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

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

Architecture of web of objects-based virtual home network

Recommendation ITU-T Y.4415

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Recommendation ITU-T Y.4415

Architecture of web of objects-based virtual home network

Summary

Recommendation ITU-T Y.4415 describes an architecture of web of objects (WoO)-based virtual home network (VHN) in accordance with Recommendations ITU-T H.622.2 and ITU-T Y.4452. The service capabilities and framework of VHN are identified in Recommendation ITU-T H.622.2. Recommendation ITU-T Y.4452 identifies the functional framework of WoO to deploy Internet of things (IoT) services in the World Wide Web environment.

History

Edition	Recommendation	Approval	Study Group	Unique ID[*]
1.0	ITU-T Y.4415	2018-06-29	20	11.1002/1000/13637

Keywords

Virtual home network, web of objects.

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[*] 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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1 Scope

This Recommendation describes an architecture of web of object (WoO)-based virtual home network (WVHN) by identifying the followings:

– overview of WVHN;

– WVHN objects processing functions;

– WVHN service functions;

– security and trust support of WVHN.

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 H.622.2]   Recommendation ITU-T H.622.2 (2015), *Service capabilities and framework for virtual home networks*.

[ITU-T Y.4452]   Recommendation ITU-T Y.4452 (2016), *Functional framework of web of objects*.

[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 composite virtual object (CVO) [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 Internet of things (IoT) [b-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 broad perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.3 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.

3.1.4 **virtual home network (VHN)** [ITU-T H.622.2]: A VHN is a logical home network, built over public and/or private network resources, used to support home network services within a group of home members.

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

3.1.6 **web of objects (WoO)** [ITU-T Y.4452]: A way to incorporate virtual objects on the World Wide Web and to facilitate the creation of IoT services.

3.2 **Terms defined in this Recommendation**

None.

4 **Abbreviations and acronyms**

This Recommendation uses the following abbreviations and acronyms:

|	
CVO	Composite Virtual Object
DB	Database
IoT	Internet of Things
RDF	Resource Description Framework
VHN	Virtual Home Network
VHN-RG	Virtual Home Network – Residential Gateway
VO	Virtual Object
WoO	Web of Objects
WVHN	WoO-based virtual home network

5 **Conventions**

None.

6 **Overview of WVHN**

The virtual home network (VHN), as defined in [ITU-T H.622.2], supports ubiquitous networking environments to allow the service coverage of a home network to expand diverse service features into a virtual group of home network users and resources. The web of objects (WoO) defined in [ITU-T Y.4452] provides a functional framework of Internet of things (IoT) in the World Wide Web environments. The WoO-based VHN (WVHN) is characterized by a collaboration of the capabilities and framework in VHN and WoO as shown in the configuration of Figure 6-1.
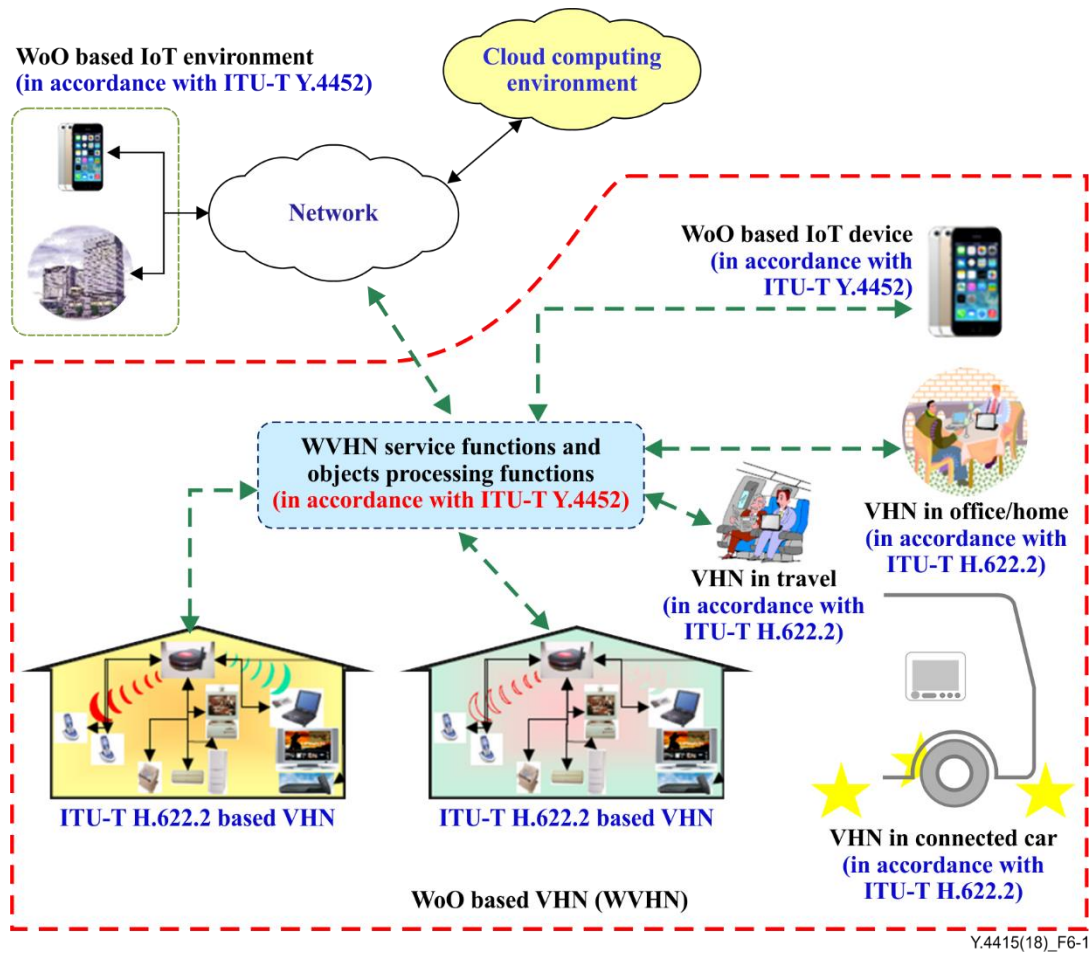
Figure 6-1 – Configuration of the WVHN

The WVHN provides VHN service functions of [ITU-T H.622.2] in alignment with the WoO framework identified in [ITU-T Y.4452]. WVHN allows users and administrators to control, orchestrate and create applications using WVHN objects processing functions and WVHN service functions indicated in Figure 6-2.

The detailed descriptions on WVHN objects processing and service functions in Figure 6-2 are provided in clause 7 and clause 8, respectively.
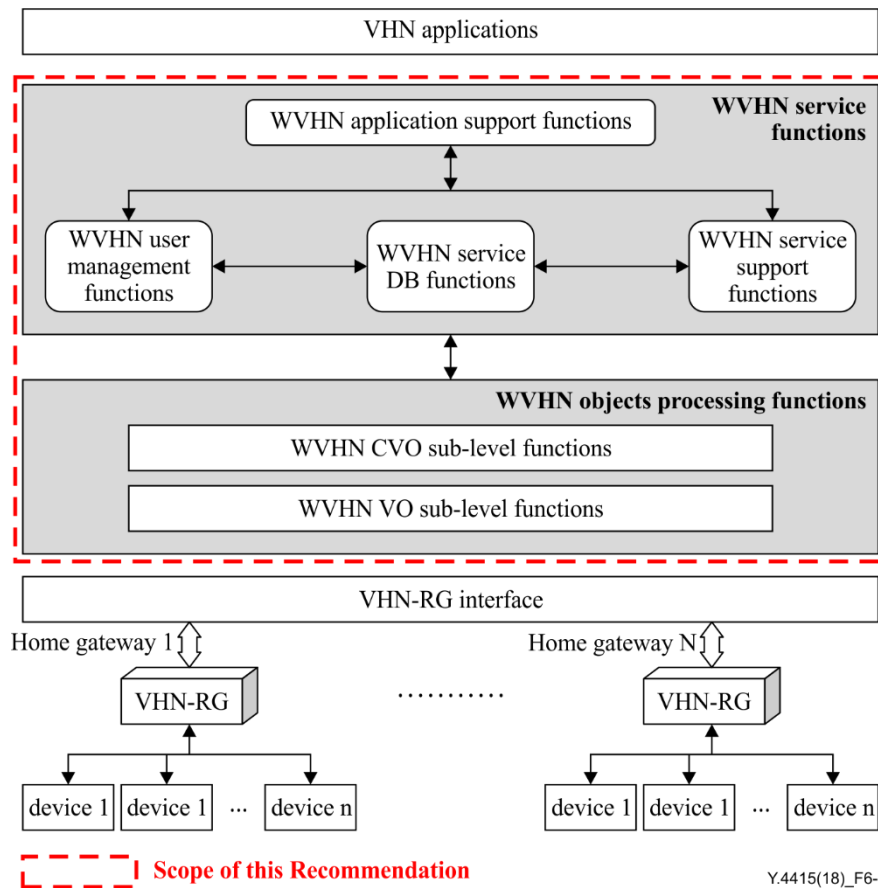
Figure 6-2 – Architecture model of the WVHN

## 7 WVHN objects processing functions

WVHN objects processing functions are responsible for creation, control and management of virtualized objects of WVHN, e.g., production, registration, lifecycle management, storing and management of virtual objects (VOs) and composite virtual objects (CVOs) in [ITU-T Y.4452]. These functions enable multiple types of WVHN VOs and WVHN CVOs to share and cooperate with them on the Web of VHN.

WVHN objects processing functions are further categorized into two sub-levels: WVHN VOs sub-level functions and WVHN CVOs sub-level functions based on [ITU-T Y.4452].

7.1 WVHN VOs sub-level functions

WVHN VOs sub-level functions are mainly responsible for creation and management of WVHN VOs and real-world objects as depicted in Figure 6-1. The major functions of VOs sub-level in WVHN are as follows.

–   WVHN VOs creation;

–   WVHN VOs management;

–   WVHN VOs registry;

–   WVHN VOs repository.
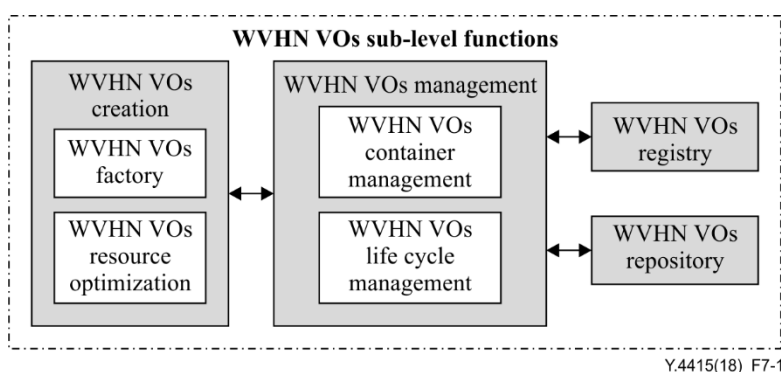
Figure 7-1 – WVHN VOs sub-level functions

7.1.1 WVHN VOs creation

WVHN VOs are created with semantically enriched descriptions and the interaction with stored data. The following functions are provided by WVHN VOs creation:

– WVHN VOs factory: production of new VO instances;

– WVHN VOs resource optimization: provides VOs resource optimization based on system knowledge necessary for VOs creation.

7.1.2 WVHN VOs management

WVHN VOs management provides the functions to manage the execution environment of WVHN VOs container management and WVHN VOs lifecycle management.

– WVHN VOs container management: provides a runtime execution environment to monitor and control WVHN VOs;

– WVHN VOs lifecycle management: supervises different states during its lifecycle, i.e., creation, execution, suspension and termination of WVHN VOs.

7.1.3 WVHN VOs registry

WVHN VOs Registry stores resource description framework (RDF) triples for the description of available WVHN VOs, which are structured using the metadata that is included in WVHN VOs information model in [ITU-T Y.4452].

The information used in WVHN VOs registry is as follows:

– a name and a list of functionalities of WVHN VOs;

– access policies for WVHN VOs;

– semantic ontology of WVHN VOs.

7.1.4 WVHN VOs repository

WVHN VOs repository provides semantically queryable collection of WVHN VOs templates and data. WVHN VOs templates are designed in accordance with VOs information model in [ITU-T Y.4452]. WVHN VOs instances are mapped with the WVHN VOs template in ontological dataset for later usage.

7.2 WVHN CVOs sub-level functions

WVHN CVOs sub-level functions are organized to support the control and management of WVHN CVOs in accordance with [ITU-T Y.4452] as indicated in Figure 7-2. The functions of WVHN CVOs sub-level are as follows.

– WVHN CVOs creation;

– WVHN CVOs management;

– WVHN system knowledge management;
– WVHN CVOs registry;
– WVHN CVOs repository.
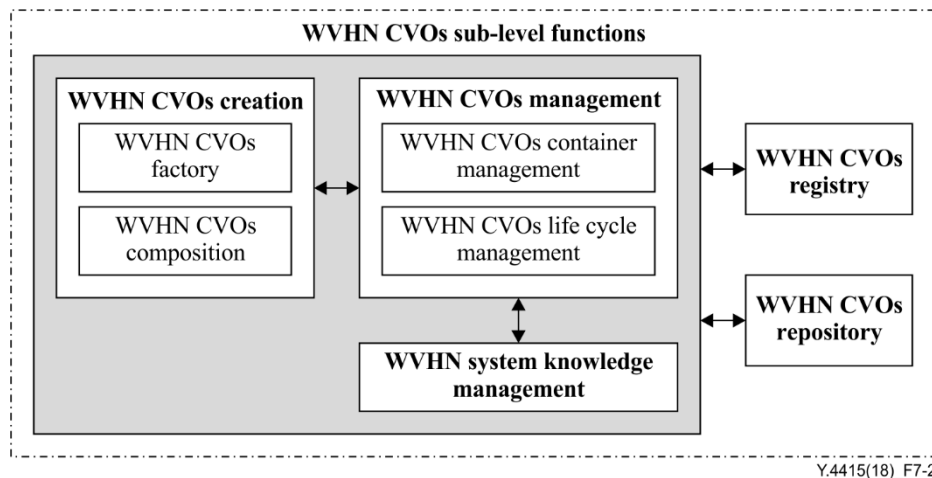
Figure 7-2 – WVHN CVOs sub-level functions

7.2.1   WVHN CVOs creation

WVHN CVOs creation is responsible for the creation of new WVHN CVOs with the mashup of appropriate WVHN VOs to fulfil the service request. To create WVHN CVOs, the requested WVHN CVOs templates are exposed by WVHN CVOs registry. WVHN CVOs templates are stored in WVHN CVOs repository, and are queried semantically based on the service request parameters.

– WVHN CVOs factory: provides the function to create WVHN CVOs templates with respect to multiple WVHN VOs;
– WVHN CVOs composition: provides a mechanism to form a mashup of multiple WVHN VOs in accordance with [ITU-T Y.4452].

7.2.2   WVHN CVOs management

WVHN CVOs management handles the lifecycle of WVHN CVOs and manages the software execution related with WVHN CVOs. It provides the function to store and update metadata of the instantiated WVHN CVOs.

– WVHN CVOs container management: provides the management functions to bundle necessary software which are used during the execution of WVHN CVOs;
– WVHN CVOs lifecycle management: supervises different states during WVHN CVOs lifecycle, i.e., creation, execution, suspension and termination of WVHN CVOs.

7.2.3   WVHN system knowledge management

WVHN system knowledge management performs functions related with knowledge of WVHN CVOs during WVHN CVOs execution. It provides intelligent mechanisms to enhance the reusability of WVHN CVOs.

7.2.4   WVHN CVOs registry

WVHN CVOs registry stores WVHN CVOs instances that are identified in the WVHN CVO registration process. WVHN CVOs instances are identified by the following WVHN CVOs information in terms of CVOs information model in [ITU-T Y.4452].

– request parameters;
– references of the associated WVHN VOs in WVHN CVOs;

– access mechanism to the registered WVHN CVOs;

– context parameters;

– related WVHN VOs;

– creation date of the WVHN CVOs instance.

7.2.5 WVHN CVOs repository

WVHN CVOs repository provides the function to store and manage WVHN CVOs templates and data. WVHN CVOs available for execution are published in WVHN CVOs repository.

8 WVHN service functions

WVHN services are created in accordance with customers' favourite application features on the Web environment. The components in WVHN service functions are in alignment with [ITU-T H.622.2] as shown in Figure 6-2.
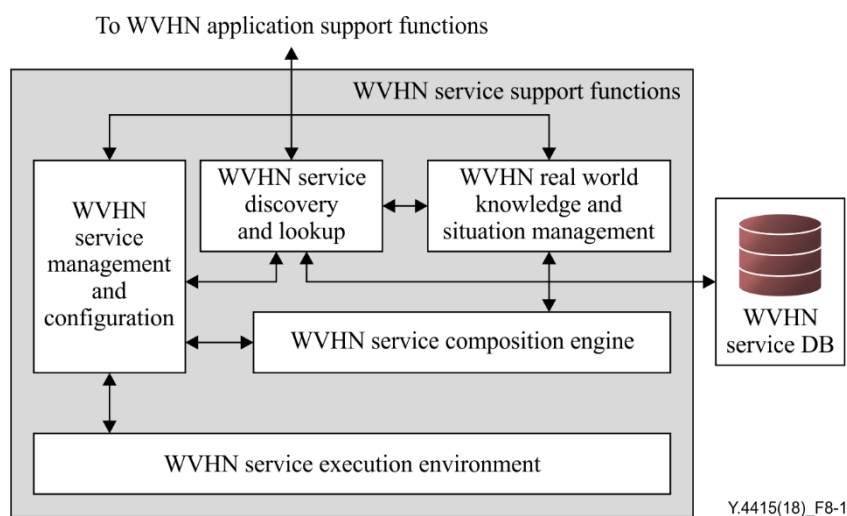
– WVHN service support functions;

– WVHN user management functions;

– WVHN application support functions;

– WVHN service database (DB) functions.

8.1 WVHN service support functions

WVHN service support functions register and manage WVHN service entities. These functions also create and manage multiple types of services defined in WVHN service DB.

WVHN service support functions to support the development of WVHN services are illustrated in Figure 8-1 and described as follows:

– WVHN service discovery and lookup;

– WVHN service management and configuration;

– WVHN service composition engine;

– WVHN real-world knowledge and situation management;

– WVHN service execution environment.

Figure 8-1 – WVHN service support functions

8.1.1   WVHN service discovery and lookup

WVHN service discovery and lookup function analyses the VHN service request based on WVHN user information and supports the discovery of services using query functions. It also maintains the cache logs to efficiently handle similar requests. It queries the services DB to access the requested services using service history, semantic matchmaking and service constraints in the discovery process.

8.1.2   WVHN service management and configuration

In order to support WVHN services, WVHN service management and configuration function performs WVHN service request evaluation, WVHN service configuration, WVHN service registration, template management and controlling service execution.

To achieve this function, necessary tasks are described as follows.

–   WVHN service request evaluation: includes mechanisms to parse and evaluate the service request so that most suitable services can be selected;

–   WVHN service control: involves in matching a service request to service instances and handles service management;

–   WVHN configuration management: includes functions to configure the service components based on service requirements, and matches service requests to the corresponding service templates;

–   WVHN service template management: includes mechanisms to create, manage and update the service templates;

–   WVHN service registration: handles service registry and provides an interface to external stack holders to add and modify service templates.

8.1.3   WVHN service composition engine

WVHN service composition engine is responsible for the creation of complex and composite services to fulfil the WVHN user request. It includes the mechanisms to facilitate the creation of WVHN composite services to satisfy user requests.

The four tasks to achieve a composition of WVHN services requested from WVHN application support functions are described as follows.

1)   WVHN service selection: chooses the appropriate services based on the service requirement and provides the selected services to the workflow management;

2)   WVHN service workflow management: supports the composition flow among various services based on their inputs and outputs;

3)   WVHN service binding: enables to associate with services to a composition graph;

4)   WVHN service coordination: identifies the dependency of services in accordance with a composition graph in order to avoid any conflict.

8.1.4   WVHN real-world knowledge and situation management

WVHN real-world knowledge and situation management provides the mechanisms to manage the situational information, to represent the current, past situations and WVHN user data. It is responsible for real-world knowledge creation. It also provides situation detection, classification and recognition of WVHN service environments.

WVHN situation management performs extraction of event streams to identify the relations among the features of interest through reasoning and learning mechanisms, and to classify the desired situations.

The principal tasks to support this function are as follows:

– WVHN user situation management: helps more efficient service selection in case of a user request with a similar service requirement using his situation information;

– WVHN user characterization and profile management: handles several facts related to the human user which includes user profile, preference, context and policies;

– Real-world knowledge library: provides methods to predict facts about the user based on his situation history and previous service requests;

– WVHN user interest crawler: helps to identify user interest with respect to a service context.

### 8.1.5   WVHN service execution environment

WVHN service goes through a number of different states during its lifecycle, i.e., service creation, execution, suspension and termination. WVHN service execution environment is responsible for service lifecycle management and execution. It constitutes of the following tasks for WVHN service execution.

– WVHN service lifecycle management: handles service switching among different states from active to release state;

– WVHN service cache: stores service references to the instances of recently used services;

– WVHN service container: manages the service instances in the WVHN service execution environment.

8.2   WVHN user management functions

WVHN user management functions support the management for WVHN application users and provide the capabilities to perform the following functions. Figure 8-2 shows a functional architecture of WVHN user management functions.

– WVHN user access: allows users to access the system by authentication and authorization, in addition, it defines the service capabilities in terms of the level of the user and service template access rights through following two functions:

• WVHN user authentication: provides a user an acknowledgment signal to grant permission to the DB. The authentication mechanisms can be selected based on the state-of-the-art authentication requirements;

• WVHN user authorization: permits a WVHN service user (including service entities) to resources on WVHN with predefined policy definitions.

– WVHN user identity management:

• Registration: registers the user for access to the application, but not to access services;

• Membership management: supports the creation, maintenance and release of WVHN service users, joining and leaving WVHN service users, and management of WVHN multicast service group membership;

• User service group management: provides the management functions on user service groups for WVHN;

• User profile management: provides the user profile information in alignment with user profile DB.
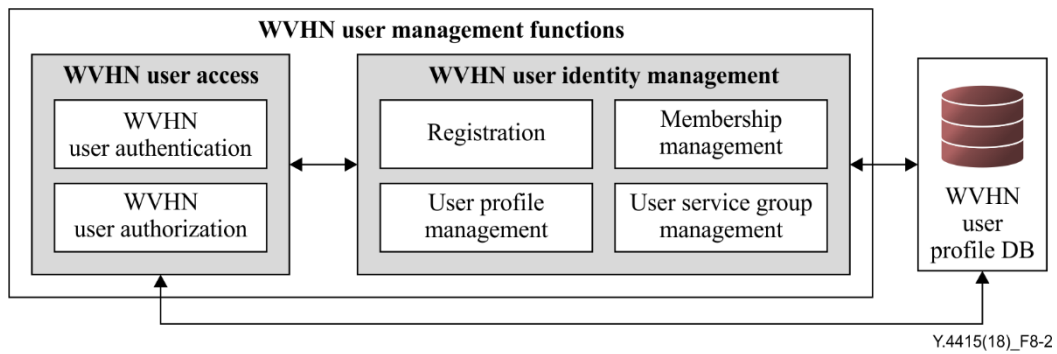
Figure 8-2 – WVHN user management functions

8.3 WVHN application support functions

WVHN application support functions facilitate enhanced service utilization in alignment with WVHN application scenarios. These functions enable consistent WVHN service functions to span multiple home environments and multiple IoT devices. The features provided by WVHN application support functions are as follows.

– user preference and feedback to update the configuration of WVHN service functions;

– service capabilities to promote intelligent WVHN application environment;

– consistent WVHN service provisioning to external entities and environment;

– dynamic adaptation of WVHN services in the changing computing environment;

– dynamic adaptation of WVHN user environment.

8.4 WVHN service DB functions

The WVHN service DB is an RDF graph DB 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 rest of the units. Registration of the WVHN service is supported with the SPARQL endpoint to help the WVHN service management function access the service registry using SPARQL queries.

WVHN service DB functions provide the following service repositories indicated in Figure 8-3:

– WVHN service templates;

– WVHN service registry;

– WVHN user profile;

– WVHN real-world knowledge.

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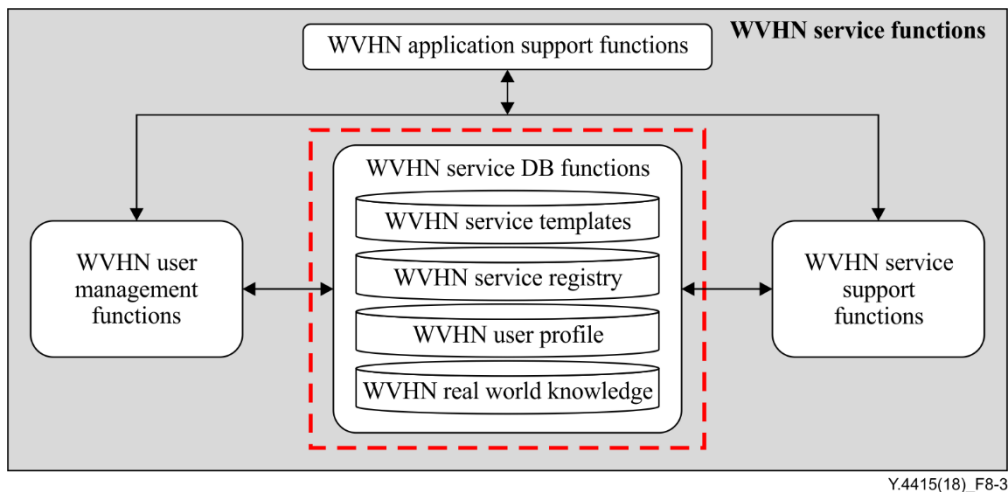
Figure 8-3 – WVHN service database functions

9 Security and trust support in WVHN

9.1 Security support in WVHN

The security in WVHN is considered in accordance with WVHN objects processing functions (WVHN VO sub-level, WVHN CVO sub-level) and service functions depicted in Figure 6-2. WVHN needs the following considerations to support security and privacy in WVHN service and object processing functions.

–   WVHN object processing functions in WVHN VOs and CVOs to support security and privacy;

–   WVHN service functions to support secure and privacy protected service provision;

–   WVHN service functions to integrate different security policies and techniques related to the variety of WVHN service features;

–   WVHN objects processing and service functions to support mutual authentication and authorization.

9.2 Trust support in WVHN

WVHN provides functions to share the home related application contents among home members in distributed environments. A trust provisioning in WVHN environment needs to guarantee the trustworthy sharing of contents generated by home members and devices.

Trusted contents collection and aggregation of WVHN VOs and CVOs are necessary to support trustworthy relationship among WVHN members and objects (WVHN VOs and CVOs).

Bibliography

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

[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*.

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