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Implementation of Internet of Things-based Water Monitoring System in Vertical System based Crab Farming

Purba Daru Kusuma*, Helmy Widyantara, Muhammad Dwi Hariyanto, Seno Adi Putra, Andrew Brian Osmond

Universitas Telkom, Indonesia

*Corresponding Author: purbodaru@telkomuniversity.ac.id

Abstract
Crab is one of protein resource with high economic value. The vertical system is a crab farming method that provides several advantages including increasing space utility, minimizing crab mortality that is affected by cannibalism, and improving precision farming. As a continuation of 2024 research under the strategic collaboration (Katalis) scheme, a community service project has been conducted by implementing the Internet of Things (IoT) based water monitoring system to support precision farming in vertical system-based crab farming. Surabaya crab supermarket has become the partner in this community service. The objective of this activity is to implement this prototype in the real crab farming environment to investigate its effectiveness. This activity also gives experience for students at Telkom University that are involved in this project of implementing the developed precision farming system in the real environment despite the laboratories scale environment. Moreover, this project is also important to give insight from the crab farmer regarding the real problems that occur in crab farming. In the future, the system can be expanded by adding more features including the machine learning method to give predictions regarding the water quality and the growth of the crabs.

Keywords: precision farming, crab, vertical system

INTRODUCTION

Mud crabs or mangrove crabs (genus: Scylla spp.) are families of Portunidae, that live in the coastal area, especially in the mangrove area, estuary, and muddy coast (Fujaya et al., 2020). Mud crab becomes the key species in the mangrove ecosystem, especially in keeping the environmental balance. Through hole digging activity, it improves the soil aeration, accelerates the organic decomposition, and keeps the ecosystem productivity. Mud crab also has high adaptability in various environmental circumstances, especially the temperature and salinity fluctuation in the mangrove habitat. Moreover, mud crabs can live without water for certain times (Rahman et al., 2022). This ability helps the spreading of mud crabs in the coastal area.

There are four species of mud crabs in Indonesia. They are red mud crab (Scylla olivacea), green mud crab (Scylla serrata), purple mud crab (Scylla tranquebarica), and white mud crab (Syclla paramamosain) (Damiska et al., 2024). Each of these species can be acknowledged based on its exoskeleton, shell, and claws shape. Moreover, they can be identified through the existence of the spines on their head (lobus frontalis) (Damiska et al., 2024). As crustacean, the mud crab has a characteristic of hard shell. As a crustacean, mud crabs have a molting mechanism known as decalcification. During this activity, the crabs leave their old shell to construct a new bigger shell (Pamuru & Hosani, 2016). This activity is important so that they have space to grow. This soft-shell crab is one of crab products with high economic value (Aslamyah et al., 2022).

Vertical based crab farming is a new crab farming system. The farming environment consists of certain numbers of crab boxes that are arranged vertically. A single crab box is filled with only one crab exclusively. There are advantages in conducting crab farming through vertical systems. First, it improves efficiency in land use because through vertical arrangement, a certain unit of area can be used for more crabs. Second, by using exclusive crab boxes, cannibalism among crabs (Zi et al., 2023) can be avoided so that the mortality rate can be reduced. Third, this exclusive mechanism provided better observation including feeding, maintenance, and crab growth observation.

Meanwhile, the water management system is managed as a closed-loop model where the system consists of two parts. The first part is the crab house, and the second part is the water reservoir. Water is channeled from the reservoir and irrigates the crab houses one by one. Furthermore, water from the crab house is returned to the water reservoir. In this mechanism, closed-loop water management provides benefits in terms of saving water use but also causes its own problems. In the open air, the physical and chemical conditions of the water tend to be ideal because seawater always neutralizes it. In the closed-loop system, the water that comes out of the crab house is mixed with food waste and crab excretion so that its physical and chemical content changes, especially the levels of ammonia, pH, salinity, and others. Thus, water management in the water reservoir pool is key. On the other hand, water quality outside normal conditions can cause crab death.

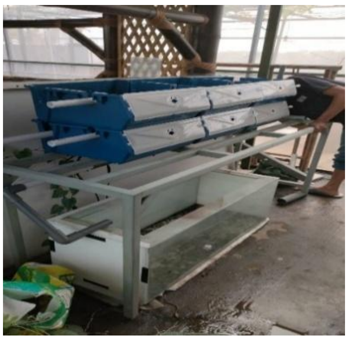
Surabaya crab supermarket has become a partner in research in the subject of crab farming under a Katalis scheme implemented in 2024. The research was carried out in collaboration between Telkom University, Bina Nusantara University, and Surabaya University. The relationship between the research team and Surabaya crab supermarket went well and the partners are committed to continuing it in subsequent activities. In addition, the partners showed a high commitment to the implementation of technology and cooperation with universities.

This community service project is a continuation of the research activities. Currently, the system implemented in the Surabaya Crab Supermarket is modern and attention to aspects of water management, especially its physical and chemical conditions, is good. However, the use of information technology is still relatively limited.

On the other hand, the team of students and lecturers involved in the research are developing an IoT-based water quality monitoring system under the umbrella of the final capstone design project. This community service project is very useful for implementing prototypes in real environments. Thus, proof of concept, both the usefulness of the system, its advantages, and disadvantages can be observed.

METHOD

In the 2024 research, the team has created a crab cultivation pond using the vertical method, both at the main campus of Telkom University and the Surabaya campus. The achievement in last year's research was to master crab cultivation so that the problems and challenges of crab cultivation using the vertical method were known. However, cultivation is still carried out manually so that IoT technology has not been applied. The installation of vertical-based crab farming in Surabaya campus of Telkom University was found in Figure 1.



(a)

(b)

Figure 1. Crab house installation at Surabaya campus of Telkom University

Based on these problems, in this community service project, a solution in the form of implementing an IoT-based water quality monitoring system at the Surabaya Crab Supermarket has been developed. In general, the system takes water quality information in real time using sensors. Furthermore, the water quality data is sent to the cloud periodically. Users access the information using Blynk or Telegram software.

In general, the system consists of three parts. The first part is the hardware. The second part is the cloud server. The third part is the client system. The first part consists of a set of microcontrollers connected to sensors. The microcontrollers chosen are Arduino as the main choice and ESP 32 as an alternative. Furthermore, there are 3 sensors, namely a temperature sensor, a pH sensor, and a DO (dissolver oxygen) sensor. The hardware captures water condition information from these sensors and then sends it to the cloud server. Furthermore, users, both partners and the community service team can access water quality information through Blynk or Telegram applications.

The hardware accesses the water condition from the reservoir that will be channeled to the crab house. As is known, the reservoir consists of several rooms because there are several stages of filtration. The first room is a room containing water that has just entered from the crab house. This water is the worst quality because it also contains leftover food and crab waste. Furthermore, the water quality is improved using physical filters and chemical filters. The last room is a room containing water that will be channeled to the crab house which reflects water with the best condition.

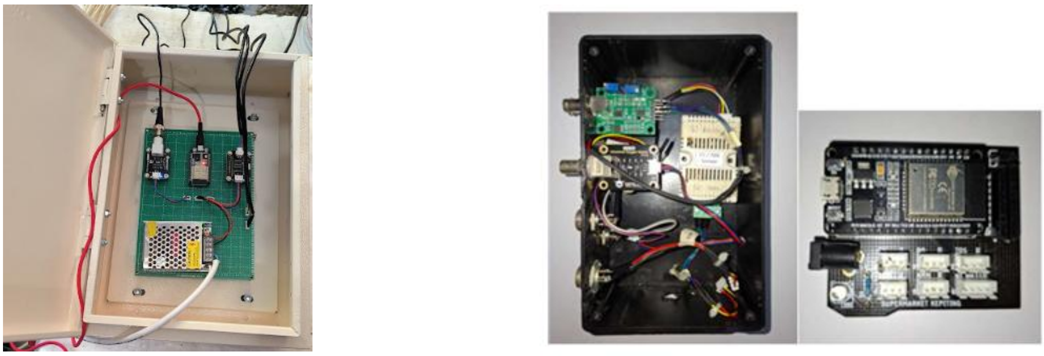
Students involved in the research are currently also doing their final assignments with a relevant topic, namely the development of water quality monitoring using IoT technology. Thus, the methods and stages carried out in this community service activity are as follows. Development of a prototype of an IoT-based water quality monitoring system for crab cultivation. The prototype development was carried out by both student teams at the main campus and the Surabaya campus with supervision from their respective lecturers.

Implementation of the monitoring system prototype at the partner location, namely the Surabaya Crab Supermarket. In this stage, the performance, reliability, advantages, and disadvantages of the system are evaluated periodically. The implementation was carried out more intensively by the Surabaya team considering the proximity of the location.

RESULT AND DISCUSSION

Prototype

In this project, there are two hardware modules that have been developed. The first module was developed by a team of students from Bandung campus while the second module was developed by team of students from Surabaya campus. In general, both modules have similar features. The hardware modules from both teams are presented in Figure 2.

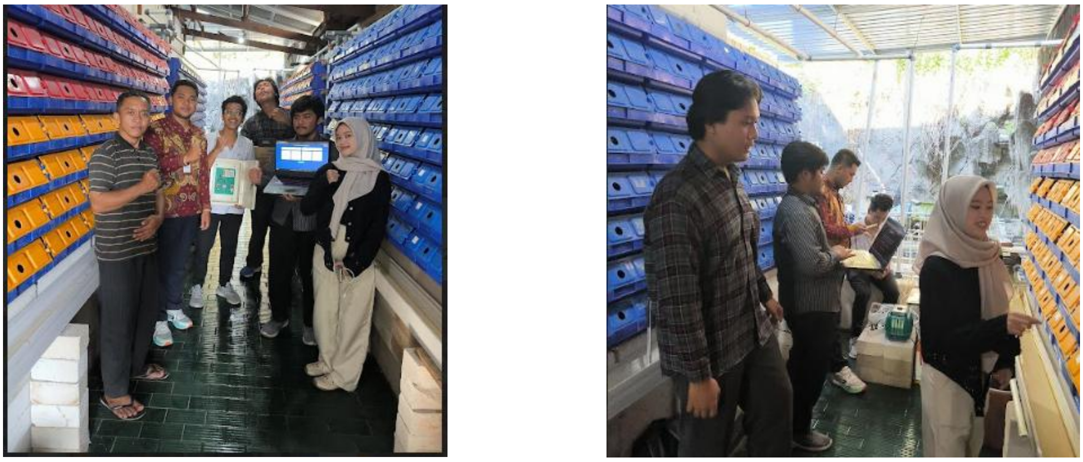


(a) (b)

Figure 2. Hardware modules

Implementation

The prototype of the IoT based water monitoring system for crab farming has been implemented in Surabaya crab supermarket. This implementation has been conducted on June 5, 2025. Team of students from Telkom University and their supervisor have visited the partner and implements this prototype in the partner's crab farming. Previously, the system was tested in laboratory environments on the roof top of the Surabaya campus building of Telkom University. The result shows that the prototype accuracy of the prototype is acceptable. Figure 3 provides evidence of the implementation of the prototype in the partner's farming environment.



(a) (b)

Figure 3. Implementation at Surabaya crab supermarket

Partner contributions

During the previous partnership, Surabaya crab supermarket provided water condition from its farming environment. This data represents the water quality parameters that should be monitored and controlled. The data is provided in Table 1. Parameters in Table 1 are linear to the common parameters that are observed in many IoT-based water monitoring systems, such as dissolved oxygen (DO) (Shete et al., 2024), temperature (Shete et al., 2024), salinity (Ahmed et al., 2024), water pollutant (Simone Soares et al., 2024), and so on.

Table 1. Water quality parameters

Parameters	Value
Temperature	29.5 – 30.5 C
pH	7.1 – 7.5
Salinity	23 – 26 ppt
Dissolved oxygen	7.9 – 8.8 ppm
Amonia (NH_3)	0 ppm
Nitrit (NO_2)	0 ppm
Nitrat (NO_3)	0 ppm
Calcium (Ca)	450 ppm
Magnesium (Mg)	1,300 ppm
Kalium (K)	300 ppm
Alkalinity	7.5 – 7.8 DKH
Probiotic	Nitrosomonas, Nitrobacter, Nitrospira, Thuibacillus denitrificants

Moreover, the partner has provided his farming environment, especially the water reservoir to be used to investigate the performance of the prototype. The partner also shares practical experience and the best practice in cultivating the crab, including the mechanism, operational, and threats. Moreover, Surabaya crab supermarket has commitment to support the collaboration for future development of this IoT-based smart farming for crab cultivation based on vertical system.

Continuity potential

This community service project has the potential for sustainability with the following considerations. First, this activity is a continuation of research in 2024 under a strategic collaboration scheme. In addition, this activity is in line with the final assignment or capstone project of students who are involved in research who develop an IoT system and supply chain management for crab cultivation using the vertical method. Furthermore, this community service is in line with the expert group road map in Telkom University, one of which is in the field of IoT. The roadmap of the IoT based smart farming is presented in Table 2.

Table 2. Road map of IoT-based smart farming

Year	Milestone
2024	Study of the IoT based smart farming model
2025	Prototype development of IoT based smart farming
2026	Proof of concept and finalization of IoT based smart farming system
2027	Monetization and initial phase of commercialization of the IoT based smart farming system
2028	Startup initiation and mass production of the IoT based smart farming system

This IoT-based water monitoring system can be expanded not only for crab farming but also for any fishery farming or aquaculture, such as shrimp. Like in crab farming, similar parameters like temperature, pH, salinity, turbidity, and dissolved oxygen (Herlinawati et al., 2025) should be monitored too. The existence of cameras can be integrated into this IoT system to provide additional validation regarding the water quality (Khuen Cheng et al., 2024). Another potential is embedding new techniques that can predict the concentration of nitrite and ammonia which in many ways is difficult by using common sensors (Chen et al., 2024). In the end, implementing this technology in the context of smart farming or precision aquaculture will benefit the farmers to improve their productivity.

CONCLUSION

The implementation in the actual environment of IoT-based water monitoring system for crab vertical farming has been conducted. This implementation is under the community service project umbrella. The implementation is being conducted at Surabaya crab supermarket as partner of this project. This project is also integrated with the capstone project that is conducted by team of students from Bandung campus of Telkom University and team of students from Surabaya campus of Telkom University. This project is a collaboration of lecturers from both campuses under Telkom University as the continuation of the research that has been conducted previously under strategic collaboration scheme with Binus University and Surabaya University. The findings expose the active contribution of the partner in this project and strong commitment for future collaboration, especially improving the prototype through feature expansion. Moreover, this project is in line with the expert group regarding the IoT-based smart farming in Telkom University where the end goal is the commercialization of technology.

ACKNOWLEDGEMENT

This community service project was funded by Telkom University under grant: 0251/ABD07/PPM-JPM/2025.

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