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SSF: Smart city Semantics Framework for reusability of semantic data

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***Abstract*—Semantic data has semantic information about the relationship between information and resources of data collected in a smart city so that all different domains and data can be organically connected. Various services using semantic data such as public data integration of smart cities, semantic search, and linked open data are emerging, and services that open and freely use semantic data are also increasing. By using semantic data, it is possible to create a variety of services regardless of platform and resource characteristics. However, despite the many advantages of semantic data, it is not easy to use because it requires a high understanding of semantics such as SPARQL. Therefore, in this paper, we propose a semantic framework for users of semantic data so that new services can be created without a high understanding of semantics. The semantics framework includes a template-based annotator that supports automatically generating semantic data based on user input and a semantic REST API that allows you to utilize semantic data without understanding SPARQL.**

***Index Terms*—semantics, smart city, template-based annotation**

I. Introduction

Semantic technology enables the connection of all data without being limited to domains by creating meaning for raw data collected through various IoT platforms in smart cities and forming relationships between data [1]. Semantic data can be expressed in formats such as Resource Description Framework (RDF) and Web Ontology Language (OWL), and discovery is possible through Sparkle Protocol and RDF Query Language (SPARQL), a query language dedicated to semantic data. As an example of the use of semantic data, the Linked Open Data (LOD) service can provide open integrated data through semantic data in order to reuse data and provide new value.

In Korea, the national geospatial information portal service operated by the Ministry of Land, Infrastructure, and Transport and the Korea Land Information Corporation to support the LOD opening of national geospatial data, and the National Library of Korea supporting the LOD management and publication of national bibliographic works preserved by the National Library of Korea are representative. It supports several services using semantic data in various fields such as LOD.

The international IoT standardization organization, oneM2M also define semantic data resources and common ontology and do standardization activities to be used in smart cities such as Semantic Descriptor (SD) [2]. The Internet of Things open platform group, European Telecommunications Standardization Institute (ETSI) also defined standard API for Context Information Management (NGSI-LD API) enabling close to real-time access to information coming from many different sources [3]. In particular, semantic modeling works with NGSI-LD so that various domains can be integrated. With this kind of research, various areas such as water, parking, and weather can be provided for applications in smart cities.

However, despite the many advantages of semantic data, a high degree of understanding of semantics is required to use semantic data. Semantic data has a triple structure that includes information on the connection relationship between resources, and all data can be connected through Uniform Resource Identifier (URI). The higher the understanding, the more diversified its use can be. Therefore, in this paper, we propose a semantic framework that enables new domain extension in smart cities without a high understanding of semantics and supports semantic data utilization without using SPARQL.

In summary, the main contributions of this article are as follows:

- A Semantics Framework system, that enables the generation of semantic data from template-based annotations with an annotation template creation interface that can accept user input.
- Semantic REST API based on SPARQL, that can be used user who does not have any semantic knowledge, so anyone can create various service with semantic data in the smart city.

The structure of this paper is as follows. Chapter 2 describes the structure and function of the Smart city Semantics Framework (SSF) system. Chapter 3 discusses the conclusion and future research.

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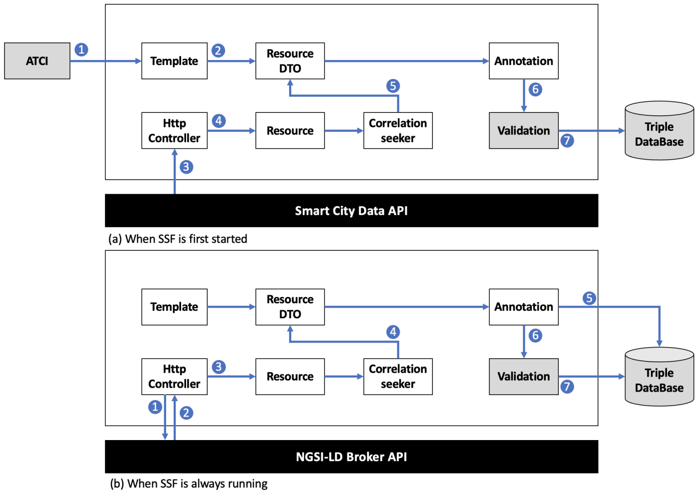

Fig. 1. semantic annotation of SSF

II. Smart city Semantics Framework

This paragraph describes the semantics function and structure of the SSF system.

A. Semantics function

The most important main functions of the SSF system are template-based annotations and semantic REST API. Template-based annotation can semi-automatically generate semantic data by creating a template necessary to generate semantic data through minimal user input and annotated based on the generated template, unlike existing handcraft annotations. Semantic Rest API is implemented in the form of REST API so that semantic data can be used without understanding SPARQL and can be used in smart city services.

1) Template-based annotation: The template-based annotation works based on the smart city ontology. Figure 1 shows the process of semantic annotation in SSF. ATCI is an annotation template creation interface that generates ontology templates by receiving user input so that semantic annotations can be made semi-automatically. ATCI helps create a domain corresponding to the semantic data that the user wants to create as an ontology template based on the rules of the common ontology already established in the smart city. The ontology template is created according to the triple structure required for semantic annotation when object properties and data properties, which are components of semantic data, are selected from the common smart city ontology for a specific domain.

The ontology template created by ATCI is stored inside the SSF, and as smart city data is collected by smart city data API, the annotator creates semantic data by mapping the resources at the same time. Figure 2 is an example of ontology template. The generated semantic data is verified through validation to see if it conforms to the rules of the smart city common ontology and then is stored in the triple database (TDB), a database dedicated to semantic data.

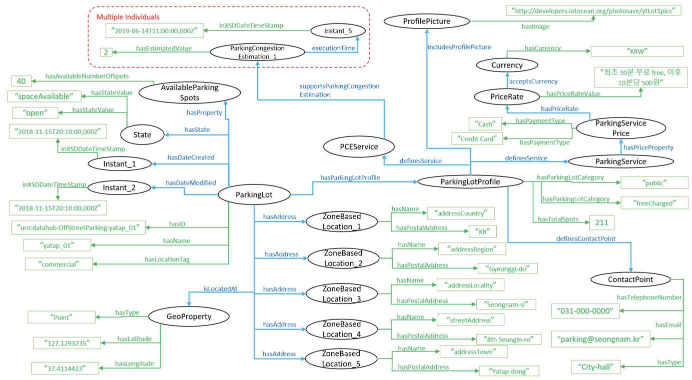

Fig. 2. Example of ontology template

2) Semantic REST API: Semantic Rest API of SSF is designed to enable users to search and discover semantic data without knowledge of SPARQL, a query language dedicated to semantic data. Semantic data can be provided in various forms, such as JSON and OWL, and various types of search results such as graph unit search, ontology search, and keyword search are derived.

B. architecture

Figure 3 shows the configuration diagram when providing linked open data (LOD) service using the semantics framework within the smart city. The data core module collects data from various domains collected in the smart city, integrates it with the data schema predefined in the smart city, and delivers

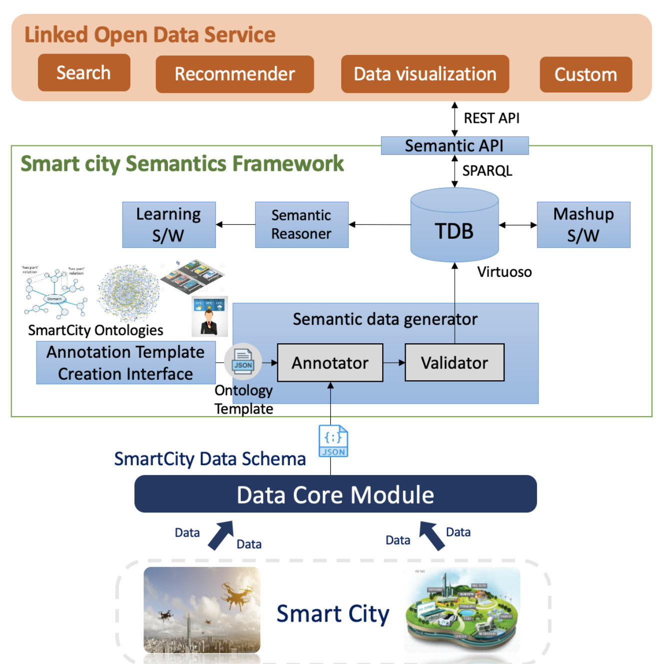

Fig. 3. Architecture of SSF system

it to the SSF with smart city data API. The SSF converts the received data into semantic data, stores it in the TDB, which is dedicated storage for semantic data, and supports the use of semantic data in the linked open data service through the semantic API. The SSF includes an annotation template creation interface and a semantic API, which are tools that help users use semantic data without a high-level understanding of semantics. The modules composing the semantics framework are as follows.

1) ATCI: The ATCI is a tool for creating ontology templates so that annotators can operate with minimal human intervention when generating semantic data. It helps creates ontology templates. Based on the existing ontology or the newly introduced ontology, it helps Smart City create a new ontology template by selecting conditions according to the domain the user wants to introduce.

2) Semantic data generator: The semantic data generator consists of an annotator that generates semantic data and a validator that verifies the generated semantic data. Based on the ontology template created in the template creation interface, semantic data is generated according to the rules, and the correct structure is verified according to the smart city ontology rules. In this paper, semantic data validation was performed using HermiT [4].

3) TDB: The TDB is a store dedicated to semantic data, and it is possible to store the smart city ontology along with the semantic data in the triple form. In this paper, the open software Virtuoso Universal Server is used as the triple storage [5].

4) Semantic Reasoner: Semantic reasoning refers to a function of generating new high-level knowledge data based on a predefined rule. In this paper, if the triple data stored in the TDB meets a specific condition, the semantic reasoner creates a new triple data and forms a new relationship. The newly created knowledge data is used as training data for the learning software and continuously learns the results.

5) Mashup S/W: A semantic mashup refers to a function that organically connects data by linking with each other by forming a new relationship between different domains. In this paper, the mashup software creates a link between the parking lot of a smart city and multiple domains such as weather and air quality to derive new services.

6) Semantic API: The semantic API supports various functions in the form of REST API so that semantic data can be utilized without the knowledge of SPARQL. Since semantic data includes information on the connection between data, information on the complex connection between semantic data can be retrieved, but knowledge of the semantic query SPARQL is required. Services that open semantic data, such as national bibliographic LOD [6] and Ministry of Foreign Affairs OPEN DATA portal [7] , are increasing, but one of the reasons for not increasing the reusability of such semantic data is SPARQL, which is difficult to access.

The semantic API of the semantic framework proposed in this paper supports the REST API format so that users can search and utilize semantic data without using SPARQL.

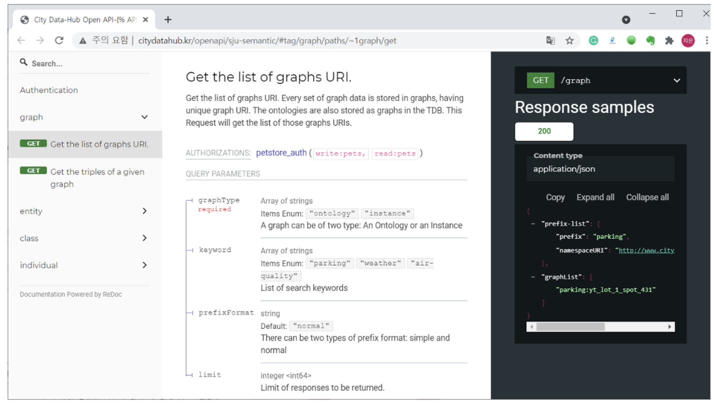

Fig. 4. Open API homepage

Semantic API provides not only direct search for desired data, but also various functions such as related data search according to the meaning of the data to be searched, specific relation search, ontology search, and semantic class search. In addition, as shown in Figure 4, it is disclosed as an open API so that anyone can utilize and use semantic data (http://www.citydatahub.kr/).

III. Conclusion

In this paper, a semantic framework is proposed to increase the reusability of semantic data used in the smart city environment. Although services that open semantic data are increasing due to the value and advantages of semantic data, the frequency of use is insufficient compared to open semantic data because a high level of understanding is required to utilize semantic data. In this paper, we propose a semantic framework including a template-based annotator and a semantic REST API to support the creation and use of semantic data freely, even for users without a high understanding of semantics. In addition, by releasing it as an open API, anyone can use it and it is expected that it will become a basis for creating new services.

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