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AN APPROACH TO ENHANCE A SOLAR PUMPING SYSTEM WITH CLOUD COMPUTING AND INTERNET OF THINGS FOR THAILAND SMART FARMING 4.0

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Abstract. *As multidisciplinary integration system development and project-based learning for our university computing students to cooperate with renewable energy and smart grid technology researchers, an approach to enhancing our existing solar pumping system with cloud computing and Internet of Things (IoT) for Thailand smart farming 4.0 was proposed. The primary functionality of the enhanced system that can be built from the proposed approach is to monitor farming environment factors, including humidity, temperature, and solar irradiance in real time. We believe that our proposed approach will be able to monitor and collect the essential farming environment data. This data can be used by farmers to achieve the smart farming trend that is promoting by the Thai government. The proposed approach enables the students to have a core competency in both the principles and practices of cloud computing and IoT. With our simple system architectural design from the approach, the students successfully learn how both technologies can be effectively adapted and to support capabilities in smart agriculture application areas. This paper describes many aspects related to the architectural system design from the proposed approach. This induces the main additional components and technologies of the approach to enhance the existing solar pumping systems, then the system architecture of the enhanced solar pumping system with cloud computing and IoT, finally parts of the fictitious contents of the expected log data from the architecture. This provides the students with a significant learning experience based on real application analysis and design. The architectural design of our enhanced system is described, and the success in providing a good learning experience for the students is discussed.*
Keywords: Cloud computing, Internet of Things, Solar pumping system, Smart farming, Monitoring system

1. **Introduction.** Based on the essential selections of development tools that are recent and available within the context of the cloud computing and the Internet of Things (IoT) technologies, this paper proposes an approach adopting both technologies to effectively and efficiently equip academic abilities of a new direction to system development for our university students and researchers. The proposed approach is project-based learning that is important to teaching and learning that was considered essential to enhance student learning. We selected a familiar environment to Thai culture, the farming or agricultural system. We also focus on a useful system type, environment monitoring, to ensure the students could see an example of a real world, useful, potentially smart farming system.

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Kosaiyapattanapundit and Sangthong [1] stated that Thailand 4.0 is the policy to transform the Thai economy into a value-based economy. The significant vision of the policy is that Thailand is to be an innovative industry to technology-driven creativity and innovation rather than commodity industry. The vision is also to concentrate on the service sector more rather than on product manufacturing [1]. They also argue that this policy should shift the methodology it is operated to modern agriculture. The significance is on management and technology (smart farming) by farmers to be an entrepreneurial farmer and wealthy. [2] defined smart farming as "is about empowering with the decision tools and automation seamlessly integrate products, knowledge better productivity, quality and profit". Moreover, if policies do not change, the results from a scientific model developed by a team at Anglia Ruskin University's Global Sustainability Institute show that within about 20 years society will face critical food shortages [3]. One of the approaches to mitigating this crisis can be the mentioned smart farming concept above.

There are many recent related studies as our motivations and innovation for proposing the approach mentioned above to enhance a solar pumping system with the cloud and IoT for Thailand 4.0 and smart farming concepts. Examples of these related studies are following. To support the concepts, the researchers implemented a prototype system to enable a lingzhi mushroom smart farm [4]. The system can monitor and control the environmental factors in the farm such as humidity and temperature with IoT technology. Then farmers can also monitor these factors via mobile devices. This project usually deploys free technologies or tools which are a good solution for their prototyping system. Another group of researchers proposes an automatic planting/gardening prototyping system for elderly users [5]. This system is with IoT technology such as grow light and soil moisture, temperature, and water sensor. The users can also easily monitor their plants or control watering processes via Android applications. Lastly, [6] proposed the automatic water sprinkle and monitoring system that deploys many IoT components such as soil a moisture sensor to detect the soil moisture level in a chili plant greenhouse. Then, the system sends the moisture data to be processed. Based on soil moisture data, then the system enables the water sprinkle automatically and appropriately to work for planting. Farmers can also monitor their plants' conditions via mobile devices.

From the studies above and Thailand 4.0 and smart farming concepts, we aim to enhance our existing solar pumping systems to support the mentioned smart farming concept above. Thai government [7] funded our previous project called 'the solar pumping system for community agriculture and agricultural cooperatives'. In this previous project, we provided farmers with solar pumping systems with high performance to use in non-irrigated agricultural areas. These systems can reduce the cost of farming, increase the chances of farming, and mitigate the drought in non-irrigation areas. By the systems, farmers can achieve economical level farming and will not leave their agricultural communities to work in big cities. Then they can be self-reliant farmers. Section 2 will further describe the details of these systems. However, our existing solar pumping systems stored important planting data (such as plants' humidity, temperature, and solar irradiance levels) in local storages. This is difficult to enable the data to be ready to be further used in real time. This data can be used effectively and efficiently for many farmers' smart activities such as farming management or forecast. This is very important in the near future to support the mentioned smart farming concept above for farmers to better their productivity, quality and profit of farming. Then this can be one of the solutions to mitigate the food crisis mentioned above.

This paper mainly leverages a combination of two recent, available, inexpensive technologies: the cloud computing and the IoT. The example of the usefulness of both technologies computability is a classroom environment monitoring system in [8]. This system exploits the cloud by sending IoT classroom environment data to a cloud server for storing and processing. We propose in this paper an approach to enhance a solar pumping system with cloud computing and Internet of Things for Thailand smart farming 4.0, to exploit the benefits of the cloud and IoT, demonstrating the ease of use, convenience, and power of cloud coupled with IoT to support smart farming.

Summary of contributions. There are three contributions to this paper. The first is a system design based on multidisciplinary integration. This design is the first time that our researchers and students from the Department of Computer Science and Information Technology (CSIT) and School of Renewable Energy and Smart Grid Technology (SGtech) can effectively work together and share their core knowledge to propose the approach to enhance existing solar pumping system with the appropriate system design. This contribution could be guidelines for us to prepare more upcoming integration projects with others such as the biology department or faculty of allied health sciences. The second is a contribution to education. This paper demonstrates the efficiency and achievement of project-based learning method to CSIT and SGtech students. They learned the concepts and practices of the proposed approach to building architectural design of the enhanced system. The last is a contribution to an aspect of technologies: the cloud computing and the IoT. The approach and the method of enhancement illustrate how the cloud and IoT benefit applications and services in the agricultural area with simple system design, to support Thailand smart farming concept. This is to ensure that our approach can be appropriately implemented in our future work.

Details of components and methodologies of the proposed approach are following: cloud computing and Internet of Things (Section 2.1), the existing solar pumping systems (Section 2.2), an MQ Telemetry Transport or MQTT and its brokers in the cloud (Section 2.3), main additional components and technologies of the proposed approach to enhancing the existing solar pumping systems (Section 3), finally and importantly the system architecture of solar pumping system with cloud computing and IoT for Thailand smart farming 4.0 (Section 4), then discussions (Section 5) and conclusions (Section 6).

2. **Background.**

2.1. **Cloud computing and Internet of Things.**

Cloud computing or cloud provides computing resources such as virtual machines, CPUs, networks or storages to customers in pay-as-you-go manners [9]. Internet-connected devices (such as sensors) can also access to these resources. The cloud benefits many application area as argued by [10, 11, 12, 13] for example in education area as demonstrated in [14] and in business as discussed by [15]. Internet of Things or IoT is the concept that enables any smart object connected to the Internet to be able to interact with any other smart object or objects connected to the Internet [16]. The proposed approach introduced by this paper will deploy these kinds of smart objects (sensors) in the plating areas. These sensors can send and receive data to and from the cloud via the Internet. Section 3 will fully describe the details of these sensors. This paper exploits both the cloud and IoT to propose an approach to enhance a solar pumping system for Thailand smart farming 4.0. Both technologies need to cooperate as discussed below.

Liu et al. [17] discuss IoT weaknesses as following: reliability, performance, security, and privacy. They can be mitigated by sharing of IoT and cloud advantages. The cloud can provide a partial solution for these issues. This is because the cloud can offer huge storage capacity, processing power, and level of reliability [17]. To deal with the data produced by the IoT, the cloud is the practical and easy solution to IoT information processing requirements. This can mitigate the IoT issues. This paper exploits the advantages of the cloud and IoT, demonstrating the ease of use, convenience and power of the cloud cooperates with IoT. With these advantages, this paper proposes an approach to enhance our existing solar pumping systems by using the composition of both technologies. The details of the approach are mainly in Section 3 and Section 4.

2.2. **The existing solar pumping systems.** Thai Department of Alternative Energy Development and Efficiency Ministry of Energy [7] funded our existing solar pumping systems. By the systems, farmers can achieve economic level farming and will not leave their agricultural communities to work in big cities; then they can be self-reliant farmers. Figure 1 illustrates how one of our existing solar pumping systems works. The main related, additional components and technologies of our proposed approach introduced by this paper here are shaded boxes with the numbers 1 to 5 and with the alphabets a to d. Section 3 will fully describe all the boxes. This figure without these shaded boxes is how an existing solar pumping system works. This paper rather discusses the proposed approach to enhance this system with the cloud and IoT than discuss the details of the existing system. Figure 2 mainly shows the physical ambient temperature sensor[1], solar panel (left side of and behind this sensor), and water storage tanks (right side of and behind the panel) in this project or Figure 1. Also, Figure 3 mainly shows also the concrete water tank in the existing system.

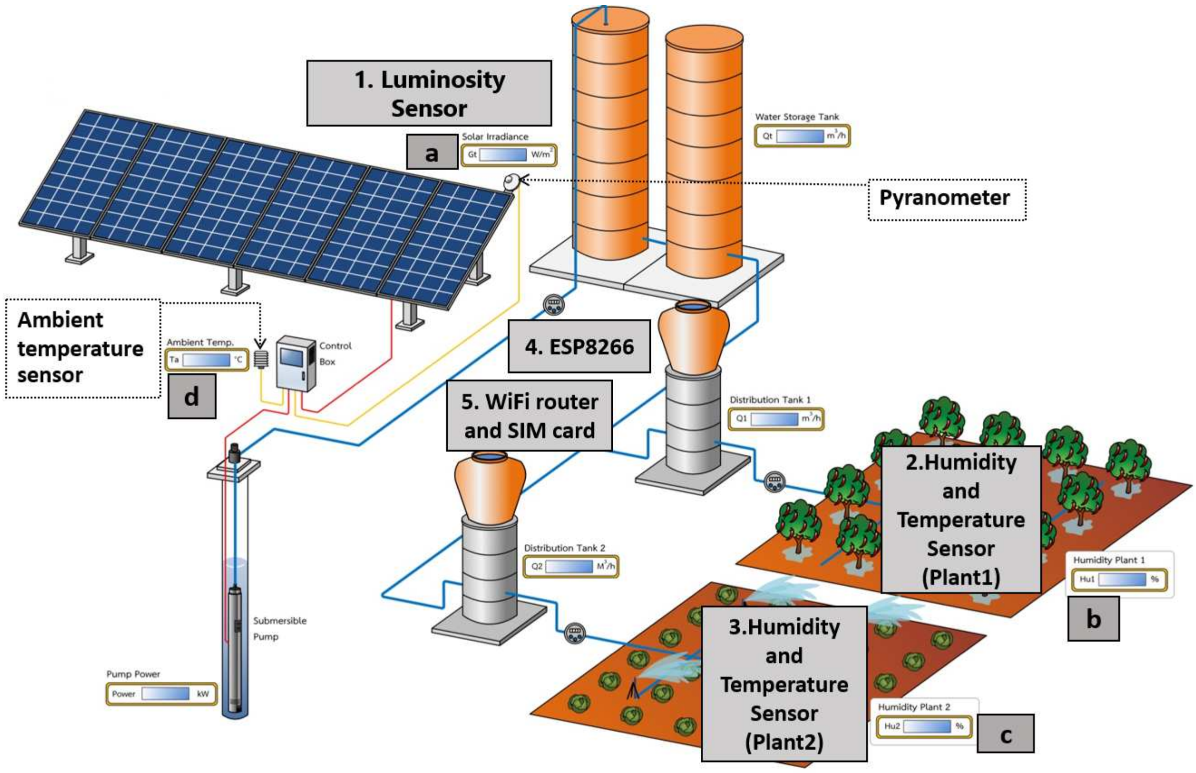

FIGURE 1. The solar pumping system, the main additional components and technologies, and their locations in the field

2.3. **An MQ Telemetry Transport and its brokers in the cloud.** In our proposed approach, an MQ Telemetry Transport enables sending the data that is collected from the sensors in Figure 1 to the cloud (such as the luminosity sensor, which assumes that this sensor is located in the field as the shaded box labeled being with number 1 in Figure 1). [19] states that "MQTT or MQ Telemetry Transport is a machine-to-machine (M2M)/'Internet of Things' connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport". Xu et al. [20] state that an MQTT is designed on top of traditional transport protocols such as Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). They also argued that an MQTT's architecture comprises two components as MQTT clients (such as publishers and subscribers) and

[1]This sensor is to measure the temperature of the air that surrounds a component [18].

Figure 2. The water storage tanks

Figure 3. The water tank

MQTT broker. Both subscribers and publishers exchange messages through this MQTT broker [20].

Hunkeler et al. [21] explain these messages exchanges as the following. Step 1, a subscriber sends a message as 'sub(topic)' to update the MQTT broker of its intention in the indicated topic. Step 2, a publisher also sends a message as 'pub(topic,data)' to the broker. This message contains the data to be published together with the related topic. Step 3, the broker transfers the pub(topic,data) message to the subscriber when the publisher's and the subscriber's topics are matched. There are many MQTT brokers in the cloud [22]. Our proposed approach will deploy Adafruit IO [23] which is also considered as one of the cloud platforms that is possibly growing and support MQTT protocol [24].

[25] discusses the benefits of the Adafruit IO cloud platform as the following. This cloud platform supplies many programming libraries that can be used to implement IoT communications. These libraries are available in many languages such as C or Python, and this cloud platform also provides many kinds of blocks to enable attractive and effective dashboard presentations. It is easy to edit the dashboard designing this cloud platform. Our proposed approach will deploy a C like programing language called an Arduino programming language [26] because this language is compatible with both Adafruit IO broker and NODEMCU ESP8266 microcontroller. All the details of how both work together are in Section 3 and Section 4.

3. **The Details of the Main Additional Components and Technologies of the Proposed Approach to Enhancing the Existing Solar Pumping Systems.** As discussed in Section 2.2 Figure 1 illustrated the main related components and technologies of the enhanced system architecture design of the proposed approach introduced by this paper. This section here will fully describe the details of the components and technologies, in Subsections 3.1 and 3.2.

The proposed approach in this paper discusses only measuring the values that relate to the newly enhanced system. These values are solar irradiance, temperature, and humidity of the field in Figure 1. They are examples of measuring the values of the other essential parameters in this field. These parameters will be considered to be measured according to the actual system requirements. The requirements can be acquired from the discussion of related parties of the system such as the farmers, system developers, or even merchants. The types of the sensors such as humidity sensors can be changed or added later based on the mentioned system requirements. The primary purpose of our proposed approach of this paper is to monitor the solar irradiance, temperature, and humidity of the field in Figure 1 via web interfaces.

3.1. **Main components and technologies.** From Figure 1, the shaded box labeled beginning with number 1 is a tsl2561 luminosity sensor which is an advanced digital light sensor, ideal for use in a wide range of light situations [27]. This sensor measures solar irradiance (in Gt units), and it will be placed near the existing pyranometer[2] of the existing system to have the same solar irradiance values as the existing pyranometer does. See the rightmost of Figure 1, the shaded boxes labeled beginning with numbers 2 and 3 are DHT22 humidity and temperature sensors. They are basic and low-cost digital temperature (as Celsius units) and humidity (as %) sensors [29]. Both sensors use a capacitive humidity sensor and a thermistor to measure the surrounding air, and output a digital signal on the data pin [29]. Both sensors will be placed in plant1 and plant2. The collected temperatures from both sensors will be averaged and compared to the collected temperature from the existing ambient temperature sensor, see the white dot box on the leftmost side of Figure 1.

See the middle of Figure 1, the shaded boxes labeled beginning with number 4 are NODEMCU ESP8266 (for short ESP8266) that will be deployed in our system architecture design of the proposed approach. A Node MicroController Unit or NodeMCU is an open source software and hardware development environment that is built around an inexpensive System-on-a-Chip called the ESP8266 [30]. The ESP8266 chip is composed of all essential components of the modern computer [30]. Examples of these components are a central processing unit, main memory, networking (Wi-Fi), and even the modern operating system. This chip is also considered as a Wi-Fi module [31], and makes it a useful tool for IoT projects [30]. It will be located in the middle of the field to centrally connected to and work with other components. This chip can be used to send data from sensors to the cloud over the Wi-Fi as also done by [31]. Lastly, see the middle of Figure 1 then the shaded box labeled beginning with number 5, to enable the ESP8266 chip to connect to the Internet then to the cloud, one of the solutions suggested by [32] is using a WiFi router and SIM card. The router and card will be placed near the chip in the middle of the field to connect the chip to the Internet. In Thailand, this solution can be obtained from Thai mobile phone operators such as [33].

3.2. **The output screen interfaces of the enhanced system.** These output screen interfaces of the enhanced system can be the shaded boxes labeled alphabets a to d in Figure 1. The shaded box labeled a will be the interface to display the values from the luminosity sensor. The shaded boxes labeled b and c are the interfaces to display humidity values of DHT22 sensors of plant1 and plant2. Lastly, d is the interface to display the averaged temperature values collected from the existing ambient temperature sensor (see the white dot box on the leftmost side of Figure 1) and collected from the DHT22 sensors in plant1 and plant2. The components apart from a to d in Figure 1 are future output screen interface design of this enhanced system such as water levels in all the tanks which will not be discussed in this paper.

4. The System Architecture of the Enhanced Solar Pumping System with Cloud Computing and Internet of Things for Thailand Smart Farming 4.0.

The main aim of our proposed approach of this paper is to monitor the solar irradiance, temperature, and humidity of the field in Figure 1 via web interfaces.

[2]It is a tool that can measure the overall amount of sunlight reaching a horizontal plane on the surface of the Earth [28].

4.1. **How the enhanced system architecture works with the cloud broker and IoT.** Figure 4 illustrates this architecture. All the related technologies and components of the architecture were already discussed in Section 2 and Section 3 above. At the most top left of Figure 4, x is the tsl2561 luminosity sensor. Then y and z are the DHT22 humidity and temperature sensors. All these three mentioned sensors will be connected to the ESP8266 chip. Then the collected data values from these sensors will be sent to the cloud broker. As discussed in Section 2.3, both subscribers and publishers exchange messages through the broker [20]. The publishing and subscribing messages exchanges explained by [21] are also discussed in Section 2.3. Thus, step 1 to step 3 in the architecture or Figure 4 will be based on the discussions in Section 2.3.

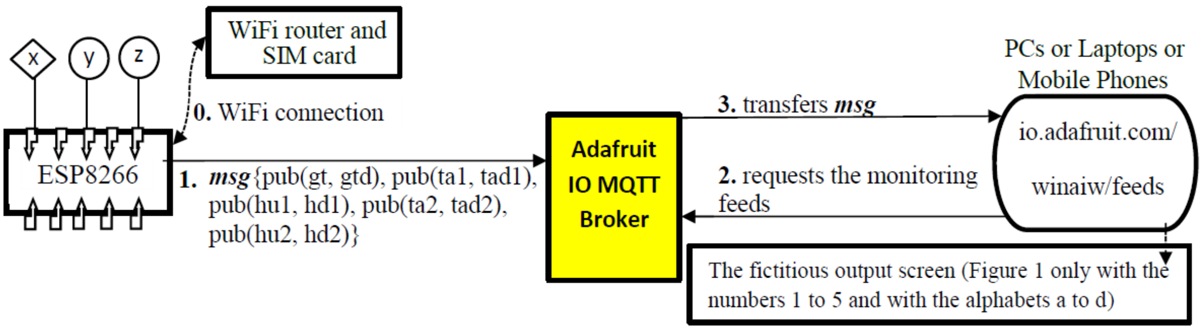

FIGURE 4. The system architecture of solar pumping system with cloud computing and Internet of Things for Thailand smart farming 4.0

In the system architecture in Figure 4, we describe only the monitoring ability of the architecture but controlling. Thus, there will not be the subscription mechanisms in the architecture. From Figure 4, to perform step 1 to step 3 below, programmers can use the broker's web interfaces ('io.adafruit.com' from Adafruit IO cloud broker) with the programmers' adafruit accounts to generate the adafruit keys to be used to customize the desired output pages. These pages can easily be customized by the programmers to illustrate, for example, feeds or dashboards of the sensors' data according to the indicated topics. The URI examples of the feeds can be **/io.adafruit.com/winaiw/feeds**/humidity or **/io.adafruit.com/winaiw/feeds**/temperature, see the rounded shape box at the rightmost of Figure 4.

In Figure 4, step 0, the ESP8266 chip (the box at the leftmost of the figure) will connect to the WiFi router with SIM card (the box at the top leftmost of the figure). This connection is performed by the pre-written Arduino programming language [26] program in the chip. This program enables the chip to connect to the Internet and to be ready to send the necessary data collected from the three sensors discussed above to the cloud or Adafruit IO MQTT broker (for short 'cloud broker'). Then step 1, the publisher (the pre-written program in the chip) sends the message to the cloud broker as ***msg***{pub(gt, gtd), pub(ta1, tad1), pub(hu1, hd1), pub(ta2, tad2), pub(hu2, hd2)}. This message contains the data (gtd, tad1, hd1, tad2, and hd2) to be published together with the related topics (gt, ta1, hu1, ta2, and hu2).

Step 2, the programmers then request the desired feeds via 'io.adafruit.com' with any devices (PCs or laptops or mobile phones, see the rounded shape box at the rightmost of Figure 4). It assumes that requesting feeds in this step is following. The first is to request the data on the topics of the solar irradiance (gt). The last is to request the ambient temperatures and humidity of plant1 (ta1, hu1) and of plant2 (ta2, hu2) respectively. Step 3, the cloud broker transfers the ***msg*** message to the requester to be displayed in the feeds' interfaces via the appropriate URI such as **/io.adafruit.com/winaiw/feeds**/humidity. The content of ***msg*** message in step 3 is the same content as ***msg*** message in step 1. Finally, the programmers can enable this URIs to be publicly accessed by their appropriate users. The users can also download log data from this enhanced system architecture as described in the next section.

4.2. **Parts of the fictitious contents of the expected log data from the architecture.** It assumes that the expected log data that will be discussed below is produced according to the system that is built based on our system architecture of the enhanced solar pumping system with cloud computing and IoT for Thailand smart farming 4.0 or Figure 4. This expected log data can be Figure 5, spreadsheet files, and downloaded from the appropriate interfaces in Figure 1. In Figure 5, the row of record NO. 1 could contain the date and time of data collections (the second column) of three sets of values from the sensors. The first is the solar irradiance values (the third column), and the second is the average of ambient temperature values of the two humidity and temperature sensors in the plants and of the existing ambient temperature sensor (the fourth column). The last is both plants' humidity values (the fifth and the last columns). In Figure 5, it assumes that the system that is built from the system architecture of our proposed approach (Figure 4 from Section 4) can collect data every 5 seconds, see the time intervals in the second column of the figure. This collected data on the farming areas in Figure 1 could be stored for the periods of days, months, or years. This data will become big data to be used for analysis or prediction for smart farming by farmers. This can be useful for these farmers to efficiently and effectively manage their smart framing activities to achieve better productivity, quality, and profit of their farming. This is the ultimate goal of our future work. Then the appropriate output interfaces of the system architecture of the future work can be designed according to these periods.

NO.	Date/Time	Solar Irradiance	Ambient Temp (Avg)	Humidity Plant1	Humidity Plant2
		(W/m^2)	°C	(%)	(%)
1	5/7/2017 7:01	54.56	24.88	8.30	10.08
2	5/7/2017 7:06	58.58	25.42	8.85	10.29
3	5/7/2017 7:11	55.30	24.89	9.46	10.76

FIGURE 5. Parts of the fictitious contents of the expected results

5. Discussions.

5.1. **Study significance.** The first study significance is that the system design of the proposed approach is based on multidisciplinary integration. To enable this system design, for example, the CSIT students and researchers need to be familiar with almost all aspects of the existing solar pumping system (Section 2.2) which were provided by SGtech. We needed to collaborate with SGtech students and researchers and also study the system's two hundred pages report being able to simulate the academic and appropriate idea for the proposed approach. This includes an understanding of the non-IT system components such as pyranometer, the physical ambient temperature sensors, and solar panels. Then, this assists in enabling us to integrate our core IT knowledge (such as IoT, cloud, and MQTT) with the non-IT components to propose the system architecture to enhance the existing solar pumping system with cloud computing and Internet of Things for Thailand smart farming 4.0 in Figure 4. On the other hand, the SGtech students and researchers also learned the core IT knowledge to achieve the goal of this paper. This paper was also completed by the multidisciplinary integration of the supervision of both CSIT and SGtech researchers.

The second study significance is a contribution to education. We demonstrated the strength and efficiency of our project-based learning approach in our previous work [14] that is for a classroom environment monitoring system. However, in this paper here, we drove especially the CSIT students to participate in the new project-based learning environment which is renewable energy and agricultural areas. They needed to carefully investigate relevant available main components and technologies of the proposed system architecture (in Section 3) such as the relevant sensors (in Section 3.1) and the related cloud brokers (Section 2.3). They needed to determine and compare those components and technologies to obtain the suitable ones for the project. This enables the students to gain learning by doing strategy with the actual existing pumping system to appropriately propose the approach to enhance such system. Then, the students could achieve the goal of this paper with the strategy. The students were also familiar with the strategy, and excited about what they have learned in classrooms can be immediately applied to real-world applications outside the classrooms. They also have more motivations to go back to the classrooms to gain more IT knowledge to be able to achieve more real-world projects outside their classrooms. An example of a project-based learning approach provided by this paper is our laboratory for our students. They may not only work with organizations after their gradations but also can be equipped with knowledge and experiences to be independent researchers or innovators. This is very important for, especially, students in a Thai education system.

Lastly, Fried who is a founder of a $40 million open-source hardware business called Adafruit Industries stated in [34] that ‘instead of standing in line to buy the next new thing, we get to make the next new thing ourselves, and we decide what that thing is’. She also argues that a key to the future economy is making things rather than consuming. Fried suggests that at home we can build IoT applications such as a secret knock activated door lock [35]. This making things concept is the same as the concept of ‘do it yourself’ or DIY IoT applications thoroughly discussed by [36]. This means we shall build IoT applications by ourselves with some available technological facilities. This paper encourages farmers to develop their own DIY IoT smart farming applications, for example, following our proposed approach.

5.2. **Extending the study scope.** Firstly, [37] investigated an energy consumption by placing sensors in a classroom to monitor the indoor weather. Following the idea in [37], for example, the system architecture from our proposed approach can be modified to be able to calculate the amount of energy the system consumes per a plant. This can enable the farmers efficiently and effectively manage their farms by reducing energy consumptions aspects. It is eventually reducing farming investment and to achieve better productivity, quality, and profit of farming. Secondly, new sensors can be added to measure other appropriate aspects to improve the system's abilities of the system architecture from our approach based on new system requirements. For example, pH levels in soil can affect plants [6]; thus, pH sensors can be added to the new system. We believe the system architecture in our approach can be applied to measuring new, essentials planting factors; this will enable the system architecture to work effectively and efficiently.

Lastly, we believe the system architecture from the proposed approach can be applied to many types of plants such as lingzhi mushrooms which can be industrial crop [4]. This will be based on soil moisture conditions and the appropriate soil moisture levels or other significant measurable factors of the mushrooms. To demonstrate enhancing of our existing solar pumping systems, this paper exploits available technologies we have such as the cloud brokers to enhance such systems. We believe that our enhancing approach can be applied to different types of plants. Thus, we conduct this research without focusing on specific plants yet as also done by [38, 39].

6. **Conclusions.** This paper proposes the approach to enhance our existing solar pumping system with cloud computing and Internet of Things (IoT) for Thailand smart farming 4.0. The proposed approach is considered as a multidisciplinary integration system design

and project-based learning for our university CSIT students to cooperate with SGtech researchers. The approach is essential for applications and services in developing smart systems to monitor then control solar pumping environment. Based on the approach, a prototype system can be developed and tested with our straightforward system architectural design in our future work. We also fully describe in detail the components and technologies related to the proposed approach and its possible results to support smart farming. For example, to reduce energy consumption, the proposed approach can be modified to yield more of its abilities such as automatic environment control. The proposed approach illustrates how cloud computing and Internet of Things could benefit applications and services in agriculture with simple system design. Rattanongphisat et al. [37] discuss an air conditioning control system. Following their guidelines, to enable our approach to automatically control the monitored solar pumping environment to be continuously suitable for planting in real time could be one of the future research directions. This same opportunity could be expanded to other systems such as monitoring the conditions in domestic animal and fishery farming. We hope that with the simple design introduced by our approach could benefit farmers to be equipped with 'do it yourself (DIY)' capabilities to appropriately develop their smart farming systems themselves to suit their absolute requirements of different agricultural farming.

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