A Secure and Intuitive IoT Architecture for Container Farm

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Abstract

In this paper, we propose an IoT architecture based on an open-source cloud platform, MCS lite, and low-cost application development boards, LinkIt 7697. The messages between the original cloud platform and the boards are not encrypted so there exists a serious risk. We establish a secure channel among them to protect the messages. In addition, a web server is incorporated to provide a scene functionality which helps users intuitively watch/control the sensors/actuators in his/her container farms.

Key words: IoT, security, scene, container farm.

Introduction

The Internet of Things, IoT, generally consists of four main layers [1-2], namely the sensing layer, the network layer, the data processing layer, and the application layer. The devices in the sensing layer measure the desirable physical, chemical or biochemical information around themselves. The network layer transmits the collected information from the sensing layer to any particular information processing system through existing communication networks like the Internet, LoRa, NB-IoT or 4G. The data processing layer stores the data collected in the sensing layer and analyzes the data to take automated actions. For example, it may turn on a fan when the temperature from a certain sensor exceeds a threshold. The application layer presents the data from the data processing layer in a customized way to achieve IoT applications needed by users. For example, in smart agriculture, the soil moisture, together with the level information of a water tank, may be displayed on a daily basis so that the farmer can better manage the water.

Due to the popularity of IoT, many customized and generalized IoT solutions are implemented. A solution provided by MediaTek Inc. [3] consists of an open-source cloud platform, MCS lite [4], and low-cost application development boards, LinkIt 7697 [5]. The MCS lite implements the data processing layer and parts of the application layer. The LinkIt 7697 implements the sensing layer. By default, Wi-Fi is adopted by LinkIt 7697 to communicate with MCS lite. Since the messages between MCS lite and LinkIt 7697 are not encrypted, there exists a serious risk. In such a system, unauthorized parties may detect, intercept and modify messages among the cloud platform and the boards. In addition, the MediaTek's open-source solution visualize the collected data of only one board at a time. However, it would be much more convenient that all the sensor data of the field are displayed simultaneously and the positions of the data shown on the screen approximately reflect the physical positions of the sensors in the field. This convenient functionality is called *scene* and is provided in their commercial solution only. In this study, we enhance the security of the above-mentioned open source IoT architecture and incorporate a scene functionality to help users intuitively watch/control the sensors/actuators in his/her container farms. In addition, our system can remotely control the fan of the container farm.

The rest of the paper is organized as follows. Section 2 describes our new IoT architecture for the provision of security and scene functionality. Section 3 describes the preliminary results of our implementation. Finally, section 4 concludes this paper.

Our IoT Architecture

Our IoT architecture is shown in Fig. 1. There are four hardware components in our architecture, namely LinkIt 7697 boards with sensors/actuators, an access point, a server and user devices. The connections between the boards and the access point use WPA2 to secure their Wi-Fi data. This technique is inherited from MediaTek. Different from the original architecture, our access point creates a secure connection to the server using VPN. The MCS lite remains unmodified and runs in the server. In addition, a web server is incorporated to provide the *scene* functionality. We implement the corresponding web applications based on Laravel [7]. The positions of the sensor information shown on the webpage are arranged by CSS technique. A software firewall is adopted by the server to protect the MCS lite. As a consequence, only the access point and the web server can communicate with the MCS lite application. Finally, the connections between user devices and the web server are protected by TLS 1.1 and 1.2. Even though the messages to/from the MCS lite are still unencrypted HTTP, our architecture can protect the messages from being accessed by unauthorized parties.

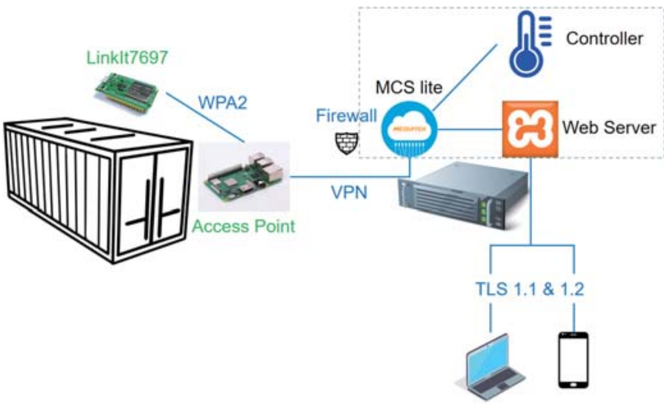

Fig. 1 Our IoT architecture.

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Fig. 2 shows our original fan control system. In the figure, the only one temperature sensor measures the air temperature outside the container and transmits the data to the PID temperature controller [8]. Then, the PID temperature controller turns on/off the relays according to the measured temperature. For ease of explanation, the relays are numbered 0 to 3 moving left to right as shown in Fig 3. When the temperature was below 27 degrees Celsius, all the relays will be turned off. At this time, the AC micro drive [9] won't drive the fan. As the temperature is raised, more relays will be turned on so that the AC micro drive increases the fan speed. The relationship among the temperatures, relays and fan speeds is described in table I. However, the temperature distribution of a closed container is unlikely to be uniform. Thus, the fan may not be activated even though the temperature in the opposite location of the container is too high. To solve this problem, we replace the local PID temperature controller by a LinkIt 7697 and four grove relays. The LinkIt 7697 controls the four original relays via the four grove relays. Further, the remote controller process in our server subscribes all the temperature data from the MCS lite. If it founds that at least one sensor reports a high temperature, it commands the MCS lite to control the LinkIt 7697 to turn on the corresponding grove relays. Since we deploy many temperature sensors in the container farm, we can activate the fan if any one location of the container is too hot. Thus, the temperature distribution will be more uniform than the original solution.

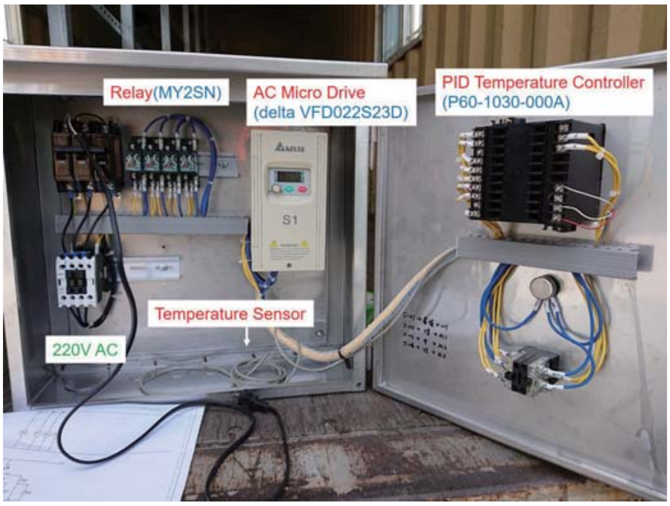

Fig. 2 Original fan control system.

Fig. 3 Four relays controlling the AC micro drive.

TABLE I
Relationship among the temperatures, relays and fan speeds

Temperature(°C)	Relays turned on	Fan speed
< 27	None	Stopped
27~28	0	Slowest
28~29	0, 1	Second slowest
29~30	0, 1, 2	Second fastest
>30	0, 1, 2, 3	Fastest

Preliminary Result

Fig. 4 illustrate the preliminary results of our implementation. In the center of Fig. 4, there is a map layout of the container farm. Six IoT devices, labeled A, B, C, D, E and F are put in the approximate positions corresponding to their actual positions in the container farm. In this snapshot, the IoT devices A, B and C are on while the remaining ones are off. The name of the board is displayed in top-right corner of each label. Below the display name, the live sensed data, relative humidity and temperature in this example, are shown respectively. Hence, the user can monitor all the sensed data of his/her container farm through a single web page. Currently, the contents of the web page are refreshed automatically every 5 seconds. During the refresh, the webserver issues HTTP Post messages to the MCS lite application to get the latest sensed data.

Fig. 4 Preliminary result.

Conclusion

In this paper, we propose a secure and intuitive IoT architecture for container farm. In our architecture, the messages are transmitted through secure channels. We also implement a convenient *scene* functionality to show all sensed data simultaneously in a single web page. The positions of the displayed data are the approximate physical positions of the corresponding sensors. Thus, users can intuitively understand the statuses of their container farms. In the future, we will

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analyze the sensed data through machine learning.

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