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Recommendation

ITU-T Y.4606 (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 – Services, applications, computation and data processing

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Requirements and functional model of the data management system for smart greenhouse service

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Recommendation ITU-T Y.4606

Requirements and functional model of the data management system for smart greenhouse service

Summary

Data analysis technologies can develop Internet of things-based smart greenhouse services more intelligently. To enable these services, a huge size of data related to environmental condition as well as farm configuration is required to be analysed; to enable the data to be well analysed, a well-defined data management system that has the functionalities of data collection, data storage, data disposal, data process and data use is required.

Recommendation ITU-T Y.4606 defines requirements and functional model of a data management system from the perspective of a smart greenhouse service. The general requirements and functional model of the data management system are not under the scope of this Recommendation.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.4606	2023-11-29	20	11.1002/1000/15691

Keywords

Data management system, smart greenhouse, smart greenhouse service.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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Recommendation ITU-T Y.4606

Requirements and functional model of the data management system for smart greenhouse service

1 Scope

This Recommendation addresses a data management system for a smart greenhouse service including the following:

– An overview of a data management system for a smart greenhouse service;

– Requirements of a data management system for a smart greenhouse service;

– A functional model of a data management system for a smart greenhouse service;

– Consideration on deployment in various service environments.

The general requirements and functions of a data management system are not under the scope of this Recommendation.

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 management [b-ITU-T Y.4602]: Activities of defining, creating, storing, maintaining and providing access to data and associated processes in one or more information systems.

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

3.1.3 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.

3.1.4 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:

AI Artificial Intelligence

DMS Data Management System

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 of the data management system (DMS) for smart greenhouse service

As the distribution of smart greenhouse services spreads and related technologies evolve, the type and amount of data for the smart greenhouse services are rapidly increasing. [b-ITU-T Y.4495] defines data requirements and data models for the smart greenhouse services and classifies the data for the smart greenhouse services into configuration data and the measurement data as follows:

– Configuration data: farm data, greenhouse data, device data, device installation data and user data;

– Measurement data: environmental status data and device status data.

For data analysis, the smart greenhouse can provide resource data related to the input and usage of fertilizers, pesticides, water, electricity and labour, or crop production data in addition to the above configuration data and measurement data.

Collection, storage, disposal, process and use of these data are very important functionalities in a smart greenhouse service. In particular, for more diverse smart greenhouse services according to user's demands, the smart greenhouse service provider needs a data management system (DMS) that has various functionalities related to data.

Figure 1 shows a conceptual diagram of the DMS for the smart greenhouse service. The DMS collects data from the smart greenhouse and stores them in a storage, and then the DMS processes data for data analysis. The smart greenhouse service provider uses the processed data for data analysis to create various data services; an example of such data service includes "a farm adjustment and production forecast service" using artificial intelligence (AI) or big data technologies. As a user of the DMS, a farmer interacts with the DMS to monitor and control the environmental condition of the smart greenhouse. For the purpose of security, the DMS should dispose of the data after its usage for the smart greenhouse service. Third party service providers may request the data stored or processed in the DMS for any form of collaboration between the smart greenhouse service providers.

NOTE – The details of the service provider, service user and third party are not covered in this Recommendation.

This Recommendation defines the requirements and functional model of the DMS for the smart greenhouse service.

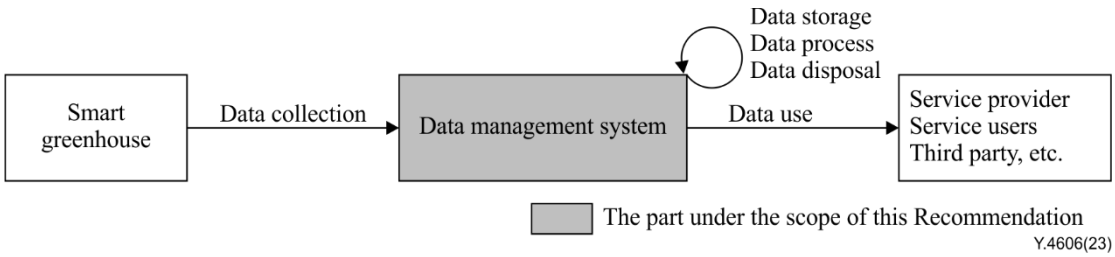

Figure 1 – Conceptual diagram of a data management system for the smart greenhouse service

7 Requirements of the DMS

7.1 Requirements on data collection

The DMS is required to provide the following capabilities for data collection:

– The capability to collect the environmental status data;

NOTE 1 – The environment status data may include data related to temperature, humidity, carbon dioxide, insolation, wind direction, wind speed, light quantum, soil moisture tension, rain detection, electrical conductivity, potential of hydrogen and so on.

– The capability to collect the crop growth status data;

NOTE 2 – The crop-growth status data may include data related to crop height, stem thickness, leaf temperature, soil moisture saturation and so on.

– The capability to collect the configuration data of the smart greenhouses and the smart farm from the service provider or the service user (farmer);

NOTE 3 – The configuration data of the smart greenhouses may include data related to an identifier, a type, size, a geographical location, a type of irrigation, a type of heating system and the utilization status of the greenhouses. Also, the configuration data of the smart farm may include data related to an identifier, a name, an address, a geographical location and area, meaning the size of the farm, changes in configuration settings and so on.

– The capability to collect the configuration data of the devices from the service provider or the service user (farmer);

NOTE 4 – the configuration data of the devices may include data related to a device code, a name, a device type, a model name, available measurement range, a manufacturer name, changes in configuration settings and so on.

– The capability to connect with the data source;

– The capability to identify the authorization of data source;

NOTE 5 – Examples of data sources include the devices, the smart greenhouses, the service provider and service users.

– The capability to collect data related to information about stakeholders involved in the smart greenhouse service, including their access right to data;

– The capability to collect data on control commands and results of executing these commands;

– The capability to collect data on the optimal crop-growth model from the service provider;

– The capability to detect that data are not being collected from a sensor and to notify the service provider or the service user (farmer).

NOTE 6 – This can be verified based on the configuration data of a sensor. The service provider or the service user receiving the notification can check the status of the sensor and take appropriate action.

The DMS is recommended to provide the following capabilities for data collection:

– The capability to collect data related to resource consumption or crop production;

NOTE 7 – This data can be used to create production plans and strategies for the smart greenhouse service.

– The capability to collect external data.

NOTE 8 – The external data may include data related to weather forecasts, agricultural statistics, agricultural market information and so on. Weather forecast data, for example, can be used to predict environmental changes and identify environmental conditions that may affect crop growth.

7.2 Requirements on data storage

The DMS is required to provide the following capabilities for data storage:

– The capability to store internal and external environmental status data;

– The capability to store the crop-growth status data;

– The capability to store the configuration data of the greenhouses and the farm, including any changes in configuration settings and their history;

– The capability to store the configuration data of the devices installed in the smart greenhouse, including any changes in configuration settings and their history;

– The capability to store data related to the information about stakeholders involved in the smart greenhouse service, including their access right to data;

– The capability to store data on control commands and their execution results;

– The capability to store data on the optimal crop-growth model.

The DMS is recommended to provide the following capabilities for data storage:

– The capability to store data related to resource consumption or crop production;

– The capability to store the collected external data;

– The capability to store data systematically.

NOTE – The stored data can be selectively available for data processing, depending on the type and purpose of the data.

7.3 Requirements on data disposal

The DMS is required to provide the following capability for data disposal:

– The capability to dispose of data according to the retention period.

NOTE – The disposal of data follows the rules established between the service provider and the service user, considering the purpose of the data, data security, data protection and the cost of storage management for large amounts of data.

7.4 Requirements on data process

The DMS is required to provide the following capabilities for data process:

– The capability to select and combine specific data;

NOTE 1 – The environmental data of the smart greenhouse and the crop-growth status data can be processed as a combined data set for data analysis. This is because they have a cause-and-effect relationship with each other.

– The capability to validate data;

NOTE 2 – For accurate data analysis, it is necessary to identify and correct duplicate data, missing data and data with anomalous values.

– The capability to convert data units;

– The capability to transform data to have a specific type and format.

NOTE 3 – Data can be transformed to have a type and format appropriate to the needs of the service provider or the service users for analysis.

The DMS is recommended to provide the following capability for data process:

– The capability to provide statistically derived parameters.

NOTE 4 – For example, the average temperature or the crop-growth rate derived from the combined data set can be used as the basis for data analysis.

7.5 Requirements on data use

The DMS is required to provide following capabilities for data use:

– The capability to provide environmental status data and crop-growth status data for real-time monitoring;

– The capability to provide processed data for the service provider's analysis to create various data services;

NOTE 1 – Examples of such data services include an optimal crop-growth model service, production forecasts service and optimal resource utilization strategies service. For in-depth analysis, technologies such as AI and big data can be applied.

– The capability to control the data access rights of the data users.

NOTE 2 – Differentiated data access rights should be granted based on the type of data users and the purpose of data use.

The DMS is recommended to provide following capability for data use:

– The capability to provide processed data to the third parties according to their specific needs.

8 Functional model of the DMS

Figure 2 shows a functional model of the DMS for smart greenhouse service. The DMS has the following four functions to manage the smart greenhouse service data:

– A data-collection function;

– A data storage function;

– A data disposal function;

– A data process function;

– A data use function.

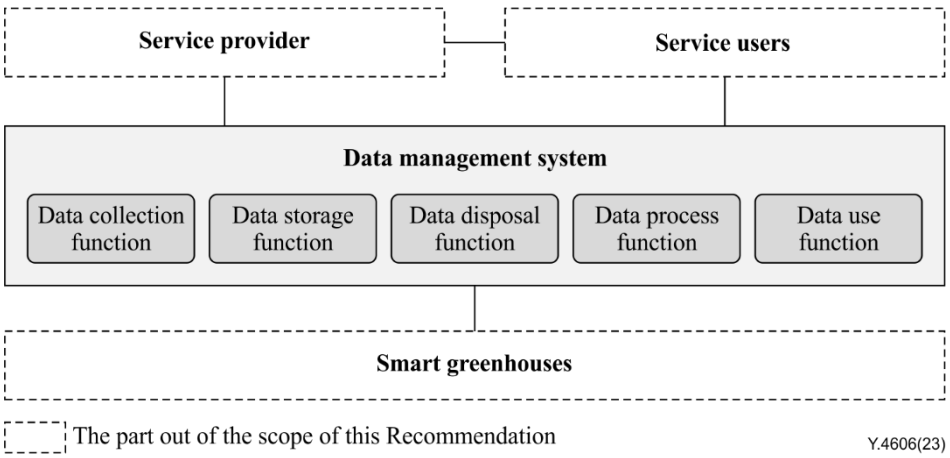

Figure 2 – Functional model of the DMS for smart greenhouse service

8.1 Data-collection function

The data-collection function is for collecting data from various data sources. For this purpose, this function provides capabilities of data collection from the data sources in various manners, such as real-time, periodic and so on. This function also provides capabilities of connection to the data sources, and it detects when data are not being collected.

The collected data are then delivered to the data storage function, where they are carefully stored and efficiently managed for subsequent analysis and use.

8.2 Data storage function

The data storage function provides capabilities of data storage and data organization. With this function, the collected data are efficiently and securely stored and managed to ensure their validation, future processing and use; for this purpose, the DMS stores the collected data in a structured format and the quality and accuracy of the data are verified.

Finally, all the stored data are then delivered to the data process function for future processing, by enabling the creation of various data services for the smart greenhouse service.

8.3 Data disposal function

The data disposal function provides capabilities of deleting data in accordance with predefined retention periods. This function follows rules agreed between the service provider and the service users, taking into account the intended purpose of the data, security and privacy requirements, and the costs associated with managing and storing large volumes of data.

Through the data disposal function, the stored data can be disposed of based on factors such as expiration of validity period and data usage policies.

8.4 Data process function

The purpose of the data process function is to process the data in various ways to maximize their value. For this purpose, the data process function provides the capabilities of removing or modifying incorrect data, converting data, combining data from different data sources, validating data and creating new meaningful data.

After the data are processed, they are delivered to the data use function for the use of the smart greenhouse service provider and the service users.

8.5 Data use function

The purpose of the data use function is to provide smart greenhouse service data according to the data users' requirements. The service provider analyses the processed data from the data use function by applying AI and big data technologies and creates various data services; and the service user (farmer) can monitor the environmental status of the smart greenhouse or the crop-growth status in real time. In addition, third party data users can use these data to provide valuable new smart greenhouse services. The data use function also provides a data access control mechanism to protect the data from unauthorized access.

Appendix I

Consideration on deployment in various service environment

(This appendix does not form an integral part of this Recommendation.)

As technologies for the smart greenhouse service evolve, so do the environments in which they are deployed and used. This appendix provides considerations for deploying the data management system (DMS) in different service environments.

I.1 Stand-alone smart greenhouse service model

Although it is an early model for providing a smart greenhouse service, the stand-alone smart greenhouse service is still widely used in small-scale smart greenhouses.

As shown in Figure I.1, the DMS is installed in a smart farm that consists of one or more smart greenhouses. The DMS has four functions to manage data for the smart greenhouse service, which are the data-collection function, data storage function, data disposal function, data process function and data use function.

In the stand-alone smart greenhouse service model, all devices are installed in a smart farm, and all data generated by these devices are under the management of the user (farmer). Therefore, for the stand-alone smart greenhouse service model, it is necessary to consider the following:

– Farmer's lack of expertise in data self-management and security;

– Increasing cost of data self-management due to the increasing the type and amount of data.

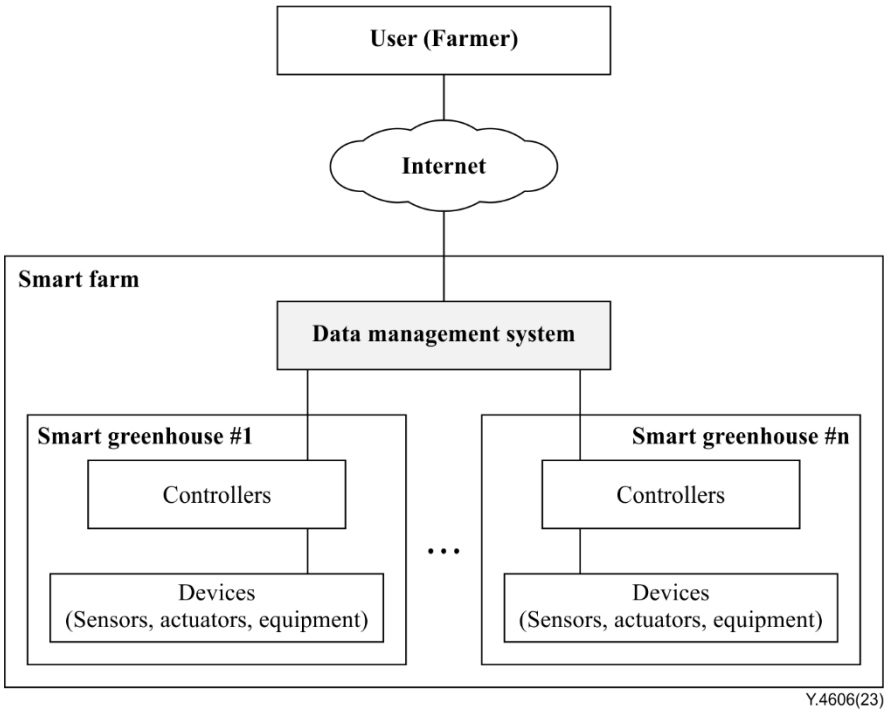

Figure I.1 – Example of a deployment of a stand-alone smart greenhouse service

I.2 Smart greenhouse service with cloud support model

As cloud technologies develop, the existing stand-alone smart greenhouse service model is evolving into a form that uses an external cloud system for data analysis.

As shown in Figure I.2, the DMS is installed in an external cloud system of the smart greenhouse service provider. The external DMS collects all data for smart greenhouse services from the smart farm, which consists of one or more smart greenhouses, and stores, processes and uses all data.

The model in Figure I.2 has the advantage of simplifying the data management for the smart greenhouse service since it uses the external DMS. However, it has the disadvantage of network dependencies such as network disconnection or delay due to excessive traffic. Therefore, for this model, it is necessary to consider the following:

– A reliable and stable network infrastructure between the smart farm and the external DMS;

– A real-time means of controlling environmental conditions to ensure a fast response time.

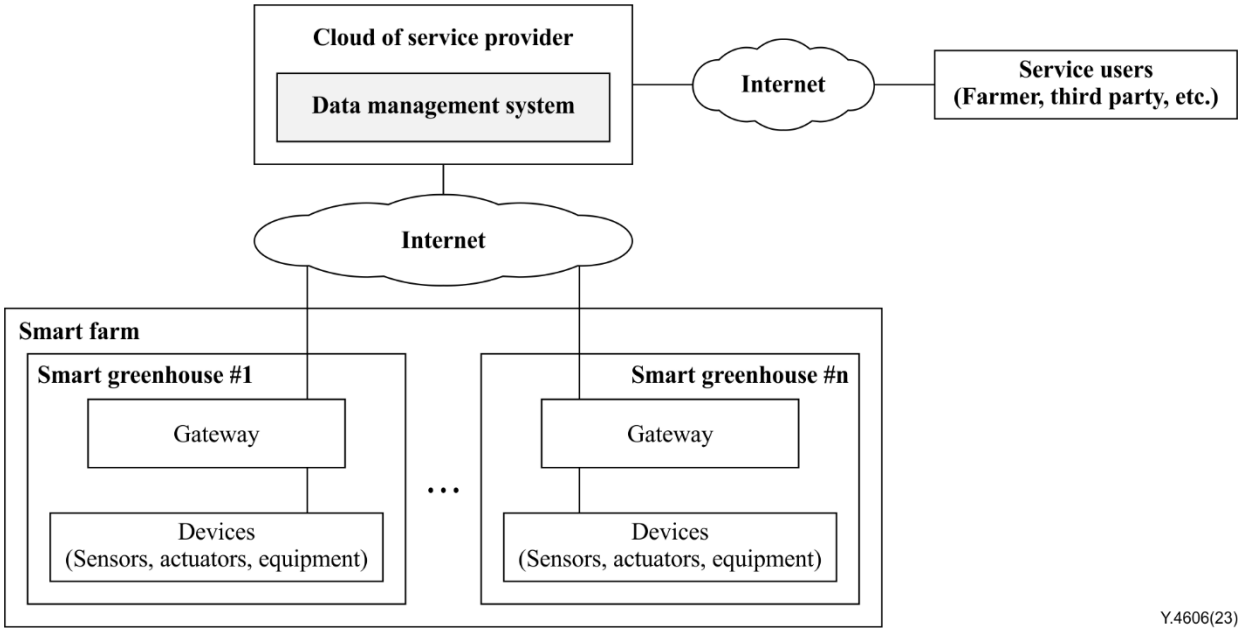

Figure I.2 – Example of a deployment for smart greenhouse service with cloud support model

I.3 Smart greenhouse service with edge-cloud support model

As edge-server technologies are addressed, the disadvantages addressed in the smart greenhouse service with cloud support model are resolved.

In Figure I.3, an edge server is installed in the smart farm to connect the smart greenhouse service provider's cloud system. The DMS installed on the edge server, DMS-edge, collects real-time data from the smart farm and directly performs pre-processing tasks such as processing the collected data into an appropriate format; in addition, it can control environmental conditions in real-time.

The DMS installed on the cloud system, DMS-cloud, manages and processes the large amount of data provided by the DMS-edge. In addition, the DMS-cloud may provide external interfaces to collaborate with any external stakeholders.

NOTE – One or more edge servers can be installed in a smart farm, and one edge server can manage one or more smart farms.

For this model, it is necessary to consider the followings:

– Data delivery and synchronization mechanisms between the DMS-edge and the DMS-cloud;

– Data security and privacy capabilities for both the DMS-edge and the DMS-cloud;

– Performance levels of both the DMS-edge and the DMS-cloud for data management.

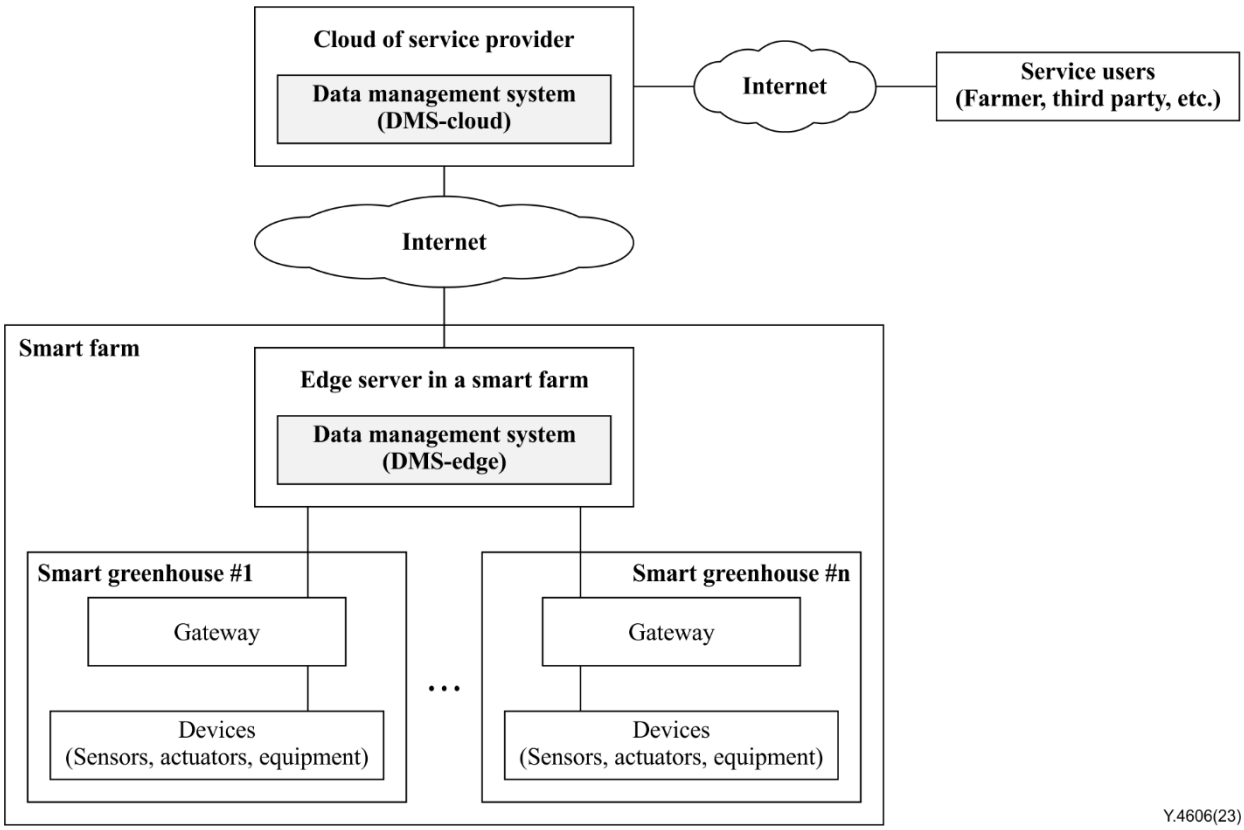

Figure I.3 – Example of a deployment for smart greenhouse service with edge-cloud support model

Bibliography

[b-ITU-T Y.4466] Recommendation ITU-T Y.4466 (2020), *Framework of smart greenhouse service*.

[b-ITU-T Y.4495] Recommendation ITU-T Y.4495 (2023), *Requirements and a reference model of data for smart greenhouse service.*

[b-ITU-T Y.4602] Recommendation ITU-T Y.4602 (2023), *Data processing and management framework for IoT and smart cities and communities*.

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