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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

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

Functional framework of web of objects

Recommendation ITU-T Y.4452

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Recommendation ITU-T Y.4452

Functional framework of web of objects

Summary

Recommendation ITU-T Y.4452 provides the functional framework including the concept, reference model, functional capabilities and information models of the web of objects (WoO).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.4452	2016-09-13	20	11.1002/1000/13027

* 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

The web of objects (WoO) supports a functional framework to deploy Internet of things (IoT) services in the World Wide Web (WWW) environment.

This Recommendation covers the following:

– the concept of WoO;

– the reference model and functional capabilities of WoO;

– information models of WoO.

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.4000] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things*.

[ITU-T Y.4552] Recommendation ITU-T Y.4552/Y.2078 (2016), *Application support models of the Internet of things*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Internet of things (IoT) [ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.2 object [b-ITU-T Y.4404]: An intrinsic representation of an entity that is described at an appropriate level of abstraction in terms of its attributes and functions.

NOTE 1 – An object is characterized by its behaviour. An object is distinct from any other object. An object interacts with its environment including other objects at its interaction points. An object is informally said to perform functions and offer services (an object which makes a function available is said to offer a service). For modelling purposes, these functions and services are specified in terms of the behaviour of the object and of its interfaces. An object can perform more than one function. A function can be performed by the cooperation of several objects.

NOTE 2 – Objects include terminal devices (e.g., used by a person to access the network such as mobile phones, Personal computers, etc.), remote monitoring devices (e.g., cameras, sensors, etc.), information devices (e.g., content delivery server), products, contents, and resources.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 virtual object (VO): A virtual representation of a real world object (e.g., sensor, device, task, process and information).

NOTE – Real world objects are identifiable through their virtual representation.

3.2.2 composite virtual object (CVO): A collection of multiple VOs to abstract a service feature, operation or management function, to enable the mash-up and collaboration.

3.2.3 web of objects (WoO): A way to incorporate virtual objects on the world wide web and to facilitate the creation of IoT services.

3.2.4 information model: A model to define how the elements (i.e., VO and CVO) in an information environment are represented as a common set of objects and the relationships between them.

3.2.5 resource: This Recommendation does not limit the scope of what might be a resource; rather, the term "resource" is used in a general sense for whatever might be identified by a URI (based on the definition given in [b-IETF RFC 3986]).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

CVO Composite Virtual Object

foaf Friend of a friend

HTTP Hypertext Transfer Protocol

IoT Internet of Things

IP Internet Protocol

MAC Media Access Control

RDF Resource Description Framework

URI Uniform Resource Identifier

VO Virtual Object

WoO Web of Objects

WWW World Wide Web

XML Extensible Markup Language

5 Conventions

None.

6 Concept of web of objects

The web of objects (WoO) is a way to structure relationships between IoT services [ITU-T Y.4000], where virtualized objects (i.e., VO and CVO) are connected, controlled and incorporated with

resources to facilitate development, deployment and operation of IoT services on the World Wide Web.

Figure 6-1 illustrates the relationship among WoO entities. VOs are used to deliver the related information, situation and condition of real world objects and are described by a rule (e.g., resource description framework (RDF) and ontology). Multiple VOs are combined into a composite virtual object (CVO) to abstract a service feature, operation or management function. A CVO includes information such as time, location, profile, features and performance of a group of VOs for future service capability. A resource is related to a VO and a CVO and is used by a service at any particular instance in time.

The WoO enables multiple types of VOs and CVOs to share and cooperate with resources on the World Wide Web. WoO facilitates collaboration and harmonization among distributed VOs and CVOs to support user-centered and context-aware features.

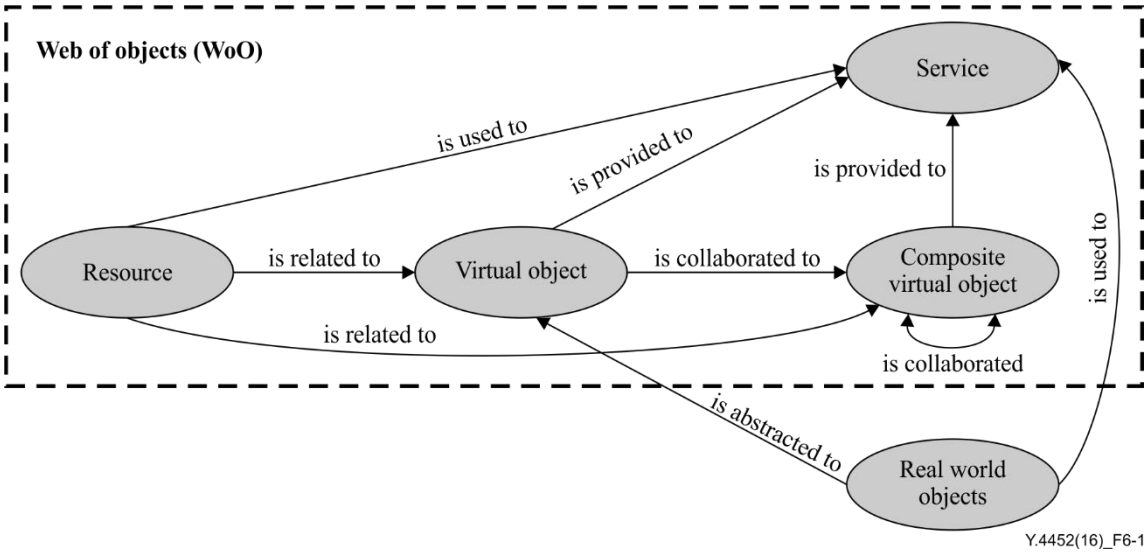

Figure 6-1 – Relationship among WoO entities

7 WoO reference model and functional capabilities

Figure 7-1 shows the WoO reference model. It is composed of two levels called the WoO virtual level and the WoO service level. The WoO virtual level is divided into two sub-levels called the VO sub-level level and the CVO sub-level. Three types of databases (the registry database, the template repository and the information database) for 3 levels (service level, CVO sub-level and VO sub-level) are created, designed and monitored in the WoO reference model.

IoT applications in Figure 7-1 will be supported on the World Wide Web with the capabilities specified in [ITU-T Y.4552]. These application support models are the configurable application support model, the adaptable application support model and the reliable application support model.

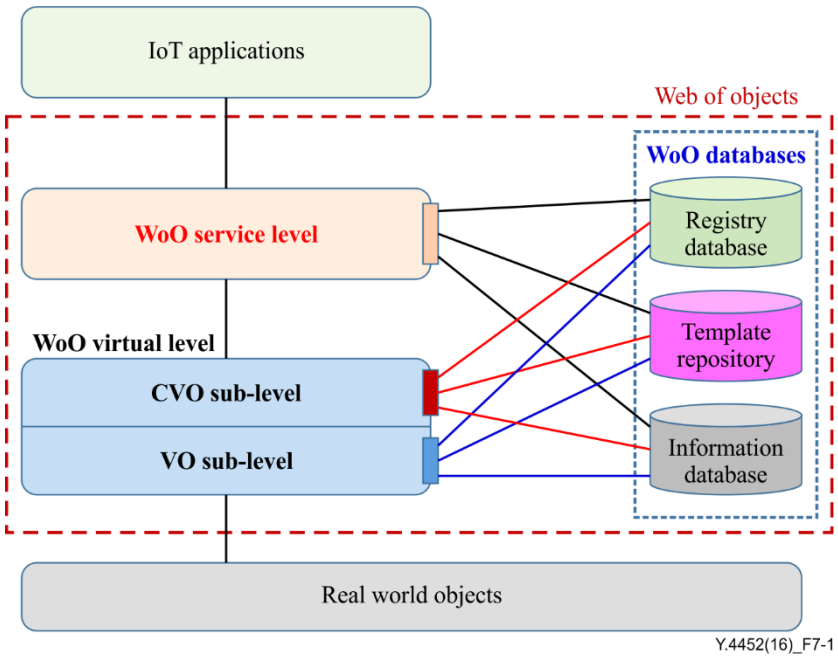

Figure 7-1 – WoO reference model

7.1 WoO virtual level

In the WoO virtual level of the WoO reference model, the functional capabilities of the VO sub-level and the CVO sub-level are described respectively in clause 7.1.1 and clause 7.1.2.

7.1.1 VO sub-level

The VO sub-level provides the functional capabilities responsible for the control and management of VOs. Figure 7-2 depicts the functional capabilities of VO sub-level based on the WoO reference model shown at Figure 7-1.

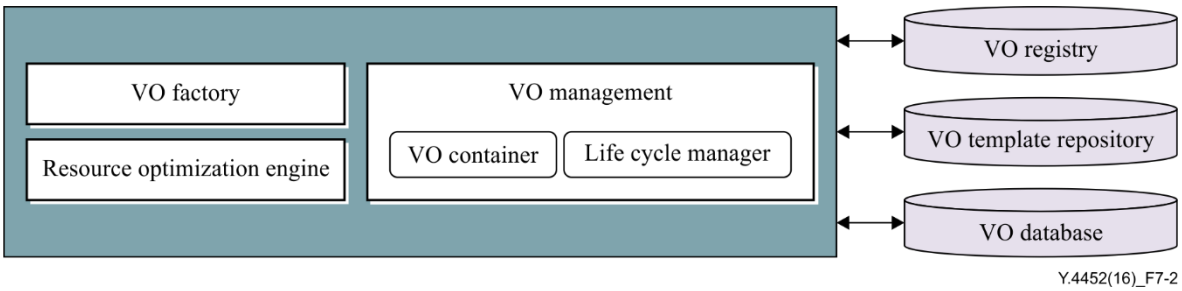

Figure 7-2 – Functional capabilities of VO sub-level

The functional capabilities of VO sub-level are as follows:

– VO factory: is concerned with the production of new running VO instances;

– Resource optimization engine: manages system knowledge for optimal resource utilization;

– VO management: includes the capabilities to manage the VO container and the life cycle manager:

  • VO container: provides a runtime execution platform. The VOs are monitored, controlled and managed by a life cycle manager:

  • Life cycle manager: VO goes through a number of different states during its life cycle such as creation, execution, suspension, and termination. The life cycle manager manages the life cycle of a VO.

– VO registry: is a registry database that stores RDF triples for the description of available VOs;
– VO template repository: contains a semantically query-able collection of VO templates;
– VO database: provides data storage and access capabilities.

7.1.2 CVO sub-level

The CVO sub-level is responsible for control and management of CVOs. Figure 7-3 depicts the functional capabilities of the CVO sub-level based on the WoO reference model shown in Figure 7-1.

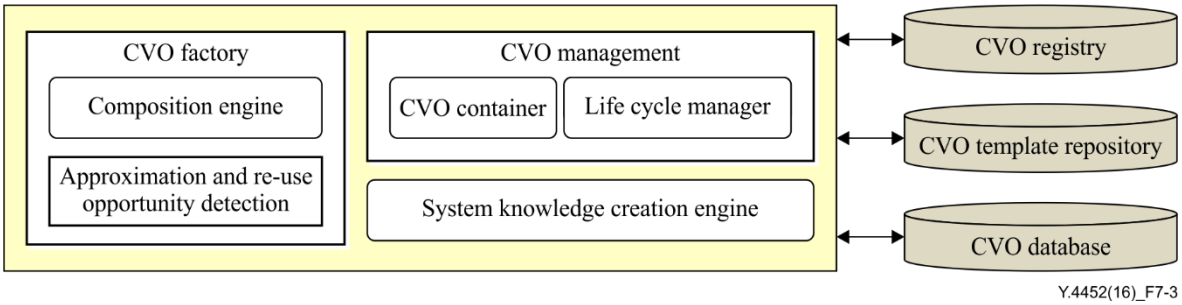

Figure 7-3 – Functional capabilities of CVO sub-level

The capabilities of each of the functional entities in the CVO sub-level are as follows:

– CVO factory: provides capabilities concerned with the production of new running CVO instances;
  • Composition engine: includes mechanisms to create complex and composite services to fulfil the user request;
  • Approximation and re-use opportunity detection.
– CVO management: supports the management functions of the CVO container and life cycle manager;
  • CVO container: provides a runtime execution platform. The CVOs are monitored, controlled and managed by a life cycle manager;
  • Life cycle manager: a CVO goes through a number of different states during its life cycle such as creation, execution, suspension and termination. The life cycle manager manages the life cycle of a CVO.
– System knowledge creation engine: provides a capability to manage a system knowledge which is then stored in the system knowledge database;
– CVO registry: is a registry database that stores RDF triples for the description of available CVOs. It allows the creation of a semantically enriched description of CVOs, the interaction with stored data and communication with other entities of the WoO;
– CVO template repository: provides a repository capability with a semantically query-able collection of CVO templates;
– CVO database: provides data storage and access capabilities in the CVO sub-level.

7.2 WoO service level

WoO service level supports functions to create and manage IoT service entities in [ITU-T Y.4000]. Figure 7-4 depicts the functional capabilities of the service level:

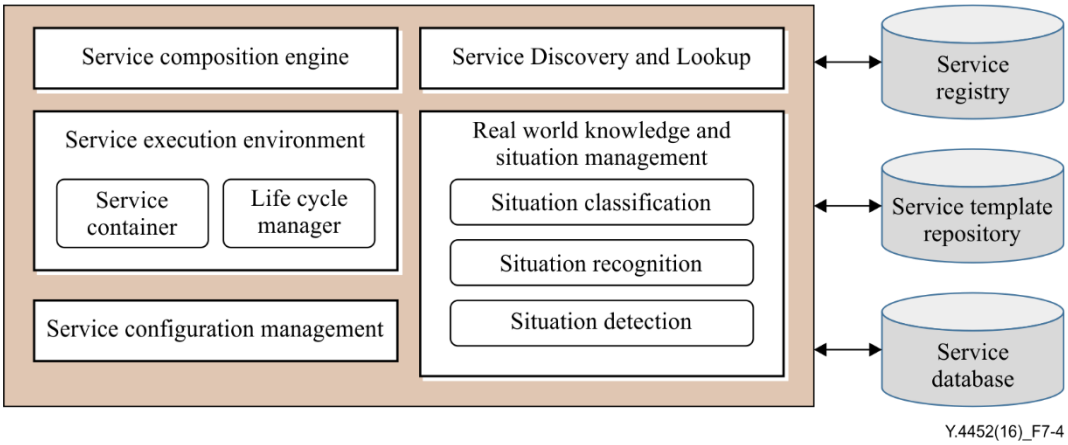

Figure 7-4 – Functional capabilities of the service level

– Service composition engine: includes mechanisms to create complex and composite services to fulfil the user request;

– Service execution environment: includes the service container and the life cycle manager;

  • Service container: provides a service execution platform. The services are monitored, controlled and managed by a life cycle manager;

  • Life cycle manager: a service goes through a number of different states during its life cycle such as service creation, execution, suspension and termination. The life cycle manager manages the life cycle of a service.

– Service configuration management: manages the configuration of the service user and devices through detecting system and service data and recovering the faults;

– Service discovery and lookup: analyses service requests based on user information and supports discovery of services based on history, semantic matchmaking and service constraints;

– Real world knowledge and situation management: manages a database which includes knowledge and situation data related to real world objects;

– Service registry: is a database that stores RDF triples for the description of available services. It allows the creation of a semantically enriched description of services, the interaction with stored data and communication with other entities of the WoO;

– Service template repository: contains a semantically query-able collection of services and service templates;

– Service database: stores user profiles, user's access rights and real world knowledge.

8 Information models of WoO

The WoO needs a foundation to understand the interrelationships between resources and attributes, IoT service entities and interfaces at virtual and service level in the World Wide Web. This clause addresses basic information models to denote attribute types, events, time, location, actions, tasks and associated behaviours.

8.1 VO information model

The VO information model in Figure 8-1 includes information that characterizes a VO.

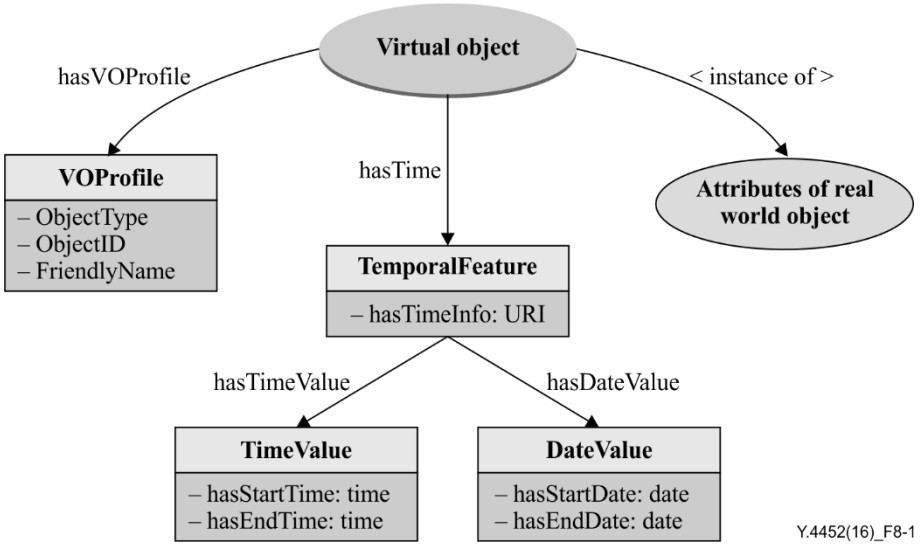

Figure 8-1 – VO information model

– VOProfile: consists of details that identify VOs;

– TemporalFeature: has sub-portions that indicate time- and data-related information;

– attributes of real world objects: includes information on real world objects.

8.2 CVO information model

The CVO information model in Figure 8-2 includes basic information that characterizes a CVO.

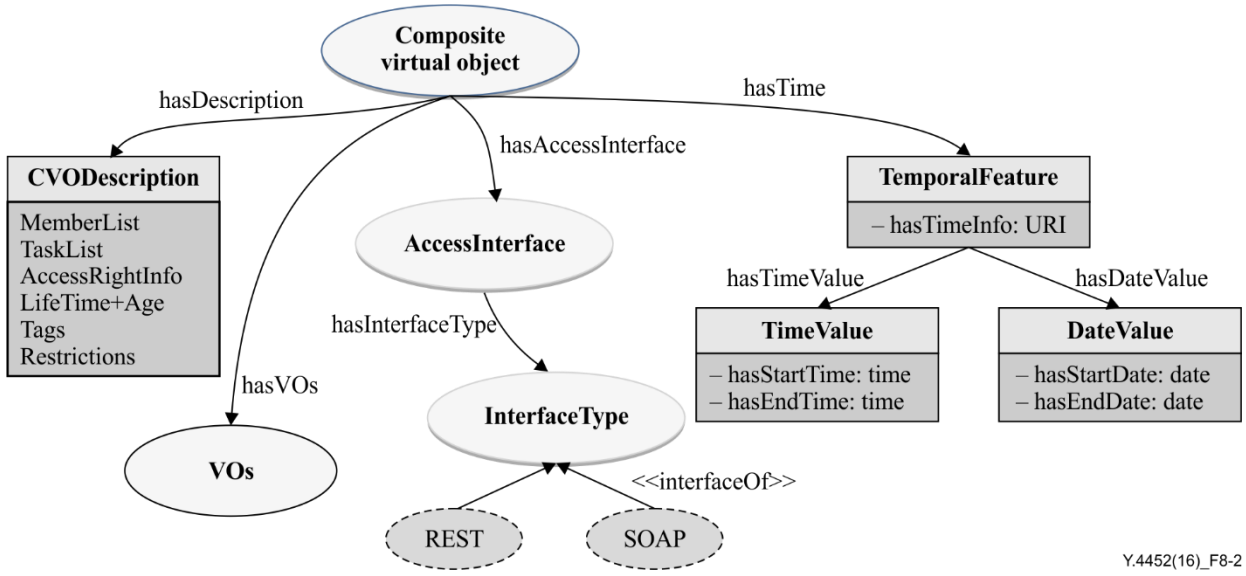

Figure 8-2 – CVO information model

– CVODescription: indicates details of functional aspects of CVOs and the details of the template base structure are described in Figure 8-2;

– AccessInterface: denotes the interface types between a CVO and the WoO service level and between remote CVOs;

– TemporalFeature: has sub-portions that indicate time- and data-related information of CVOs.

8.3 Service information model

The service information model in Figure 8-3 includes information elements that characterize a service at service level.

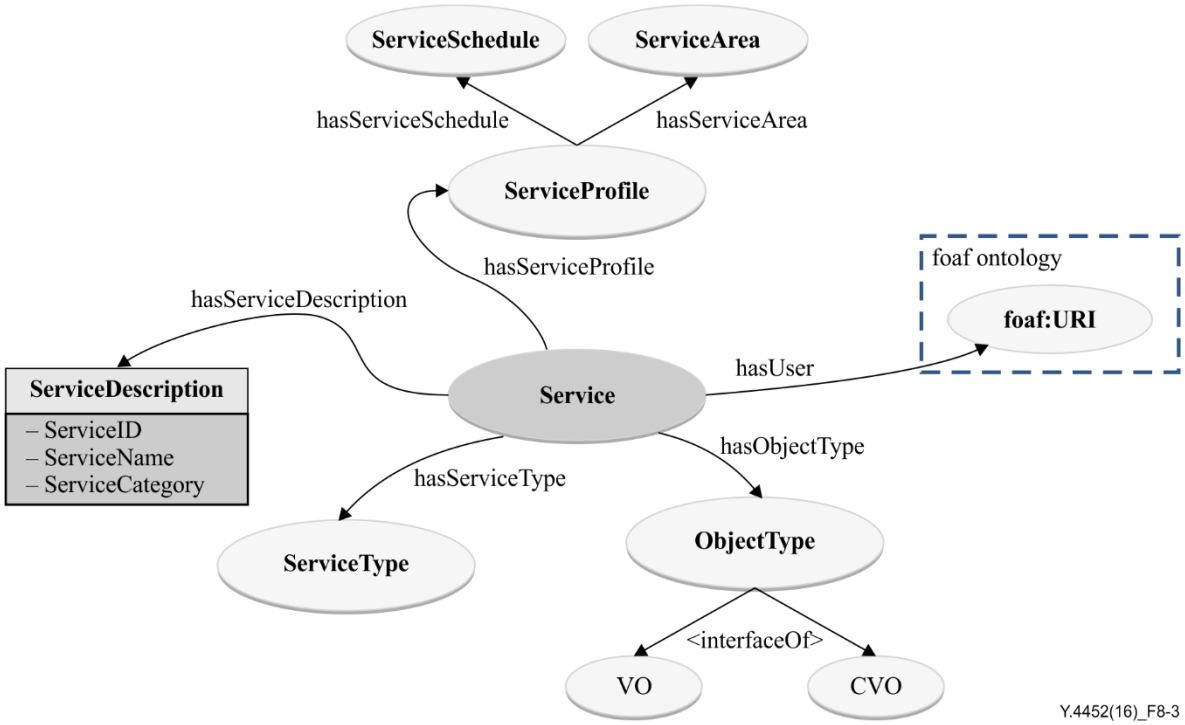

Figure 8-3 – Service information model

– ServiceDescription: includes information to identify the service name, ID and service category;

– ServiceType: the service modeling language type technique;

– ServiceProfile: the profile of a service includes a range of service, a schedule, an input and output, a precondition, an effect, other related information and the connection of each device to the ValueContainer in the real world environment;

– ObjectType: refers to an instance indicating various combinations of VOs and CVOs;

– Friend of a friend (foaf) ontology: external ontology defining the user of the service.

Bibliography

[b-ITU-T Y.4404] Recommendation ITU-T Y.4404/Y.2062 (2012), *Framework of object-to-object communication for ubiquitous networking in next generation networks*.

[b-IETF RFC 3986] IETF RFC 3986 (2005), *IETF Uniform Resource Identifiers (URI): Generic Syntax.* <http://datatracker.ietf.org/doc/rfc3986/?include_text=1>

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