Rapid Application Development (RAD) model method for creating an agricultural irrigation system based on internet of things

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Abstract. The development of the internet of things has penetrated in several lines, including in agriculture. To respond to the development of this IoT requires rapid technological adaptation as well. To build a system quickly, one can utilize the Rapid Application Development (RAD) method. RAD is a model that allows non-experts to benefit from high-performance computing, while allowing expert programmers to take full advantage of the underlying hardware. This enables rapid prototyping, retargeting, and reuse of existing software, while allowing hardware-specific optimization if needed. The RAD system emphasizes the fast development cycle that is designed and high-quality results from other methods such as waterfall, agile, scrum and others. The system was built using the minimum NodeMCU system with the help of a soil moisture sensor. The use of the RAD method in building an IoT-based agricultural irrigation system gives good results in testing all functions and equipment controls. The average delay level on testing IoT devices is around 4.6 seconds so that the RAD method can be used as a reference in the construction of an IoT-based system.

1. Introduction
The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. With the growth of this technology, the proportion of distributed embedded control systems is increasing, and the interactions of parts of these systems becomes more complicated [1-3].

Agriculture is the largest freshwater consumers in the world, amounting to 70% of total usage [4]. Irrigation systems and field application method for the cultivation of plants play an important role in it. In an attempt to avoid the loss of productivity caused by water pressure (low irrigation), farmers spraying more water than necessary (excessive irrigation) and consequently challenged not only productivity but also water and energy is wasted [5].

In agriculture, the IoT can assist farmers to make water management, especially in the uncertain weather in Indonesia. In the unpredictable weather requires an intelligent system that can help in the irrigation system. The irrigation system is done by giving the water when the soil is considered to have low humidity and vice versa if it is too high then the irrigation system can be turned off. When the weather is erratic weather was not difficult for farmers to predict soil moisture levels.
To establish an Internet-based system of the Thing's one methodology that can be used is the method of Rapid Application Development (RAD). With this method emphasizes designed development cycle much faster with higher quality results than those achieved with other development methodologies. In RAD less emphasis on the task of planning and an emphasis on further development [6].

in developing internet devices of things rapid application development is the best method for non-expert developers at IoT [7-9]. Challenges when developing systems with RAD is the sustainability and success rate. In this study tries to make system-based IoT testing with the RAD method to test the success of the manufacturing system.

2. Methods

2.1. Research methodology
In designing the study IoT (Internet of Things) at this chilli plant irrigation system, researchers used the approach or methodology prototyping. Prototyping approach is chosen so software developers can know all too well what the user wants to leave no rules as well as the technical foundation of software development, which in turn produced software that fits the needs of users [10]. Stages in the methodology prototyping can be seen in Figure 1.

![Figure 1. Stages of RAD methodology.](image)

Listen to the customer is the first stage, which is done by listening to users or customers to analyze the needs of the user. Things - things that need to be considered in this stage is business process and problems - the problems faced by users [5]. Build or revise the mock-up is a stage in the effort to design and build software quickly adapted to the needs of users [11]. To illustrate the design of the software to be built, in this study described the architectural design of software, design, user interaction with the system and the design mock-up to give a clear picture of the software.

2.2. Model system
The proposed system introduces several new sensors in the physical layer which will bring radical changes in the monitoring model, research and analysis. The sensor is connected directly to the ground in various places and connected to the controller wirelessly.

2.2.1. Sensor integration. The Internet of things is an amalgamation of the internet and things word meaning a word of the Internet is a computer network that uses network protocols and the meaning of things can be interpreted as a physical object. The object e.g. sensor data read by the sensors can be sent over the internet. Data from the sensor readings that have been sent over the Internet requires a presentation that can be understood by the user in order to facilitate the exchange of information between language module analogue sensor with digital language or application server that can be understood by users of the application [12,13].
2.2.2. **NodeMCU.** NodeMCU IOT platform is open source and it is built-in ESP8266 integrated Wi-Fi module. It is also involved with the firmware running on a Wi-Fi system on a chip ESP8266 and consists of 17 general-purpose input/output pins, 10 digital and 1 pin analogy. By using the NodeMCU development platform for hardware and software modules [14].

2.2.3. **Sensor soil moisture.** The moisture sensor is a humidity sensor that can detect moisture in the soil. These sensors are very simple, but ideal for monitoring the city park, or the level of water in the home kitchen garden plants. The sensor consists of two probes to pass current through the ground, then read the resistance to get the value of the humidity level. The more water to make the soil more easily conduct electricity (minor resistance), while the dry soil is very difficult to conduct electricity (major resistance) [8].

Results of soil moisture sensor output of the ADC values in the form of an analogue value from 0 to 1023. Seeing the needs of soil moisture in pepper ranged from 60% to 80%, the value of ADC values are concatenated into a percentage value [5]. To change the value to a percentage value of the ADC can be used formula as follows:

\[
\text{Soil Moisture} = (100 - (((\text{ADC Value})/1023) x 100) \tag{1}
\]

2.2.4. **Cloud storage.** Soil moisture data will be sent and stored in the cloud using the IoT Platform, and that will also save on websites or mobile applications. Real-time parameters based on cloud storage are simplified. The humidity parameters are also analyzed based on the parameters determined by the experts and their deviations. It is important to save statistical information because it can be very useful in the future [14].

3. **Results and discussion**

The early stages of this research are to conduct an analysis of system requirements. This analysis is done by communication with prospective users of the software to be built. The communication process to determine the focus of the business processes that exist today and explore the problems faced by users today. The results of the data analysis, the researchers conducting data processing and produced an inference of functional and non-functional requirements of the process.

After defining the functional needs of researchers within their hardware design system functional requirements that are connected and integrated. The analysis was made by the design of the software architecture modelling, modelling of user interactions with the system as well as a mock-up software. Here is an architectural design software to be built.
Figure 3. Architecture-based irrigation IoT (Internet of Things).

In the picture above shows some of the hardware used IOT-based irrigation systems. NodeMCU function as devices that integrate soil moisture sensor with relay module to turn on the irrigation pump. NodeMCU equipped with WiFi so it can run in the Internet network. Humidity ground sensors used to detect the moisture content of the soil that will be sent to NodeMCU so NodeMCU can send a signal to the relay to turn on and turn off automatic irrigation pumps. In addition to irrigation pumps to turn on automatically, the user can turn on or turn off the pump manually via android smartphone users who connect to the Internet with NodeMCU.

With the above architectural design users can turn on the pump without having to go to the location of the plant. So users will be able to further make good financial planning as well as allocation to the installation of the pump. To understand the existing process flows related to IoT based irrigation system, researchers interpret process flow using a flow diagram. The process flow system is shown in Figure 5.

In figure 5 seen the flow begins with the setup of smartphone devices that have been installed and connected to the Internet application. Display menu is visible from two menu system that is monitoring soil moisture and control irrigation pumps. In the irrigation pump control user interaction from the user, it will automatically specify the notification system to smartphones that have installed the application. To model how users interact with the system Figure 4 is a use case modelling of the system.

Figure 4. User interaction with the system design.

Once the system is modelled in the form of system architecture, process flow and the interaction model are made from the applications installed on the smartphone, the researchers make the design mock-up of the system which can be seen in Figure 5.
Of all the modellers have been made then the researchers create android based applications and assemble the hardware components corresponding system design has been created. Once the hardware and software were made after it was made the testing of the device. Assembling the hardware used for testing can be seen in Figure 6.

![Figure 6. Installing Prototype IOT based irrigation system.](image)

On 7 and 8 visible image software and hardware circuits that are connected to ensure the system is running according to user needs. Testing irrigation pump control can be seen by measuring the interval of the command in the smartphone with the completion of the command that is in hardware. Table 1 shows the time, and a delay pause command result in information.

### Table 1. Results of testing control irrigation pumps.

| No. | Time       | Jeda Delay | Note                        |
|-----|------------|------------|-----------------------------|
| 1.  | 08.00.00 – 08.00.05 | 5 seconds  | The irrigation pump is on   |
| 2.  | 10.25.02 – 10.21.05  | 3 seconds  | The irrigation pump is on   |
| 3.  | 12.10.04 – 12.10.07  | 3 seconds  | The irrigation pump is on   |
| 4.  | 14.20.20 – 14.20.30  | 10 seconds | The irrigation pump is on   |
| 5.  | 16.00.33 – 16.00.36  | 3 seconds  | The irrigation pump is on   |
| Average | 4,8 seconds |            |                             |

In Table 1 shows the results of the average delay that occurs when the irrigation pump control for 4.8 seconds. With an average of 4.8 seconds powering irrigation pumps command conveyed from smartphones to NodeMCU and forwarded to the relay.
4. Conclusions
Rapid Application Development methods can build a system based on Internet of Thing's (IOT). The success of the show with the device IOT testing to try testing with measurable control irrigation pumps. In this study, the average delay that occurs when the control is 4.8 seconds of orders delivered from smartphones to NodeMCU forwarded to the relay.

The design focuses on the development of testing methods, it is advisable for the implementation into devices smarter so that it can control the smart irrigation with the addition of weather sensors, soil acidity and so forth.

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