

Recommendation

ITU-T Y.4495 (11/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet of things and smart cities and communities – Frameworks, architectures and protocols

Requirements and a reference model of data for smart greenhouse service

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Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

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Recommendation ITU-T Y.4495

Requirements and a reference model of data for smart greenhouse service

Summary

For data interoperability, Recommendation ITU-T Y.4495 defines requirements and a reference model of data for smart greenhouse service.

Smart greenhouses have improved productivity by controlling the growing environment of crops. The demand for data-based smart greenhouse services has been increasing, as the importance of converged agricultural services (autonomous farm control, pest control, etc.) based on big data is emphasized. Accordingly, the data generated and consumed by IoT devices in the smart greenhouse have been increasing continuously.

In order to efficiently manage and analyse vast amounts of data and create various services based on the analysed data, a standardized data model for data collection and management system is required. In particular, compatibility of data generated and consumed by heterogeneous devices must be guaranteed to ensure interoperability between devices of heterogeneous vendors.

History *

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Data model, reference model, smart greenhouse service.

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Recommendation ITU-T Y.4495

Requirements and a reference model of data for smart greenhouse service

1 Scope

This Recommendation addresses requirements and a reference model of data for smart greenhouse service including the following:

- Overview of crop-growth related data for smart greenhouse service;
- Requirements of crop-growth related data for smart greenhouse service;
- Reference model of data for smart greenhouse service;
- Use cases of the data model for interoperability.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 data model [b-ITU-T J.380.8]: A data model is a formal view of the data items contained in an information store to which an information service implementing this standard will provide access and is specified for purposes of formulating and executing queries against the information store's data. This standard specifies one data model that may be used for querying a logical service's information store with this standard's "basic query" interface. More complex data models may be specified independently of this standard and may be queried with this standard's "advanced query" interface. In this latter case, the mechanisms by which a consumer incorporates a data model specification so that meaningful queries may be issued against it are outside the scope of this standard.

3.1.2 greenhouse [b-ITU-T Y.4466]: A facility that can control a crop-growth environment (i.e., light, temperature, humidity, etc.).

3.1.3 smart farm [b-ITU-T Y.4466]: A group of smart greenhouses under the management of an administrator.

3.1.4 smart greenhouse [b-ITU-T Y.4466]: A facility that can control the environment of a greenhouse with minimum human intervention using Internet of things (IoT) technologies.

3.1.5 smart greenhouse service [b-ITU-T Y.4466]: A service that enables precision farming based on a smart greenhouse.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CO ₂	Carbon Dioxide
CCW	Counterclockwise
CW	Clockwise
DMS	Data Management System
EC	Electrical Conductivity
GNSS	Global Navigation Satellite System
pH	potential of Hydrogen
ppm	parts per million
RPM	Resolution Per Minute
SG	Smart Greenhouse

5 Conventions

The following conventions are used in this Recommendation:

- The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.
- The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Overview

Smart greenhouses have improved productivity by controlling the growing environment of crops. The demand for data-based smart greenhouse (SG) services has been increasing, as the importance of converged agricultural services (autonomous farm control, pest control, etc.) based on big data is emphasized. Accordingly, the data generated and consumed by IoT devices in the smart greenhouse have been increasing continuously.

Figure 1 shows a general conceptual diagram of the data flow generated and consumed for the smart greenhouse service. In the smart greenhouse, a controller collects data from various sensors of environmental conditions such as temperature, humidity, and CO₂ level as well as crop-growth status indicators like crop height, stem thickness, leaf size, number of flowers, and fruit status. And according to the analysis result of the collected measurement data, the controller controls various actuators to adjust the environmental conditions suitable for the crop-growth.

In addition to the measurement data, the smart greenhouse service also requires configuration data which the user configures on greenhouse or farm facilities such as installation location, structure, scale, as well as specification data like the use, form, model number, and manufacturer of various devices installed in the greenhouse. The configuration data also includes user data such as the information on the user of the farm, smart greenhouses, and data managed for the smart greenhouse service.

Business data which a user may provide, related to resource input plans for farming, production plans from sowing to harvest, production, etc. are also necessary as configuration data in order to increase income. Moreover, a user may provide user data describing the information of the user.

The measurement data and configuration data are managed by a data management system (DMS) installed for the smart greenhouse, collects and manages all the data collected and can transmit the

data to the smart greenhouse service provider for more in-depth analysis. The smart greenhouse service provider analyses the delivered various and vast big data and establishes the optimal operation model for the smart greenhouse and the optimal growth model for crops based on the analysis results.

In order to provide smart greenhouse services provided by service providers to users as described above, the collection and analysis of various data must be performed efficiently. This Recommendation presents requirements and reference models for measurement data and configuration data for the smart greenhouse service.

NOTE – Data related to crop growth status, operation model, growth model, and business for smart greenhouse or smart farm management are not under the scope of this Recommendation.

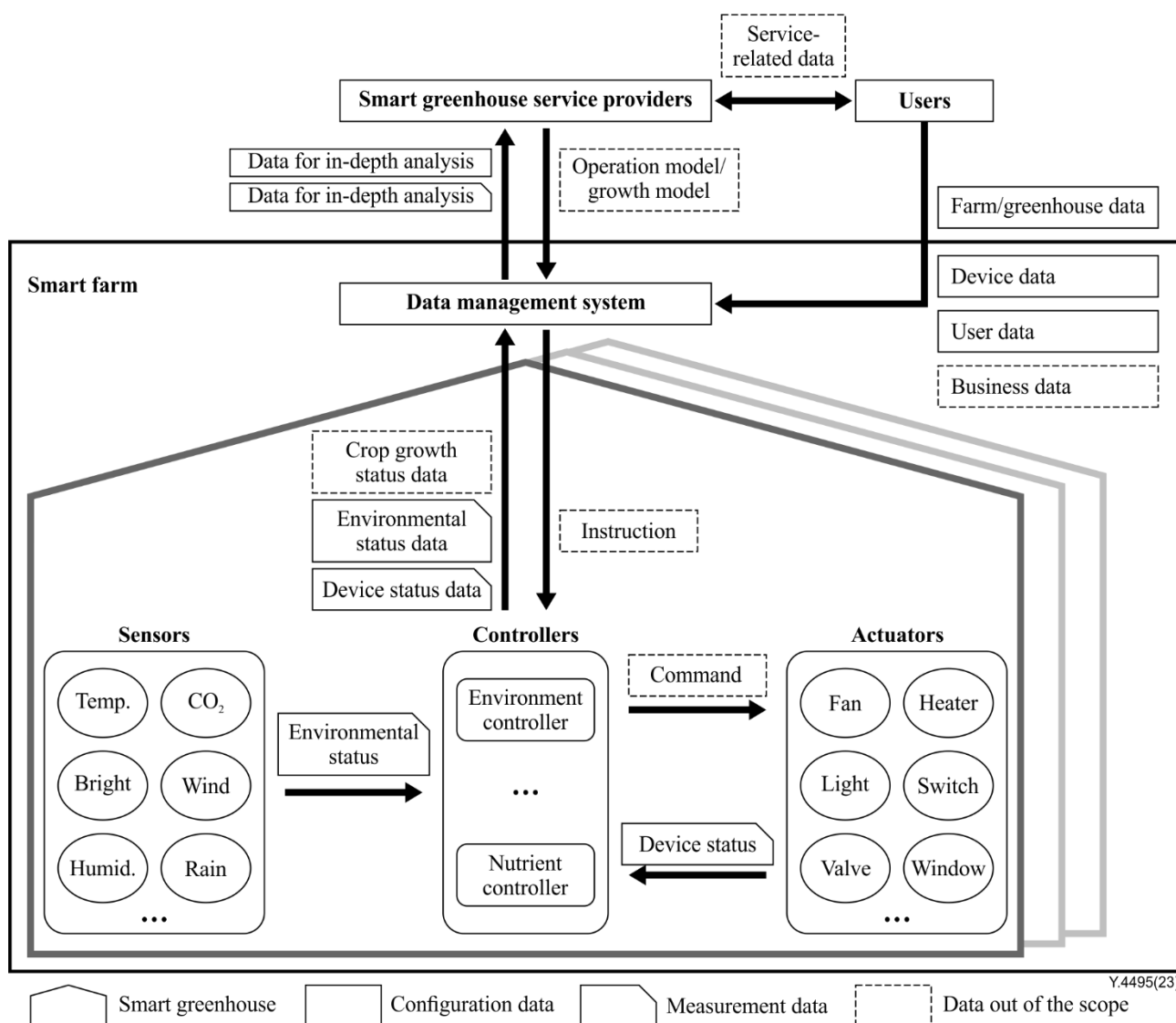


Figure 1 – Conceptual diagram of data flow for smart greenhouse service

NOTE – This Recommendation is not applicable to the data with dashed boxes in Figure 1.

7 Requirements of crop-growth related data for smart greenhouse service

Crop-growth related data used in smart greenhouses can be classified into two categories, which are configuration data and measurement data. Configuration data are used to identify a farm, smart greenhouses in the farm, and devices or equipment used in the smart greenhouses and specify their characteristics. The configuration data are set by a data administrator. Measurement data are used to collect and analyse the environmental status of smart greenhouses and the status of devices installed

in the smart greenhouses. The measurement data can either be collected by sensors in the smart greenhouse or provided by external data providers.

7.1 General requirements

To properly utilize the crop-growth related data, two categories of data need to have a relationship. For example, the configuration data including the shape of the greenhouse and device installation information, and the measurement data including environmental status information are considered together for the status of the smart greenhouse during a specific period in the past. Thus, each data needs to have information showing the relationship with other data, and it needs to be distinguishable. The crop-growth related data also need to have temporal and spatial information for precise analytics. The temporal information provides the time value such as the time when a specific configuration is set or when a sensor reports the sensing value. The spatial information provides the value indicating the location of the entities including a smart greenhouse, device or sensor installed in the smart greenhouse. The crop-growth related data can be used by various users such as administrators, farmers, data analysts, etc, and each user needs a different type of authority. As an example, an administrator can create and update configuration data, while a farmer can retrieve part of the data. Thus, each crop-growth related data needs to have authority information regarding the user type.

Crop-growth related data used in smart greenhouses have the following general requirements:

- Crop-growth related data are required to be stored and managed by a data management system (DMS) supporting create, retrieve, update, and delete operations;
- Crop-growth related data are required to include temporal and spatial information;
- The temporal information is required to be presented by the time in year, month, date, hour, minute, second, and subsecond (if supported);
- The temporal information is required to be presented by supporting various resolutions;
- The temporal information is required to be presented in a specific format such as yyyy/mm/dd/hh/mm/s;
- The temporal information is recommended to conform to the time notation which DMS uses;
- The spatial information is required to be composed of absolute position information and relative position information;
- The spatial information is required to represent the position in a 2-dimensional space and 3-dimensional space;
- The spatial information is recommended to include absolute position measured by equipment such as global navigation satellite system (GNSS) and relative position set representing relative direction and distance from the reference position set by the administrator;
- Crop-growth related data are required to have an identifier which may conform [b-ITU-T X.667];
- Crop-growth related data are required to have the authority information to access, use, and administer the data.

7.2 Requirements of configuration data

Configuration data provide information about smart greenhouse configuration and it is set and used by a data administrator such as an owner of the smart greenhouse. Configuration data are merely changed after initial configuration. Configuration data are composed of farm data, greenhouse data, device data, device installation data, and user data.

7.2.1 General requirements

Configuration data have the following general requirement: