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Recommendation

ITU-T Y.2248 (01/2023)

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

Next Generation Networks – Service aspects: Service capabilities and service architecture

Service model for entry-level smart farms

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Recommendation ITU-T Y.2248

Service model for entry-level smart farms

Summary

Entry-level smart farms can provide convenience of use and increased economic profits to agricultural producers previously unfamiliar with high-level information and communication technologies. Recommendation ITU-T Y.2248 describes the service model for the entry-level smart farm. The scope of this Recommendation covers reference architecture, service requirements and service scenarios for the entry-level smart farm.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2248	2023-01-13	13	11.1002/1000/15232

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Entry-level smart farm, farm management system.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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1 Scope

This Recommendation describes the service model for entry-level smart farms. The scope of this Recommendation covers:

- Reference architecture for the entry-level smart farm;
- Service requirements for the entry-level smart farm;
- Service scenarios for the entry-level smart farm.

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.

[ITU-T T.135] Recommendation ITU-T T.135 (2007), *User-to-reservation system transactions within T.120 conferences*.

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[ITU-T Y.4105] Recommendation ITU-T Y.4105/Y.2221 (2010), *Requirements for support of ubiquitous sensor network (USN) applications and services in the NGN environment*.

[ITU-T Y.4109] Recommendation ITU-T Y.4109/Y.2061 (2012), *Requirements for the support of machine-oriented communication applications in the next generation network environment*.

[ITU-T Y.4401] Recommendation ITU-T Y.4401/Y.2068 (2015), *Functional framework and capabilities of the Internet of things*.

[ITU-T Y.4450] Recommendation ITU-T Y.4450/Y.2238 (2015), *Overview of smart farming based on networks*.

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

[ITU-T Y.4806] Recommendation ITU-T Y.4806 (2017), *Security capabilities supporting safety of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 actuator [ITU-T Y.4109]: A device performing physical actions caused by an input signal.

3.1.2 agricultural producer [ITU-T Y.4450]: The service role that actually produces agricultural products to be supplied to distributors or consumers.

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

3.1.4 sensor [ITU-T Y.4105]: An electronic device that senses a physical condition or chemical compound and delivers an electronic signal proportional to the observed characteristic.

3.1.5 service user [ITU-T T.135]: A person, an organization or any intermediate entity using the services provided by a service provider.

3.1.6 smart farming based on networks [ITU-T Y.4450]: A service that uses networks to actualize a convergence service in the agricultural field to attain more efficiency and quality improvement and to cope with various problems.

3.1.7 smart farming service provider [ITU-T Y.4450]: The service role that provides the requested Smart Farming services, such as providing a portal or consulting based on data gathered from agricultural fields, to requesting users.

NOTE – This Recommendation uses 'service provider' with the same meaning as that of 'smart farming service provider'.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 active device interface function: A function that controls actuators in the entry-level smart farm on service users' command or manipulation.

3.2.2 administrative management function: A function that allows service registration, operation management and fault analysis to support the continuous operation of the farm management system.

3.2.3 entry-level smart farm: A smart farm that can provide convenience of use and increased economic profits to agricultural producers previously unfamiliar with high-level information and communication technologies (ICTs).

3.2.4 farm management system: A system that controls active devices with all related data from sensor devices according to the intention of agricultural producers in the entry-level smart farm.

3.2.5 network interface function: A function that connects the functions in the farm management system with the network.

3.2.6 sensor device interface function: A function that gathers all related data from sensors distributed in the entry-level smart farm.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA Authentication, Authorization, Accounting

FMS Farm Management System

ICT Information and Communication Technology

IoT Internet of Things

MTBF Mean Time Between Failures

MTTR Mean Time To Repair

TVWS Television White Space

5 Conventions

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 specification which is recommended but which is not absolutely required. Thus, this specification need not be present to claim conformance.

The keywords "can optionally," "could" indicate an optional specification which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this Recommendation, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

This Recommendation uses 'service provider' with the same meaning as that of 'smart farming service provider'.

6 Concept of the entry-level smart farm

Entry-level smart farms can provide convenience of use and increased economic profits to agricultural producers previously unfamiliar with high-level ICT technologies. In addition, there could be necessities for a service handling various interactions and cooperation between service users, their entry-level smart farms and service providers. Entry-level smart farms mainly engage remote control and farm status monitoring by deploying a farm management system (FMS) in single-span greenhouses, multispan greenhouses or outdoor farm connected via a network as shown in Figure 1.

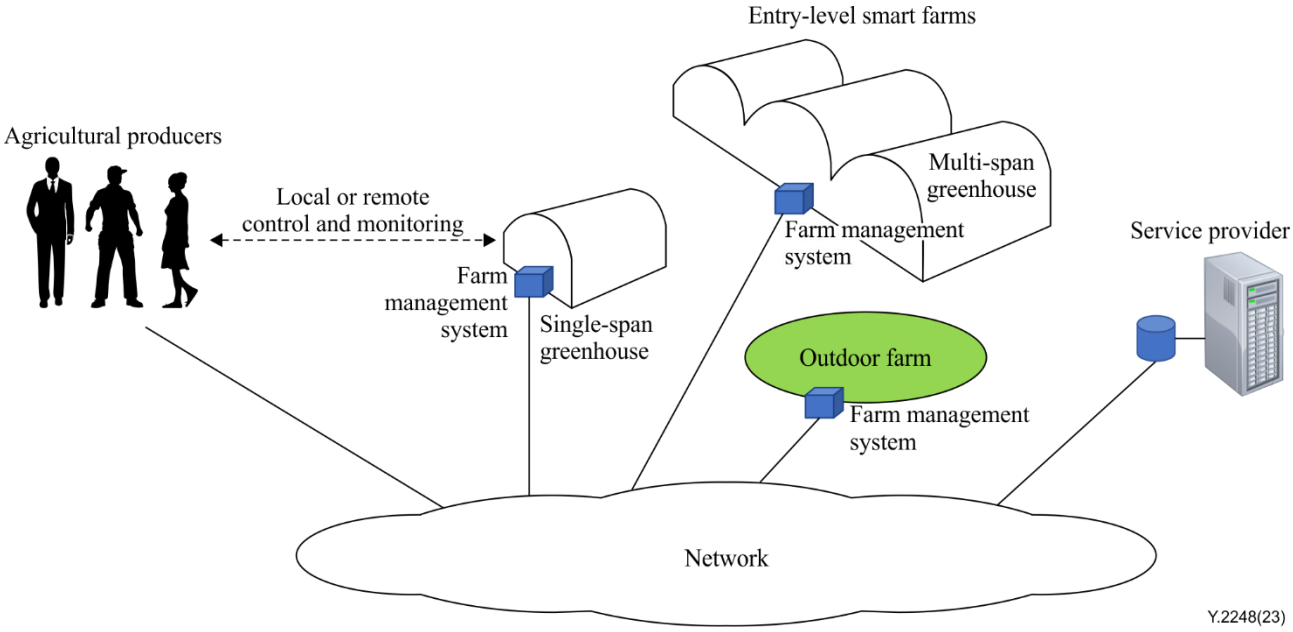

Figure 1 – Conceptual diagram of entry-level smart farm

7 Reference architecture for entry-level smart farm

Considering the motivations in the previous clause, entry-level smart farms could consist of a FMS, actuator devices and sensor devices that could differ between each smart farm and would be connected with agricultural producers and the service provider via a network as shown in Figure 2.

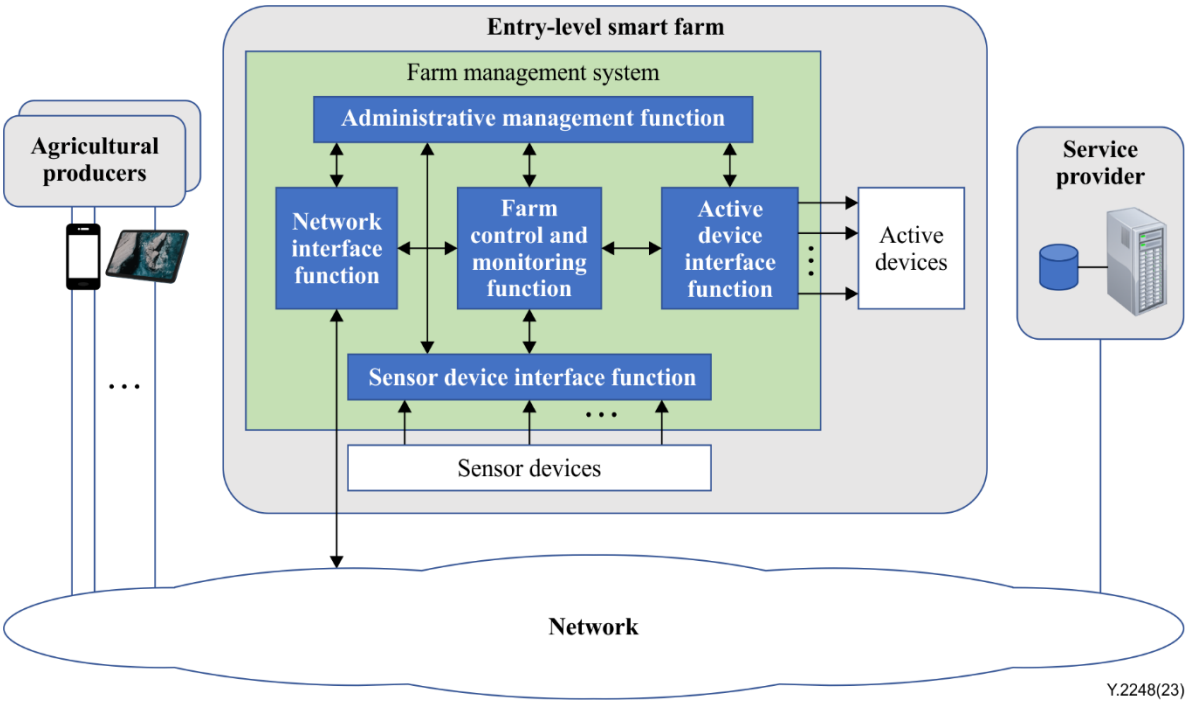

Figure 2 – Reference architecture for entry-level smart farm

The current statuses of the single-span greenhouses, multispan greenhouses and outdoor farms are delivered to the sensor device interface function of the FMS via sensor devices distributed on the greenhouse surfaces or bare ground of outdoor farms. The status data delivered to the sensor device interface function are sent to the farm control and monitoring function to be analysed. The farm control and monitoring function could provide the analysed results to agricultural producers when requested via the network interface function. The agricultural producers, who are the service users of this service, can control the farm apparatus installed in their farms manually or by manipulating their terminal devices. The control information from the terminal devices are conveyed by the network interface function to the farm control and monitoring function. The farm control and monitoring function combines the control information received and the current status of the farm, and sends control commands to active devices via the active device interface function when possible to control according to the service users' intention. Otherwise, it notifies service users of the current status that prevents control commands according to their intentions.

All the functions shown in Figure 2 are explained in the following subclauses.

7.1 Sensor device interface function

This function allows the various sensor devices to access the FMS and transfers data received from the sensor devices to the farm control and monitoring function. The sensor devices cover all or part of the following various types, among others:

– Temperature sensors that measure the current temperature of the atmosphere inside the smart farm;

– Humidity sensors that measure the current humidity of the atmosphere inside the smart farm;

– CO_2 sensors that measure the current CO_2 density of the atmosphere inside the smart farm;

– Soil moisture sensors that measure the current degree of moisture of the soil inside the smart farm;
– pH sensors that measure the current pH of the soil inside the smart farm;
– Wind direction sensors that measure the current wind direction inside the smart farm;
– Camera devices that capture the current image of the inner and outer sides of the smart farm.

7.2 Active device interface function

This function conducts the various active devices and transfers control commands from the farm control and monitoring function to the active devices. The active devices cover all or part of the following various types, among others:

– Irrigation pump devices that irrigate the smart farm supplying water from external water sources into the smart farm;
– Fertilizer devices that fertilize the smart farm supplying nutrient solution or fertilizer;
– Sprayer devices that spray water from the irrigation pump into the soil of the smart farm;
– Exhaust fan devices that absorb air inside and discharge the air to the outside to help the air circulation of the smart farm;
– Heat cover devices that prevent the smart farm from overexposure to sunlight;
– Cooler/heater devices that regulate the temperature of the smart farm by cooling or heating;
– Shutter devices that open or close the windows of the smart farm.

7.3 Farm control and monitoring function

This function analyses data received from the sensor device interface function and delivers the analysed results to agricultural producers who will be aware of the current status of their farms. Accordingly, the farm control and monitoring function delivers control commands from the agricultural producers to the active device control function that will give control commands to the active devices to in turn control the farm apparatus according to the agricultural producers' intentions.

7.4 Network interface function

This function allows agricultural producers to access the FMS and transfers the analysed results from the farm control and monitoring function to the agricultural producers, and the control commands from the agricultural producers to the farm control and monitoring function. This function also allows agricultural producers to access the service provider through the network.

7.5 Administrative management function

This function allows service registration, operation management and fault analysis to support the continuous operation of the FMS. This function is responsible for:

– Initial registration of the owner of the farm, the farm type (single-span greenhouses, multispan greenhouses or outdoor farm), relevant imaging facilities, crop type and characteristics, etc.;
– Farm operation management is carried out by farmers directly using panels/webs or by remote automatic management with the support of service providers;
– Collection of environmental information and status information and reporting of the status of basic environmental information;
– Fault analysis and notification according to the operation of the FMS's error state.

8 Service requirements for entry-level smart farm

Services provided in entry-level smart farms, as shown in Figure 2, are required to meet following requirements.

8.1 General requirements

Entry-level smart farms are required to fulfil the following:

– Installation and operating costs should be low.

– The user control panel should be easily operated by the user.

– By applying an intuitive and human-friendly interface, it should be possible to install and use the low-end smart farm without reading a complicated manual.

– Must be able to support wired and wireless communication networks.

– The sensor and actuator should be modularized so that they can be easily replaced without additional manipulation.

– All means to prevent malfunction should be included.

– The reliability of the equipment used in the entry-level smart farm must have MTBF and MTTR values that can guarantee a quality equal to or better than that of general ICT equipment.

8.2 Requirements for interfacing sensor devices

Interfacing sensor devices to the farm control and monitoring function have the following requirements:

– Adaptation of the received signals to be compatible with the signals inside the FMS;

– Addition or reduction of interface modules according to the addition or reduction of sensor devices, where slots for configuration and extension are recommended.

8.3 Requirements for interfacing active devices

Interfacing active devices to the farm control and monitoring function have the following requirements:

– Adaptation of the received control commands to be compatible with the control signals in active devices;

– Addition or reduction of interface modules according to the addition or reduction of active devices, where slots for configuration and extension are recommended.

8.4 Requirements for farm control and monitoring

Farm control and monitoring have the following requirements:

– Saving and maintenance of the registration information of agricultural producers in internal memories (e.g., flash memories) according to service registration procedures;

– Authentication, authorization and accounting (AAA) procedures utilizing the registration information of agricultural producers in internal memories to decide whether it will accept agricultural producers who are newly requesting services or not;

– Mediation that enables the service provider to answer to a registered agricultural producer's inquiry through the connection between the service provider and the agricultural producers via a network.

8.5 Requirements for the interfacing network

The interfacing network has the following requirements:

– Adaptation of the signals from/to the agricultural producers to be compatible with the signals inside the FMS;

– Connection to variable network technologies (e.g., wired, wireless, Wi-Fi, IEEE802.11ah, TVWS, etc.);

– Addition or reduction of interface modules according to addition or reduction of telecommunication equipment with changing network technologies, where slots for configuration and extension are recommended.

9 Network capabilities

The high-level network capabilities for the support of the entry-level smart farm are as follows:

– End-to-end connectivity over interconnected networks: A solution can optionally be developed to provide end-to-end connectivity between relevant users or terminals over interconnected heterogeneous networks such as next-generation networks (NGNs), other IP-based networks, broadcasting networks, mobile/wireless networks (5G [b-ETSI TS 137 141], NB-IoT, LoRa [b-ETSI TR 103]) and public switched telephone network/integrated services digital networks.

– Intermediate transmission capabilities: Provide intermediate transmission among entry-level smart farms to support control and monitoring over interconnected heterogeneous networks or field-based networks (IEEE 802.11ah [b-IEEE 802.11ah], TVWS (IEEE 802.11af/802.22) [b-IEEE 802.11af] [b-IEEE 802.22], etc.).

– Service provider access capabilities: Provide access to agricultural information originated from service providers over interconnected heterogeneous networks or field-based networks.

– Networking capabilities: Provide relevant control functions of network connectivity and transport resource control functions, mobility management or AAA [b-ITU-T Y-Sup3].

– IoT service providers offer products and services to end users, with wide area embedded connectivity. To ensure the quality and reliability of services, they also need to ensure the quality and reliability of the embedded network connectivity of each IoT device. With tens or hundreds of thousands of deployed devices, it is difficult to monitor and manage network connectivity manually by enterprise customers and IoT service providers through traditional customer care services provided by network operators. An IoT transport network is recommended to have a solution for efficient and scalable operation and maintenance.

10 Service scenarios

The operation of an entry-level smart farm is managed according to its infrastructure condition. If a service provider can be connected via the infrastructure, then service providers can answer questions sent by agricultural producers through the network. The agricultural producers will control their own entry-level smart farms referring to the given answers. Otherwise, they only can control their own entry-level smart farms manually using panel or via local connection (e.g., ad-hoc mode of IEEE 802.11 [b-IEEE 802.11], etc.). The relations between infrastructure condition and the service feature is shown in Figure 3.

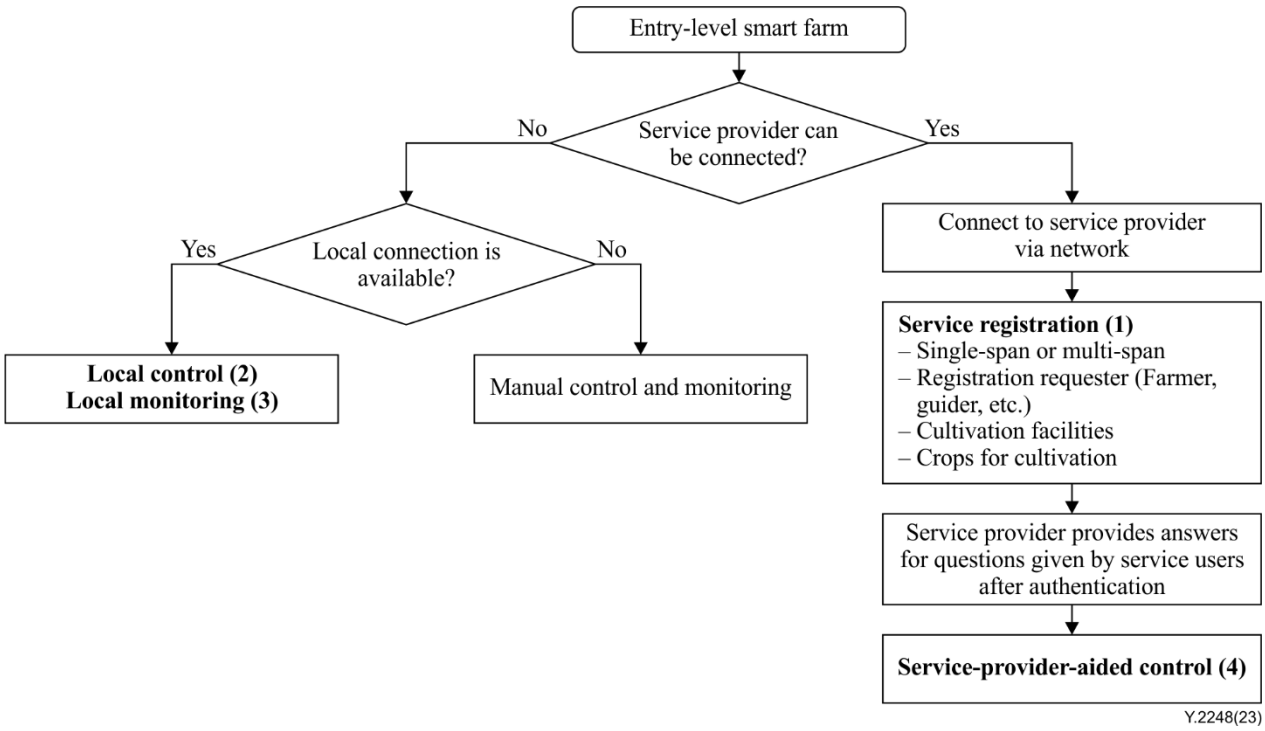

Figure 3 – Relation between infrastructure condition and service features in entry-level smart farms

Numbered service features in Figure 3, service registration (1), local control (2), local monitoring (3), and service-provider-aided control (4), are basic service scenarios for entry-level smart farms. Detailed descriptions for these service scenarios are given in the following subclauses.

10.1 Service scenario for service registration

Agricultural producers shall register to obtain benefits from their entry-level smart farms, applying their registration information ranging from personal identification to farm facilities and crop characteristics.

The information flow for this service is shown in Figure 4.

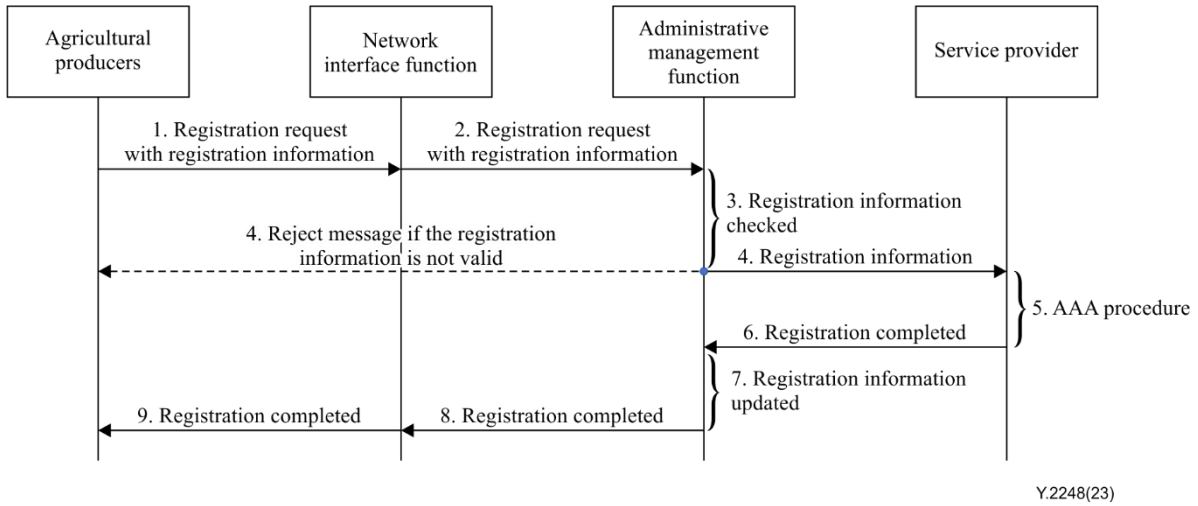

Figure 4 – Information flow for service registration

Assumption

1) The information flows shown here are at high level and not meant to show the actual protocol procedures.

Flow descriptions:

1) The agricultural producers request service registration with registration information (e.g., farm owner, farm location, crop types, farm size).
2) The network interface function conveys the requested registration request to the administrative management function.
3) The administrative management function checks the received registration information.
4) The administrative management function delivers checked information to the service provider if the checked result is valid. Otherwise, it will send a message notifying that the request is denied to the agricultural producers.
5) The service provider carries out the AAA procedure for the requesting agricultural producer.
6) The service provider sends a registration completed message to the administrative management function.
7) The administrative management function then updates its registration table for AAA with the information from the registration completed message from the service provider.
8) The administrative management function conveys the registration completed message to the network interface function.
9) The network interface function conveys the registration completed message to the agricultural producers.

10.2 Service scenario for local control

Farm facilities in single-span/multispan greenhouses and outdoors must be controlled according to agricultural producers' intention when required. The information flow for this service is shown in Figure 5.

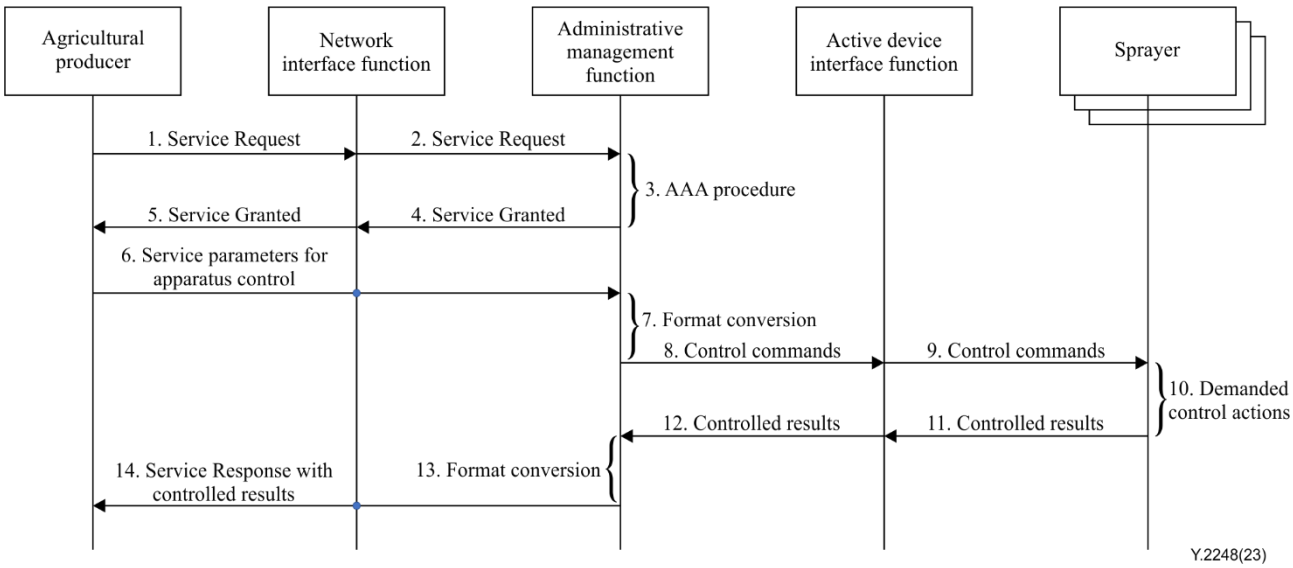

Figure 5 – Information flow for local control

Assumption

1) The information flows shown here are at high level and not meant to show the actual protocol procedures.

Flow descriptions:

1) The agricultural producer sends a service request message requesting single-span greenhouse control to the network interface function.
2) The network interface function conveys the service request message to the administrative management function.
3) The administrative management function carries out the AAA procedure.
4) The administrative management function sends a service granted message to the requesting agricultural producer if the AAA result is valid. Otherwise, it will send the message notifying that the request is denied to the agricultural producers.
5) The network interface function conveys the service granted message to the agricultural producer.
6) The agricultural producer sends service parameters for apparatus control (e.g., apparatus types, indicated control amount) to the administrative management function via the network interface function.
7) The administrative management function converts the received service information to control commands which are compatible with the entry-level smart farm.
8) The administrative management function sends control commands to the active device interface function.
9) The active device interface function conveys the received control commands to the corresponding active device.
10) The corresponding active device performs the demanded control actions.
11) The corresponding active device sends the controlled results to the active device interface function.
12) The active device interface function conveys the controlled results to the administrative management function.
13) The administrative management function converts the received controlled results to a service response message that is understandable to the agricultural producer.
14) Administrative Management Function sends the Service Response message to the agricultural producers via the network interface function.

NOTE – The service scenarios for single-span greenhouse control and outdoor farm control (e.g., simple irrigation control) are to be configured identically. The outdoor farm control performs irrigation control according to the outdoor environment and the moisture level in the soil and provides sensor and actuator information.

10.3 Service scenario for local monitoring

Farm facilities in single-span/multispan greenhouses and outdoor farms must be able to be monitored by agricultural producers when required. The information flow for this service is shown in Figure 6.

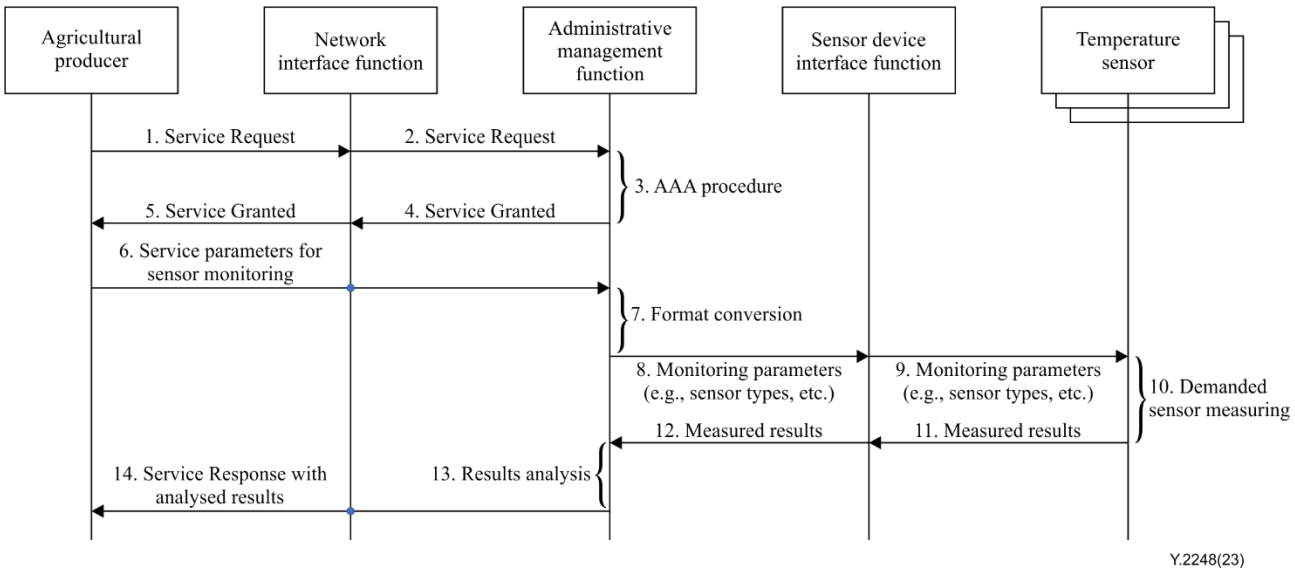

Figure 6 – Information flow for local monitoring

Assumption

1) The information flows shown here are at high level and not meant to show the actual protocol procedures.

Flow descriptions:

1) The agricultural producer sends a service request message requesting single-span greenhouse monitoring to the network interface function.
2) The network interface function conveys the service request message to the administrative management function.
3) The administrative management function carries out the AAA procedure.
4) The administrative management function sends a service granted message to the requesting agricultural producer if the AAA result is valid. Otherwise, it will send a message notifying that the request is denied to the agricultural producer.
5) The network interface function conveys the service granted message to the agricultural producer.
6) The agricultural producer sends service parameters for monitoring (e.g., sensor types, indicated monitoring range) to the administrative management function via the network interface function.
7) The administrative management function converts the received service parameters to monitoring parameters that are compatible with the entry-level smart farm.
8) The administrative management function sends monitoring parameters to the sensor device interface function.
9) The sensor device interface function conveys the received monitoring parameters to the corresponding sensor device.
10) The corresponding sensor device performs the demanded sensor measuring.
11) The corresponding sensor device sends the measured results to sensor device interface function.
12) The sensor device interface function conveys the measured results to the administrative management function.

13) The administrative management function analyses the received measured results and constructs a service response message with the analysed results (e.g., detection of water shortage from a degree of soil moisture below the critical level).

14) The administrative management function sends the service response message with the analysed results to the agricultural producer via the network interface function.

10.4 Service scenario for service-provider-aided control

Farm facilities in single-span/multispan greenhouses and outdoor farms must be controlled not only according to the agricultural producer's intention but also following the service provider's advice considering the larger scale of farming. The information flow for this service is shown in Figure 7.

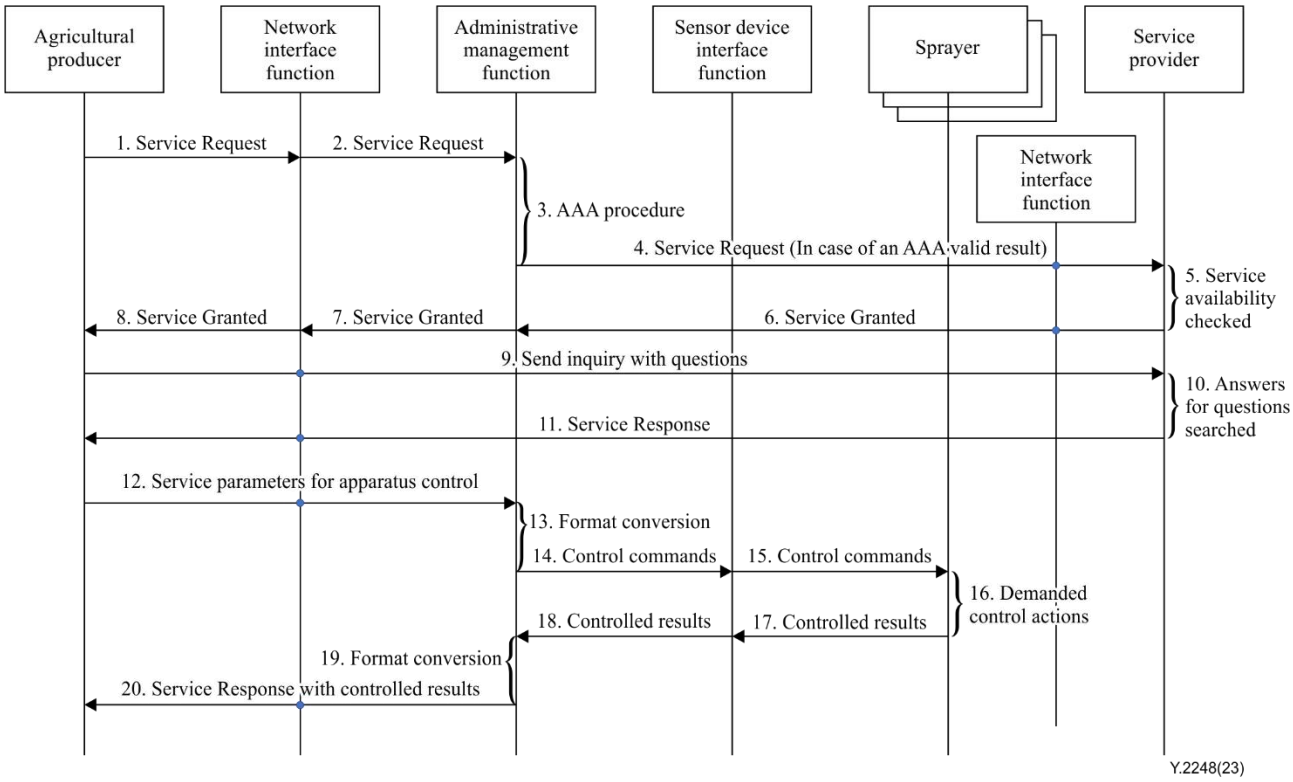

Figure 7 – Information flow for service-provider-aided control

Assumption

1) The information flows shown here are at high level and not meant to show the actual protocol procedures.

Flow descriptions:

1) The agricultural producer sends a service request message requesting multispan greenhouse control to the network interface function.

2) The network interface function conveys the service request message to the administrative management function.

3) The administrative management function carries out the AAA procedure.

4) The administrative management function conveys the service request to the service provider via the network interface function if the AAA result is valid. Otherwise, it will send a message notifying that the request is denied to the Agricultural producer.

5) The service provider checks the service availability.

6) The service provider sends a service granted message to the administrative management function via the network interface function.

7) The administrative management function conveys a service granted message to the network interface function.

8) The network interface function conveys a service granted message to the agricultural producer.

9) The agricultural producer sends an inquiry with questions to the service provider via the network interface function.

10) The service provider searches answers for the received inquiry.

11) The service provider sends a service response to the agricultural producer via the network interface function.

12) The agricultural producer, with answers from the service provider, sends service parameters for apparatus control (e.g., apparatus types, indicated control amount) to the administrative management function via the network interface function.

13) The administrative management function converts the received service information to control commands which are compatible with the entry-level smart farm.

14) The administrative management function sends control commands to the active device interface function.

15) The active device interface function conveys the received control commands to the corresponding active device.

16) The corresponding active device performs the demanded control actions.

17) The corresponding active device sends the controlled results to the active device interface function.

18) The active device interface function conveys the controlled results to the administrative management function.

19) The administrative management function converts the received controlled results to a service response message which is understandable to the agricultural producer.

20) The administrative management function sends a service response message to the agricultural producer via the network interface function.

11 Security considerations

This Recommendation is recognized as providing for services based on IP-based networks. Thus, it is assumed that security considerations in general are based on the security of IP-based networks and therefore it is required to follow the security considerations identified by clauses 7 and 8 of [ITU-T Y.2701]. The data exchanged between the entry-level smart farm and service provider should be treated as public information to be secured. In addition, it is also required to consider the security of agricultural data collected and processed with the capabilities of [ITU-T Y.4401] and [ITU-T Y.4806].

Appendix I

Smart agriculture classification and major components

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

Smart agriculture is an approach in which various cutting-edge technologies such as ICT are grafted into the overall agricultural value chain to make farming more connected and intelligent. The smart farm refers to agriculture where technologies such as ICT are converged with agriculture to enable automated remote control. Smart farm technology can implement the production stage for maximizing added value by optimally managing the growth environment of crops and livestock through external environment blocking, internal environmental informatization and automation. Smart farms are divided into smart greenhouses, smart livestock, smart open-field and smart distribution.

In the case of a smart greenhouse, temperature, humidity, and CO_2 are monitored by a PC or mobile in a glass greenhouse or plastic house, and the window opening and closing and nutrient supply are controlled remotely and automatically. Through this, the optimal growth environment of crops is maintained and productivity is increased.

Table I.1 – Smart greenhouse main components

Category		Content
Environment	Internal	Temperature, humidity, CO_2, soil moisture, nutrient solution measurement sensor (EC, pH), moisture sensor, etc.
	External	Temperature, humidity, wind direction, wind speed, rainfall, insolation, etc.
Video equipment		Infrared camera, DVR, etc.
Control equipment		Ventilation, heating, fluid fan, motor control, nutrient solution control, LED, etc.
Information management system		Real-time growth environment monitoring, facility control environment, growth level database analysis, etc.

Figure I.1 – Smart greenhouse ICT equipment installation site

Smart livestock monitors the livestock environment with a PC or mobile device, and remotely controls feed and water supply in terms of timing and amount. Various services (internal environment, birth, milking, etc.) are provided for in the growth environment of livestock, and ICT equipment is operated to provide each service.

Table I.2 – Smart livestock main components

Category		Content
Environment	Internal	Temperature, humidity, CO_2, illuminance, ammonia, short circuit (blackout) detection, etc.
	External	Temperature, humidity, wind direction, rainfall, insolation, etc.
Video and management system		Infrared camera, DVR, PC, monitor, etc.
Control equipment		Oestrus checker, feeder, feed bin, drinking water management device, thermal lamp, feed mixer, etc.

Figure I.2 – Smart livestock ICT equipment installation site

Smart open-field monitors temperature, humidity, and weather conditions, and remotely manages irrigation and pests. It is possible to create an optimal growth environment based on data on weather environment and soil information. Recently, technologies such as drone-based growth status analysis, autonomous driving of agricultural machinery, and unmanned agricultural work are being developed.

Table I.3 – Smart open-field main components

Category		Content
Environment	Internal	Temperature, humidity, CO_2, soil moisture, nutrient solution measurement sensor (EC, pH), moisture sensor, etc.
	External	Temperature, humidity, wind direction, wind speed, rainfall, insolation, etc.
Video equipment		Infrared camera, DVR, etc.
Control equipment		Ventilation, heating, fluid fan, motor control, nutrient solution control, LED, etc.
Information management system		Real-time growth environment monitoring, facility control environment, growth level DB analysis, etc.

Figure I.3 – Smart open-field ICT equipment installation site

In order to introduce such a system, there are some things to consider. Current farm items, facility types, equipment, communication, electricity and so on should be checked in advance. In addition, it is necessary to prepare a plan for the introduction of smart farms through pre-inspection in cases where it is difficult to apply them.

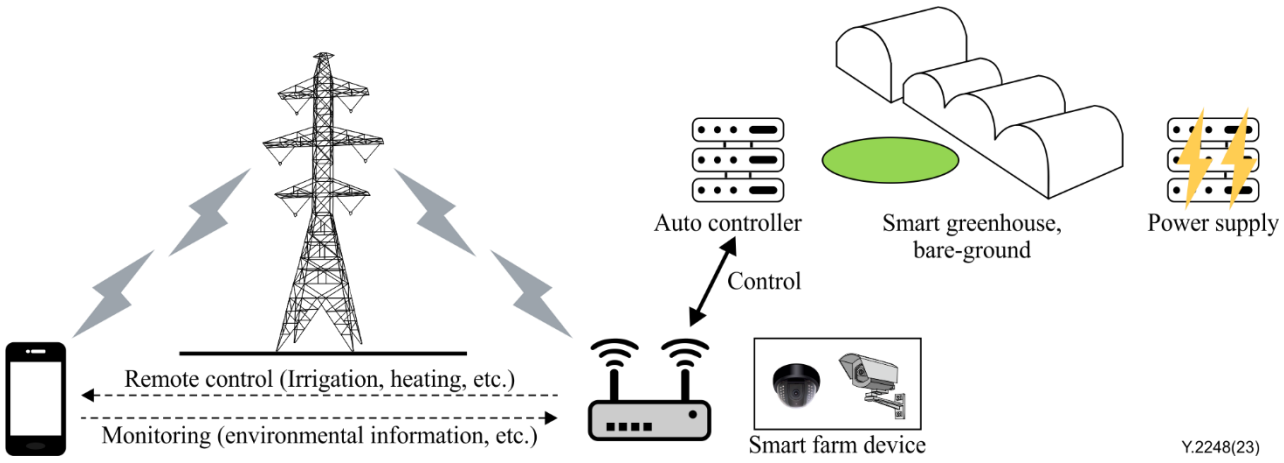

Figure I.4 – Considerations for smart farm adoption

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