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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

Smart farming education service based on u-learning environment

Recommendation ITU-T Y.2246

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Recommendation ITU-T Y.2246

Smart farming education service based on u-learning environment

Summary

Recommendation ITU-T Y.2246 provides a reference architecture and service requirements for smart farming education. It focuses on the farming education service about farming knowledge which includes farming technology, farming skills, farmers' experiences and their know-how, etc. The information related to farming knowledge will reflect current activities, farming products and the experience of farmers in the field. The core component of the automation process is the creation of a data store that will be a repository for this information. The farming sector will benefit immensely from the implementation of farming data in a farming contents repository which will serve as a knowledge base for the automation process. This Recommendation also discusses how this service may be used to develop a knowledge base intended to benefit those involved in the farming sector.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2246	2021-09-13	13	11.1002/1000/14758

Keywords

Content resource repository, education contents management function, farming education administration function, farming education service provider, information and communication technology (ICT), smart farming education service.

* 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.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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

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Smart farming education service based on u-learning environment

1 Scope

This Recommendation provides the following:

– Service requirements for smart farming education services;

– Concepts of smart farming education service;

– Reference architecture for smart farming education service;

– Smart farming education service scenario;

– Security and network capabilities for smart farming education service.

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 composite virtual object [b-ITU-T Y.4452]: A collection of multiple VOs to abstract a service feature, operation or management function, to enable the mash-up and collaboration.

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

3.1.3 smart farming service provider [b-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.

3.1.4 virtual object [b-ITU-T Y.4452]: A virtual representation of a real world object (e.g., sensor, device, task, process and information).

3.1.5 ubiquitous self-directed learning [b-ITU-T Y.2241]: A self-directed learning (SDL) process in a ubiquitous computing environment.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 beginner farmer: Farmer who starts farming as a beginner.

3.2.2 content resource repository: Storage that stores objected content information related to smart farming education information.

3.2.3 expert farmer: Farmer who has expertise in farming with possessing overall know-how and knowledge of success and failure information.

3.2.4 farmer: A farmer is a person who is engaged in agriculture.

NOTE – Agriculture is the term used to refer to the science or practice of farming, growing of crops and rearing of animals.

3.2.5 farm as a service: An operation service that supports data collection and control management in a cloud environment that provides smart farm service through virtualization of agricultural resources, and an application service for farm operation, monitoring and control, data management, and device management.

3.2.6 farming education service provider: Provider that provides farming education services.

3.2.7 learner: Service user who receives farming education services, could be a beginner farmer or an expert farmer.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA Authentication, Authorization and Accounting

AI Artificial Intelligence

CCFE Content Composition Functional Entity

COFE Content Object Functional Entity

CRR Content Resource Repository

CVO Composite Virtual Object

DRM Digital Rights Management

ECMF Education Contents Management Function

EIFE External Interface Functional Entity

EMFE Education Management Functional Entity

FaaS Farm as a Service

FEAF Farming Education Administration Function

FESP Farming Education Service Provider

ICT Information and Communication Technology

IoT Internet of Things

ML Machine Learning

PaaS Platform as a Service

SCFE Service Coordination Functional Entity

SDL Self-Directed Learning

SNS Social Networking Service

uSDL ubiquitous Self-Directed Learning

VO Virtual Object

5 Conventions

The keywords "is required to" indicate a requirement that must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement that is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance. The keywords "can optionally", "could" indicate an optional requirement that 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 document, 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 is to be interpreted as having no normative intent.

6 Overview

The smart farm education service provides smart farm education information based on farm technology information in the smart field, smart farm knowledge related to farmers' experience and know-how and self-directed learning (SDL) service.

The smart farming education service provides operation management information and farming technology of the smart farm field and education on the experience and know-how of farmers who are learners and those who have farming knowledge.

As shown in Figure 1, the service users are referred to as learners and maybe beginner farmers or expert farmers. Farmers learn by using information materials in their field of interest and field experience know-how information and improve and add related materials discussed on the web to gain information to form new or updated technical information materials. Expert farmers process and store the learners' professional technical information and technical knowledge acquired during discussion.

This service provides a process for learners to dynamically use SDL and register learning content for other learners based on field information, farmer's experience knowledge, and expert knowledge information based on the Internet of things (IoT). It aims to alleviate the entry barriers of farming.

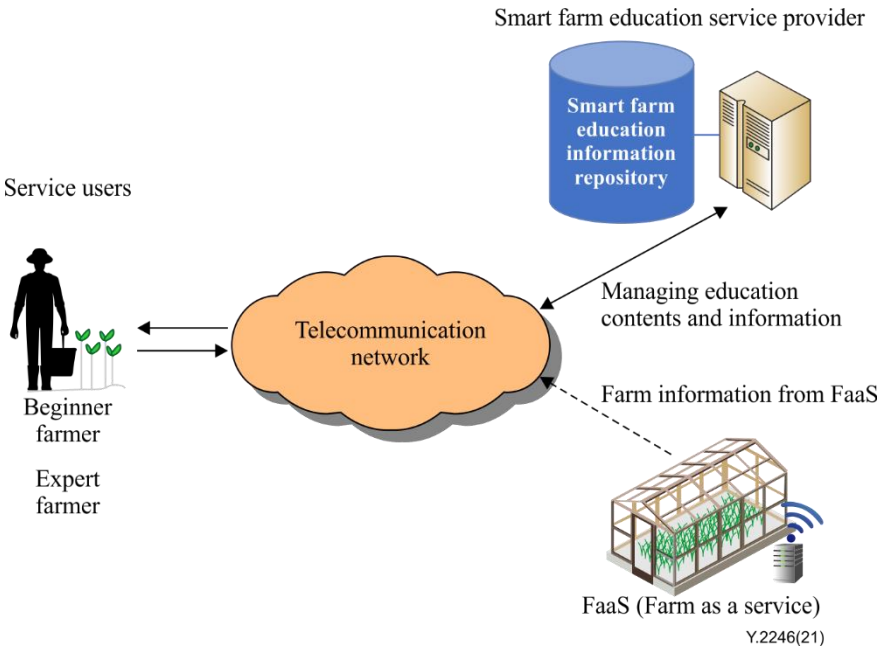


Figure 1 – Conceptual model of smart farming education service

7 Service requirements of smart farming education service

Smart farming education services should satisfy the following requirements:

– It should allow for the provision of self-directed learning services to learners.

– It should have the capability to analyze the farming education process and classify farming education into different farming modules and domains and provide smart farming knowledge.

– It should support farming education and evaluation by providing objectives and farming education courses.

– It should be flexible and must allow for efficiency in ubiquitous environments based on information and communication technology (ICT).

– It should support interactive access by farmers to a variety of multimedia-based materials.

– It should be adaptable so that it can provide smart farming knowledge and adapt to farming technology changes.

– It should support the distribution of education content services to farmers.

– It should support the collection of information gained from farmers who have generated solutions to problems, so that this information can be used to improve the content of the education service system.

– It should support the decision-making process for farmers in farm management. That is, farming education service providers assist farmers in developing proficiency in the management and operation of farms.

– It should allow educational knowledge information and specialized knowledge information to be distributed to users by social networking services (SNS), etc. It should facilitate service users in providing the learned content to the service provider so that it can be made available for future learners. The service provider stores the new or updated learned content and manages it in the content resource repository (CRR).

– It should assist in collecting and utilizing practical information from the farm as a service (FaaS) operating at the external site if there is no educational information from the smart farming education service provider.

8 Reference architecture of application model for smart farming education service

A smart farming education service reference architecture is provided in Figure 2.

8.1 Farming education service provider (FESP)

The relationship between the farming education service provider (FESP), the farming education administration function (FEAF) and the education contents management function (ECMF), when providing farm as a service (FaaS) is shown in Figure 2.

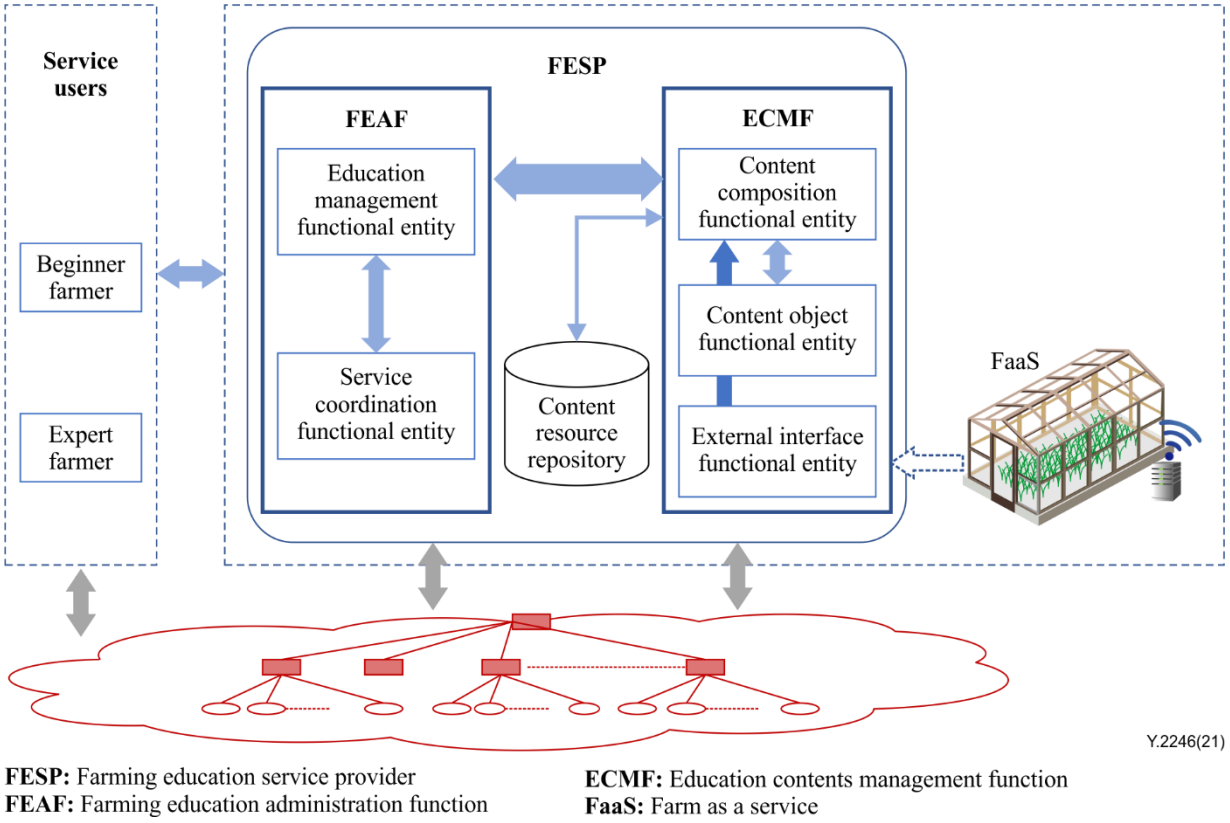


Figure 2 – Reference architecture of a smart farming education service

Smart farming education service provides context–aware computing and adaptive learning service by a farming education service provider (FESP). The smart farm education service provider (FESP) consists of the farming education administration function (FEAF), the education contents management function (ECMF) and an external interface with farm as a service (FaaS) as shown in Figure 2. Users interconnect with FESP through a web object-based service provisioning environment. It satisfies major needs such as cost-effectiveness, reliability, adapting to the lifestyle, time sensitive content and can adapt to multiple learning styles.

8.1.1 Farm education administration function (FEAF)

Smart farm education administration function (FEAF) consists of a service coordination functional entity (SCFE) and an education management functional entity (EMFE), and a description of these two functions is as follows.

8.1.1.1 Education management functional entity (EMFE)

The education management functional entity (EMFE) operates the farm education service that manages the delivery of services and farm contents for each task. This functional entity performs a variety of functions, such as processing learning evaluation, registration, scheduling education

services, content creation, management of instructional procedures, and manages the process of improving the learning ability of users by evaluating each learner's learning ability.

It manages tasks according to each user's request and grants authority levels according to each user's service request task. Learning services for users are provided according to each learning process. It creates a curriculum and creates courses that engage users' services in learning more effectively. Through the service, learners can choose according to their personal interests, define learning goals to achieve, and improve the quality of learning through self-assessment.

Depending on the user's level of interest, the user who has reached each task level through the evaluation procedure is given the right to perform each task, and all users can subscribe to the smart farm education service within the given permission ranges.

8.1.1.2 Service coordination functional entity (SCFE)

This functional entity monitors each user's request status, identifies the user's service type, classifies service tasks according to the user service type and adjusts the appropriate farming content allocation. It performs educational support service functions such as linking social networking services (SNS), linking lecture URLs and open source utility, providing bulletin boards, delivering farming knowledge, and linking web browsers through external access services. Learners may find answers based on discussions in FESP and by disclosing issues through SNS, etc. For issues that cannot be found in FESP, through third-party interfaces such as FaaS, key information such as farming management, cultivation know-how, disease and pest mitigation information, legal system information, etc. are learned to find solutions to issues previously addressed by external experts.

8.1.2 Education contents management function (ECMF)

The farming contents management function, i.e., the education contents management function (ECMF) contains all the content related to smart farm education and application information of FaaS and all the content of farming contents. It focuses on the development, management and publication of content and enables interaction, rapid response, personalized support, and new forms of learning approaches. This function is composed of two functional entities: Content composition functional entity (CCFE) and content object functional entity (COFE). It provides tools for content creation, reuse and repurposing, as well as virtual spaces for learner interaction, such as discussion forums, live chat rooms and live web conferences.

8.1.2.1 Content composition functional entity (CCFE)

The content composition functional entity (CCFE) manages education content consisting of media contents and content objects. It performs the following functions:

– Identifies content, retrieves content, and tracks usage of content such as title, author, subject keywords, date of publication, security classification, access permissions, and information rights, etc.
– Specifies what data will be collected, how it will be collected and what purpose will it serve.
– Organizes digital resources, including archiving and preservation.
– Manages key information assets, files (image, doc, txt), folder and HTML, etc.
– Keeps track of multimedia files via clip properties such as log notes, comments, scene number and so on.
– Controls multimedia content and meta-data for ubiquitous self-directed learning (uSDL) objects.
– Applies digital rights management (DRM) solutions.

8.1.2.2 Content object functional entity (COFE)

The content object functional entity (COFE) converts the collected educational content information (image content, video content, audio content, text content) into an object. This content individuation function entity makes the contents related to farm education and farming operation of FaaS available as separate entities for online education and performs the following functions:

– Objectize educational contents and stores objectified contents in the storage.

– Manages the content objects to be created by the creation task.

– Facilitates farming content handling such as indexing and reuse.

– Creates new objects (Virtual object (VO), composite virtual objects (CVOs)) combined with other object-based environments.

8.1.2.3 FaaS external interface functional entity (EIFE)

The FaaS external interface functional entity (EIFE) collects various field site information by interfacing to FaaS, related to farm management, pest mitigation, third-party linkage services, and high-level application services that support management.

8.1.2.4 Content resource repository (CRR)

The content resource repository (CRR) performs the function of storing the objectified information from the content object functional entity (COFE) and provides the farming education information for each service to the content composition functional entity (CCFE) through interaction with COFE. The following information is stored in the CCR:

– Smart farm site information: pesticide information, fertilizer information, soil health, disease, insect information, plant nutrition, etc., and weather information such as climate change and information such as irrigation and water use status, business information, service information provided by the government and NGOs, marketing area and agricultural product price information, stock information, etc.

– Farmer's know-how information.

– Learning evaluation processing information, registration information, educational service information, etc.

– Learners managed registration requests, basic captured data for learning targets (beginners), captured solutions developed through open questionnaire preparation and discussion, captured solutions developed through open discussion of the questionnaire through external FaaS, and converts and captures the final learning content into a CRR.

9 Smart farming education service scenario

For self-directed learning on smart farms, smart farming education service scenarios provide educational services for new or existing farmers with learning and training on crop technology production and knowledge learning services through self-directed learning when changing crop production. These education scenarios help to minimize failures in crop production which may ultimately increase productivity.

Various farming education service scenarios can be developed. The following two representative service scenarios have been selected: 1) a beginner learner who has recently started farming, and 2) an expert learner who has expertise in farming and who possesses overall know-how and knowledge of success and failure information, knowledge about the process of selecting crops before production, and knowledge about integrating production and distribution packing. Appendix I describes two example service scenarios.

Three flows are considered. The first is about the service scenario functional flows, the second is about the service scenario service flows, and the third is about the service scenario information flows.

Figure 3 provides a functional flow diagram of a service scenario for beginners and experts.

The functional flow diagram is divided into learners (beginners, experts) and educational service providers. The main functional roles are described.

Learners may request education registration for specific crops, and service providers may conduct learning guidance and evaluation such as providing learning materials and providing opportunities for question-and-answer discussions through social networking services (SNS).

For expert learners, service providers provide opportunities for external SNS community and know-how information education such as virtual field farming, and after completion of self-directed learning the expert learners register the learning materials and the learned results in a database so that the information can be provided to future learners.

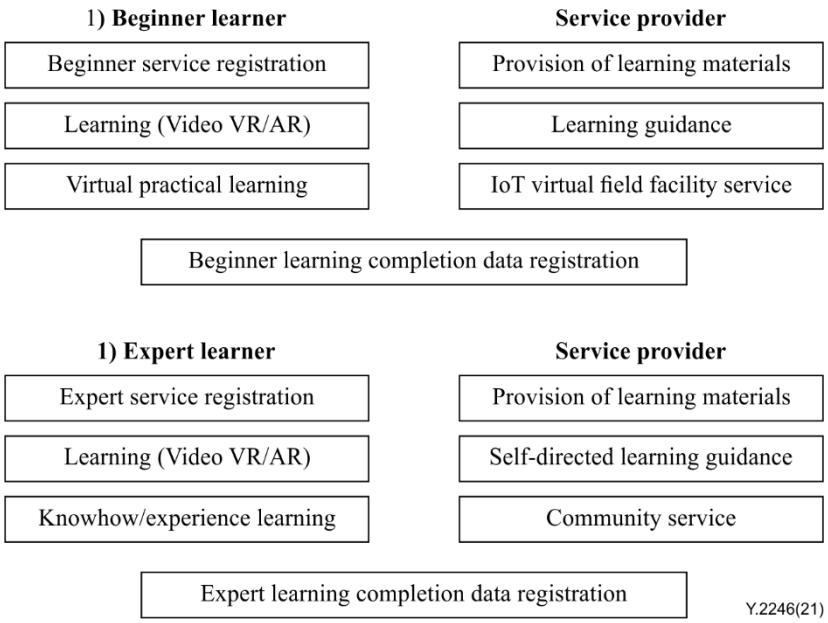


Figure 3 – Functional flow diagram of service scenario

Appendix I describes two example service scenarios. Figure I.1 shows the service scenario flow for beginners and experts and Figure I.2 shows the service information flow procedures.

10 Network capabilities

The high-level network capabilities required for the support of smart farming education services are as follows:

– Connecting to anything capabilities: These capabilities refer to the support of different ubiquitous networking communication types (person-to-person communication, person-to-object communication, and object-to-object communication) and include the support of tag-based devices (e.g., radio frequency identification (RFID)) and sensor devices. Identification, naming and addressing capabilities are essential for supporting "connecting to anything".

– Open web-based service environment capabilities: Emerging ubiquitous services and applications will be provided based upon an open web-based service environment, as well as legacy telecommunication and broadcasting services. In particular, application programming interfaces (APIs) and web with dynamics and interactivities will be supported. Such a web-based service environment will allow not only the creation of retail community-type services but also the building of an open service platform environment which third-party application developers can access to launch their own applications. Using interactive, collaborative and

customizable features, the web can provide rich user experiences and new business opportunities for the provision of ubiquitous networking services and applications.

– Context-awareness and seamlessness capabilities: Context-aware means the ability to detect changes in the status of objects. Intelligent systems associated with this capability can help to provide the best service to meet the situation using the user and environmental status recognition. Seamlessness is a key capability for "5 Any" (anytime, anywhere, any-service, any-network and any-object).

– Multi-networking capabilities: A transport stratum needs multi-networking capabilities in order to simultaneously support unicast/multicast, multi-homing and multi-path. Because of high traffic volume and the number of receivers, ubiquitous networking requires multicast transport capability for resource efficiency. Multi-homing enables the device to always be best connected using multiple network interfaces including different fixed/mobile access technologies. These capabilities can improve network reliability and guarantee continuous connectivity with a desirable quality of service (QoS) through redundancy and fault tolerance.

– End-to-end connectivity over interconnected networks: For risk mitigation, it is critical to develop a solution 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 and public switched telephone network/integrated services digital networks (PSTN/ISDNs).

– Networking capabilities: Provide relevant control functions of network connectivity and transport resource control functions, mobility management or authentication, authorization and accounting (AAA) [b-ITU-T Y-Sup.3].

– The device capabilities include, but are not limited to the following:

  • Allow for direct interaction with the communication network.
  • Allow for the gathering and uploading of information directly (i.e., without using gateway capabilities) to the communication network.
  • Have the ability to directly receive information (e.g., commands) from the communication network [b-ITU-T Y.4000].

– 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 to 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.

– The device is required to have enough precision to sense IoT data from monitored things in order to measure and record the characteristics of the monitored things.

– The device is recommended to mark the sensed IoT data with labels to indicate the types (related to the monitored things characteristics) of the sensed IoT data so that other IoT components can understand the types of the sensed IoT data.

– Big data, where a large amount of data will be transferred from those sensors and cameras to the IoT platform. All data will experience the data collection, data transfer, data pre-processing, data storage and data analysis procedures.

– During the data collection procedure, the data collection schedulers in the IoT platform will arrange the collection period and collection sequence to balance the network and the IoT platform load. The collected data from the city environment sensors will be partially annotated with time stamps and semantic information according to the capability of sensors.

– To provide a reference implementation of an end-to-end machine learning (ML) pipeline for ML coding and integration, tools for data processing and management, tools for ML model selection, training, optimization, and verification to control artificial intelligence/machine learning (AI/ML) integration [b-ITU-T Y.3176].

11 Security consideration

While implementing requirements related to u-learning service networking, the best security practices should be adopted such as authentication, authorization and access control.

The following considerations on security and privacy are required to construct a u-learning service capability:

– Availability: Reliable provision of data and information services to authorized users.

– Confidentiality and data protection and privacy: Assurance that information is not disclosed to unauthorized individuals, processes or devices. This area also includes data protection and privacy requirements. This also means anonymization or pseudonymization on the one hand and using the minimum set of data needed for the use case on the other hand. For example: position information on the user should not be accessible by unauthorized parties.

– Integrity: This requirement area includes the requirements which guarantee the logical correctness of the operating system; the logical completeness of the hardware and software implementing the protection mechanisms; and the consistency of the data structures and occurrence of the stored data.

In addition, the network infrastructure includes multiple communication network interfaces for u-learning services to ensure the interconnection networking will be protected to avoid data leaking and data destruction.

Further operations related to network resources should have reliability capabilities built in to ensure that incorrect operation to network resources and degradation of network performance will not occur.

This Recommendation is recognized as an enhancement of IP-based networks. Thus, it is suggested that security considerations, in general, be based on the security of IP-based networks and thus it is required to follow the security considerations identified by clauses 7 and 8 of [ITU-T Y.2701].

Additionally, while no specific guidance is provided in this Recommendation in regard to security, implementers should be aware of the security information that is published in [ITU-T Y.2701] and [b-ITU-T Y.2702].

Appendix I

Information flows for smart farming education service

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

I.1 General

This appendix provides examples of information flows for learner service flows for the service scenario flows of clause 9. This appendix is divided into three parts. The first is about the functional flow diagram of the service scenario, the second is about the service scenario flows, and the third is about the information flows of the service scenarios.

I.2 Service flows

Figure I.1 shows the service scenario flow for beginners and experts and Figure I.2 shows the service information flow procedures.

The functional operation flow procedure. To understand the functional flow procedure, all actions go to the 'yes' flow if the conditions are met, and if they are not met, returns immediately to the previous step, and repeats the process. The procedure is described as follows:

1) Beginner learners register with farming education service provider (FESP) and input learner information (educational experience, crops of interest, farmland information, facility information, etc.), and the FESP receives the necessary learning materials (text, video information, expert instruction, etc.). Realistic multimedia learning such as practical experience is conducted, crop cultivation is started based on the learning, and cultivation experience learning materials are registered with the farming education service provider to provide experimental empirical knowledge to future learners.

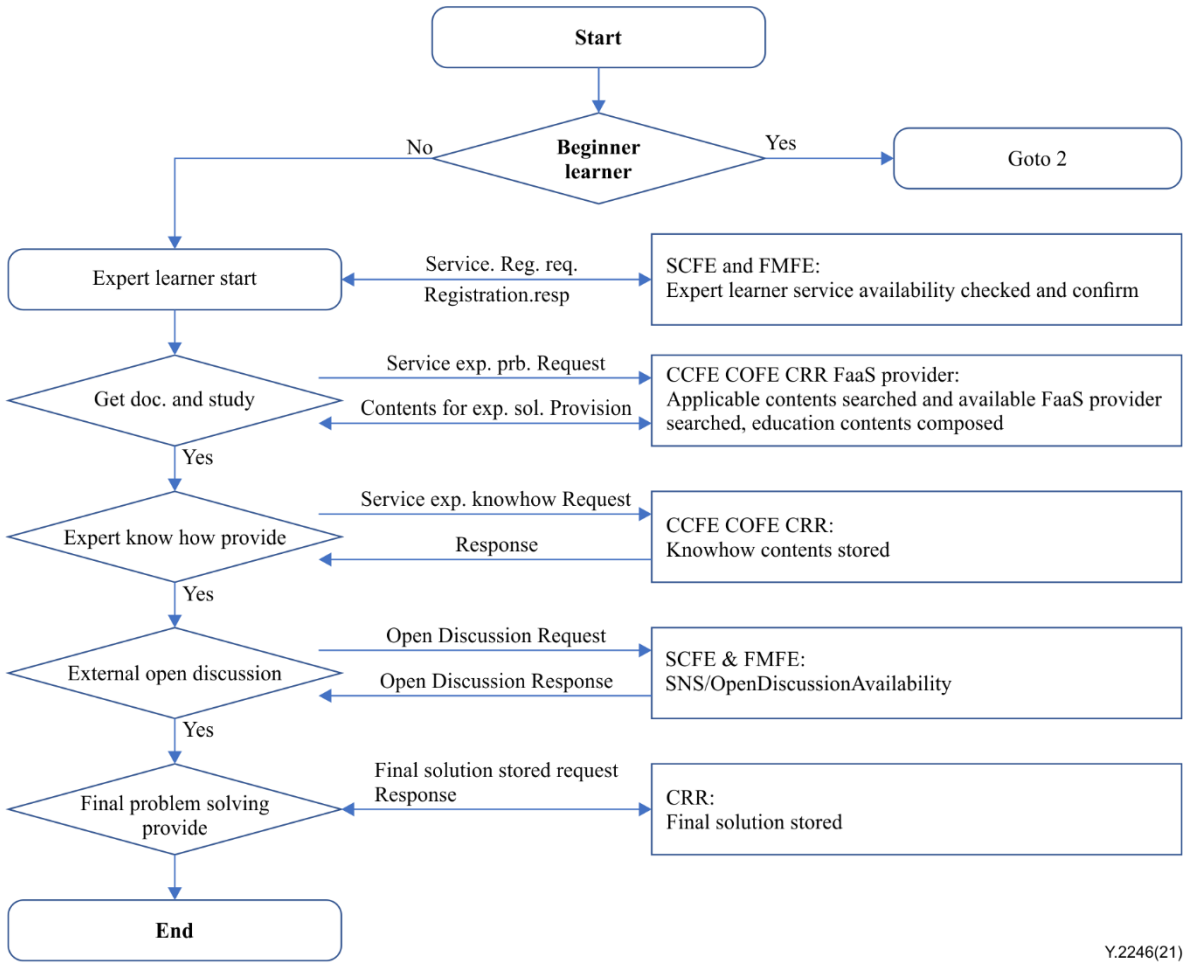
2) Expert learners prepare solutions through discussions between cultivators about problems and improvements that occur while cultivating crops through learning. The COFE provides information for learners by creating and arranging learning results about cultivation know-how information, disease and pest information, and sales information.

2.1) When a learner selects a target crop for expert learner registration to the FESP and requests registration, the FESP makes available the necessary learning materials to the learners.

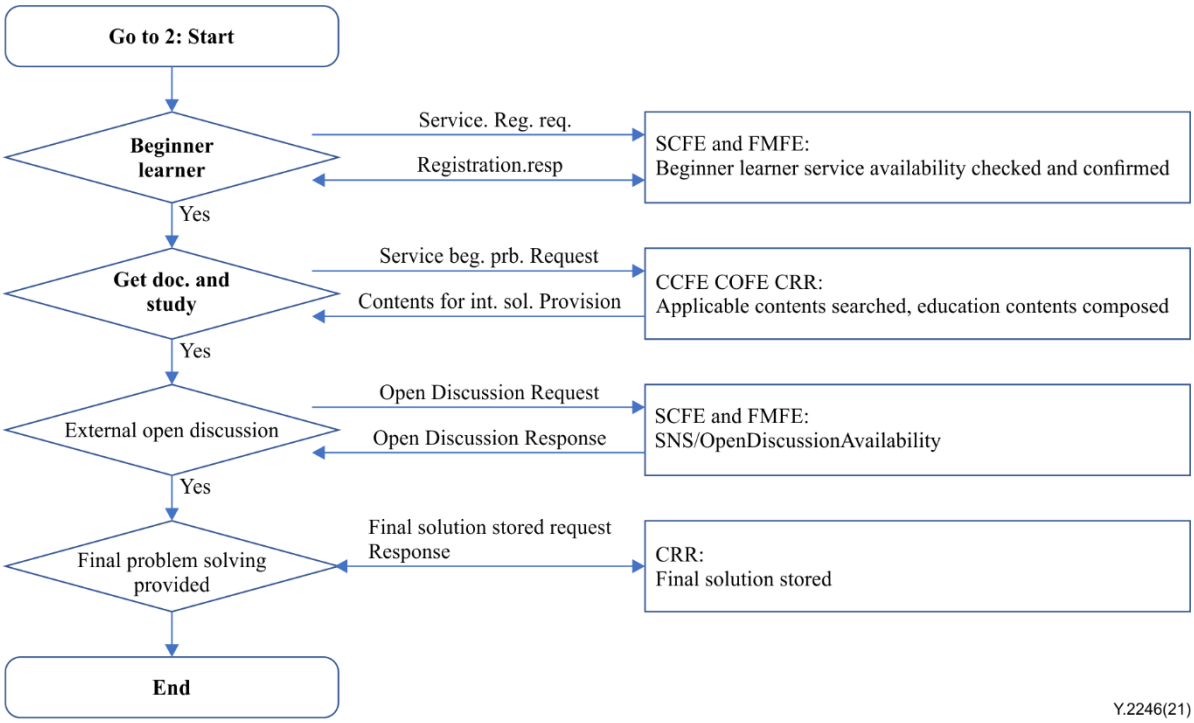
2.2) A questionnaire on issues related to crops is requested from FESP, and the FESP secures its own content and provides a reply with information to the learners.

2.3) The learner seeks a solution to the unresolved issue through an open discussion on SNS in the FESP.

2.4) In case of insufficient issue solution through open discussion, it connects to the FaaS which manages the external farming sites, analyzes the latest content information on farming field management, growth, and pests and finds the best solution. Its contents are then registered and stored in the FESP so that it can be provided to future learners.



a) Service scenario flow for expert



b) Service scenario flow for beginner

NOTE – The following abbreviations are used: int. prb. req (internal problem request); ext.prb (external problem); prb.open (problem open); int.sol (internal solution); ext.sol (external solution).

Figure I.1 – Service scenario flow for beginners and experts

I.3 Information flows

This clause identifies the information flows which would normally occur between the functional entities. When a learner requests service registration, the registration request is checked through SCFE and EMFE, and educational content is provided through CCFE, COFE, and CRR. In the case of an expert, FaaS education materials are provided through EIFE.

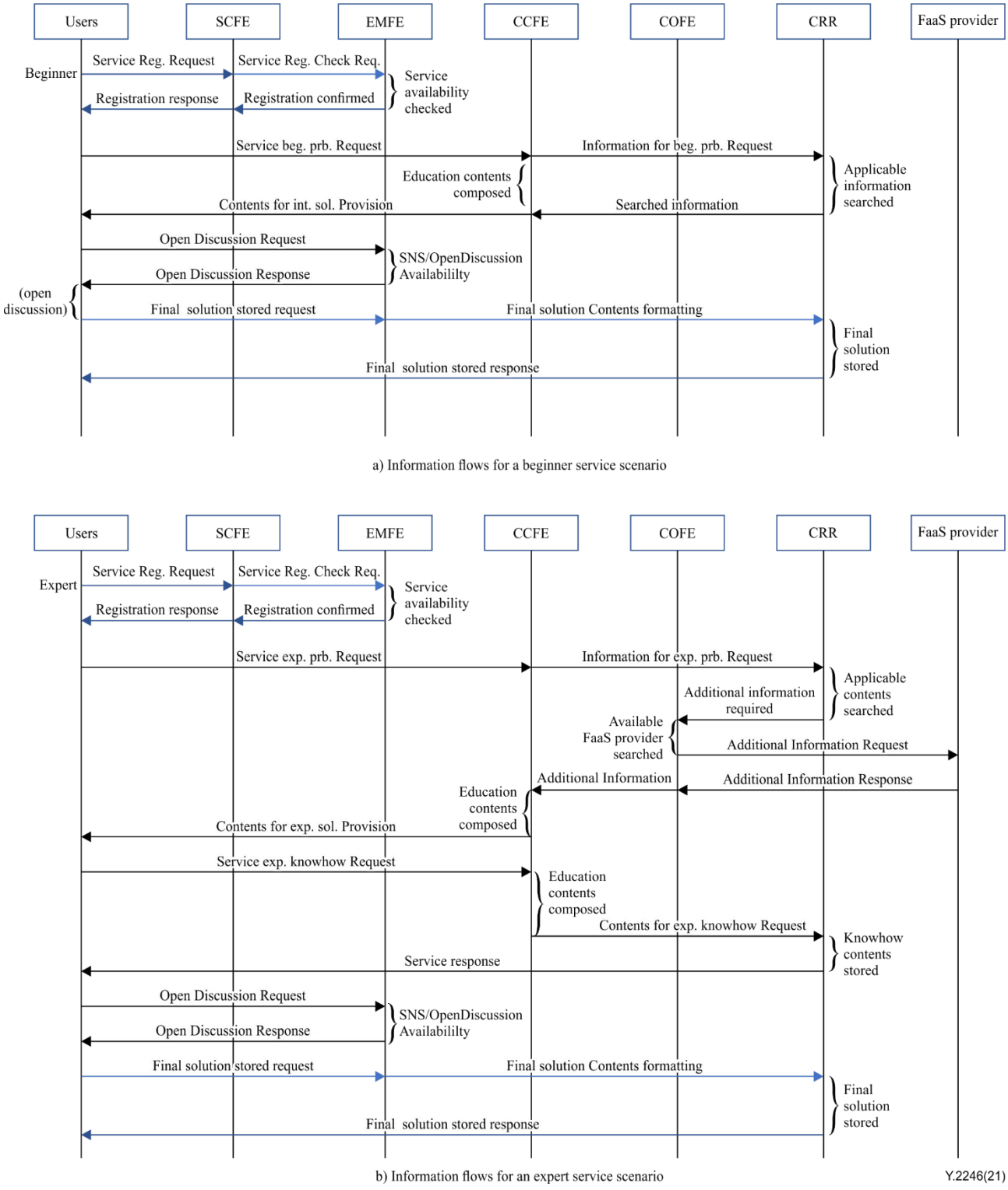


Figure I.2 – Information flows for an example service scenario

In the case of beginner users, the following information flows apply:

1. Beginner users send service reg. request to SCFE.
2. SCFE decides the service class from the received service reg. request and sends the decided service class to EMFE.
3. EMFE checks the service availability and sends a registration confirmed to users if available.
4. The registered users send service int. prb. request to CCFE.
5. CCFE sends the information for int. prb. request to CRR.
6. CRR searches applicable information and sends the searched information to CCFE.
7. CCFE is composed of the education contents and sends contents for int. sol. provision to the beginner users.
8. Beginner users send an open discussion request to EMFE.
9. EMFE checks the open discussion availability and sends an open discussion response to beginner users.
10. Beginner users send a final solution stored request to EMFE which then sends a final solution contents formatting, resulted from the open discussion between the beginner users who participated in the discussion to CRR.
11. The received final solution contents are stored to CRR and the final solution stored response is sent to the beginner users.

In the case of expert users, the following information flows are applied:

1. Expert users send service reg. request to SCFE.
2. SCFE decides service class from the received service reg. request and sends the decided service class to EMFE.
3. EMFE checks the service availability and sends a registration confirmed to users if available.
4. The registered users send service exp. prb. request to CCFE.
5. CCFE sends contents for service exp. prb. request to CRR.
6. CRR searches applicable contents and sends additional information required to COFE if needed.
7. COFE searches available FaaS providers and sends additional information request to the FaaS provider.
8. FaaS provider sends additional information response to COFE.
9. COFE sends the received additional information to CCFE.
10. CCFE composes the education contents and sends contents for exp. sol. provision to users.
11. Expert users who want to contribute their know-how, send service exp. knowhow request to CCFE.
12. CCFE which composes the education contents sends contents for exp. knowhow request to CRR.
13. The knowhow contents/received education contents are stored to CRR and a service response is sent to the expert users.
14. Expert users send an open discussion request to EMFE.
15. EMFE checks the open discussion availability and sends an open discussion response to the expert users.

16. Expert users send a final solution stored request to EMFE which then sends a final solution contents formatting, resulted from the open discussion between the expert users who participated in the discussion to CRR.

17. The received final solution contents is stored to CRR and the final solution stored response is sent to the expert users.

Appendix II

Example of FaaS configuration diagram

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

This appendix deals with a cloud-based smart farm service, specifically farm as a service (FaaS).

II.1 FaaS

The requirements standard for a cloud-based smart farm service (FaaS: farm as a service) defines the technical requirements and configurations of the service required to manage and operate a smart farm based on cloud computing technology.

In particular, it is the content of the upper application service for collecting, controlling, operating and managing API service data that virtualizes various types of smart farm resource information based on PaaS (Platform as a service) and provides a service operation and a development environment.

The cloud-based smart farm service uses cloud technology that shares IT infrastructure resources such as server storage middleware application software through the network.

In addition, smart farm devices such as sensor node driver nodes are also virtualized and operated. Through this, it is possible to integrate and operate legacy systems, which are installed and operated by existing farms and operated individually and distributed by different types of smart farm systems and suppliers, through cloud technology, and the farm management function can be used in the form of a low-cost service.

The smart farm service can provide a crop growth information monitoring service tailored to the needs of the farmers by applying technologies such as cloud computing and IoT big data to greenhouse orchards and can also provide a growth environment control service.

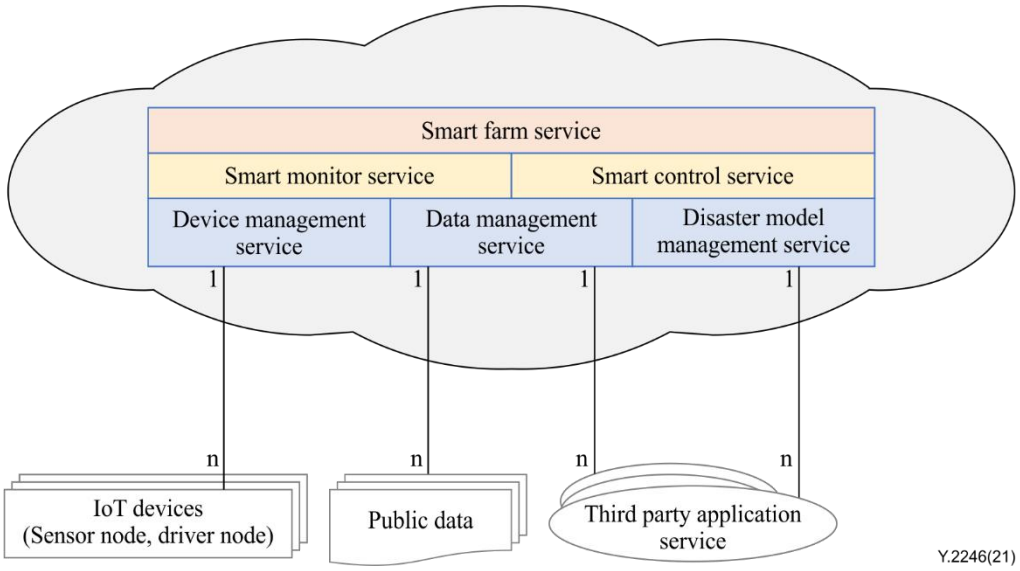


Figure II.1 – FaaS configuration diagram

Appendix III

An example of scenarios of the architecture on object tagging and customization of smart uSDL objects

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

III.1 VO/CVO based description of learning object metadata in uSDL

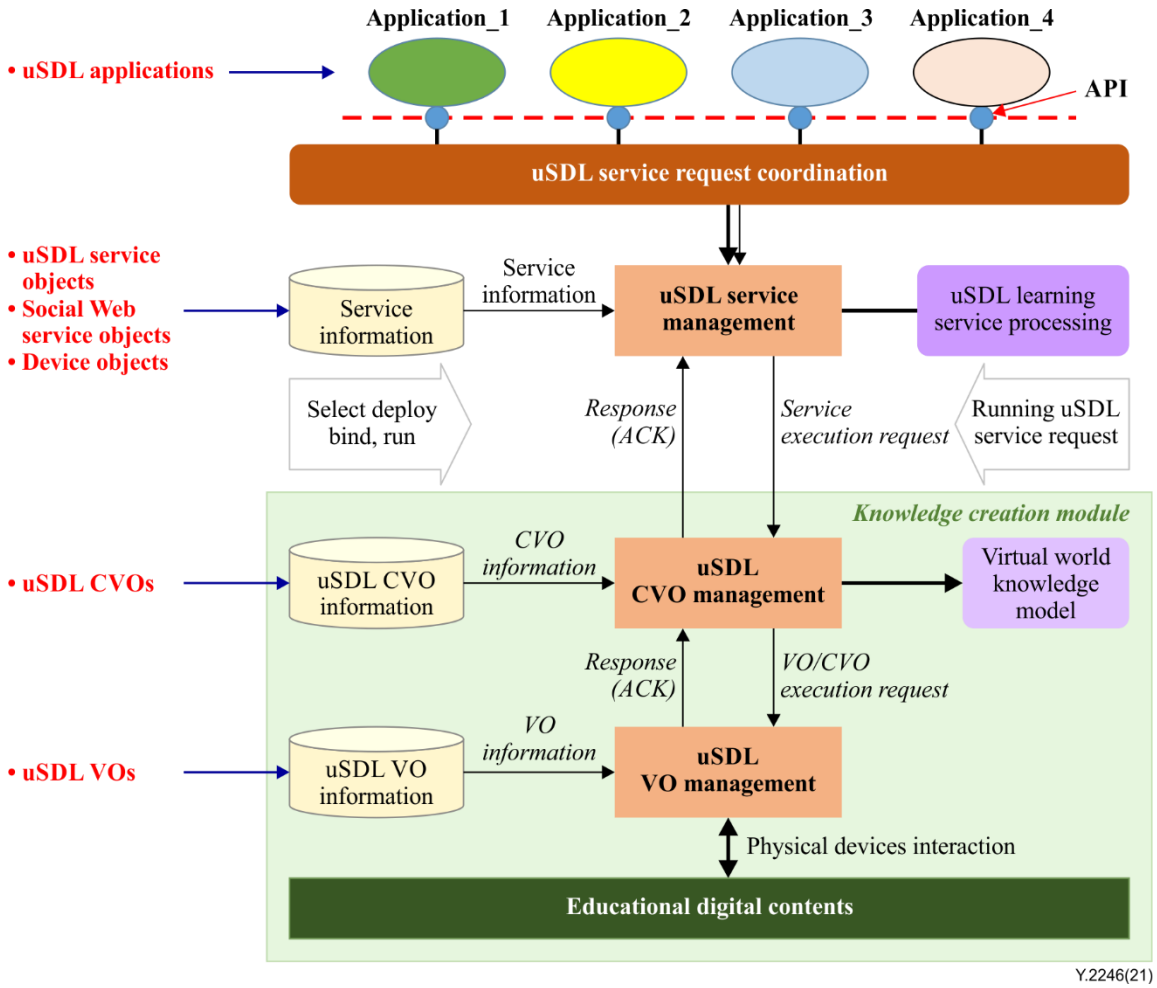


Figure III.1 – Service procedure of web objects based uSDL system

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