Exploratory investigation of semantic reasoning in oneM2M

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***Abstract*—Today important challenges in the Internet of Things (IoT) include; providing interoperability among IoT data, interpreting data generated by IoT devices, and assisting developers in accomplishing these tasks by defining rules. Current standard development organizations such as oneM2M have a vital role to design the semantic-based IoT architecture to address such challenges. Semantic reasoning is introduced by oneM2M, which is a potential capability that oneM2M-compliant IoT instances have. This paper did an exploratory investigation of semantic reasoning in the oneM2M, which is a global initiative that develops specifications to ensure the most efficient deployment of Machine-to-Machine (M2M) communications systems and the Internet of Things (IoT)**

***Index Terms*—Semantic Reasoning, oneM2M**

I. INTRODUCTION

RECENTLY, in IoT the task requires the mashup services in the sense that knowledge can be combined from various resource and reaching a conclusion is easy. The semantic rules and reasoning engines have been developed for various use cases and have been utilized for automatic event handling. Semantic reasoning is a mechanism to derive implicit facts that are not explicitly expressed in the existing knowledge/facts (such as RDF triples) by leveraging a set of reasoning rules. RDF data/triple is the type of semantic metadata used in oneM2M system, which is in the form of a 3-tuple representation, i.e., "subject-predicate-object". The RDF data is usefully written based on various ontologies, which define formal vocabularies (i.e., class) and their relationships for different application domains.

A. Semantic Reasoning Function (SRF)

This section defines a Semantic Reasoning Function (SRF) to support the functioning of semantic reasoning in the oneM2M system. The main features of SRF are shown in Figure 1. There are several key concepts that are involved with semantic reasoning:

1) Existing facts – An existing fact is an already-known knowledge or an assertion.
2) Reasoning rules (RR) – A RR has an IF-THEN construct. When a given RR is applied over the existing facts, if the condition (i.e., the IF part) is true, then the conclusion (the THEN part) also holds.
3) Inferred facts – The output of a reasoning process, which is the reasoning result derived from the existing facts by applying RR [1].

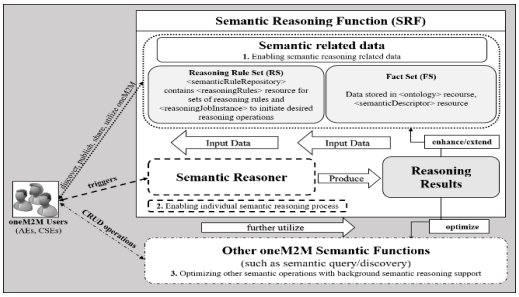

Fig. 1. Key features of SRF

B. Key features of SRF

The SRF is divided into three features as shown in Figure 1. Feature-1: The main functionality of Feature 1 is to enable the semantic reasoning related data by being able to find and publish/enable different entities through the oneM2M system (shown as with number 1 in Figure 1). The semantic reasoning related data can be a fact set (FS) and/or role set (RS). An FS refers to a set of facts. For example, a collection of RDF triples stored in the resource can be considered as FS. In general, a FS can be used as an input to a semantic reasoning process (i.e., an input FS) or it can be can be used as a result of semantic reasoning process. A RS refers to a set of semantic reasoning rules. For example, oneM2M applications may define their own reasoning rules (user-defined reasoning rules) for different application needs. In General, Feature-1 includes the publishing/discovering/sharing of semantic reasoning related data through suitable oneM2M resources. In feature 1, originators can send requests to certain receiver CSEs in order to publish/discover/update/delete the FS/RS-related resources through the corresponding CRUD operations. Once the processing is done, the receiver CSE will return a response to the originator. Feature-2: Enabling individual semantic reasoning process the originators may also directly interact with the SRF by triggering an individual semantic reasoning process (which are shown by number 2 in Figure

1). In this feature, an oneM2M user shall first identify the interested facts (as input FS) as well as the desired reasoning rules based on their application needs. When the input FS and RS are identified, the oneM2M user shall send a request to the SRF for triggering a specific semantic reasoning process by specifying the inputs (i.e. the input FS and RS). The SRF will then initiate a desired semantic reasoning process. Once the SRF works out the semantic reasoning result, it will be returned to the oneM2M users for further usage. Feature-3: The existing semantic operations supported in the oneM2M system (e.g., semantic resource discovery and semantic query) may not produce desired results without semantic reasoning support. The main functionality of Feature-3 of SRF is to give strength to semantic reasoning as a "background support" function to optimize other semantic operations (e.g., a semantic query) (which are shown by number 3 in Figure 1). During the processing of this operation, semantic reasoning may be further triggered in the background, which is however fully transparent to the user. In Feature-3, an originator can send requests to certain receiver CSEs for the desired semantic operations (such as semantic resource discovery, semantic query, etc.). During the request processing, the receiver CSE, assuming it supports SRF, can further leverage the reasoning capability. In general, the reasoning capability of the SRF is realized by an underlying semantic reasoner. By leveraging the outputs of semantic reasoning (i.e., reasoning result), the receiver CSE will further produce the ideal result for the semantic operation as requested by the originator (e.g., the semantic query result, or semantic discovery result) and then return the response to the originator. [2][3]

C. Reasoning Resources

The enablement of semantic reasoning and ontologies is a semantic service layer of IoT that would provide support of smart data management and derive new facts to extend the scope of data beyond sharing and creation. The addition of a semantic rule resource for each semanticDescriptor resource to support semantic reasoning will facilitate the IoT application to retrieve smart data by adding rules for semantic information stored in the semanticDescriptor and the <ontology> resource in order to derive implicit facts by leveraging a set of semantic reasoning rules. For this purpose, the semanticRule resource is used, is a child resource of the <semanticRuleRepository> resource (Figure 2 illustrates the attributes and relationship of semanticRule with other resources). By performing the CRUD operations on the resources, various reasoning rules (e.g., user-defined reasoning rules based on business logic) can be created, discovered, retrieved, updated, and deleted inside the oneM2M system.

<semanticRuleRepository> resource (resource type for storage of different reasoning rule sets) is a child resource of the CSEBase resource. The <semanticRuleRepository> resource may have one or multiple child <reasoningRules> resources to represent different sets of reasoning rules in the oneM2M system. A reasoning initiator can create child <reasoningJobInstance> resources of a

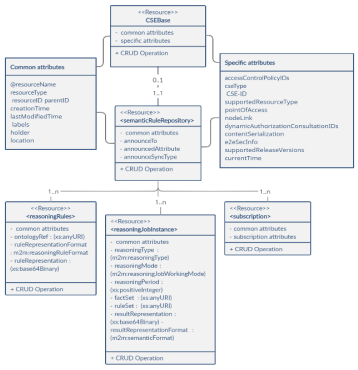

Fig. 2. Attributes and relationship of semanticRule resources

<semanticRuleRepository> resource to initiate desired reasoning operations. A Reasoning Initiator (RI), such as an AE or CSE, may trigger two types of reasoning operations. One type is a "one-time" executed over a Fact Set (FS) and a Rule Set (RS) that may not change over time. In comparison, the other type is a "continuous" reasoning operation. The second type is applicable to the cases where the input FS and RS for reasoning may change over time, and accordingly, the previously inferred knowledge may not be valid anymore. Therefore, new reasoning is executed over the latest version of FS and RS in order to generate up-to-date inferred knowledge. A <reasoningJobInstance> resource represents a specific reasoning job instance for enabling the two types of reasoning operations. A RI initiates the desired reasoning operation by creating a <reasoningJobInstance> resource as a child resource of a <semanticRuleRepository> resource. The specific attributes of reasoning resources are ontologyRef, RuleRepresentationFormat, ReasoningType, ReasoningMode, reasoningPeriod, FactSet, RuleSet.[3]

II. Conclusion

The Internet of Things (IoT) primary objective is to make a hyper-connected world for various application domains and oneM2M has a very important role to develop the semantic-based IoT architecture. The goal of the paper to acquire detailed overview of the section i.e. semantic reasoning guided by oneM2M, so as to substitute more intelligent and practical IoT applications.

III. ACKNOWLEDGMENT

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