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An architecture and Design of Data Converter for IoT-Based Smart Farm

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Abstract

Recently, the food self-sufficiency rate has been declining due to the declining productivity and efficiency of the rural population and aging population. Due to this, applying smart farm related technologies are gradually increased in a wide range of farming circumstances. However, the extendibility and compatibility among sensors and control system are still having long way to go due to the lack of standardization for smart farm. To enhance the extendibility and compatibility in the smart farm circumstance, we propose and describe the data converter which is able to support a various interface of sensors as well as actuators. The main control part in the data converter communicates with sensor-actuator interface using internal communication protocols to be able to enhance the compatibility and extendibility. Extendable sensor-actuator interface supports sensor data gathering as well as actuator control. And, there are also the system configuration and network interfaces. Communication with server is supported by using the MQTT protocol and JSON data format.

Keywords: *IoT, Smart farm, Data converter, Sensor-actuator interface, MQTT*

1. Introduction

Recently, UN FAO has forecast that the world food production by 2050 should be increased [1], as the United Nations projects that the global population will increase from 7.3 billion in 2015 to 9.7 billion in 2050. However, we are still suffering from a rapidly aging population, a low self-sufficiency rate of food, an income reduction, and a decreased productivity depending on a climate change[2]. To solve problems, the government of Korea has established many policies to encourage a distribution of smart farm system which is a more advanced technology integrated with ICT in a cultivation. The smart farm system can be used for the increment of productivity as well as for the reduction of usage of energy with an adaptation of smart farm system. Due to insufficient monitoring technology, and the low availability and connectivity of various control method, there is a growing need for research and development on monitoring and control methods that take into account scalability and compatibility in agriculture. Most of the existing smart farm systems are designed as to exchange data between many sensors and actuators and one main controller which is the directly connected with them [3][4]. In this case,

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there is the restriction on the expandability depending on the sensor/actuator interface. Although the development of the integrated environmental controller has been proceeded[5], the after-service has been not possible to customers who have adopted the smart farm system because the smart farm companies are out of business. Due to this, customers who want to equip a new sensor or actuator could not integrate on their smart farm system. Despite of the development of standard in PG 426 (smart farm project group) to solve the extensibility and compatibility, the agriculture in an open area, fishery, and livestock are still in the start stage. Moreover, the distribution of smart farm system in the field of the fishery and livestock industry is not easy because of the bad accessibility of the information to be able to adopt the new advanced system [6].

In order to solve problems faced by existing companies and farmers, it is necessary to study the smart farm system that can support previously purchased sensors/actuators. With this, the scalability and compatibility of the sensor-actuator interface can be solved by design of smart farm system which can to mount more sensors and actuators. In this paper, we propose the data converter architecture for the smart farm system, and describe its configuration and communication scheme.

2. Data converter architecture and its interface

With the incorporation of ICT technology, the smart farm technology can be used for maintaining growing conditions with the high productivity and the management efficiency. To be able to maintain the stable growing condition, the sensor data should be gathered, and the various actuators can be able to be controlled by using the sensor data. As the actuator control architecture depending on the multiple sensors for the smart farm system, we propose is able to support various sensor and actuator interfaces, it is available to construct the system with the high compatibility and extensibility.

2.1. Architecture of data converter

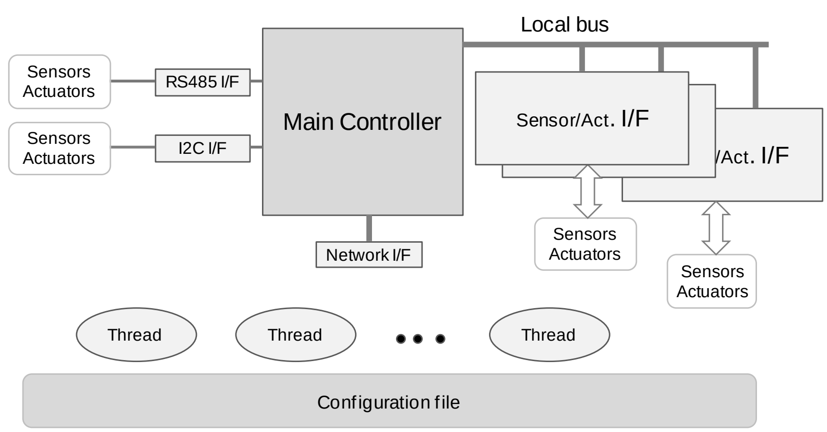

Figure 1. Architecture of the data converter for smart farm

The structure of data converter for the proposed smart farm system is shown in [Figure 1]. It is divided into the main controller, the sensor-actuator interface for various sensors and drivers, and network part. A modularization of each part improves the scalability and compatibility of the sensor-actuator interface. In order to use various sensors and actuators in one device, the sensor-actuator interface is designed separately. As a result, it is possible to support various kinds of interfaces in the sensor-actuator interface because the sensor data acquisition and processing and the driver are separated. In the main controller, data processing is enabled regardless of the sensor-actuator interface.

The sensor of the sensor-actuator interface is available to use depending on its signal type such as voltage and current and is supportable of the RS-232C interface, so that it can process various types of signals. After the collected bunch of sensor value is processed in the main controller, the actuator mounted on the sensor-driver interface is controlled according to the processed result. It is designed as the modular structure so that modules can be easily added or removed depending on the number and type of sensors/actuators. In addition, Modbus and I2C interfaces are provided, which are provided independently with the sensor-actuator interface. It can support the additional scalability depending on the signal type of the sensor and actuator. We have developed the software as the modular device drivers and the threads to be able to support various types of the interface and function. In order to do this, the system configuration is available so that the necessary sensors and actuators and their interfaces can be configured. The collected sensor values and the operation results of actuators are transmitted to the user's computer or smart phone.

2.2. Sensor-actuator interface

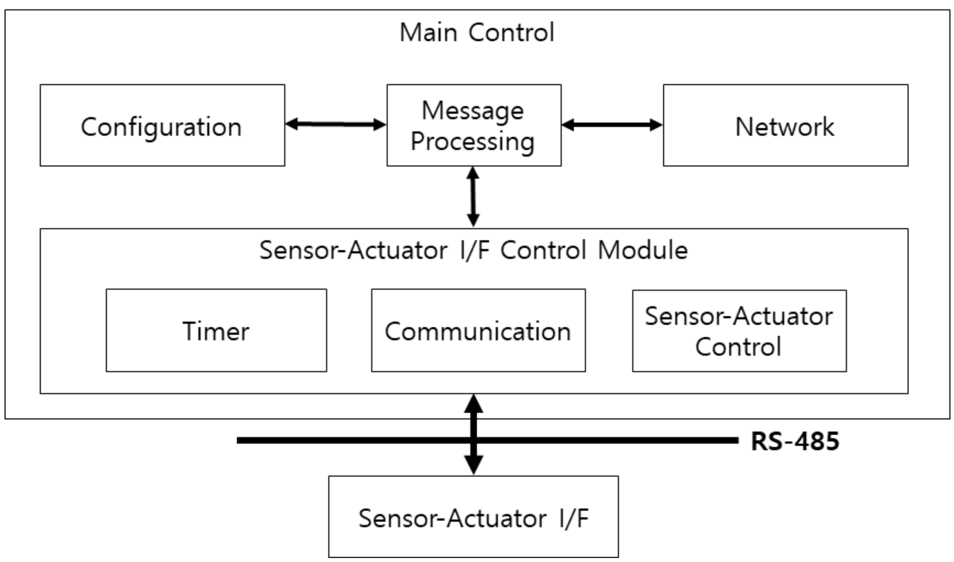

Figure 2. Control module of sensor-actuator interface

The message processing and the time management for controlling the sensor-actuator module are shown in [Figure 2]. Individual configuration by user which can be supported by directly setting in the local management process as well the network process is performed in the message processing unit of the main controller. After collected sensor values and actuated results are generated as a JSON message in the message processing unit, status message for them is transmitted to a server through the network. To be able to present on the user interface, the transmitted message is parsed and processed. The time management is used for managing the generation, transmission, and response time of the control command for control of the actuator according to the sensor value and generates an error message according to the response time.

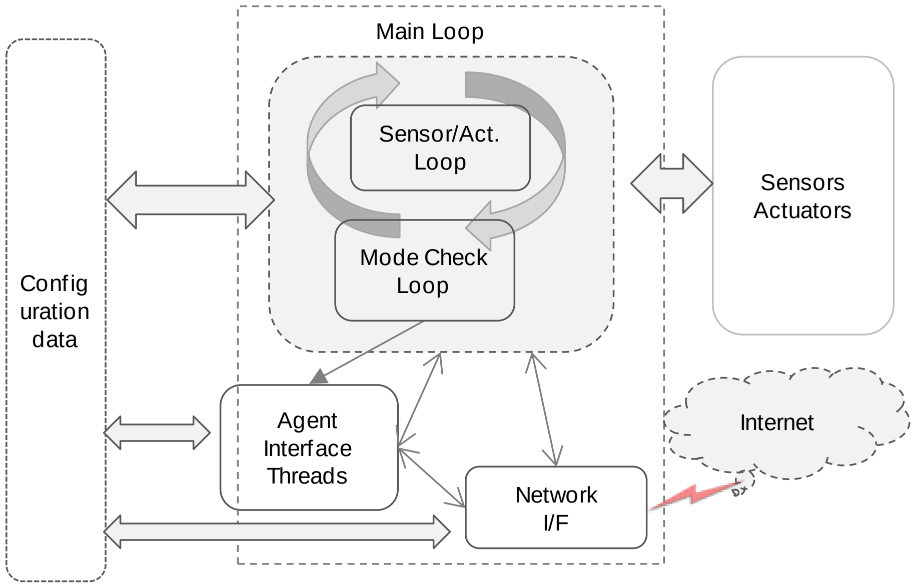

Figure 3. Interface structure for controlling data converter

[Figure 3] shows the interface structure for data converter control. For data acquisition and control, each function module can be operated by using threads. The configuration information for the data converter is stored in the JSON files, and memory is allocated according to the data structure suitable for each module. Data structures can be managed by organizing each module into a linked list format. With this, the driver control is possible according to various requirements such as reservation scheduling and automatic control. Also, since the sensor and the driver are provided as the linked list, this information can be easily added, deleted, and retrieved according to the its ID. As a result, it is easy to set up and manage various sensors and actuators. The actuator control based on sensors can also be easily set up and managed.

3. Conclusion

In this paper, to improve the extensibility and compatibility, we described and proposed the architecture of data converter system which is available to support various interfaces for sensors and/or actuators. The sensor data collection and various actuator control method can be supported by using the module type sensor-actuator interface with additional mounting capacity as well as by using the internal protocol with the extensibility and compatibility. In addition, data structures of the sensor and actuator corresponding to the required requirements or constraints are also provided by using the linked lists, so that they can be set according to the number and types of sensors and actuators. With results, the system configuration, network communication, independent interface module control, and various reports and alarms are designed to be processed by separate threads. The system configuration, network communication, independent interface module control, various reports and alarms are designed to be processed by separate threads. With the result, we proposed the structure that can support the scalability as well as the compatibility. In the future, it is necessary to develop algorithms considering the performance based on this structure, to develop standardization, and to verify the system through implementation.

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