

# Design and Implementation of Interworking between oneM2M and External Systems

Tao Li\*

School of Computer Science and Technology, Chongqing University of Posts and Telecommunications, Chongqing, Chongqing 400065, China

\*18502298201@163.com

**Abstract.** As an important application mode of the Internet of things, M2M technology has been paid more and more attention by industries. In this system, various intelligent services play a crucial role. However, M2M shows a trend to decentralized development, which is challenging for traditional single channel communication. Fortunately, oneM2M as the largest international Internet of things standard organization tries to establish a set of universal IoT interoperability method, hoping to solve the problem of M2M interoperability. Therefore, this paper proposes a novel and effective model to solve the interoperability in IoT with high accuracy. The basic idea is to combine with semantic technology on the oneM2M standard platform to achieve machine equipment interworking.

**Keywords:** M2M, Internet of Things, Interoperability, OneM2M, Semantic.

## 1. Introduction

Machine to machine (commonly abbreviated as M2M) refers to direct communication between devices using any communications channel. It is machine terminal intelligent interaction as the core of the application and service [1]. With the development of M2M technology, the types of M2M devices are becoming more and more abundant. According to the prediction of Machina Research [2], the number of global M2M connections will reach 27 billion by 2025, and these devices would be widely used in any parts of life. Nevertheless, the current development of M2M industry still faces a closely coupled development trend of island style and the lack of interaction of platforms [3]. The data collected by the underlying sensor network in each system is limited to its own independent application system. Different systems have different framework and data patterns, and they cannot share and reuse resources between systems, thus forming an information island [4]. In order to achieve the effective integration different services of enterprises and the reduction of repeated work, some industries raise the IoT application infrastructure based on the service-oriented architecture (SOA), and deploy IoT applications separately. However, the interface between applications is different and the communication is not unified, which causes the problem of poor scalability and high complexity of the whole platform. The international Internet of things standard organization oneM2M recently releases the latest IoT standard, which modularized the integration of each type of IoT service, and then classified them to the same type of oneM2M node, and reduced the complexity of M2M intercommunication through the unified provision of the intercommunication method between internal nodes, however, for non-onem2m devices, additional interface nodes need to be developed to support the intercommunication.

Based on the oneM2M platform, this research is conducted to simplify the currently interface nodes, mainly using semantic technology on the aspect of oneM2M and external nodes communication, simultaneously, it highlights the advantages of oneM2M scheme via the case of the oneM2M and smart home communication.

## 2. Related Work

This chapter briefly introduces the framework of the oneM2M platform, its universal usage in experiments, as well as the limitations of the interoperability between oneM2M and external systems via the intercommunication between oneM2M and external systems, furthermore establish the principle to simulate the interaction between oneM2M and external systems based on semantic ontology technology.

## 2.1 oneM2M Service Layer Platform Framework

Under the wide research of M2M technology and the penetration of the market promotion, the heterogeneity problem in IoT platform gradually emerges. In order to solve this problem, a number of organizations focus on IoT standards, which attempts to establish a unified platform and standard for the IoT. As initiators, ICT industrial standards organizations from seven countries including ARIB (Japan), ATIS (United States), CCSA (China), ETSI (Europe), TTA (United States), TTC (Japan) and tdsI (India), sign the partnership agreement to establish the "oneM2M" in the field of IoT [5]. OneM2M focuses on a unified standard establishment of the IoT service. The standard is to change the conventional scattered industrials model into a generic platform development model via integrating and deploying the same level's services provided by all kinds of industrials, further avoid the circumstance of one service to one platform, which greatly alleviates the platform-scattered and repetitive investment' situation.

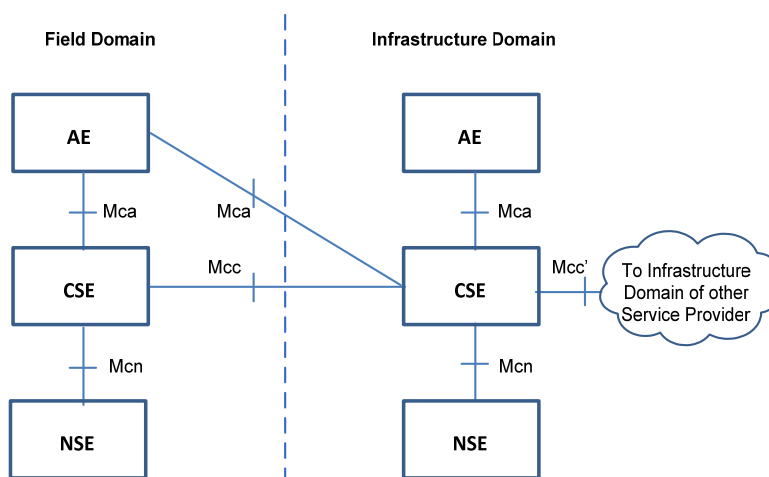


Figure 1. OneM2M Function Framework.

Fig.1 is the function diagram that can be achieved based on the general oneM2M standard. It can be seen that oneM2M is a hierarchical model that could support node-to-node M2M services between application layers. OneM2M abstracts the logic of each layer into entities, combines them with physical devices, and obtain three types of entities: application entity, public service entity, and underlying network service entity. The following is the function of each entity:

(1) Application Entity (AE): OneM2M mapped the application logic in the Internet of things system through AE entity, such as road monitoring application.

(2) Common Service Entity (CSE): Contains a complete set of independent instantiations of the "public service functions" defined by oneM2M. These functions are open to AE through the Mca interface, or to CSE in or outside the domain through the Mcc or Mcc' interface, and NSE can also provide services to CSE through the MCN interface.

(3) Underlying Network Services Entity (NSE): Provide network transmission service for oneM2M.

The interaction mode between each entity is defined as the reference point by oneM2M. The reference points between different nodes are different, and the reference point is composed of any interface. The meaning of the reference point is as follows:

(1) Mca Reference Point: Communication flows between an Application Entity (AE) and a Common Services Entity (CSE) cross the Mca reference point. AE and CSE may or may not be in the same physical entity. AE and CSE may or may not be in the same physical entity.

(2) Mcc Reference Point: Communication flows between two Common Services Entities (CSEs) cross the Mcc reference point. CSE can use this node to leverage other CSE-enabled service capabilities.

(3) Mcn Reference Point: Communication flows between a Common Services Entity (CSE) and the Network Services Entity (NSE) cross the Mcn reference point. The NSE provides the CSE basic

support services (including network communication and information interaction, etc.) through this node.

(4) Mcc' Reference Point: Communication flows between two Common Services Entities (CSEs) in Infrastructure Nodes (IN) that are oneM2M compliant and that resides in different M2M SP domains.

## 2.2 OneM2M Interoperability with External Systems

The interoperability of devices in heterogeneous platforms in the IoT is always as a concern in the industry [6]. To install generic drivers for networked devices can solve the intercommunication problem between different devices, but the existence of drivers severely limits the inherent flexibility of devices [7]. In addition, a great number of network-connected devices might complicate the drivers. Drivers cannot solve the interoperability problem for the cross-platform device interoperability, while one of the ways to solve this problem is to develop a middleware system, which not only need the support of all the request and response of all systems connected, but it also need to match the differences between the data format of the heterogeneous system, under which the middleware system development would face more challenges.

Above-mentioned oneM2M system has the service-distributed characteristics when communicate with an external platform, a service, or a device through the Interworking Proxy Entity (IPE) node. As shown in Fig.2, the partial intelligence household with one node in oneM2M communication diagram, all the external nodes in communication with internal CSE oneM2M node need map to the oneM2M resource type from IPE, thus it is a kind of CSE nodes. Therefore, when external nodes communicate with the IPE, it should also pass a special interface port to change the received requests into the CSE recognizable types. Whenever the external system communicates with the oneM2M, it need at least one interface node, the interface port is developed based on the actual needs of the software, and each interface port is special, which would result in a lot of work and software maintenance.

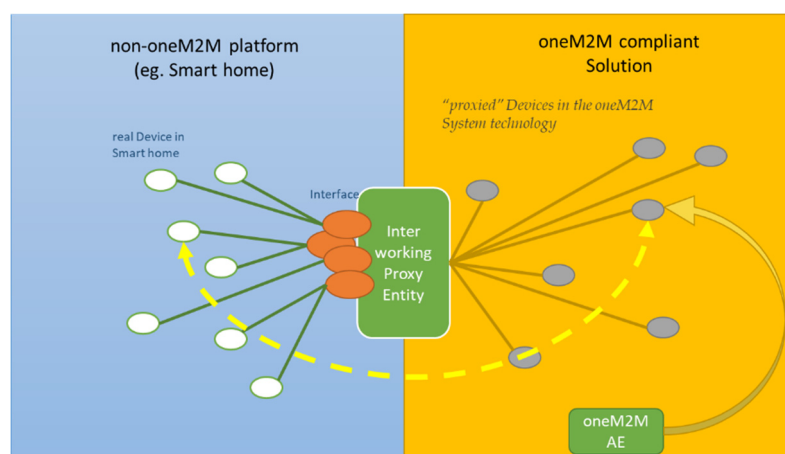


Figure 2. OneM2M and non-onem2m interworking scheme

## 3. Heterogeneous Devices Implement Semantic Annotation

The interoperability of oneM2M and cross-platform IoT devices mentioned in this essay is the improvement of the original scheme of oneM2M and external systems, further optimizing the machine-to-machine interoperability mode combining cross-platform semantic web conducted by Amelie Gyrard et al [8].

### 3.1 Acquisition of M2M Device Data

OneM2M supports data access of multi-version protocols, including the most popular ZigBee, 3GPP and CoAP. Scientists such as S Husain make M2M applications running on top of oneM2M use the respective underlying network services provided by 3GPP through the communication

between oneM2M and 3GPP [9]. However, this method is only applicable to the intercommunication between oneM2M and devices in the communication network layer, and cannot support the intercommunication between oneM2M and physical devices served by the transport layer. In the field of M2M, transport layer services account for the vast majority, and there are various types and functions provided. CoAP protocol is a rest-based special Web transport protocol for application and restricted network and nodes. The so-called restricted network has only a small amount of memory space and limited computing power. CoAP protocol is similar to the role played by HTTP protocol in the Internet.

This is followed by a communication M2M device using its own symbol to describe the property name, such as the temperature property "t" of a temperature sensor, "temp" or "temperature" to describe the temperature value, and "pluviometer" or "sensor" for the sensor. To be more precise, in the context of the Internet of things, M2M devices can automatically identify each other without human intervention and realize barrier-free communication with each other. Therefore, it is necessary to unify these terms with differences. To this end, we designed the classification and reference of sensors in each M2M field under the oneM2M architecture to unify the description of M2M data.

### 3.2 Ontology Construction Method

In recent years, semantic ontology has been widely used in the interoperation of M2M of IoT. Through the semantic representation of the concept and relationship between the domain and oneM2M, the normalized identification of the interoperation between M2M devices and oneM2M is realized. Secondly, it comprehensively describes the knowledge in the field of M2M, providing a basis for the understanding of IPE nodes in oneM2M. As the core technology, ontology provides semantic IoT search for oneM2M, as well as support for the interoperation of heterogeneous devices and external IoT service consulting.

The establishment of semantic ontology is currently divided into four steps: preprocessing the M2M device information; Extracting knowledge tuples from device information; Counting the complete set of knowledge tuples and similarity concept of relational semantics, constructing initial ontology manually; The ontology is composed by initializing the concept and relationship model of ontology.

Apart from describing the domain ontology of M2M devices by means of concept and attribute, it is also necessary to create the semanticDescriptor information resource type under the subscription label of the IPE resource structure of each oneM2M node, so as to store the semantic description of the physical devices reflected by AE. In this way, the semantic interworking requirements in semanticDescriptor can be described. The attribute of each kind of device is further refined and the corresponding ontology model structure is established for each type of smart semantic home device, including the basic information of equipment, status, function, data, description, etc.

As is shown in Fig.3, information contains device id, device name, device type, identification, and other information; status indicates the running state of the device. Each function is indicated into on/off state or others. Function records the appearance of some parameters of smart devices and internal commands; Data contains the historical data, data types and unit information that generated during the operation. Describe describes the rules of the device when process the send and receive requests and so on.

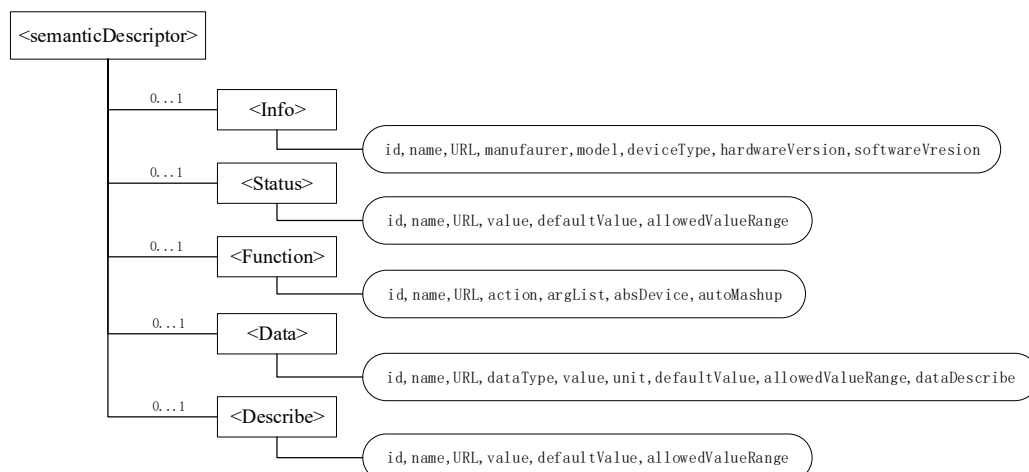


Figure 3. semantic structure of the device

### 3.3 Intelligent Home Semantic Ontology Construction

The modern living is gradually developing with a smarter and diversified trend. Faced with the large amount of heterogeneity of the system and the characteristics of intelligent equipment in real life, a large number of scholars conducted researches on the aspect of semantic interoperability technology. In the specification process of the second edition of the oneM2M standard, the semantic service module was introduced [10]. It integrates all semantic services into the Common Service Function, and named it as SEM CSF, based on which, the applications can manage semantic information and provide functionality.

### 3.4 Smart Home Structure

Smart home system needs to meet user's requirement for providing intelligent services of traditional home. The issue is that most of the structures mentioned by the academic circle presently are only concentrate on the acquisition of services under the corresponding operations in specific situations, without providing all-round solutions from smart home aspect [11]. From the perspective of semantic annotation, this paper proposes a feasible smart home system by using the original features of semantic technology to support cross-domain recognition and the support of oneM2M for heterogeneous devices.

The smart home structure contains a lot of single-function services, including household appliances of different brands, various sensors, devices and so on, which can use oneM2M framework that the figure represents for the standardization arrangement, making each kind of service under every kind of physical devices is reflected into the node oneM2M. The second part of the chapter will introduce the design thinking of the general structure, the semantic function of smart home environment. Building ontology model of each kind of device, and using semantics labelling for marking property of each device, making the equipment with each other without heterogeneous problem, which can also support the development for the similar functions.

### 3.5 Semantic Interoperability Modeling

According to the key element theory of the basic architecture in oneM2M, it is divided into objects, devices, services, architectures and operations in the field of smart home. We use intelligent refrigerator and intelligent light system to demonstrate the basic method of ontology construction [12].

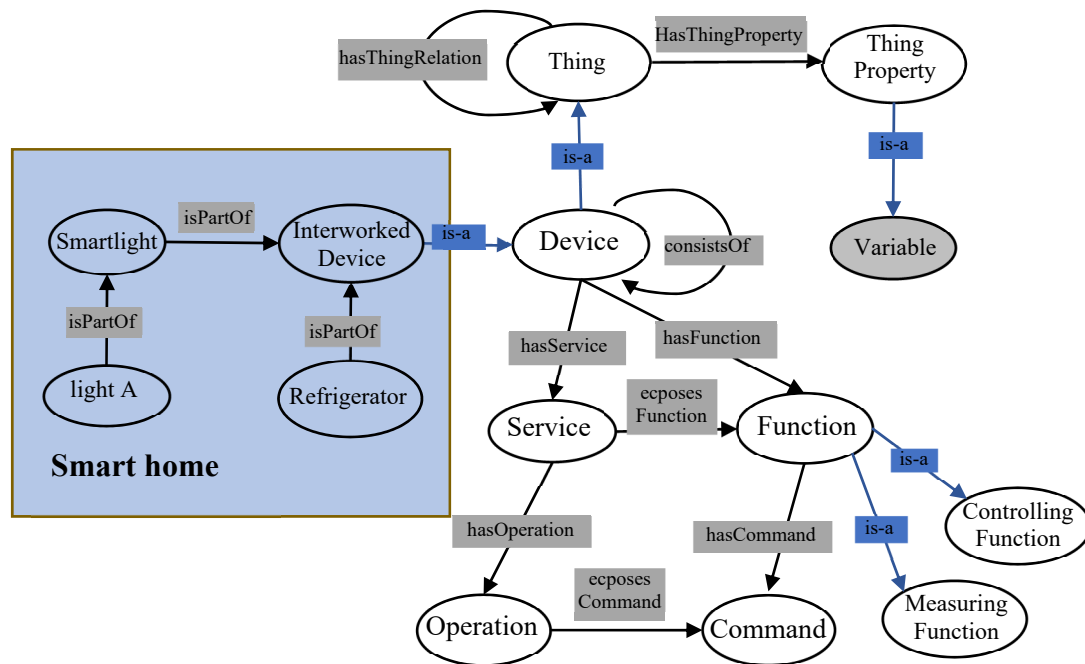


Figure 4. oneM2M instantiation of the Base Ontology

Fig. 4 shows the classes and properties of the basic ontology. Nodes represent classes, and arrows represent relationships between them. Understanding of the elements in the figure is as follows:

**Thing:** it means any oneM2M entity that can be recognized, Thing may be attributes, such as thingProperty: may also be a relationship between objects. In oneM2M, for example, the modeling of the temperature of the room and another room temperature with "isAdjacentTo" relationship.

**ThingProperty:** used to denote thing properties, may be a specific physical property can also be things of the relationship between attributes.

**Variable:** said some specific data entity, such as integer, text or structured data. These variables are often used to describe the real world.

**Device:** is a subclass of a Thing, said the specific equipment entity, can through the network electronic interaction.

**Service:** functions in the oneM2M schema can be invoked to provide various services within the oneM2M schema. A Service can be one or more functions. These features can be discovered and registered.

**Interworked Device:** it belongs to the Smart part of home, Interworked Device does not belong to oneM2M equipment, only through each agent entities (IPE) created by "agent" equipment and equipment interoperability of oneM2M, message send and receive messages shall be carried out in accordance with the REST-ful way.

Support a mapping relation to the domain ontology library, which can get the semantic description of the device from the domain ontology library in real time. Ontology USES OWL, the network ontology language recommended by WSC, to model various properties of the home [13]. OWL is a language based on RDF similar to REF/XML syntax [14]. An OWL syntax consists primarily of classes and properties. The direct relationship between classes is generally represented by triples. This paper will use Protégé to construct the semantic ontology in the field of smart home under the oneM2M standard system. Due to the length, only a part of the semantic ontology of smart home is given here:

```
<rdf:RDF xmlns="http://www.semanticweb.org/****/ontologies/****/ontology"
  xml:base="http://www.semanticweb.org/*****/ontologies/****/ontology"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:owl="http://www.w3.org/2002/07/owl#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
```



```

<owl:Class rdf:about=applicationDedicatedNode-applicationEntity>
  <rdfs:subClassOf rdf:resource=Application_Dedicated_Node/>
</owl:Class>
<owl:Class rdf:about=applicationServiceNode-applicationEntity>
  <rdfs:subClassOf rdf:resource=Application_Service_Node/>
</owl:Class>
...
<owl:Class rdf:about=Non-oneM2M_Device_Node>
  <rdfs:subClassOf rdf:resource=Externalsystem/>
</owl:Class>
...
</rdf:RDF>

```

### 3.6 oneM2M Semantic Inference

After the ontology construction of the smart home domain is completed, various semantic entity types can be added, deleted, modified and checked according to the description of the instance model. Ontology inference language SPARQL is a query language and data acquisition protocol developed for RDF. It is RDF query statement recommended by W3C [15]. This implements the semantic generation of rules as entities and their relational attributes, the syntax of which is as follows.

```

PREFIX owl:<http://smart-home /Device. owl >
SELECT? deviceInfo_ID
WHERE {? device <http://smart-home /Device. owl /smart-home-rdf/3.0#FN> rdfs }

```

Query RDF triples for their corresponding relationships. The parameters in the owl file are matched to find the final target device that you want to query.

## 4. Conclusion

The research on semantic cross-platform interoperability of the IoT is getting going which has not yet completed to be a cross-system interoperability solution using semantic technology. It not only need to build a set of domain semantic ontology database recognized in the industry, but the semantic ontology database the industry belongs should also be constantly improved to follow its industrial fast-developing pace, which makes it very difficult to build common cross-platform middleware through semantic technology.

This report uses cross-platform interoperability of the IoT generic platform, oneM2M, with external systems, taking smart home as the example to simulate a set of semantic interoperability, which effectively solves the problem of heterogeneous sensors, putting forward to a set of semantic technology which is used to simulate the communication between intelligent household equipment and oneM2M. In addition, the usage of sensor data manual-labeling method standardizes the communication of intelligent household equipment and oneM2M, overcomes the specific middleware development difficulty, using a generic scenario to solve most of the problems. However, there are still two main problems of this method: A) Facing the development of the industry itself, this solution cannot update the ontology database dynamically in real time, which requires the establishment of a special authority to maintain; B) this scenario does not take the interworking efficiency into account, which might cause severe delay in semantic recognition, and this is unacceptable in some fields. It is necessary to solve these problems in future research and further improve the stability and efficiency of intercommunication.

## References

- [1]. Machine-to-Machine (M2M) communications: A survey[J]. Journal of Network & Computer Applications, 2016, 66(C):83-105.
- [2]. Machina Research, "IoT Global Forecast& Analysis 2015-25" [R], 2016-08.

- [3]. Zarei M, Mohammadian A, Ghasemi R. Internet of things in industries: A survey for sustainable development[J]. International Journal of Innovation & Sustainable Development, 2016, 10.
- [4]. Porkodi R, Bhuvaneswari V. The Internet of Things (IoT) Applications and Communication Enabling Technology Standards: An Overview[C]// International Conference on Intelligent Computing Applications. IEEE, 2014.
- [5]. oneM2M-TS-0001, "oneM2M Functional Architecture Technical Specification" [S]// <http://www.onem2m.org/>.
- [6]. Blackstock M, Lea R. IoT interoperability: a hub-based approach[C]// International Conference on the Internet of Things. IEEE, 2015.
- [7]. GB/T 7714 Song J S, Kunz A, Prasad R R V, et al. Research to Standards: Next Generation IoT/M2M Applications, Networks and Architectures[J]. IEEE Communications Magazine, 2016, 54(12):14-15.
- [8]. Gyrard A, Bonnet C, Boudaoud K. Enrich machine-to-machine data with semantic web technologies for cross-domain applications[C]// Internet of Things. IEEE, 2014.
- [9]. Husain S, Kunz A, Song J S, et al. Interworking architecture between oneM2M service layer and underlying networks[C]// Globecom Workshops. IEEE, 2015.
- [10]. oneM2M-TS-0004, "oneM2M Service Layer Core Protocol" [S]// <http://www.onem2m.org/>.
- [11]. Soliman M, Abiodun T, Hamouda T, et al. Smart Home: Integrating Internet of Things with Web Services and Cloud-Computing [C]// IEEE International Conference on Cloud-Computing Technology & Science. IEEE, 2014.
- [12]. Yang Y, Wang Z, Yang Y, et al. An Ontology Based Semantic Service Model in Smart Home Environment[C]// International Conference on Computer & Electrical Engineering. 2012.
- [13]. Chaochaisit W, Bessho M, Koshizuka N, et al. Human Localization Sensor Ontology: Enabling OWL 2 DL-Based Search for User's Location-Aware Sensors in the IoT[C]// IEEE Tenth International Conference on Semantic Computing. IEEE, 2016.
- [14]. Martin D, Paolucci M, Mcilraith S, et al. Bringing Semantics to Web Services: The OWL-S Approach[J]. 2004.
- [15]. Prud'Hommeaux E, Hausenblas M. Use Cases and Requirements for Mapping Relational Databases to RDF[J]. 2010.