

Design of Interfaces among Functionalities for Smart Greenhouse

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Abstract—In order to analyse the impact of environment condition to the crop, it is necessary to accumulate the data generated by the smart greenhouse. Thus, it is important to define the standard interface and data format among functional entities within smart greenhouse to be able to use the accumulated data is meaningful. In this paper, we will describe the status of standardization in ITU-T and TTA regarding smart greenhouse briefly, and introduce the reference architecture and functional entities defined in standardization document. Additionally, we will suggest the considerations of interfaces and related information among functional entities

Keywords— Smart Greenhouse, Agriculture

I. INTRODUCTION

With the development of ICT (information and communication technology), there are movements that want to apply ICT in agriculture. Smart Greenhouse is the representative approach for crop production by applying ICT technology to the greenhouse. The goal of Smart Greenhouse is to provide and maintain optimal conditions for growing crops in greenhouse environment (light, temperature, humidity, etc.). Smart greenhouse has facilities that enable the control of factors affecting the main growing environments of the crops.

Therefore, in this paper, we will describe the status of standardization in ITU-T and TTA regarding smart greenhouse briefly, and introduce the reference architecture and functional entities defined in standardization document. Additionally, we will suggest the considerations of interfaces and related information among functional entities.

II. OVERVIEW OF SMART GREENHOUSE

Smart greenhouse collect various environment information through sensor node for monitoring and managing the growth status of crops. And it can control the actuators through the actuator node to maintain the proper growth environment by utilizing this information. In addition, the smart greenhouse provides application service functions such as management and control of growth environment.

Each sensor node may include various sensors, and each actuator node may include various actuators.

The greenhouse integration controller collects information from the sensor node and transfers it to the greenhouse operation system, and transmits the command received from the greenhouse operation system to the actuator node. It also translates protocols as needed and may contain simple control logic.

The greenhouse operation system can monitor environment and crop growth information from the sensor inside and outside the greenhouse, and it is possible to control and operate through the greenhouse environment control algorithm. The collected data can be stored in the database. And the greenhouse operation system manages the operation cycle and failure of the sensor node and the actuator node.

The integrated greenhouse management system links the data server with the greenhouse operation system located at other sites and feeds back information on the growth of crops.

Figure 1 shows use case for smart greenhouse defined in ITU-T Y.ISG-fr[1], TTA.KO-10/0844[2].

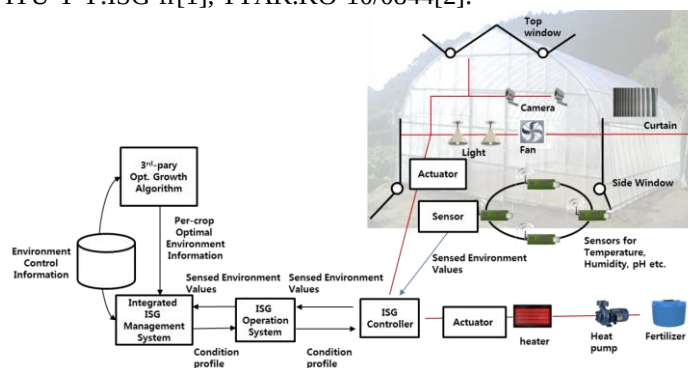


Figure 1. Reference architecture of smart greenhouse

III. REFERENCE ARCHITECTURE

Figure 2 shows reference architecture for smart greenhouse defined in ITU-T Y.ISG-fr[1].

Each component of the smart greenhouse can be developed individually or in groups, and when multiple components are grouped and developed, interoperability is possible if only the final interface of the grouped components is matched.

In this case, “user” is a person or his/her own device that interacts with other components within greenhouse for exchange of information.

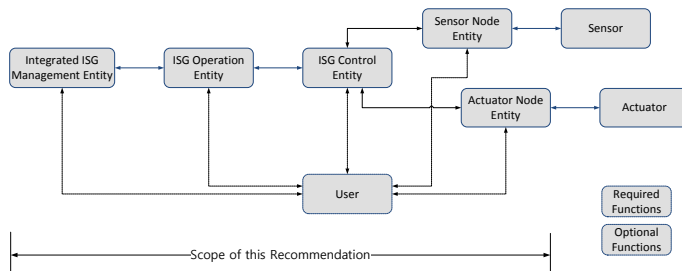


Figure 2. Reference architecture of smart greenhouse

IV. INFORMATION FOR INTEROPERABILITY AMONG FUNCTIONAL ENTITY

This clause describes the considerations on the information for interoperability among functional entity in the smart greenhouse.

- **Configuration information:** It has the following information such as how many ISG components within the designated smart greenhouse is or what the identification information of ISG components is. It aims to better understand how actuators in the greenhouse affect the environment and how their environmental information affects growth of crops.
- **Attribute information:** It has the following information such as sensor identifier, type of sensor, type of sensor data, collection type, collection period, upper and lower limits of sensing value, precision, margin of error, actuator identifier, data type of actuator, IP address, serial number, OS type and version, etc. This is aimed at how often the sensor in the greenhouse can measure the level of environmental information at what period.
- **Operation status information:** It requests to get the status information of ISG components and receives the status information during specified periods or receives the status information directly on request. The examples of status information are such as normal status, communication error, service error, etc. This is for the purpose of determining to what extent the environmental information measured in the greenhouse is valid.
- **Environment measurement information:** It requests to get the environment information and receives the environment information collected during specified periods or receives the environment information directly on request. As an example of environment information, there is the pair information (ID and measured values) for each sensor and each actuator.
- **Crop growth information:** Currently, it contains information which is directly written farmers. However, it should be expected to change as the information

obtained by measuring the degree of crop growth through the sensor, camera and the like.

V. INTERFACES AMONG FUNCTIONAL ENTITY

This clause describes the considerations on the the interfaces among functional entity in smart greenhouse.

Considered interfaces will be classified as establishment of connection, confirmation of network status, retrieval of operation status on the devices within the greenhouse, measurement on the environment information within the greenhouse, measurement on the growth information of crop, control of the actuator device within the greenhouse, etc.

The requirements level of each interface is divided into the following three categories. M stands for Mandatory, R stands for Recommended, and O stands for Optional.

A. Interfaces between sensor node entity and ISG control entity

Detailed interfaces between sensor node entity and ISG control entity, and its requirement level are as follows.

TABLE 1. DETAILED INTERFACES BETWEEN SENSOR NODE ENTITY AND ISG CONTROL ENTITY

Ref. No.	Detail function	Req. level
R1-1	Establishment of connection	M
R1-2	Confirmation of network status	R
R1-3	Retrieval of operation status on the devices within the greenhouse	M
R1-4	Retrieval of measurement information on the environment within the greenhouse	M
R1-5	Retrieval of measurement information on the growth of crop	O
R1-6	Notification of operation status on the devices within the greenhouse	M
R1-7	Notification of measurement information on the environment within the greenhouse	M
R1-8	Request on the control of actuators within the greenhouse	-
R1-9	Retrieval of configuration information on the sensor node	R
R1-10	Retrieval of attribute information on the sensor node	R
R1-11	Initialization of sensor node and sensors	M

B. Interfaces between actuator node entity and ISG control entity

Detailed interfaces between actuator node entity and ISG control entity, and its requirement level are as follows.

TABLE 2. DETAILED INTERFACES BETWEEN ACTUATOR NODE ENTITY AND ISG CONTROL ENTITY

Ref. No.	Detail function	Req. level
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R2-1	Establishment of connection	M
R2-2	Confirmation of network status	R
R2-3	Retrieval of operation status on the devices within the greenhouse	M
R2-4	Retrieval of measurement information on the environment within the greenhouse	M
R2-5	Retrieval of measurement information on the growth of crop	-
R2-6	Notification of operation status on the devices within the greenhouse	M
R2-7	Notification of measurement information on the environment within the greenhouse	-
R2-8	Request on the control of actuators within the greenhouse	M
R2-9	Retrieval of configuration information on the actuator node	R
R2-10	Retrieval of attribute information on the actuator node	R
R2-11	Initialization of actuator node and actuators	M

C. Interfaces between ISG control entity and ISG operation entity

Detailed interfaces between ISG control entity and ISG operation entity, and its requirement level are as follows.

TABLE 3. DETAILED INTERFACES BETWEEN ISG CONTROL ENTITY AND ISG OPERATION ENTITY

Ref. No.	Detail function	Req. level
R3-1	Establishment of connection	M
R3-2	Confirmation of network status	R
R3-3	Retrieval of operation status on the devices within the greenhouse	M
R3-4	Retrieval of measurement information on the environment within the greenhouse	M
R3-5	Retrieval of measurement information on the growth of crop	O
R3-6	Notification of operation status on the devices within the greenhouse	M
R3-7	Notification of measurement information on the environment within the greenhouse	M
R3-8	Request on the control of actuators within the greenhouse	M
R3-9	Retrieval of configuration information on the ISG control entity	R
R3-10	Retrieval of attribute information on the ISG control entity	R
R3-11	Initialization of the ISG control entity	M

D. Interfaces between ISG operation entity and integrated ISG management entity

Detailed interfaces between ISG operation entity and integrated ISG management entity, and its requirement level are as follows.

TABLE 4. DETAILED INTERFACES BETWEEN ISG OPERATION ENTITY AND INTEGRATED ISG MANAGEMENT ENTITY

Ref. No.	Detail function	Req. level
R4-1	Establishment of connection	M
R4-2	Confirmation of network status	R
R4-3	Retrieval of operation status on the devices within the greenhouse	M
R4-4	Retrieval of measurement information on the environment within the greenhouse	M
R4-5	Retrieval of measurement information on the growth of crop	O
R4-6	Notification of operation status on the devices within the greenhouse	M
R4-7	Notification of measurement information on the environment within the greenhouse	M
R4-8	Request on the control of actuators within the greenhouse	-
R4-9	Retrieval of configuration information on the ISG operation entity	R
R4-10	Retrieval of attribute information on the ISG operation entity	R
R4-11	Initialization of ISG operation entity	-

VI. DESCRIPTION ON THE ESTABLISHMENT OF CONNECTION

This clause describes the considerations on the the detail description on the establishment of connection as an example.

A. R1-1: Interface between sensor node entity and ISG control entity

A connection establishment request occurs when:

- When the sensor node is booted (either powered on or recovered from a failure)

The information contained in the request message is as follows.

- Configuration information
- Attribute information

Action is as follows.

- The ISG control entity decides whether to approve or not based on the attribute information (sensor node ID, version, etc.) of the lower sensor node it manages.
- The ISG operation entity updates the changed configuration information in the configuration information that the lower sensor node entity manages.
- When the connection is approved, the ISG control entity transmits the sensor information to the device information of the sensor node it owns.
- The sensor node updates the received sensor device information.

Message flow is as follows.

- Connection setup request message → Response message for connection setup

B. R2-1: Interface between actuator node entity and ISG control entity

A connection establishment request occurs when:

- When the actuator node is booted (either powered on or recovered from a failure)

The information contained in the request message is as follows.

- Configuration information
- Attribute information

Action is as follows.

- The ISG control entity decides whether to approve or not based on the attribute information (actuator node ID, version, etc.) of the lower actuator node it manages.
- The ISG operation entity updates the changed configuration information in the configuration information that the lower actuator node entity manages.
- When the connection is approved, the ISG control entity transmits the actuator information to the device information of the actuator node it owns.
- The actuator node updates the received actuator device information.

Message flow is as follows.

- Connection setup request message → Response message for connection setup

C. R3-1: Interface between ISG control entity and ISG operation entity

A connection establishment request occurs when:

- When the ISG control entity is booted (either powered on or recovered from a failure)
- When the configuration of ISG control entity is changed

The information contained in the request message is as follows.

- Configuration information
- Attribute information

Action is as follows.

- The ISG operation entity decides whether to approve or not based on the attribute information (ISG control entity ID, version, etc.) of the lower ISG control entity it manages.
- The ISG operation entity updates the changed configuration information that the lower ISG control entity manages.

Message flow is as follows.

- Connection setup request message → Response message for connection setup

D. R4-1: Interface between ISG operation entity and integrated ISG management entity

A connection establishment request occurs when:

- When the ISG operation entity is booted (either powered on or recovered from a failure)
- When the configuration of ISG operation entity is changed

The information contained in the request message is as follows.

- Configuration information
- Attribute information

Message flow is as follows.

- Connection setup request message → Response message for connection setup

VII. CONCLUSIONS

In this paper, we present the status of standardization in ITU-T and TTA regarding smart greenhouse briefly, and introduce the reference architecture, functional entity. Also, we suggest the considerations on the related information and interfaces for interoperability among functional entities.

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