A flexible extension of WSDL to describe non-functional attributes

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***Abstract*—Internet of Things (IOT) connects visible physical things to information network and extends the network data source from edge servers to visible physical objects, and Web service (WS) can play a role of real thing's representation in information system. In order to describe a complete object, its service must contain both functional and non-functional information, because they are important attributes and the keys to distinguish things from each other. As a standard of WS, Web Service Description Language (WSDL) cannot describe an object with its all information, as WSDL provides no method for describing services' non-functional aspect while it only focuses on functional parts. This paper proposes a flexible extension of WSDL to describe non-functional attributes. Based on principles and standards of Model Driven Architecture (MDA), the process consists of a WSDL metamodel extension and transformation between UML models and XML syntax. Base On the basis of our extension model, the mapping from a physical object to a web service will be more accurate and complete. In this way, WSDL can completely describe a physical object in the form of a service.**

Keywords-model extension; metamodel; non-function; MDA; WSDL; IOT;

I. INTRODUCTION

Internet of Things (IOT) is a technological revolution and represents the future of communication and computing. Just as its name implies, IOT is a world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. IOT mainly comes from the combination of Radio Frequency Identification (RFID) and Internet. On one hand, Internet is the core and basis of IOT which is the extension of Internet. On the other hand, clients are expanded to any visible physical goods.

Web Service (WS) is considered as a platform-independence, self-describing, modular application that can be published, located, and invoked across the network. The service-centric environment composed by the services is naturally open, platform independent, flexible and adaptable. So it is evident that Service-Oriented Architecture (SOA) is suitable for the application/solution level design for IOT, and it is also possible to describe a thing as a service.

Web Services Description Language (WSDL) is a standard that use XML syntax to address capabilities and invocation mechanisms of web services, and it has been used widely. To create a complete picture, a service must contain a physical object's all information, which consists of both functional and non-functional components. However, WSDL cannot finish this assignment since it provides no method for representing non-functional aspect of a service while it only focuses on functional parts. So it is necessary to make a service's WSDL document to inform what it is and how it is while it addresses what it can do.

So far there are many research productions on non-functional aspect of web service, but they are mainly about QoS (Quality of Service) [1-5]. In [6], a model-based approach is presented to implement QoS monitors by describing them as platform-independent models. Then, Model-Driven Development transformations are introduced to create both a system implementation and QoS constraints in the form of aspects according to the Aspect-Oriented Programming (AOP) paradigm. Reference [7] proposes a lightweight WSDL extension for the description of QoS characteristics of a web service by a metamodel transformation. The WSDL metamodel is introduced and then transformed into the Q-WSDL (QoS-enabled WSDL) metamodel. And this method also supports the automated mapping from WSDL documents to Q-WSDL ones and from UML models to Q-WSDL web services.

This paper addresses a flexible extension of WSDL to describe non-functional attributes of services and physical object based on some theory in [7]. According to some special requirements of IOT, a two-level model is introduced to describe the non-functional attributes of visible physical objects in the form of web services. And this extended model will link to WSDL metamodel to realize WSDL extension based on the basis of model-driven theroy. This extension method also supports the transformation between UML model and XML syntax. So it can be exact and complete to depict a physical thing by using a web service in the condition of IOT. And in this way a service will also address what it is and how it is while presenting what it can do.

The rest of the paper is organized as follows: IOT is presented in section 2; section 3 gives the WSDL metamodel

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and the extension process; then a case study is shown in section 4; finally conclusion and future work is presented in section 5.

II. INTERNET OF THINGS

IOT links visible physical things with Internet by using RFID, laser scanning, sensor networks and special protocol to achieve information exchange and communication automatically. It also achieves automatic identification, positioning, tracking, monitoring and management of physical things. As the basis of IOT, RFID consists of tags, reader, antenna, host and some supporting software [8]. Tags, including a chip with a globally unique ID, will be embedded in one physical thing for identify this unique object. So the source of network information is extended from edge server to any visible physical object.

IOT is a key part of the Future Internet. The role of IOT is to bridge the gap between the physical world and its representation in information systems. So physical objects will be seamlessly integrated into the information network and become active participants in business processes. Services are also available to interact with these 'smart objects' over the Internet, query their state and any information associated with them, taking into account security and privacy issues. Moreover, it is faster and easier to integrate, exchange, transmit and store information.

WS focuses on functional implementation. However, in terms of data integration and management, applying WS to IOT will benefit business management and information exchange in enterprise environment. It will be faster and easier to integrate and exchange between host and server as well as that between one server and another one. Meanwhile WS can also transmit data to remote server in the form of service speedily and safely.

III. THE MODEL EXTENSION

A. *WSDL model*

WSDL define web services as a collection of communication endpoints able to exchange messages in a XML document [9]. It consists of basic description, function and invocation. WSDL describes what the web service does by input and output interfaces and represents a contract between the service requestor and the service provider. Using WSDL, a client can locate a Web service and invoke any of its publicly available function. Moreover the whole process can be done automatically with WSDL-aware tools.

So it is obvious that WSDL only address what it can do and how to use it without what it is and how it is. In IOT environment a physical object is represented as a service. However each physical thing has many functional and non-functional features which are important for these objects. So it is essential to make WSDL having ability to describing comprehensive non-functional attributes of services and objects but not only QoS.

B. *The extension process*

The extension process is based on the theory of Model Driven Architecture (MDA), which is Object Management Group's (OMG) standard for software engineering by model-level design and exploitation. In MDA-based approaches, model is the core element, and the focus is upon creation of software via the development of Unified Modeling Language (UML) models. Metamodel shows basic structure of a special model, and it is the basis for model extension and transformation [10]. WSDL metamodel can be extracted from its XML Schema by XML-based Metadata Interchange (XMI) [11] and the result is shown in Fig. 1.

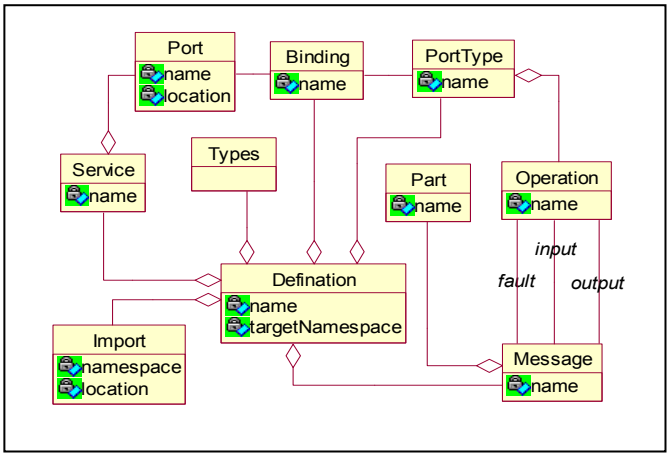

Figure 1. A WSDL metamodel

Meta Object Facility (MOF) is an abstract language and framework for describing, designing and managing intermediate model. As the core element of MDA, MOF will be the key for the extension. According to MDA theory, each model is an instance of a special MOF metamodel which is an instance of a particular MOF meta-metamodel at the same time. XMI provides a set of rules for mapping from models and MOF metamodels into XML documents and XML Schemas.

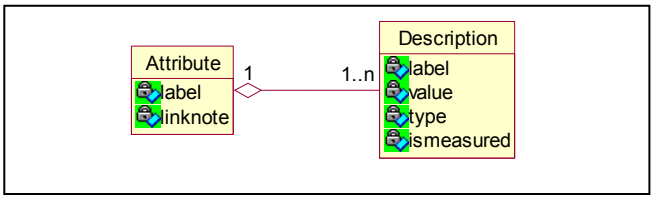

Figure 2. A two-level descriptive model

OMG give some transformation and UML profiles of QoS in [12, 13] for extend model to support QoS description. Based on these concepts, this paper gives a model extension for providing WSDL with extensive non-functional attributes besides several QoS elements. A two-level descriptive model is carried out for this destination and shown in Fig. 2.Class Attribute (CA) is an overall description of service's features and consists of two attributes, label and linknote:

- *Label* (A.LA) depicts the name of attribute, such as size, price and material;

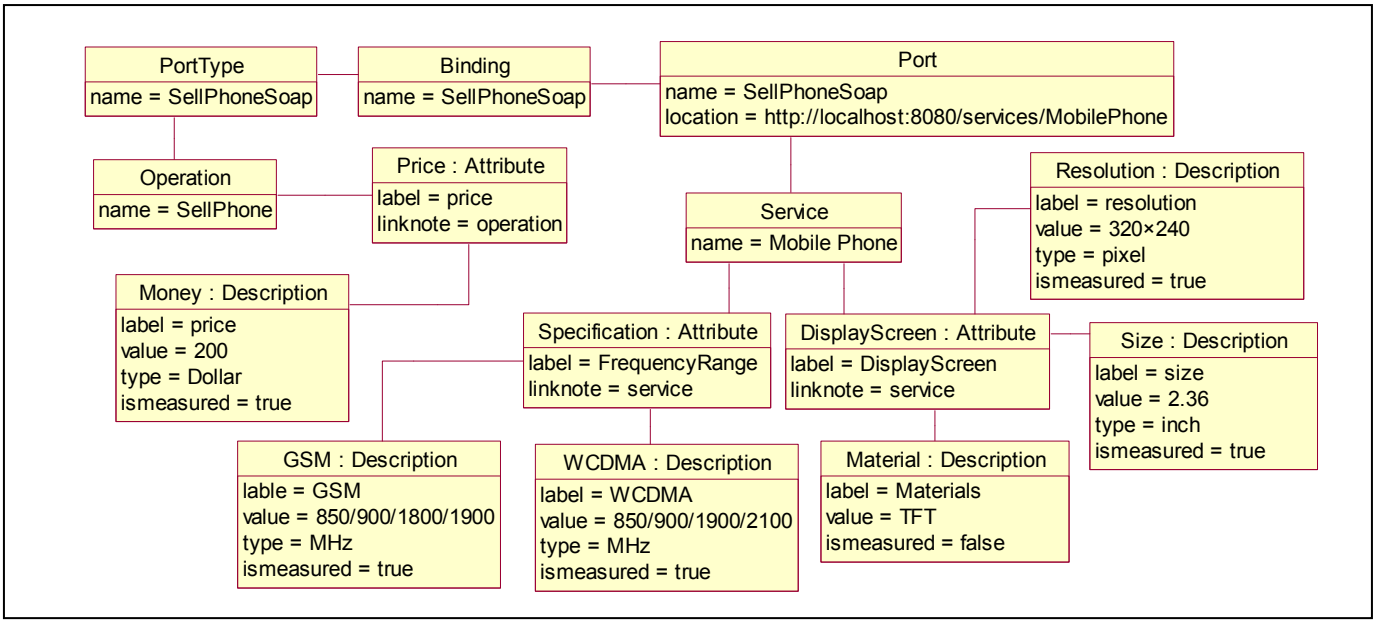

Figure 3. An Example of model extension

- *Linknote* (A.LI) tells the point where the attribute links to WSDL structure.

Class *Description* (CD) shows the details of a special CA, such as length of size and money of price. CD consists of the following dimensions:

- *Label* (CD.L) addresses the name of the description such as length;
- *Value* (CD.V) is the specific content of the description. It can be a specific number or a qualitative description;
- *Type* (CD.T) is the measurement unit of CD.V;
- *Ismeasured* (CD.IM) is a Boolean data to inform that if CD.V can be digitized or not;

The connection between CA and CD is a one-to-many aggregative relationship, namely a CA has at least one CD. In many cases it is necessary to measure more than one item for describing one attribute. For example, length, width and height are needed for size, and an exact position also needs both of longitude and latitude.

For a special thing, designer only needs to link its service model with a set of CA and its CDs which have been already instantiated according to its non-functional attribute. Then the extended model will be obtained. However, the way of extension can be multiform due to the diverse physical objects and their various attributes, so the proposed extension has no fixed pattern. This assignment will be explained at large in the next section. XML document can be transformed from its UML model and validated by use of its XML Schema obtained from its MOF metamodel [7].

IV. A CASE STUDY

As is said before, this service model extension aims to describe physical in the form of service with complete and exact non-functional components. An application is given for describing a mobile phone for sale.

As is shown in Fig. 3, three attributes, *Price*, *Specification* and *DisplayScreen*, are selected. CA *Price* has only one description *Money* with a value of 200 dollars and is linked to *Operation* because of its connection with *SellPhone*. CA *Specification* depicts the frequency range of its supported communication standards and is part of node *Service*. *Specification* is made up of CD *GSM* (850/900/1800/1900 MHz) and CD *WCDMA* (850/900/1900/2100 MHz). Similarly CA *DisplayScreen* has three CDs, namely *Resolution*, *Size* and *Material*, and their values and types are shown in Fig. 3. *Material* is a descriptive feature, so its CD.IM is false and has no CD.T while all the others are opposite. Though only three attributes are chosen for the example, more features can be added if they are necessary.

This proposed measure is suitable for those uncomplicated objects. On one way, a physical object is a comprehensive concept with tremendous information. The model may be complicated if it is extended with all its non-functional items. On the other way some objects are complicated or even composed of some other things. So it will more suitable to model them in the form of composed services instead of some single ones.

V. CONCLUSION AND FUTURE WORK

This paper proposes a flexible extension of WSDL for describing non-functional of services and physical objects in order to make service's description more exactly and completely. On the basis of MDA, a two-level descriptive model is advanced to extend on WSDL metamodel extracted from WSDL XML Schema according to MDA. Then an example is shown to illustrate correctness and validity.

Some objects have a great number of information, and some are even composed of some other ones. So the next thinking is how to model these complicated physical things in the form of composed services.

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