Conference Paper

On/Off Temperature Monitoring and Control via the Internet of Things Using iTCLab Kit

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ABSTRACT

With the Internet of Things (IoT) gradually evolving as the next phase of the Internet's evolution, it becomes important to recognize the various potential domains for IoT deployments, and research challenges especially those related to monitoring and control applications in industry. This paper shows how to program a simple On/Off temperature control system via IoT using Arduino and the iTCLab Kit. Meanwhile, for monitoring and controlling temperature via cellphone, the IoT MQTT Panel is used. The experimental results show that the control system has worked well. This is indicated by controlling and monitoring the results of temperature control via cell phone as expected.

Keywords: Control, monitoring, IoT, iTCLab, Kit, On/Off

Introduction

The Internet of Things (IoT) is often described as an area where billions of smart objects appear that are interconnected with each other using the Internet as a means of sharing data and resources (Chahal et al., 2020). With this technology, it is possible to remotely turn on and off appliances at homes such as lights, televisions, stoves, heaters, doors, windows, Air Conditioners, and others, as long as the equipment is connected to the internet and a web broker. With the presence of this technology, it is possible to monitor and control remotely. Including monitoring and controlling remotely using a simple control technique, namely on/off the controller. Although the control technique is simple if it can be done remotely, making this control system is still quite interesting and challenging to do research and development. Because it usually starts with a simple control technique, it can then be replaced with a higher control strategy.

The application of the on/off controller, although simple, still inspires a lot of research, including how to implement an HVAC on/off the controller in EnergyPlus to simulate the energy of small residential and commercial buildings (Cetin et al., 2019). Research on how to simulate an on-off controller for Second Order System using LabVIEW (Uriča & Simonová, 2017). Research on how to analyze the effect of band-off settings and on/off controller set-points on energy consumption and switching frequency of equipment from HVAC systems in housing (Afram & Janabi-Sharifi, 2016). Research on how to compare fuzzy controllers and on/off controllers for indoor climate management during winter in a model poultry house (Mirzaee-Ghaleh et al., 2015). Included in this research, a simple remote on/off control technique is proposed, which is applied to the Internet-Based Temperature Control Lab (iTCLab) Kit.

The iTCLab kit developed by the State Defense Campus of the Universitas Pembangunan Nasional "Veteran" Jawa Timur Indonesia (https://www.upnjatim.ac.id), was originally inspired by the development of the Temperature Control Lab Kit (TCLab), which was developed by Brigham Young University. One of the private campuses in Provo, Utah United States (BYU, 2018).

TCLab is a temperature control lab that can be used for feedback control applications built using Arduino, LEDs, two heaters, and two temperature sensors. The heater power output is adjusted to maintain the desired temperature setpoint. Thermal energy from the heater is transferred by conduction, convection, and radiation to the temperature sensor. Heat is also transferred from the device to the environment (BYU, 2018). The main difference between iTClab and TCLab is that the Arduino UNO microcontroller is replaced with the ESP32 so that this kit can connect to the Internet of Things (IoT). An overview of iTCLab is shown in Figure 1.

Both iTCLab and TCLab kits can be used to learn Control Systems, System Dynamics, Arduino and Python programming, Machine Learning programming, and others. Several studies on TCLab applications include the introduction of digital controllers for undergraduate students using the Arduino TCLab Kit (de Moura Oliveira et al., 2020). Another research on TCLab is how to benchmark the temperature controller used for dynamics and process control (Park et al., 2020). Another research on TCLab is how to evaluate and demonstrate laboratory equipment that can be taken home (Rossiter et al., 2019). Another research on TCLab is how to experiment with APMonitor Lab Temperature PID Control for Undergraduate Students (Oliveira & Hedengren, 2019). Furthermore, what TCLab can do, should be proven in the future, that it can also be done by iTCLab.

Figure 1. Internet-Based Temperature Control Lab (iTCLab) Kit

Material and Methods

The basic system of an Internet of Things (IoT) based application with the Message Queuing Telemetry Transport (MQTT) protocol consists of at least 4 main components, namely Hardware/physical (Things) in this case the iTCLab device, internet connection, Cloud data center as a place to connect, save or run applications as MQTT Brokers, and IoT MQTT Panels to monitor and control remotely via mobile phones. The proposed system architecture is shown in Figure 2.

The MQTT broker, which is at the core of the MQTT Publish/Subscribe protocol, is a server that receives all messages from the MQTT client and then routes the messages to the appropriate subscribed clients. The MQTT broker used in this study is a free online public MQTT broker from HiveMQ. Meanwhile, the IoT MQTT Panel is an application that allows for the management and visualization of IoT projects, based on the MQTT protocol. With this application, an IoT-based iTCLab On/Off Kit control system project can be created.

From the system architecture in Figure 2, to run as desired, a program using the Arduino programming language is first made. The program contains temperature data retrieval. Equipped with a way of connecting to IoT. The program is embedded in the iTCLab Kit. When run, if the settings are correct, it will successfully connect to the MQTT Broker. Next, settings are made

according to the topic created, on the IoT MQTT Panel. If it is appropriate, monitoring and controlling on/off via cellphone can be carried out.
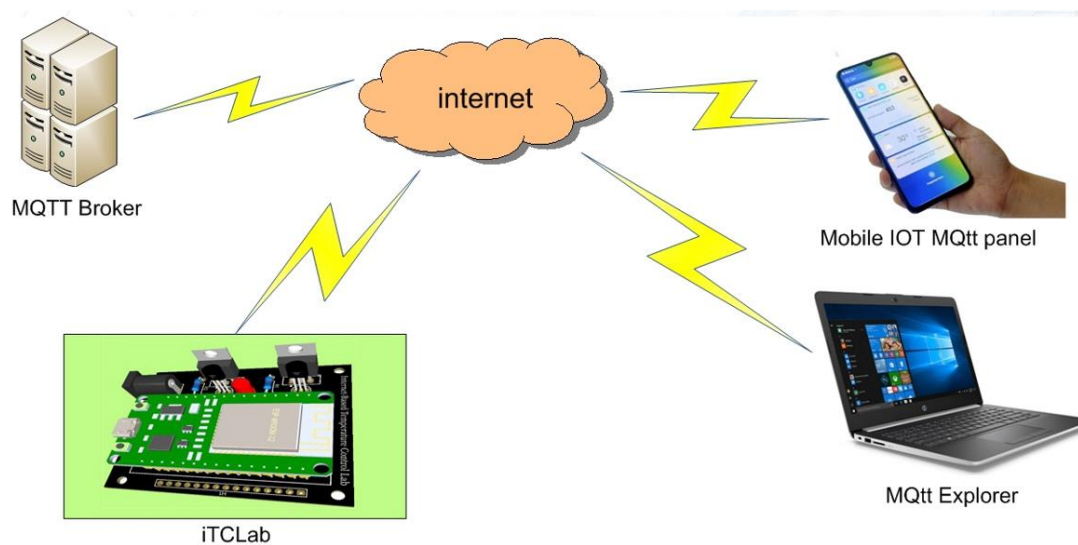

Figure 2. The Architecture of on/off temperature monitoring and control system using the internet of things

From the system architecture in Figure 2, to run as desired, a program using the Arduino programming language is first made. The program contains temperature data retrieval. Equipped with a way of connecting to IoT. The program is embedded in the iTCLab Kit. When run, if the settings are correct, it will successfully connect to the MQTT Broker. Next, settings are made according to the topic created, on the IoT MQTT Panel. If it is appropriate, monitoring and controlling on/off via cellphone can be carried out.

Results and Discussion

The testing programming and setting on the iTCLab Kit are shown in Figure 3. Through the serial monitor on the PC, it can be seen the temperature readings from the iTCLab Kit. Some important program snippets include the following command line:

```
// Connect to WiFi network
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("WiFi connected");

  // Connect to Server IoT (CloudMQTT)
  client.setServer(mqttServer, mqttPort);
  client.setCallback(receivedCallback);
  while (!client.connected()) {
    Serial.println("Connecting to CLoud IoT ...");

    if (client.connect("iTCLab Suhu On/Off")) {
        Serial.println("connected");
```

```
            Serial.print("Message received: ");
        } else {
            Serial.print("failed with state ");
            Serial.print(client.state());
            delay(2000);
        }

        client.subscribe("heater1");
        client.subscribe("heater2");
    }
}
```
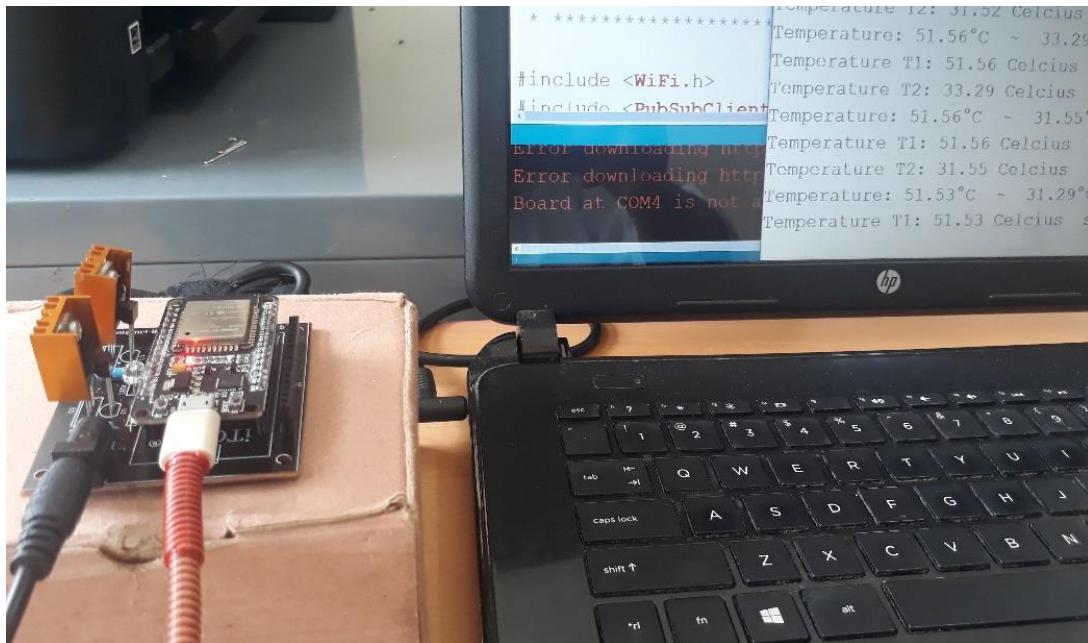

Figure 3. System testing using the iTCLab Kit

Next, settings are made according to the topic created, on the IoT MQTT Panel. The selection of the panel used, and the settings that must be made on the IoT MQTT Panel, are shown in Figures 4 to Figure 6. If the settings are appropriate, On/Off monitoring and control via Mobile Phones can be carried out. In this experiment, an example of the results of On/Off temperature monitoring and control is shown in Figure 7.
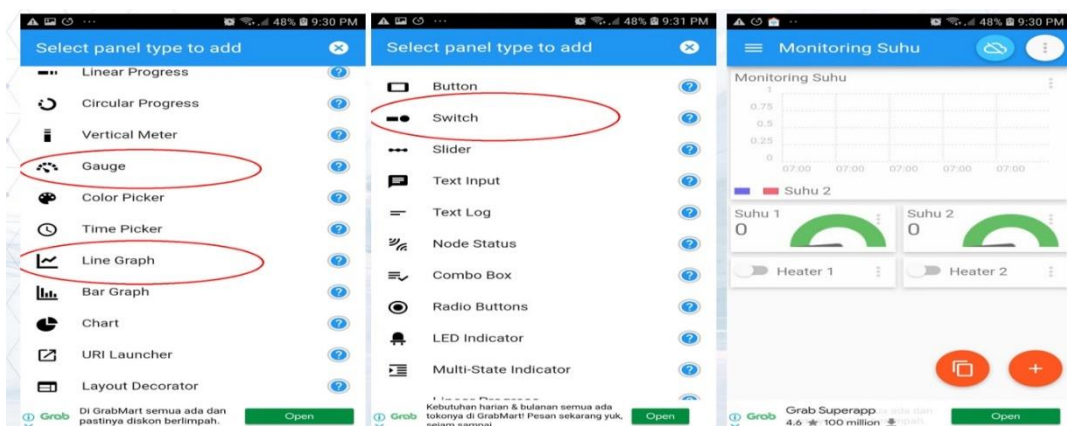

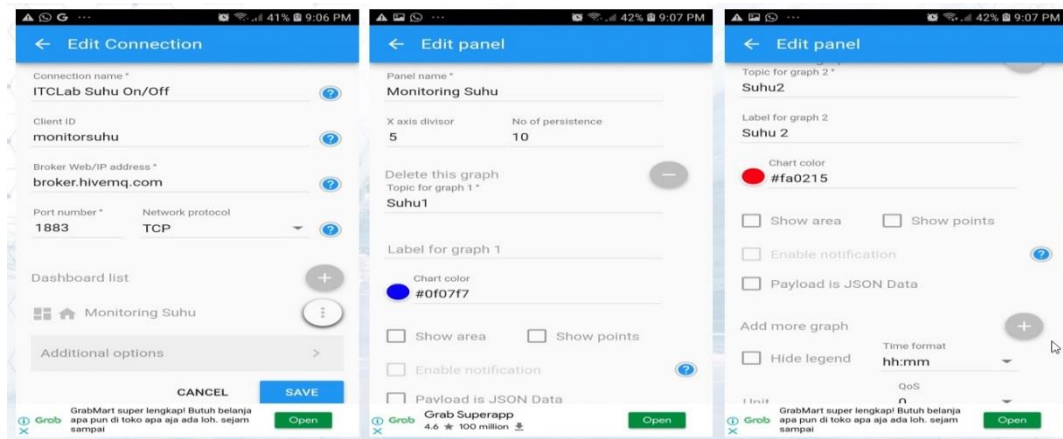Figure 4. Panels used in IoT MQTT Panel

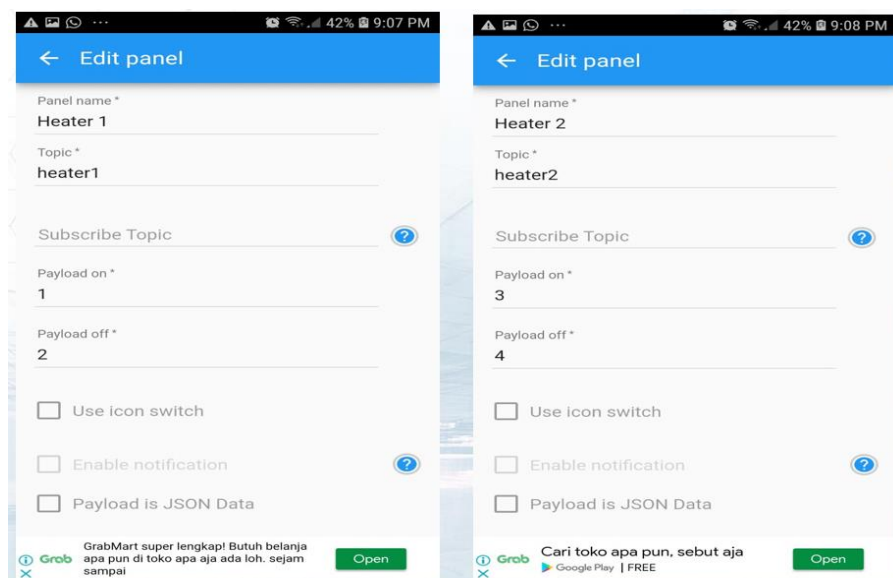Figure 5. Connection settings in IoT MQTT Panel

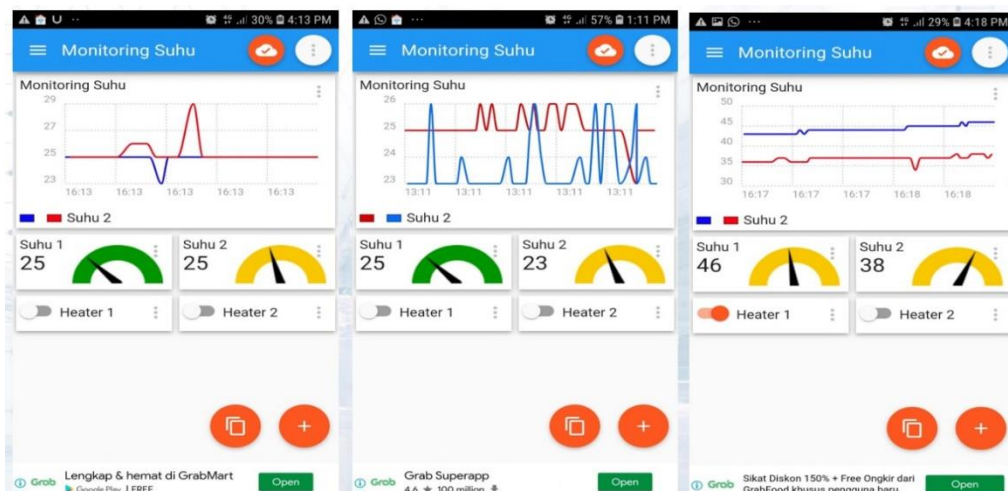
Figure 6. Setting Topics in IoT MQTT Panel

Figure 7. Experimental results on the IoT MQTT Panel

From the experimental results in Figure 7, it can be seen that the IoT MQTT Panel has been successfully connected to the MQTT Broker. This means that the program and settings on the iTCLab Kit are correct. The reading of the temperature sensor from sensor 1 and sensor 2 has also been successful. It looks like the reading is a few degrees Celsius. Then it remains only to increase and decrease the temperature, by turning the heater On/Off. This test has also been successful. It can be seen that there is a difference in the temperature readings of each sensor. This is caused by the different On/Off heating control when the button is pressed.

Conclusion

From the experimental results, it can be shown that the iTCLab Kit can be used as a device for On/Off temperature monitoring and control testing via the Internet of Things (IoT). The On/Off temperature monitoring and control program was created and embedded in the iTCLab Kit. Furthermore, management and arrangements for monitoring and controlling mobile are made using the IoT MQTT Panel. The experimental results show that the control system has worked well. This is indicated by the results of monitoring and controlling on/off via mobile as expected.

Acknowledgment

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