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Linked Data Construction and Utilization of Public Data for Tourist Information Service

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Abstract **—** Korea, as well as other developed countries in the field of information technology, is making various efforts to enhance the industrial competitiveness, not to mention the competitiveness of information services, by constructing and utilizing a data model through private use of public data and production, distribution and utilization of data. The purpose of this study is to design an ontology for tourist information service and construct linked data for 44 public data held by the City of Seoul to enhance the tourist information service. To do this, we analyzed the attributes of domestic public and tourist information and examined data linkage method. In other words, we added classes and properties to express tourist information based on schema ontology to link the information with external data, and proposed a method of providing tourist information using the linked data. The results of this study can reduce the time and costs for various private and public organizations, which use tourist information, in acquiring the tourist information, and help improve the industrial competitiveness through distribution and utilization of public data.

Keywords - *Linked Data Construction; Tourist Information Service; Public Data Utilization; Ontology Modelling*

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I. INTRODUCTION

Advanced countries in the field of information are making efforts to improve productivity by disclosing, utilizing and sharing public data held by the government. Korea is also trying to provide customized services and create jobs, through communication and cooperation among government departments, by actively disclosing and sharing information held by the government and thus getting rid of barriers among the departments. As part of this, various efforts are being made to introduce data models to facilitate private use of public data and production, distribution, and use of the data, along with the release of Government 3.0. Local governments are also making efforts to improve the accessibility and usability of data, centering on highly public data they hold.

Linked data is a technology for disclosing and sharing data in the web environment [1], which has been used as a method for disclosing public data. Developed countries like the United States and the United Kingdom disclose data through linked data and, in Korea, local governments and public agencies also use the linked data as a means for disclosing public data [2].

Seoul intends to effectively provide the information necessary for foreign tourists, focusing on tourist information. When tourists can acquire the tourist information about Seoul promptly and with ease and quickly from public data, it will improve the level of their satisfaction with tourist and attract more tourists. The purpose of this study is to choose public data from the tourist information Seoul has, to design an information model to utilize it for the tourist service, and to build data suitable for the model. In other words, this study aims at developing a model to link and utilize public data as tourist information and suggesting ways to build suitable data.

In this study, we modeled a tourist information ontology by analyzing the classes, relationships, and properties of data registered in "Seoul Open Data Plaza", domestic public data, and external ontology. We also examined methods to construct tourist data as linked data and utilize it for tourist information service. Chapter 2 describes the related studies to construct and utilize public data as linked data and the studies about utilizing ontology for tourism; Chapter 3 ontology modeling and linked data construction for tourist information service; Chapter 4 information service plans using the linked data; and Chapter 5 conclusion and future studies.

II. RELATED STUDIES

Public data produced and held by the government is recognized and appreciated for its authority and value in our society, but it is not easy to access and utilize the public data due to the heterogeneity and complexity of data sources and types [3]. Raising the competitiveness of information through production, processing, and utilization of information by building a data ecosystem for the public data retained by the government has a significant impact on improving the industrial competitiveness. The United States and the United Kingdom are making efforts to build, disclose, and utilize public data. The US has disclosed more than 190,000 datasets in 14 categories including agriculture, climate, consumer, ecosystems, education, and energy through the "data.gov" site [4]. It has created a platform where the government and the private sectors can share data, by disclosing the public data the government retains and allowing the public to freely utilize and fuse them. The UK also has disclosed more than 40,000 datasets via the "data.go.uk" site [5]. In addition to their efforts to ensure transparency in public data and services, the UK continues striving to create value of the data it provides through the site. Although Korea has had more than 20,000 data disclosed through "data.go.kr" site, it is still far less than the US and the UK in terms of data types, size, and data services.

Studies utilizing ontology to automatically generate tourist guide information have been carried out [6, 7, 8, 9]. Hagen *et al.* [6] developed a mobile agent that computes a few hours' itinerary to travel around the city and used the ontology to identify tourist information and tourists' interests. Jakkilinki *et al.* [7] developed a semantic web-based intelligent tour planning tool, by comparing the tourists' needs and the

contents of travel products using the travel ontology. The ontology was used to provide domain information that both people and machine can understand. Park *et al.* [8] proposed a tourism domain ontology composed of the information about tourist sites and their locations and a travel service application ontology for various intelligent travel services. They also developed an ontology-based intelligent ubiquitous tourist information system for interactive tourist information service suitable for both travel service agencies and tourists in the ubiquitous environment. Kanellopoulos [9] developed an ontology on tourist information to find a package tour suitable for user's needs and then, using the ontology, conducted research to help search package tours suitable for personal travel environment.

III. Ontology Modelling of Public Data

The process of modeling an ontology and constructing data as linked data requires several steps such as data selection, analysis, and transformation. In this study, the process of modeling an ontology for tourist information and constructing data into linked data consists of the following 5 steps as shown in Fig. 1.

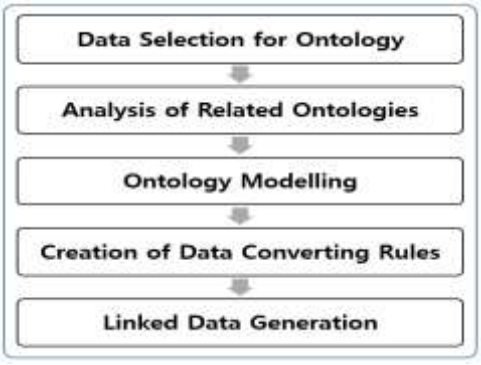

Figure 1. Process for Ontology Modelling and Linked Data Construction.

A. Data Selection for Ontology

This is a process of selecting data required for constructing an ontology and providing services. Seoul provides public data for various areas such as administration, culture, tourism, environment, health, and education through 'Seoul Open Data Plaza' to promote the disclosure and utilization of public data [10]. For public data to be used by users, private companies, or other public agencies, it is necessary to provide various data along with the application of a standard model of the disclosed public data. Linked data is a data standard to disclose data and utilize it in linkage, which has been actively used both at home and abroad, and Seoul also provides data available on the Seoul Open Data Plaza in the form of linked data through "LOD Live Service".

TABLE I. Public Dataset for Tour Information Service

Category	Number of Dataset	Dataset (Sample)
Tour	19	Tourist Street, Visit Seoul, Tourist Information Center
Education Institution / Administrative Agency	6	Public Enterprise, University, Citizens' Self-Government Center
Traffic	1	Bus Stop
Shopping	4	Traditional Market, Restaurant, Shopping Mall
Accommodation	3	Hotel, Motel, B&B
Historical Place/ Cultural Place	6	Cultural Heritage, Museum, Temple
Medical Institution	3	Hospital, Pharmacy, Automatic Defibrillator
Convenience Facility	2	Public Wi-Fi, Post Office
Total	***44***	***Related to Tour Information***

Table 1 shows 44 public data used for ontology modeling and linked data construction in this study. Public data to be built as linked data includes tourist information, cultural heritages, educational institutions, administrative agencies, shopping centers, accommodation, medical institutions, historical places, cultural properties, and other convenience facilities. The data is provided in an excel file provided by the department that manages the corresponding data.

B. Analysis of Related Ontologies

One of the most important parts of the ontology design process is how to link the data with disclosed external data. To do this, it is important to link vocabulary and address system of the ontology to ontology models that can be mutually compatible or shared. The process of investigating and analyzing the related ontology is a necessary step to define an accurate knowledge representation method for the domain, through which the reusability of the existing ontology as well as the generality of the ontology to be constructed are determined. Therefore, it is necessary to analyze the existing ontology to define vocabulary and concepts for constructing the ontology.

Friend of A Friend (FOAF) is a technology that makes it easy to share and utilize information about others, to transfer information between websites, and to automatically expand, merge and reuse information online. Simple Knowledge Organization System (SKOS) provides various knowledge structuring methods to share and reuse knowledge. Dublin Core (DC) provides a set of metadata elements to describe information resources in all fields. Schema.org [11] is a collaborative community activity with a mission to create, maintain, and promote schemas for structured data on the web, email messages, and beyond. The schema.org defines Action, CreativeWork, Event, Intangible, Organization, Person, Place, and Product types, and their respective sub-types and properties. The Juso ontology [12] can be divided into Address Terms to express addresses, Core Terms to express the fundamental characteristics of geography, and Political Division Terms to express political administrative zones, and includes 30 classes and 29 attributes.

C. Ontology Modelling

This process defines the classes and properties that constituting the ontology in consideration of services to be provided. It is possible to use classes and attributes defined in the existing ontology, or use new classes and attributes after establishing the relationship with those in the existing ontology. The tourist information service ontology uses the vocabulary provided by FOAF, SKOS, and DC, and defines classes based on the schema.org. The linkage with cultural properties, administrative districts, and subway information available on the Seoul Open Data Plaza is taken into consideration, and the

Juso ontology is used to link location information. The added classes and properties use Seoul as a namespace.

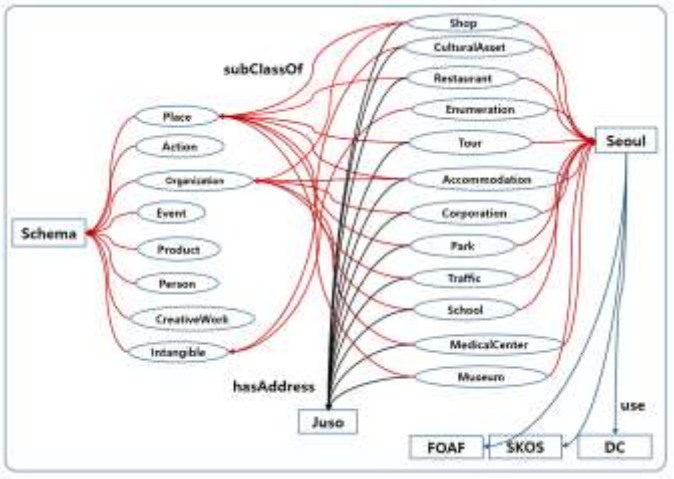

Figure 2. Relationship between Seoul and External Ontologies.

The tourist information ontology can be classified into 12 concepts in relation to subclasses of the types defined in schema.org as shown in Fig. 2, such as Shop, CulturalAsset, Restaurant, Enumeration, Tour, Accommodation, Corporation, Park, Traffic, School, MedicalCenter, and Museum. It can be further classified as shown in Table II, and 127 subclasses are added under the sub-types according to schame.org. Also, 197 properties are additionally defined to express tourist information. The additional properties are used to express historical facts of cultural assets, operating hours and admission fees for tourist sites, and restaurant types.

TABLE II. CLASS HERARCHY OF ONTOLOGY

schema.org Type	Subclass
Enumeration	Certification(FoodCertification), BusinessType(FoodBusinessType, LodgingBusinessType), BusinessCategory(FoodBusinessCategory, LodgingBusinessCategory), Genre(CulturalGenre), ReservationType, ReservationServiceStatueType, PublicServiceCategory, ServiceTargetCategory, ParkingFacilityType, ParkingFacilityOperationType, IOTUserType, ParkingFacilityAssignmentType, SubwayLine, Direction, WaterworksType, ClosureReasonType, MICECategory, FoodservicesType, OperationType, WifiType, PostOfficeCategory, HotelGrade, SmokingAreaType, EducationalOrganizationType, MICEType, EducationalOrganizationStatusType
Intangible	RevervationInfo, OperationHours, Measurement, CulturalAsset(HouseCulturalAsset, ArchitectureCulturalAsset, StorytellingItem, GovernmentOfficeCulturalAsset, PalaceCulturalAsset, PavilionCulturalAsset, CastleCulturalAsset, ShrinCulturalAsset, SculptureCulturalAsset, ReligionCulturalAsset, GroundplotCulturalAsset), PublicWifi, TourismThemeTrail, Cardioverter
ParkingFacility	PublicParkingFacility, PersonalParkingArea
CivicStructure	SubwayManagementOffice, SmokingArea, Toilet(PublicToilet, SharedToilet), CulturalCenter, BikeStation, BotanicalGarden
MedicalOrganization	MedicalTourCertificatedMedicalOrganization
Campground	AutoCampground
Park	NationalPark, CityPark, NeighborhoodPark. MiniPark,
Place	Sanctuary(EcologicallyProtectedArea, NaturalReserve), RoyalTomb, HistoricalSite(HistoricalTree), IOTLocation TraditionalCultureExperienceCenter, WasteBasket, CleanigWeakArea
LodgingBusiness	Inn, Condominium, Pension, GoodStay, KoreanStyleStay, GuestHouse
HighSchool	SpecialPurposeHighSchool, PrivateHighSchool
CollegeOrUniversity	College, CyberUniversity, IndustrialUniversity, TechnicalUniversity, TeachersCollege, CorrespondenceCollege
GovernmentOffice	LocalPoliceAgency
PoliceStation	PloiceSubstation, PatrolDivision
TouristAttraction	TouristAttractionStreet, TouristAttractionZone, FilmPlace, JongnoguTouristAttraction, JungguTouristAttraction
Store	TraditionalStore, DutyFreeStore, HandicraftWorkshop ChinaPaymentApprovalOutletStore, SouvenirStore ChinaPaymentApprovalDepartmentStore, ThemeStore, DiscountStore, ChinaPaymentApprovalDiscountStore
Mountain	RecreationForest
Restaurant	KoreanRestaurant(KoreanTrationalRestaurant), WesternRestaurant, AsianStyleRestaurant, MeatRestaurant, JapaneseRestaurant, ChineseRestaurant VegetarianRestaurant, HalralRestaurant
TouristInformationCenter	MovingTouristInformationCenter, PerformanceTouristInformationCenter
LandmarkOrHistoricalBuildings	ITSeoul
EventVenue	UniqueVenue, ConventionCenter
Hotel	ConventionHotel
SportsActivityLocation	TrainingCenter
Corporation	PublicCorporation, PublicEnterprise
SingleFamilyResidence	KoreanTraditionalHouse

D. Creation of Data Converting Rules

In order to convert CSV-type existing data into Resource Description Format (RDF), conversion rules are required. The rules shall include the following:

- Namespace: Defines with lod.seoul.go.kr/resource.
- Instance: Defines rules to designate a class for an instance and allocate Uniformed Resource Identifier (URI).
- Data Property: Defines data type of domain, property name, and range.
- Object Property: Defines the method to search instances to be referred to by domain, property name, and range.

E. Linked Data Generation

In the process of generating linked data, CSV files are converted into RDF files according to the above-mentioned conversion rules. For tourist information, basic data is written in Korean. However, and the service users are foreigners, object names and addresses are translated into English, Japanese and Chinese and added to RDF files. Fig. 3 shows an

example of the converted RDF files. Fig. 3 shows the type, address, administrative division, latitude and longitude information for the tourist street.

```
@prefix :        <http://lod.seoul.go.kr/resource/> .
@prefix dc:      <http://purl.org/dc/elements/1.1/> .
@prefix geo:     <http://www.w3.org/2003/01/geo/wgs84_pos#> .
@prefix foaf:    <http://xmlns.com/foaf/0.1/> .
@prefix sr:      <http://lod.seoul.go.kr/resource/> .
@prefix tmon:    <http://t-mon/> .
@prefix juso:    <http://rdfs.co/juso/> .
@prefix schema:  <http://schema.org/> .
@prefix rdfs:    <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dct:     <http://purl.org/dc/terms/> .
@prefix seoul:   <http://lod.seoul.go.kr/ontology/> .
@prefix owl:     <http://www.w3.org/2002/07/owl#> .
@prefix rdf:     <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix skos:    <http://www.w3.org/2004/02/skos/core#> .

sr:BE_IW01-0072_address
        a       juso:RoadNameAddress ;
        <http://rdfs.co/juso/kr/eup_myeon_dong>
                sr:Sogongdong ;
        <http://rdfs.co/juso/kr/si_do>
                sr:Seoul ;
        <http://rdfs.co/juso/kr/si_gun_gu>
                sr:Jung-gu_Seoul .

sr:BE_IW01-0058_geometry
        a       geo:Point ;
        geo:lat "37.568058597" ;
        geo:long "126.9788194313" .

sr:Bangbaedong
        a       juso:AdministrativeDivision ;
        juso:name "방배동"@ko .

sr:BE_IW01-0001
        a       juso:SpatialThing , seoul:TouristStreet ;
        rdfs:label "북악산길산책로"@ko , "북악산길"@ko ;
        juso:address sr:BE_IW01-0001_address ;
        juso:geometry sr:BE_IW01-0001_geometry ;
        juso:historical_address
                sr:BE_IW01-0001_historicalAddress ;
        schema:name "북악산길산책로"@ko , "북악산길"@ko .

sr:BE_IW01-0006_historicalAddress
        a       juso:Address ;
        juso:full_address "서울시 금천구 가산동 일대" ;
        <http://rdfs.co/juso/kr/eup_myeon_dong>
                sr:Gasandong ;
        <http://rdfs.co/juso/kr/si_do>
                sr:Seoul ;
        <http://rdfs.co/juso/kr/si_gun_gu>
                sr:Geumcheon-gu .
```

Figure 3. RDF of a Tourist Street (Example)

Verification of the results of linked data generation is done by validating the result of query through SPARQL for the sample data.

IV. Tour Information Service using Linked Data

It is possible to use and access a variety of information about cultural assets, tourism, medical institutions, accommodations and shopping, held by Seoul, easily through linked data. When a data ecosystem is built, a virtuous cycle of data required for tourist information becomes possible through production-processing-utilization by tourists, small and medium-sized enterprises and public institutions.

- Tourists: Tourists who wish for medical tourism can acquire information about accommodation, sightseeing and shopping as well as medical institutions, easily and quickly at one spot. They can search for a hospital > nearby tourist attractions using the hospital address > accommodations around tourist attractions > public transportations > nearby shopping locations and available shopping items > restaurants in turn. Using one word (hospital, cultural property, shopping, location, it is possible to access various types of information disclosed with linked data at once and easily and quickly acquire additional information about the matter of interest.
- Small and medium-sized enterprises: They can develop new information services by linking private data they own and public data, and acquire reliable tourist information with ease to utilize it for stable services. In addition, they can use linked data to design, do marketing for, and sell new tour products.
- Public Institutions: They can provide various types of public data they generate promptly, and maximize data utilization through linkage with private data.

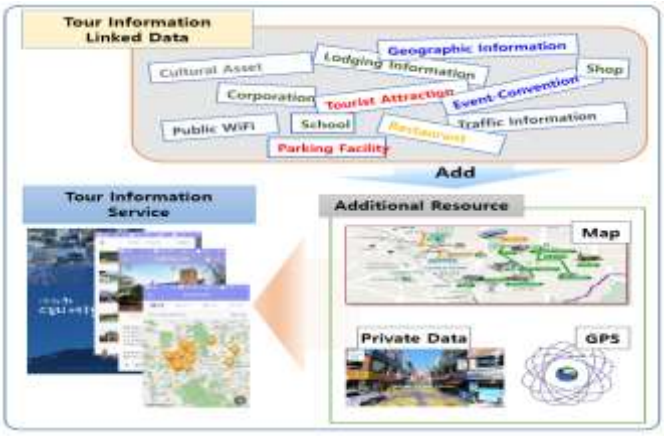

Figure 4. Tour Information Service using Linked Data

When diverse reliable public data is linked and made easy to access, it can be combined with maps, private data, and GPS data as shown in Fig. 4, to facilitate development of services that can effectively deliver information to users in the mobile environment.

V. Conclusion

As construction and sharing of public data becomes active, various supplementary services are being developed through linkage of public and private data. In particular, standardized data representation and approach are needed to enhance the utilization of public data, and linked data is recognized as a suitable technology for sharing and utilizing data in the web environment.

In this study, we modeled a tourist information ontology which is needed to provide tourism services, out of 44 public data held by Seoul, and constructed linked data through data conversion. In order to link various information such as cultural assets, accommodations, shopping, institutions, schools, and traffic, we modeled the tourist information ontology based on Schema ontology, and converted the CSV-format data into RDF according to the conversion rules. To do this, we analyzed the attributes of domestic public and tourist information, and considered ways to link them with external data. Since various types of data are provided as linked data, it is possible to save the time and costs required for acquiring information from various private and public institutions that generate and/or use tourist information. In other words, when information accessibility, economic efficiency and quality are ensured and it becomes possible to various types of data, it can help improve the competitiveness of the information service industry.

In the future, it is necessary to expand types and the scope of data as well as enhancing the linkage with the data held by Seoul, so that other data than tourist information can also be liked for utilization. It is also important to maintain up-to-date data through continuous data updates.

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