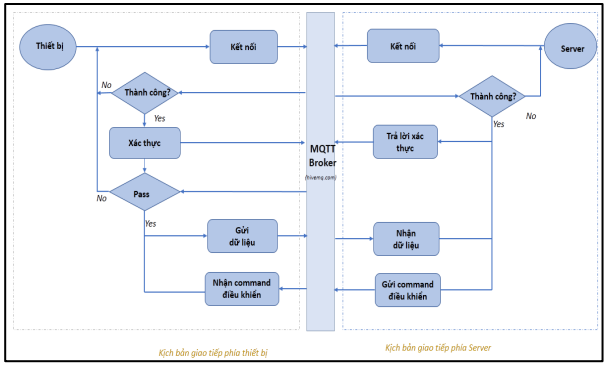




3. HUST developed Automatic Control Solution for Home Cultivation clients at big cities:







R&D results: 2nd and 6 months (1)

1. HUST/SoICT and NES and NECVN: in order to overcome the diversity, complexity and heterogeneity of this control knowledge of all farmers:

- ✓ Then it is important to select appropriate greenhouse where data collected can be used for developing control solution
- ✓ Then it is important to collect data as much as possible precisely at this greenhouse
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- ✓ So that:
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  - ✓ Our control solutions can be integrated easily to current systems of farmers

R&D results: 2nd and 6 months – Achievement (2)

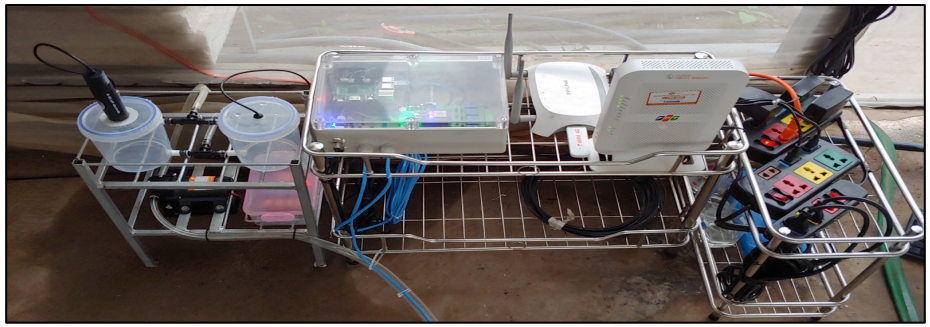
2. Under NES's orientation, HUST/SoICT and NECVN started data collecting period of cabbage:
   a. HUST/SoICT and NECVN spent 3 months (September to December 2019) for getting the acceptance of greenhouse
   b. HUST/SoICT designed the collecting data system (5 parameters and images of cabbage) and implemented stably at greenhouse: 6 weeks (between December 2019 and January 2020), but still not precisely
   c. TNQ, HUST/SoICT could not continue to collect data because of different reasons of external environment conditions:
      - ✓ Heavy rain and flooding at greenhouse (New year Lunar holiday 2020)
      - ✓ Difficulties of 2 gap periods of Covid at Hanoi
      - ✓ The roof of greenhouse is damaged due to heavy rain during June and July
      - ✓ Hot period of summer during July, August, September 2020 (greenhouse stopped to cultivate cabbage)

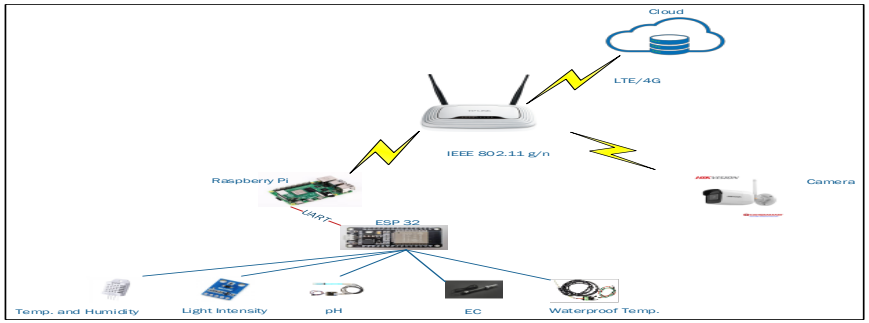
R&D results: 2nd and 6 months – Achievement (3)

3. So, HUST/SoICT continued to re-collect data again starting from September 2020 (after a gap period of 8 months between January and September 2020 due to external conditions):
   a. HUST/SoICT: collected successfully, stably and precisely data (parameters, images of cabbage)
   b. HUST/SoICT: developed and will continue to develop new optimized control solutions for minimizing controlling cost:
      - ✓ Oriented to farmers at greenhouse and open-field
      - ✓ Modelling the variations of pH-eC at all greenhouse and open-field
      - ✓ Then designed optimized solution for controlling threshold of pH-eC under different requirements of farmers
      - ✓ Submitted patents
   c. HUST/SoICT: developed and will continue to develop new AI technologies for extracting cabbage's growth based on collected images
      - ✓ Oriented to farmers at greenhouse and open-field, cultivating of cabbage
      - ✓ Designed new AI technologies (based on neural network with CNN, ResNet and many calibration algorithms for image processing)
      - ✓ Writing journal

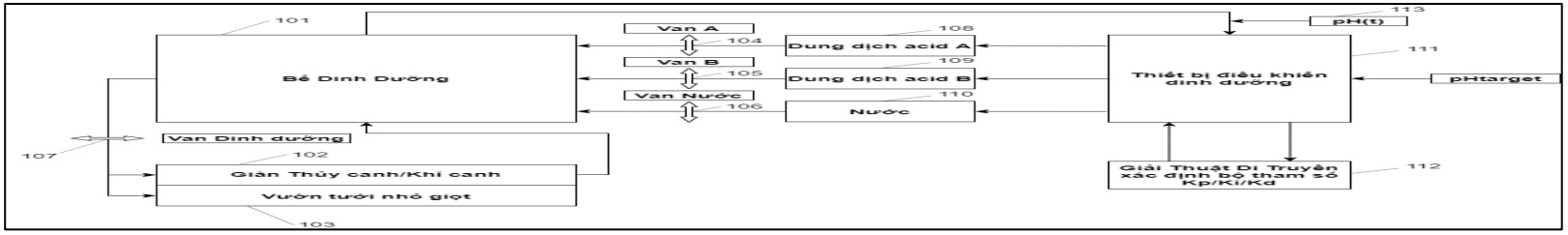
R&D results: 2nd year and 6 months – Achievement (4)

1. HUST/SoICT's data collecting system:

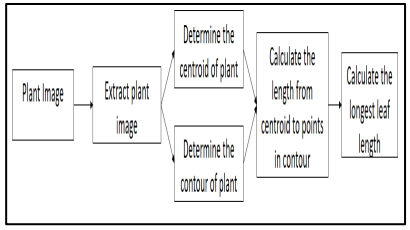


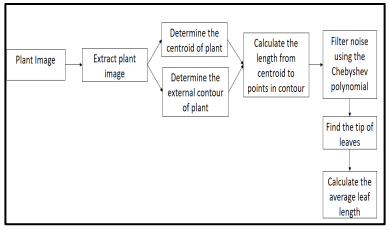


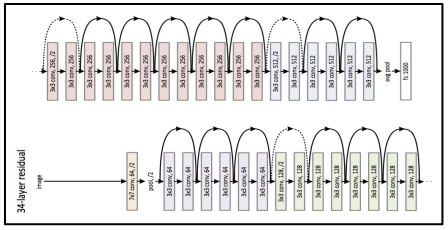
2. HUST/SoICT)'s developed new optimized control solutions:

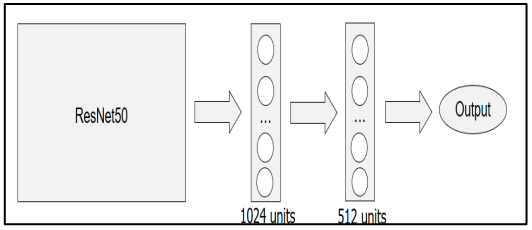


3. **HUST/SoICT** developed new AI technologies for extracting growth of cabbage based on collected images



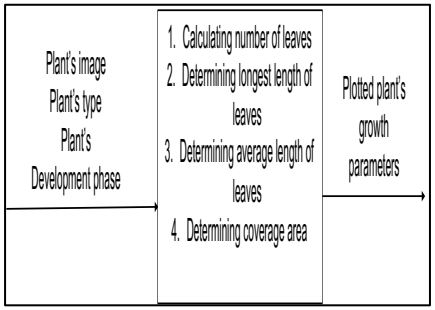


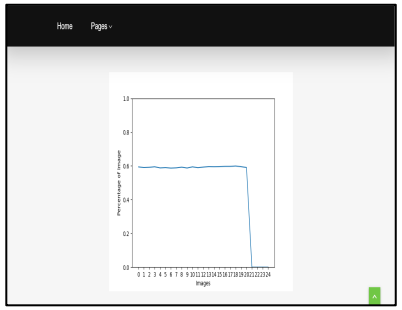


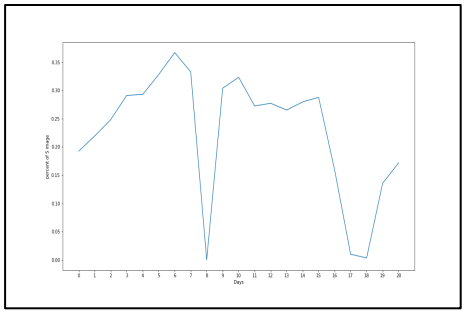


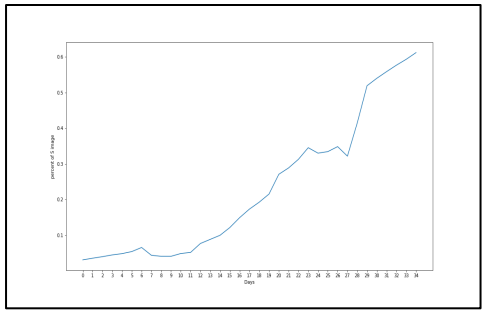
R&D results: 2nd year and 6 months – Achievement (5)

4. HUST/SoICT developed an application for extracting cabbage's growth:

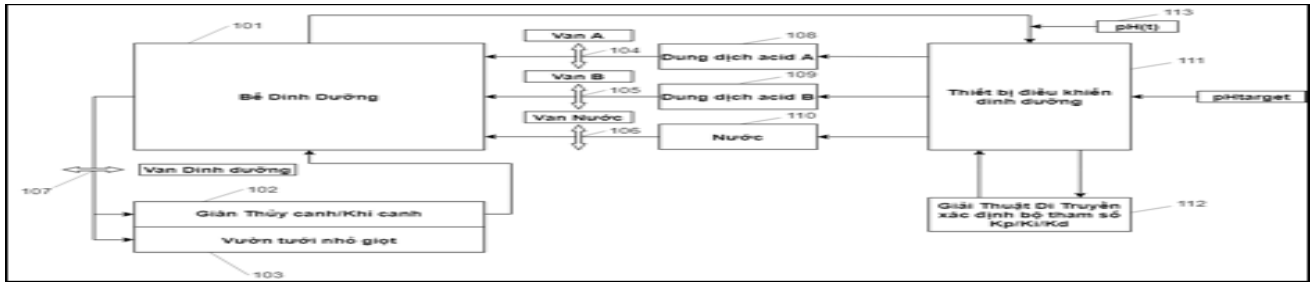




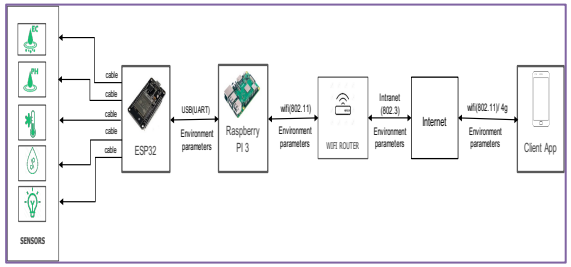


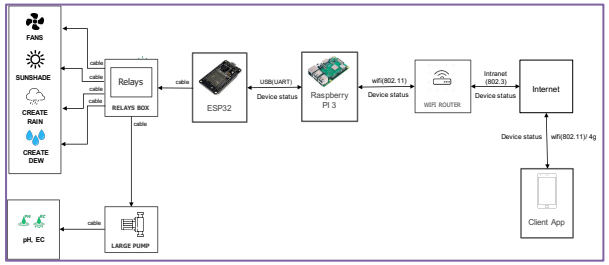


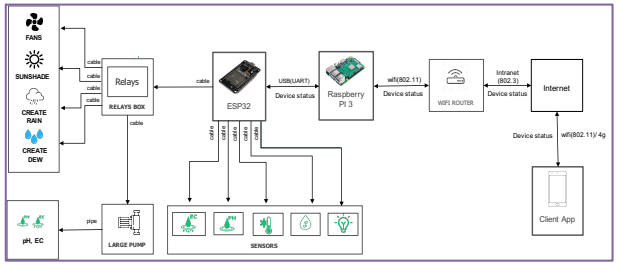
5. HUST/SoICT developed control solution for farmers at open-field and greenhouse



6. HUST/SoICT developed control solution for farmers at greenhouse







R&D results: 2nd year and 6 months – Achievement (6)

7. HUST/SoICT considered the opportunity for commercialization, surveyed the market continuously many times

Scientific Contribution:

The presentations at International Conference:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1	RL-TSCH: A Reinforcement Learning Algorithm for Radio Scheduling in TSCH 802.15.4e	Thu Ngo-Quynh, Toan-Nguyen Duc, Fumihide Kojima	HUST/SoICT, NICT	ICTC 2019	2019	Jeju, Korea
2	Nutrient Control Mechanisms for Hydroponic System based on Internet of Thing Technologies	Katsuhiko Kobayashi, Mizuho Saeki, Thu Ngo-Quynh, Hung Pham-Ngoc…	NES, HUST		2019	Lao

The Published Journal Papers:

The Submitted Patents:

1. Optimized control solution for farmers utilizing nutrients solution
2. Writing patents based on new AI technologies for extracting growth of cabbage
3. Writing new optimized control solution

Conclusion:

1. Scientific and technological while considering the opportunity for commercialization:
   - ✓ HUST/SoICT developed mechanisms and NICT comments on Markov-based Machine Learning Algorithm for Low-Power Low Cost WSN (802.15.4e) in order to minimize power consumption and to improve reliability adaptively to traffic.
   - ✓ HUST/SoICT developed under NES's orientation: using ESP32 board with FreeRTOS operating system, MQTT/TCP/IP/802.11) for designing a low-cost and simple algorithm for controlling pH, EC levels in order to reach to target
   - ✓ HUST/SoICT developed optimized control solutions for farmers at greenhouse and open-field
   - ✓ HUST/SoICT developed new AI technologies for extracting growth of cabbage cultivated by hydroponic and also by soil for farmers at greenhouse and open-field
2. Technology transfer:
   - ✓ HUST transferred the 1st version of Home Cultivation system already to CHAMP at Hanoi.

Future prospects:

1. Scientific and technological and considering the opportunity for commercialization :
   - ✓ Continue to research and develop control solution for pH-eC at all greenhouses and open-field using nutrient solutions
   - ✓ Continue to research and develop new AI technologies for extracting other vietnamese plants
   - ✓ Continue to research and develop control solutions for parameters at greenhouses
   - ✓ Extend our technologies for controlling solution at livestock/aquaculture/open-field.
2. Deployment of the system:
   - ✓ Continue to develop 2 control solutions associated with databased of Vietnamese plants
3. **NES rated the result of project: EXCELLENT!**
4. Technology transfer:
   - ✓ HUST/SoICT is discussing on business plan at Vietnamese market through different steps
   - ✓ **Our technologies are applicable**
     - ✓ **Not only at Vietnamese market, but also at other market**
     - ✓ **Our technologies are applicable not only for agriculture (greenhouse and open-field) but also for livestock and aquaculture!**
   - ✓ We are also pleased to transfer our technology to other countries:
     - ✓ In case you are interested, please contact:
     - ✓ Project's Leader: thunq@soict.hust.edu.vn.