Research on Unified Data Model and Framework to Support Interoperability between IoT Applications

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1. Introduction

The Internet of Things (IoT) presents today a huge potential in terms of both, technology deployment and business opportunities. Even though the IoT products performing similar tasks are densely deployed, a service provider needs to deploy multiple dedicated infrastructures per IoT segment if interoperable solutions and/or harmonized standards between different segments are not provided. Providing interoperability between heterogeneous IoT ecosystems is one of the most important challenges in IoT technology and industry.

Recently, some products and services have been launched on the commercial IoT platforms such as oneM2M [1], Open Interconnect Consortium (OIC) [2], AllJoyn [3]. Because no platform is overwhelming the market, multiple platforms are coexisting and competing with each other. Each IoT platform standard defines its own information and data models, and hence the same information from the same physical thing, e.g., on/off status of a light bulb, can be described through very different format and value. This heterogeneity makes it difficult for application providers to develop global-wide killer services. To overcome this, we design and implement a unified software framework which can gather and store IoT data from the heterogeneous IoT platforms. In the proposed framework, IoT data from a specific platform is transformed into the unified data structure based on IETF YANG model [4], and the data is stored in a single data store. Then, applications can access and utilize any data from the various types of IoT platforms very easily. We will implement the framework through the open source project, OpenDayLight (ODL) IoTDM [5].[6].

2. IoT Data Models from Various Standards

Each industry vertical (e.g. Smart Cities, Healthcare, and so on) has developed its own domain-specific technology solutions which cannot interoperate with other verticals. Though there have been some work to enhance interoperability, most initial researches have focused on the communication interoperability, e.g., technology to enable seamless communication between heterogeneous entities independently of the underlying network technologies. Though the recent enhancements enable to deliver messages between different systems, applications from different IoT platforms cannot understand each other due to lack of common understanding on information and data models.

Figure 1. *Fragmented IoT platforms [7]*

Various standard groups and industry consortium has defined their own information and data models. IPSO (Starter Pack), Zigbee Alliance (Cluster Library), the OMA (LWM2M), and the UPnP (IoT Management and Control:1) have worked on information and data models for IoT. Furthermore, many global ICT companies are

actively working on emerging IoT platform standards such as oneM2M [1], OIC [2], and AllJoyn [3], which have their own information and data models. We have initial interest in providing semantic interoperability among oneM2M, OIC, and AllJoyn, which are expected to have big impacts on the commercial IoT market.

3. Our Approach – Unified Data Model and Framework

ETRI has started three-year research project funded by Korean government (Ministry of Science, ICT and Future Planning) from January 2016. This project aims at enhancing interoperability in the application level to overcome fragmentation of IoT ecosystem. Because the application level federation cannot be achieved without common understanding on the information/data model of the exchanged messages, we will devote a lot of efforts to the work research about the unified data model. Final goal of our project is to design and implement a framework which allows applications to seamlessly access and utilize any data from the any type of IoT platform without or with minimum additional efforts. Specifically, our activity and contribution will include *Comparison Study for Data Models of Existing IoT Platforms, Defining IoT Data Model through IETF YANG Model,* and *Design and Open Sourced Implementation of Unified IoT Data Store Framework.*

2.1. Comparison Study for Data Models of Existing IoT Platforms

We first conduct comparison study about data models of various IoT platform standards we are interested in, i.e., oneM2M, AllJoyn, and OIC. The detailed data models are different according to the standards, but they have some common properties. We will extract the common and unique properties from the different standards.

2.2. Defining IoT Data Model through IETF YANG Model

Based on the comparison study on data models of different IoT platforms, we define the unified data model by using IETF YANG [4]. YANG is a data modeling language for the NETCONF network configuration protocol developed by NETMOD WG of IETF. YANG is initially designed for modeling of network configuration and state monitoring data, but it can be used for modeling various types of data. YANG enables a data modeler to define signatures of remote procedure call (RPC). It supports scalable embedded data type and reusable data structures by grouping. Furthermore, YANG data model is easily mapped to and converted into XML format in one-to-one manner. We have chosen YANG for the unified data model due to the flexibilities. Common properties derived by comparison study will be modeled as a Common Data Element which is contained in every IoT data. On the other hand, unique properties of each IoT platform standard will be stored separately in Unique Data Element. Some related work has been done in ODL IoTDM [6] activity.

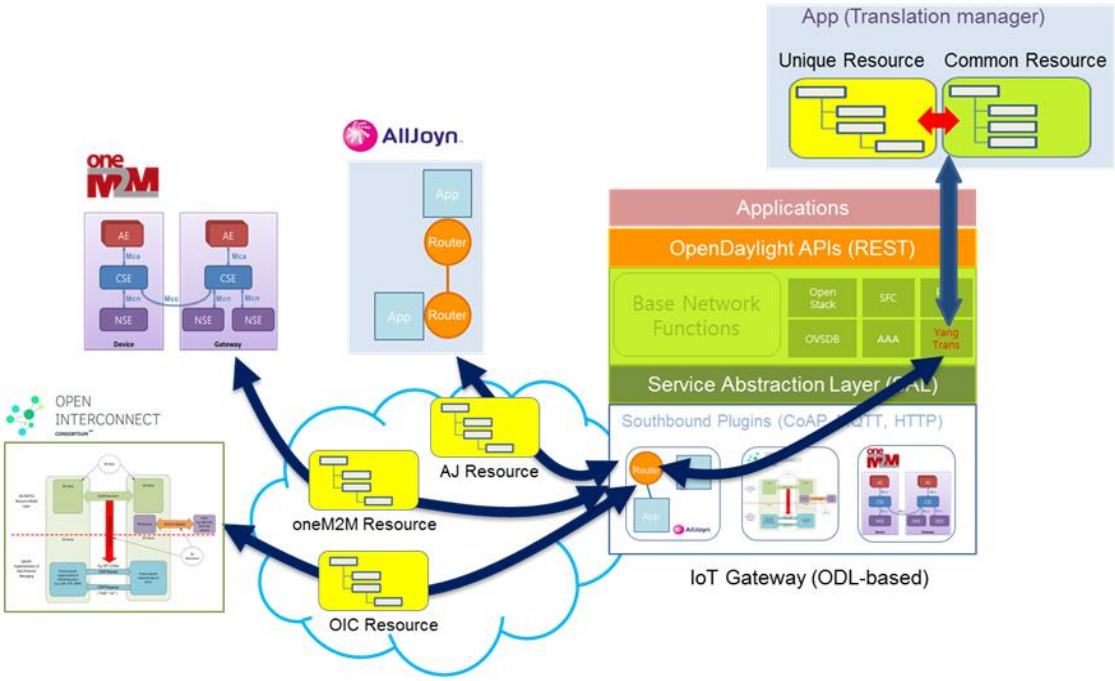

Figure 2. *Framework for Unified IoT Data Store*

2.3. Design and Open Sourced Implementation of Unified IoT Data Store Framework

Based on the derived YANG data model, we design and implement the software framework that provides data gathering, format translation, data storing and access in the same way. The overall architecture of the proposed framework is illustrated in Figure 2. Our framework supports various southbound interfaces which are specific to the IoT platform, and the gathered data is delivered to upper layer through Service Abstraction Layer (SAL) which abstracts the details of the southbound interfaces. Then, the IoT data which has its own original format is translated into the unified YANG data model by translation entity. Each stored data contains both Common Data Element and Unique Data Element. In this framework, applications can access data through the unified API, and the information in Common Data Element can be utilized with no additional processing regardless of original system the data came from. Some advanced application may utilize more detailed information in Unique Data Element through standard specific interpretation.

Our framework is implemented in the OpenDayLight (ODL) IoTDM project. ODL [5] is a well-known open source software platform for the Linux Foundation's SDN/NFV. Many major IT companies such as Cisco, Dell, HP, and Jupiter are actively participating in ODL activity. The ODL uses YANG data modeling to model the service abstraction layer. Applying YANG modeling ease adoption of various southbound interface protocols, definition of APIs, design of data structure and messages. Even though ODL is initially triggered to support SDN/NFV, there have been some efforts to extend the usage of the proven, flexible software platform to the general purposes. One of such efforts is IoTDM (IoT Data Management) project [6] which aim at developing a data-centric middleware that will act as an oneM2M compliant IoT Data Broker. IoTDM enables authorized applications to retrieve IoT data uploaded by any device, and one of our team members is actively participating in this project as a committer.

Based on our experiences in ODL platform and ODL IoTDM project, we implement our framework as an extension of current IoTDM project. Original scope of IoTDM is restricted to oneM2M standard. On the other hand, we extend the scope to include other IoT platform standards and provide interoperability between them. That extension will be our main contribution on current IoTDM project.

4. CONCLUSIONS

In this position paper, our on-going work for improving semantic interoperability have been introduced. In our project, we design and implement a unified software framework which can gather and store IoT data from the heterogeneous IoT platforms. In the framework, IoT data from heterogeneous platforms is transformed into the unified data model based on IETF YANG model. The proposed framework will be implemented on OpenDayLight (ODL), which is well-known open source platform, as the extension of IoTDM project in ODL.

Acknowledgements: This work was supported by ICT R&D program of MSIP/IITP. [R7116-16-1004, Standards Development of IoT Application Services and Interoperability Support]

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