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# A Method to Present the Uniqueness for Uniform Program Applied in Irrigation Telecontrol

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**Abstract**: This study aims to show a trick to display the uniqueness of a steady program implied in irrigation telecontrol. The instrument comprises master terminal unit (MTU, master) and remote terminal unit (RTU). The MTU can exhibit the uniqueness of each instrument by inputting the RTU number. Then the program enters an array definition. The array definition makes every RTU seems unique and distinct from the others from the aspects of 1) MTU sim card number, 2) RTU sim card number, 3) background image, 4) farmer group, 5) farmer coordinator, 6) farming area name, and 7) display colour.

Keywords: program; irrigation system; telecontrol; master terminal unit (MTU); remote terminal unit (RTU)

## 1. Introduction

Water is one of the most significant matters for any living creature, including plants. To fulfil water needs, plants invest substantial resources in locating water and growing towards it[1]. Unfortunately, there are many water problems in water quantity and quality aspects. One of the water quantity problems is water scarcity. Water scarcity occurs in urban places and rural regions[2]. Pollution as the main water quantity problem occurs almost everywhere, from upstream to downstream.

The above irrigation water problem should be solved with control systems for quantity or quality aspects[1,3]. Irrigation is the process of watering our agricultural fields[4]. We are lucky that, at present, there are many available irrigation telecontrol systems, such as using wireless[5-6], IoT[7-8], integrated system[9-10] or remotely controlled robots[11]. Even the irrigation control systems are sometimes equipped with a water level sensor[12] to detect the submersion level of the crops which will need it, the ambient temperature and humidity variations, soil moisture and the soil pH so fertilizers can be used according to it[13-15]. All systems are electrically supplied, such as using solar panels[16-17].

Although many irrigation telecontrol systems are available in markets, they still cannot fulfil every user's necessity. For example, there is a real need to use uniform irrigation control systems, but each system looks different. A uniform product is usually cheaper than a unique product. However, the users do not want the products to look cheap. This kind of necessity can only be satisfied with a tailor-made method.

Based on the above requirement, this study aims to show a trick to display the uniqueness of a homogenous program implied in irrigation telecontrol. The uniqueness of this study was dig based on Maslow's Theory. This theory shows that two human needs are esteem and self-actualization needs[18-19]. The absorption of both needs makes each system in this study unique.

The trick has been applied to five telecontrol systems installed in five different corn fields in Jeneponto, South Celebes. A farmer group manages every cornfield. Each telecontrol system (instrument) comprises a uniform couple of master terminal unit (MTU) and remote terminal unit (RTU), separated from each other for controlling their irrigation. The MTU is a subsystem of the irrigation control system where it works as the human machine interface (HMI) or human computer interaction (HCI)[20]. At the same time, the RTU is a subsystem of the irrigation control system where it works as the helper of the MTU. The five MTU (master) subsystems are moveable according to each farmer group leader who may bring the MTU anywhere, and five RTU (slave) subsystems are installed permanently in their cornfield.

If the system is assumed to be successful, then the system might be applied to many other irrigation systems, especially in Indonesia. The system is not only affordable in price, but also the appearance of the system at each place is quirky.

## 2. Methods

### 2.1 Study Method

The study method was research and development (R & D). This method began with input, process, and output (Fig. 1). It should be noted that telecontrol is not precisely the same as automation. An automated irrigation system is defined as the system's operation with no human intervention or just system monitoring[21]. There is still human intervention in a telecontrol system, but it is conducted remotely.

The input was a problem statement, namely how to show a common property telecontrol looks like a private (group) belonging to telecontrol. The process comprised flow chart setup and program development. The flow chart setup defined what kind of application program this study will develop. There were three points. The first was the response of RTU concerning its main task as a part of the irrigation telecontrol system, while the second was the uniqueness of each MTU performance. The third was the comment on some samples concerning the uniqueness displayed by MTU. Program development in this study was obtained using design and program development to fulfil the data gathering aims. There were some revisions for this activity until the program was ready. The repetition for fulfilling the first and second data aims was carried out until the system worked as it was designed. The viewer's perception was repeated once because the designer could not meet the end users during this study.

The developed application was built using the Android Studio program. Android Studio[22-23] is Android's official integrated development environment (IDE), a software application that provides comprehensive facilities to computer programmers for software development. It is purpose-built for Android to accelerate development and help build the highest-quality apps for every Android device. The Android studio supports Java, $C^{++}$, and Kotlin. The basic system requirements for the Android studio are Microsoft Windows, macOS, and Linux.

The developed application can control the pump and open and close the selected valve. Through a smartphone with an application installed, users can run agricultural irrigation remotely by selecting land as needed.

There are some controller methods. The needed controlled parameters for the pump or valves in this study are open and closed. Hence the appropriate controller method is the on/off controller method or Boolean control logic. Other methods, such as fuzzy logic[24-25], are irrelevant.

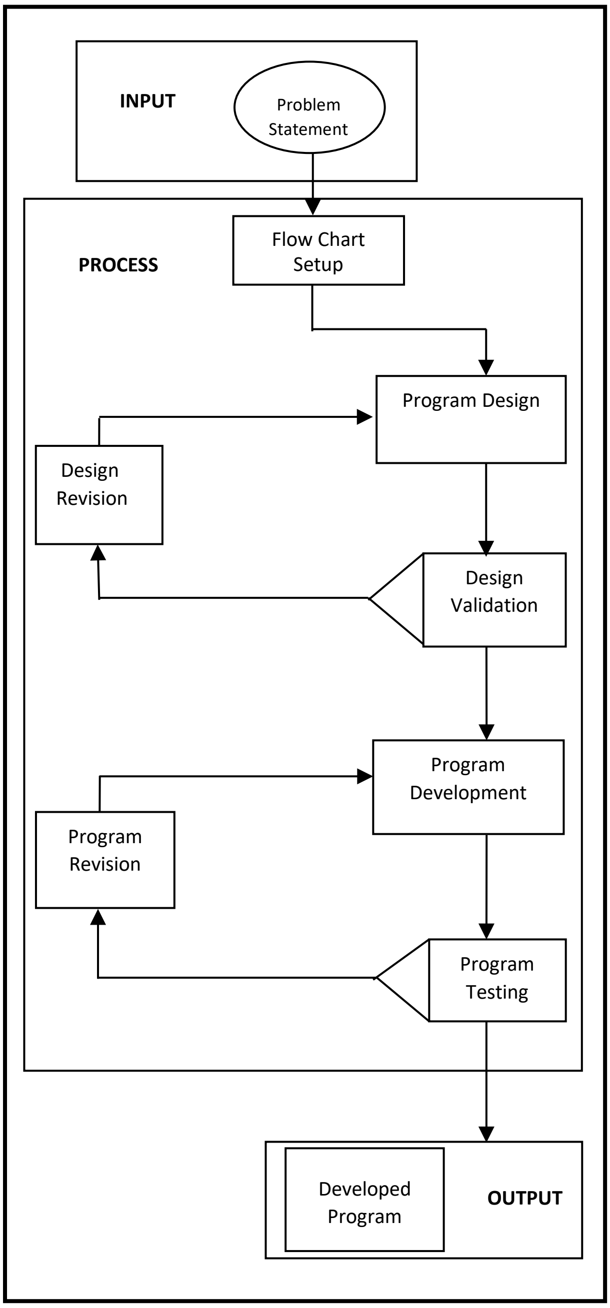


**Fig. 1:** Flow chart of study method

### 2.2 Equipment Setup

There were five uniform systems for this study. They were independent and tested in a row where the RTU distance between one system to the nearest system was around 10 cm. Each RTU has its couple. Nevertheless, the five MTUs are replaced with five in one MTU (MTU 51) to simplify this study. Hence, MTU 51 communicated with each of the five RTUs.

The experiment materials for this study were water supply, MTU (master), and RTU (slave). RTU comprises of global system for mobile (GSM) communications module, microcontroller, relay, actuator, and power supply (Fig. 2). The GSM module works a cellular communication to interface between the user and the system7) where its gate is the microcontroller. The microcontroller then interfaces the GSM and a relay. The relay will switch on and off the actuator. The RTUs were fixed in a laboratory, where the MTUs were mobile.

Rather than using a self-supporting power supply such as solar panel[26-28], the power supply in this system comes from the State Electricity Company. This condition is valid for this experiment and the actual application in fields. However, If needed, this system can also use solar panels or other self-supporting power supply. A combination of solar panels and thermal catcher (PV-T) can also be used to replace the solar panel alone (PV) because the efficiency will increase from 12.7% and 10.86% to 41.3% and 55%[29].

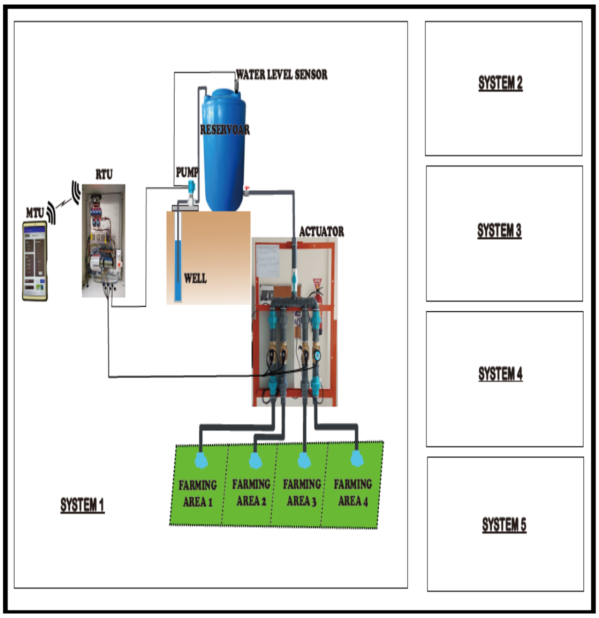


**Fig. 2:** Equipment set up for this study

### 2.3 Flow Chart

The needed data are divided into two modules. These are core instructions and array definition. The core instructions and array definition are packed together in a program (Fig. 3). The program is started from the beginning (start code in Fig. 3).

There are five RTU that have been made in this study. Each RTU is given a specific number. Hence there are numbers from 1 to 5. All the RTU number is inputted to each couple MTU.

The SIM card number of MTU is written to each MTU. The SIM card of MTU for RTU number 1 for this study is +6282110315938. Each MTU will have its own SIM card number.

One of the uniqueness of this system is that each MTU only responds to its couple RTU and two unique numbers for the system designer to communicate with all MTU without using their couple RTU. Hence, a small program inputs the correct RTU number for its couple of MTU. The MTU number for RTU number 1, for example, is +6282110316141.

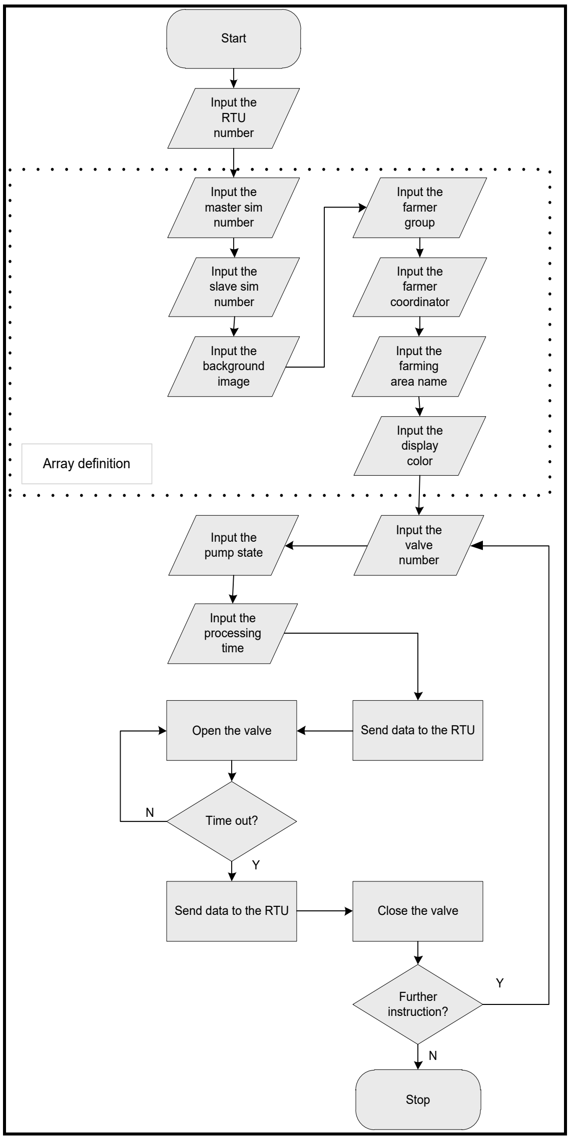


**Fig. 3:** Flow Chart of program

The background image should be the mascot or the exact location of the installed system. Therefore, the picture of one of these places should be used to input the background.

The farmer group of each system is different. The group name (such as Bungung Taesa), group coordinator (Tawa Dg Rola), and location name (Bungung Taesa, Kelara, Jeneponto) are inputted in the program one by one. Besides, the display colour is also added by giving a particular number, such as 55-00-179 (in RGB Decimal Code) for blue.

The seven aspects in the array definition were planned to make each system unique. The uniqueness was derived from Maslow's concept, especially esteem and self-actualisation needs[30-32].

The core instructions are executed after the array definition phase is surpassed (Fig. 3). The core instructions consist of four routines. The first is giving input. The second is switching on the irrigation through a specific valve. Giving inputs fills the valve number, chooses the pump state, and fills the processing time. To switch on the RTU means to send data to the (destinated) RTU, open the (selected) valve, and watch the time out. The third replaces the RTU with the steady state while the fourth waits for another command. Replacing the RTU condition is to send data to the RTU and close the valve. Shutting the valve is also to switch off the pump, and vice versa; opening the valve is also to switch on the pump. The fourth is waiting for another command to prepare the MTU for further instruction.

Table 1 shows the core instruction format, where each format comprises 6 bits. The first bit is the header or the start for processing the core instruction. Bits 2 to 5 are instructions used to open valves 1 to 4. The last bit is a particular bit to switch on the pump when one of the valves is open. The setting bit is one (1) because zero (0) is closed. Instruction 110001, for example, means to switch on solenoid valve number 2 and the pump.

Table 1. The protocol of core instruction

| Bit | Data | Value | Meaning | Value | Meaning |
|---|---|---|---|---|---|
| Bit1 | Header | 1 | Data flag | | |
| Bit2 | Valve1 | 1 | Open | 0 | Closed |
| Bit3 | Valve2 | 1 | Open | 0 | Closed |
| Bit4 | Valve3 | 1 | Open | 0 | Closed |
| Bit5 | Valve4 | 1 | Open | 0 | Closed |
| Bit6 | Pump | 1 | On | 0 | Off |

The array definition comprises seven inputs: 1) MTU sim card number (NoSimMTU), 2) RTU sim card number (NoSimRTU), 3) background image (MTUBackground), 4) farmer group (FarmerGroup), 5) farmer coordinator (FarmerName), 6) farming area name (Village), and 7) display colour (MTUColor). Therefore, the array definition makes every RTU seems unique and distinct from the others (Fig. 4).

```
int RTUNumber = 1;

String[] NoSimRTU = {“+6282110316141”, “+6282110316474”, “+6282113377353”,     “+6282110316077”,
 “+6282110315944”};
String[] NoSimMTU = {“+6282110315938”, “+6282110315709”, “+6282113161474”, “+6282110315921”,
 “+6282110316504”};
String[] FarmerGroup = {"Bungung Taesa", "Baorong Karamasa Abadi", "Balombong Jaya", "Harapan  Baru I",
 "Romangloe"};
String FarmerName = {“Tawa Dg Rola”, “Syamsudin R”, “M. Nawir”, “Jabaru”, “Syahrir DG Tangan”};
String Village = {"Bungung Taesa", "Baorong Karamasa", "Balombong Jaya", "Harapan Baru", "Romangloe"};
String SubDistrict = {“Kolara”, “Kolara”, “Kolara”, “Kolara”, “Kolara”};
String District = {“Jeneponto”, “Jeneponto”, “Jeneponto”, “Jeneponto”,  “Jeneponto”};
Integer[] RTUColor = {0, 1, 2, 3, 4};
Integer[] RTUBackground = {0, 1, 2, 3, 4};
```

**Fig. 4:** Seven inputs of the array definition

## 2.4 Program Development

The program was developed based on the program flowchart mentioned above. Application source code for RTU number definition is an example of the program (Fig. 6). The colour selection is defined in 3 bytes (6 digits) of hexadecimal format. Each byte represents the red, green, and blue colour components, respectively. The colour definition is represented using the following formulas.

$$C_n = U(R, G, B) \quad (1)$$

where $C_n$= is the colour name, $U$ is union, $R$ is the red level, $G$ is the green level, $B$ is blue level. The red colour level is

$$00 \leq R \leq FF(H) \quad (2)$$

where is hexadecimal notation and $D$ is decimal notation. The relation between hexadecimal and decimal is represented as

$$FF(H) = 255(B) \quad (3)$$

The green and the blue colours are written as

$$0 < G < FF(H) \quad (4)$$

$$0 < B < FF(H) \quad (5)$$

The above formulas are summarized in figure form (Fig. 5).

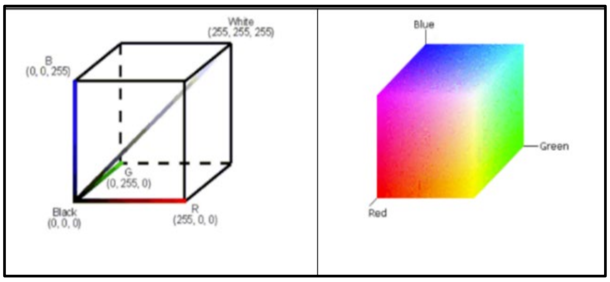


**Fig. 5:** RGB colour space and RGB colour coordinate

RGB colour cube obtained by rotating the RGB colour coordinates 90° laterally to the left. Black is the minimum point, while white is the maximum point. The hexadecimal to the chosen RGB code is converted using the following formula.

$$uvwxyz = uv\text{ (red)-}wx\text{ (green)-}yz\text{ (blue)} \quad (6)$$

$$uv\text{(hexa)(red)} = ((u*16) + v)\text{(decimal) (red)} \quad (7)$$

$$wx\text{(hexa)(green)}=((w*16) +x)\text{(decimal)(green)} \quad (8)$$

$$yz\text{(hexa) (blue)}=((y*16) + z)\text{ (decimal) (blue )} \quad (9)$$

where $uv$ is byte-1, $wx$ is byte-2, and $yz$ is byte-3;

The source code for colour initialization is packed in the colors.xml file. The five colour definitions are written as

```
<resources>
    <color name="blue_1">#3700B3  </color>
    <color name="red_1"># AACF00  </color>
    <color name="purple_1"># 8667BA </color>
    <color name="brown_1"># 634B4B  </color>
    <color name="green_1"># 0A6921  </color>
</resources>
```

Each color name is converted in the following hexadecimal, decimal, and colour (Table 2).

Table 2. Color value in hexadecimal and RGB

| Color Name | Hexa-decimal Code | RGB (Decimal) Code | Colour |
|---|---|---|---|
| Blue_1 | 3700B3 | 55-00-179 | |
| Red_1 | AACF00 | 170-207-00 | |
| Purple_1 | 8667BA | 134-103-186 | |
| Brown_1 | 634B4B | 99-75-75 | |
| Green_1 | 0A6921 | 10-105-33 | |

The section of the program for the above conversion is presented on Fig. 6.

```
RTUColor[0] = res.getColor(R.color.blue_1);
RTUColor[1] = res.getColor(R.color.red_1);
RTUColor[2] = res.getColor(R.color.purple_1);
RTUColor[3] = res.getColor(R.color.brown_1);
RTUColor[4] = res.getColor(R.color.green_1;

RTUBackGround[0] = R.drawable.jagungsatu;
RTUBackGround[1] = R.drawable.jagungdua;
RTUBackGround[2] = R.drawable.jagungtiga;
RTUBackGround[3] = R.drawable.jagungempat;
RTUBackGround[4] = R.drawable.jagunglima;

viewFarmerGroup.setText(FarmerGroup[RTUNumber]);
viewFarmerName.setText(FarmerName[RTUNumber]);
viewVillage.setText(Village[RTUNumber]);
viewSubDistrict.setText(SubDistrict[RTUNumber]);
viewDistrict.setText(District[RTUNumber]);
NoSimRTU = NoSimRTU[RTUNumber];
NoSimMTU = NoSimMTU[RTUNumber];
viewBackground.setImageResource(RTUBackGround[RTUNumber]);
textRTU.setTextColor(RTUColor[RTUNumber]);

GroupPompa.setBackgroundColor(RTUColor[RTUNumber]);
GroupValve.setBackgroundColor(RTUColor[RTUNumber]);
GroupWaktu.setBackgroundColor(RTUColor[RTUNumber]);
textWatch.setBackgroundColor(RTUColor[RTUNumber]);
textData.setBackgroundColor(RTUColor[RTUNumber]);
btnStatus.setBackgroundColor(RTUColor[RTUNumber]);
btnInputWaktu.setTextColor(RTUColor[RTUNumber]);
btnPompa.setBackgroundColor(RTUColor[RTUNumber]);
viewJudul.setTextColor(RTUColor[RTUNumber]);
```

**Fig. 6:** The section of program

It is enough to fill in the "*RTUNumber*" variable with the numbers 0, 1, 2, 3, or 4 for each of the five applications. After compilation, the application display will automatically display the name of the farmer group, farmer coordinator, farming area name, background image, and colour display according to each MTU. In running the application, communication from the MTU sim number to the RTU sim number follows the defined array definition.

## 3. Result and Discussion

### 3.1 Core Instruction

The result for core instructions is presented in Table 3.

Table 3. RTU responses for the core instructions

| No | MTU | RTU |
|---|---|---|
| 1 | 110001 | The valve1 is open and the pump is on |
| 2 | 101001 | The valve2 is open and the pump is on |
| 3 | 100101 | The valve3 is open and the pump is on |
| 4 | 100011 | The valve4 is open and the pump is on |
| 5 | 100001 | All valves are closed and the pump is on |
| 6 | 100000 | All valves are closed and the pump is off |
| 7 | 111111 | Final status |

Table 3. shows that all RTUs follow the MTU commands perfectly. Commands number 1 to 4 is switching on valve number 1 to 4, respectively. Based on the user's requirement, the valve is set one by one. Instruction number 5 or 6 is an instruction to switch on or off the pump. Instruction number 7 is a special instruction to obtain the RTU status. The response depends on the RTU's final status. The RTU does not reply to all instructions except instructions presented in Table 3.

The response is presented in numbers and phrases (Fig. 7). Number only is hard to read. MTU instruction 110001, for example, is responded to as 110001, solenoid valve number 1 is open, and the pump is on. Instruction on the MTU 100000 is responded as 100000, all valves are closed, and the pump is off.

The testing result shows that all RTU does not respond to the MTU instruction as expected. This problem, however, is not caused by the system program. It was dominantly caused by the weakness of the signal strength between MTU and RTU. The problem was solved automatically as soon as the signal was above the threshold. The signal strength can be increased by replacing the indoor antenna with an outdoor antenna. Changing RTU locations is not possible because the RTU position is fixed.

The MTU instructions are carried out using SMS (Short Message Service). The RTU also reply the instruction in SMS. Hence, it is crucial to ensure that all MTU and RTU have routine maintenance to top up the SMS quotas. The late management of the SMS quota can make MTU or RTU sim cards useless. This problem can cause further problems because the system program has to be filled with the new sim card numbers.

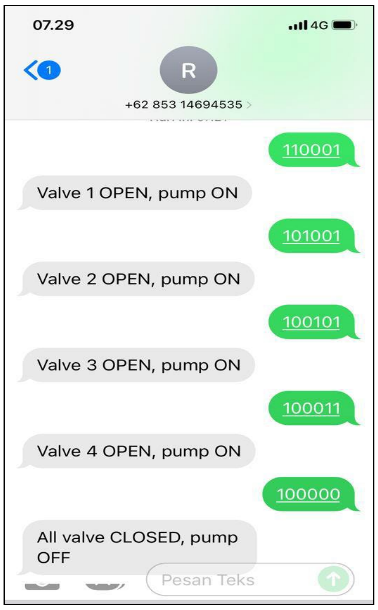


**Fig. 7:** RTU responses for the core instructions

The installed systems' primary function is obtaining a managed irrigation system. The above result shows that the system program worked well. The available problems were primarily due to the weakness of signal strength or the insufficiency of SMS quotas in MTU or RTU.

An IoT is a desirable approach to controlling and managing irrigation[33-35]. IoT in agriculture is used to increase resource efficiency[36]. IoT is a type of network technology which senses information from different sensors and makes anything join the Internet to exchange information[8]. IoT is a general concept for the ability of network devices to feel and collect data from the world around us and then share that data across the Internet, where it can be processed and applied for several interesting purposes[37]. It should be noted that there is a delay for every instruction execution in the IoT system, like in this study. This delay phenomenon, such as 3.67 seconds, is common in the IoT system[38]. The delay in this system is not constant. One of which is influenced by the telecommunication signal condition.

### 3.2 Array Definition

The private functions presented in Table 1 are 7. All MTUs can also be represented using one primary MTU. The primary MTU can exhibit the uniqueness of each instrument by inputting the RTU number. Then the program enters an array definition. The array definition comprises seven inputs: 1) MTU sim card number, 2) RTU sim card number, 3) background image, 4) farmer group, 5) farmer coordinator, 6) farming area name, and 7) display colour. The array definition makes every RTU seems unique and distinct from the others. For example, RTU 1 has MTU sim card: 082110315938, RTU sim card: 082110316141, background image: Fig. 8(a), farmer group: Bungung Taesa, farmer coordinator: Tawa Dg Rola, farming area name Bungung Taesa, and MTU display colour: blue (Table 4).

Table 4. The content of array definition

| Number | RTU1 | RTU2 | RTU3 | RTU4 | RTU5 |
|---|---|---|---|---|---|
| 1) MTU sim card number | +6282110315938 | +6282110315709 | +6282113161474 | +6282110315921 | +6282110316504 |
| 2) RTU sim card number | +6282110316141 | +6282110316474 | +6282113377353 | +6282110316077 | +6282110315944 |
| 3) background image | Fig. 8a | Fig. 8b | Fig. 8c | Fig. 8d | Fig. 8e |
| 4) farmer group | Bungung Taesa | Baorong Karamasa Abadi | Balombong Jaya | Harapan Baru I | Romangloe |
| 5) farmer coordinator | Tawa Dg Rola | Syamsuddin R. | M. Nawir | Jabaru | Syahrir Dg Tengan |
| 6) farming area name | Bungung Taesa, Kelara, Jeneponto | Baorong Karamasa, Kelara, Jeneponto | Balombong Jaya, Kelara, Jeneponto | Harapan Baru, Kelara, Jeneponto | Romangloe, Kelara, Jeneponto |
| 7) display colour | Blue, Fig.8f | Red, Fig. 8g | Purple, Fig. 8h | Brown, Fig. 8i | Green, Fig. 8j |

### 3.3 Further Development

Water control systems can be classified into control architecture, control objective, control-action variable, control variable, and control strategy[39]. The system in this study is classified as a decentralized control architecture, outflow control objective, inflow and outflow control-action variable, feedback control variable, and on-off control strategy. The five control systems' outputs are reported independently and saved in the cloud. Their outputs are collected together, but each system is a stand-alone. Hence they are categorized as a decentralized control system[40]; the objective of the control system in this study is the outflow of the irrigation reservoir. If the outflow is controlled, it automatically controls the input by giving feedback to stop the pump. This technique is called a switch on and off water irrigation.

An automatic control system will be developed in the next step by integrating the available concepts.. The system will work based on the soil moisture[41], water budget[42] and types of plant commodities. The irrigation system is stressed how to terminate irrigation before the end of a growing season if an excessive flow rate is detected or the watering is not economical[43-44]. This development is what is related to the core instructions.

The development of array instruction is related to the uniqueness of each system. Inspiration digging from local users, especially from the millennial generation, is needed. This inspiration digging is vital because agriculture should attract young people to make them remain in the village, preserve land use as an agricultural system, and encourage sustainable agriculture[45].


**Fig. 8:** Display of five programs (a) MTU1 background, (b) MTU2 background, (c) MTU3 background, (d) MTU4 background, (e) MTU5 background, (f) MTU1 colour, (g) MTU2 colour, (h) MTU3 colour, (i) MTU4 colour, (j) MTU5 colour.

## 4. Conclusion

The result shows that making unique appearances from uniform systems is achieved by developing a slight differentiation in its software. Some features, such as letter, style, format, texture, colour, composition, and background, should be made distinctly for each system. The system needs further development for core instructions and array definition aspects. The core instructions are enhanced by changing the control system into an automatic one suitable for the local site. The array definition is developed by changing the features.


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