International Journal of Engineering & Technology, 8 (1.4) (2019) 316-322

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Integrated Vehicle Service Platform based on Ontology Learning for Connected Car

Minwoo Ryu[1], Si-Ho Cha[2]*

[1]*Service Laboratory Institute of Convergence Technology, KT R&D Center*
151, Taebong-ro, Seocho-gu, Seoul, South Korea
[2]*Dept. of Multimedia Science, Chungwoon University*
113, Sukgol-ro, Michuhol-gu, Incheon, 402-803, South Korea
**Corresponding author E-mail: shcha@chungwoon.ac.kr*

Abstract

The recent efforts in academia and industry represent a paradigm shift that allow to emerge connected car. Furthermore, the fifth-generation (5G) technology accelerates realization of the connected car era. In the connected car services, the 5G enables to provide high-speed communication between vehicles to change information. In particular, they can exchange bulk data in very short period using the technology. Accordingly, connected car services would provide intelligent services. For example, they can provide self-driving service without human control. Here, the vehicles would exchange data collected from their environments to determine driving path or controlling. Furthermore, they can control diverse devices such as home appliances according to requirement of drivers. To support the services, connected car services consists of four type's service categories corresponding to their support types: vehicle to vehicle (V2V); vehicle to infrastructure (V2I); vehicle to pedestrian (V2P) and vehicle to network (V2N). In other to provide more intelligent connected car services in each service category, we propose a novel service platform named for an integrated vehicle service platform (IVSP) to integrate existing connected car services. To this end, we develop an ontology-based service repository to save and register vehicle services. We also develop a web-based service composition tool. To show the feasibility of IVSP, we develop a prototype service for intelligent vehicle service (i.e., home appliances controlling) using IVSP. We expect that our proposed platform could eventually contribute to providing people in connected car services.

Keywords: *Semantics, Autonomous vehicle services, cognitive services, service composition, service authoring, OWL, OWL-S*

1. Introduction

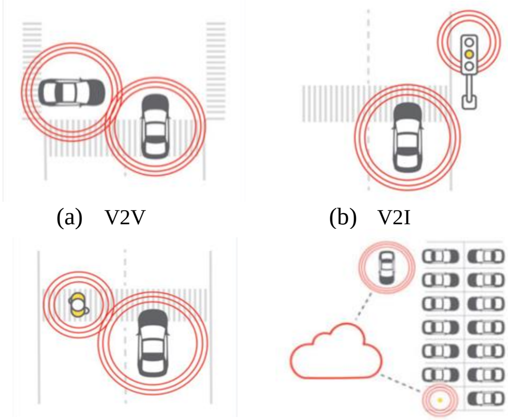
The recent efforts in academia and industry represent a paradigm shift that allow to emerge connected car. Furthermore, the fifth generation (5G) technology accelerates realization of the connected car service era. In the connected car services, the 5G technology will help speed future transition between connected and autonomous vehicles [1]. Accordingly, the 5G technology allows to exchange bulk data in very short period between vehicles, and then provide more intelligent vehicle services [2].

As shown in Figure 1, connected car services generally consists of four service categories corresponding to their support service types: vehicle to vehicle (V2V); vehicle to infrastructure (V2I); vehicle to pedestrian (V2P); and vehicle to network (V2N) [3]. The V2V describes services between vehicles. Hence, in the service, vehicles focus on driving through exchanging information such as speed, road lane, and road conditions. The V2I describes services between vehicle and infrastructure. Here, various application services such as grid system and cloud-base system are studying by many researchers [4][5]. The V2P describes service between vehicle and pedestrian [6]. Hence, in this category, vehicles focus on safety service for human. For example, traffic signal information can be used to alarm service to vehicle when pedestrian cross the street at a crosswalk. Finally, the V2N describes service between vehicle and another network [7]. In here, vehicles use public network to interwork other applications.

The goal of connected cars is to enable intelligent services via integration of services. To this end, we need an integrated service system infrastructure including platforms and applications. For this, in this paper, we propose a novel service system infrastructure named for an integrated vehicle service platform (IVSP).

The proposed IVSP is designed to support existing vehicle services. To do this, the IVSP provides an ontology-based service repository. The ontological model located in the reposition is designed to support Semantic Markup for Web Services (OWL-S). OWL-S is an ontology, within the web ontology language (OWL)-based framework of the semantic web [8]. It describes semantic web services, and enables users and applications to automatically discover, invoke, and compose regarding the web services. From these advantage of the OWL-S, it is used to support integration or interoperability of between existing services [9-11].

Therefore, vehicle service developers and providers can register their service to the IVSP without convert their service format. In addition, we use OntoLearn ontology learning system [12] to support dynamic vehicle services and to provide updating repository in real-time. The OntoLearn is a methodology for automatic learning of domain ontologies. Accordingly, the proposed IVSP can easily create and update their ontological model when a new service is registered in service repository of IVSP. We also implement the web-based registration tool to support that vehicle service developers and providers can define their APIs including create, read, update, and delete (CRUD) method. The web-based registration tool sends the information to the IVSP corresponding to the representational state transfer (RESTful) API provided by the IVSP. A RESTful API is a method of allowing communication between a web-based client and server that employs REST constraints.



(a) V2V (b) V2I

(c) V2P (d) V2N

Fig. 1: Four service categories of connected car services

Finally, to show the feasibility of the IVSP, we develop a prototype service for an intelligent vehicle service, named for home appliance controlling, using the IVSP. The prototype service provides automatic home appliance controlling according to weather condition. To this end, the IVSP work with existing the Internet of Things (IoT) service platform, named for Mobius [13].

The rest of this paper is organized as follows. The existing related work in this research field is introduced in Section 2. The detail description of the IVSP is presented in Section 3. Section 4 presents a performance evaluation of the IVSP through a developing prototype service. We discuss practical issues to support integrate existing service in Section 5. Finally, we conclude our remarks in Section 6.

2. Related Works

In this section, we introduce related works in this research field. The term connected car, introduced by General Motors with OnStar in 1996, has been growing technical trend in nowadays. It would allow to connect devices to other devices within in the vehicles and/or devices, networks and services outside the car such as home, office or infrastructure [14].

Tobias *et al.* proposed prototyping of telematics services [15]. In this article, they provide a prototyping platform for connected car and reusable application template. To this end, they applied Christoph Fehling and his colleagues' design process [16] to the platform and template. And then, they consider a certain set of the cloud computing patterns about each step of the process to use in the application architecture. Accordingly, developers could build their application prototypes using provisioning template in the proposed platform. Consequently, the proposed platform provide environment in order to easily create their connected car services.

Hassan *et al.* proposed novel V-Cloud architecture which includes vehicular cyber-physical system (VCPS), V2V, and V2I [17]. In this article, the proposed architecture combines the concept of the Vehicular Ad-hoc Network (VANET), Cyber Physical System (CPS), and cloud computing to provide safety and comport service to driver. To this end, the proposed architecture is divided into three layers including in-car vehicular cyber-physical system, vehicle to vehicle network, and vehicle to infrastructure layers. Each layer is used to support communication with other vehicles, service system infrastructures, and users' smartphones. In particular, in-car vehicular cyber-physical system layer is used to collect condition of driver and vehicle, and then send the condition data to infrastructure in order to provide services. Accordingly, the proposed architecture would provide the Intelligent Transport Service (ITS). Although these research works provide environment for creating new connected car services and realize ITS, they could not support and integrate existing connected car service.

Ryu *et al*. proposed integrated semantic service platform IoT [18]. In this research work, the proposed platform could support ontological model in various IoT-based service domain of smart city. In particular, they resolved three main problem in order to provide integrated semantic services together with IoT systems. They also show feasibility of the proposed platform through a prototype service, named for smart office. However, this research work does not support dynamic update ontology.

Michael *et al.* proposed automotive ontology for vehicle [19]. The proposed ontology represents core of the car's information system. In addition, they consider overall system from in-vehicle to application services. The proposed ontology consists of two main models including the User Model and Context Model. Accordingly, the proposed ontology could contribute to enhance intelligent vehicle services. However, this research work focuses on design ontology. Hence, in order to apply the ontology to integrate service system infrastructure for connected car domain, we have to know all of meaning of the ontology.

Due to several technological advances, many researchers have been trying to realize connected car services by interworking with diverse service domains such as home, office, and building. However, to provide connected car service, existing services in diverse domains are integrated and provided in one service system infrastructure. In this perspective, we proposed a integrated vehicle service platform.

3. Integrated Vehicle Service Platform

In this section, we describe our proposed platform named for an integrated vehicle service platform (IVSP). IVSP enables to integrate existing diverse services using an ontological model. To this end, we applied OWL-S to our platform. Accordingly, developers and service providers can register their service to the ISVP without convert their service format. Figure 2 shows the overall concept of the proposed IVSP.

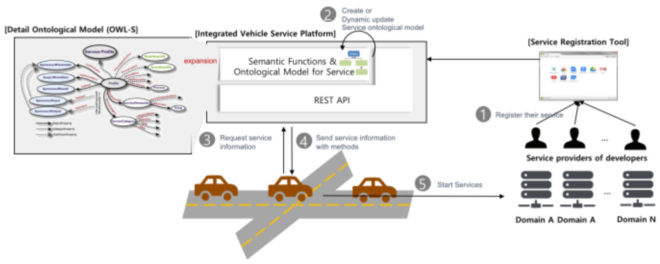


Fig. 2: Overview of IVSP

First, developers or service providers in each service domain register their service using web-based registration tool provided by the IVSP as shown in Figure 2-①. At this time, they can define their APIs including CRUD method. After registration of their service, the web-based registration tool sends the information to the IVSP corresponding the REST API provided by the IVSP. In this procedure, the IVSP creates or updates current ontological model stored in service repository of IVSP as shown in Figure 2-②. Here, to support integrated vehicle service, the ontological model designed by OWL-S [20]. Furthermore, to dynamically create and update ontological model, we apply OntoLearn to our method. Accordingly, the IVSP can easily create and update their ontological model when a new service is registered in service repository of IVSP. Now, the IVSP is ready to provide the connected car service to vehicles or drivers. In order to start the service, vehicles or drivers request service information according to their requirements as shown in Figure 2-③. In this procedure, the IVSP searches service information in the service repository using semantic functions (e.g., SPARQL), and then sends the information with the APIs registered by developers or service providers to the vehicles as shown in Figure 2-④. Finally, vehicles or drivers request starting service to start via accessing service domain platform as shown in Figure 2-⑤.

3.4. Ontological Model

In this section, we introduce ontological model stored in service repository of the IVSP. The ontological model is designed to support OWL-S. Accordingly, the ontological model complies with W3C standard. Nevertheless, to support dynamic creating and updating ontological model according to services registered by web registration tool, we use four main top classes including class of Service, ServiceProfile, ServiceGrounding, ServiceModel and CRUDmethod. Figure 3 shows our ontological model base on OWL-S.

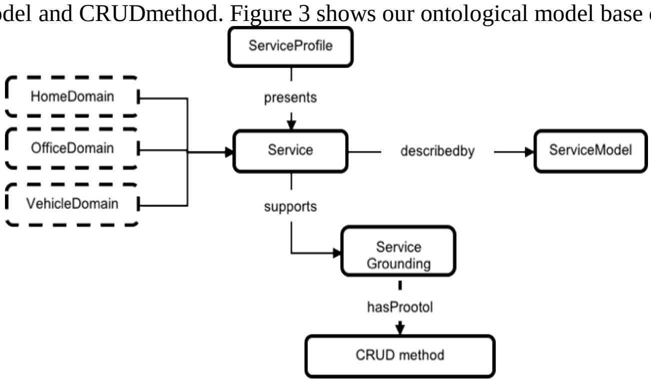


Fig. 3: ontological model (excerpt)

In the ontological model, the Service class represents the service domain such as home, office, and vehicles. The class ServiceModel represents the method to control services and it has the relationship with class ServiceProfile, class ServiceModel, and class ServiceGrounding via object properties including presents, describeby, and supports, respectively.

In addition, class Service has some subclass such as HomeDomain, OfficeDomain, and VehicleDomain. The class ServiceProfile represents the description of service. The class ServiceGrounding represents the accessing information of service function (i.e., APIs) and it has the relationship with class CRUDmethod via object property hasProtol. Finally, the class CRUDmethod represents HTTP verb including PUT, GET, POST, and DELETE. Accordingly, we can support RESTful APIs when a service requires interworking with another service platforms.

Although the proposed ontological model defines three main service domain including home, office, and vehicle, service provider and developer can add new service domain in the ontological model. Furthermore, the ontological model supports dynamic creates and updates for a new class and individual corresponding to adding service by using the web registration tool. To this end, we apply the Semantic disambiguation method of OntoLearn to our method. The Semantic disambiguation method uses WordNet, and allows to distinguish multi word term. Accordingly, we use this procedure to create and update classes and individuals. For example, when a new service information is registered in the service repository, the IVSP searches matching term in the ontological model. If matched term is existed in the model, the IVSP creates the individual in matched class. On the contrary, if there is not exist, the IVSP creates a new class using the Semantic disambiguation method.

3.3. Implementation

In this section, we describe the implementation of the proposed IVSP. The ontological model is developed using well-known protégé [21]. In this implementation, we use protégé version 5.0. Figure 4 shows the result of implementation of the ontological model. In Figure 4, yellow circles denote classes and blue boxes denote object properties. Finally, green boxes denote data type properties.

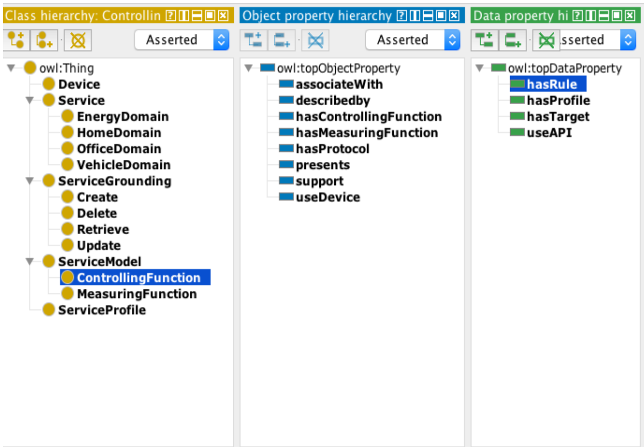


Fig. 4: Implementation result of ontological model using: (from left) classes hierarchy, object properties hierarchy, and data type properties hierarchy.

To register existing services, we also developed the web-based service registration tool using HTML. Accordingly, service providers and developers do not install program in order to register their service. Furthermore, the web-based registration tool also can support all kind of smartphones. Figure 5 shows a snapshot of the implementation of registration tool.

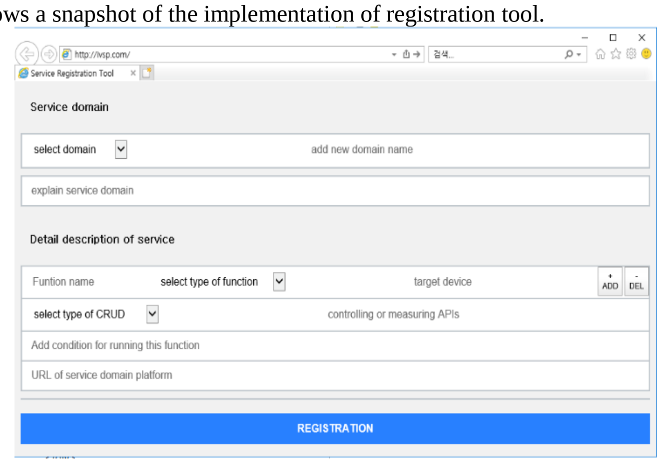


Fig. 5: Implementation result of web-based registration tool

In Figure 5, the target domain is inputted in the first input field. Here, service providers and developers could select predefined domain name. If there is not matched domain, they can select "add new domain", and then input a name of new domain. This domain filed would discover or create from/to the ontological model. Service profile is inputted in the second field. Accordingly, the service provider and developer can explain their service using simple text. This text would represent as an individual of class Service.

After finishing the service input, we can input the detailed description of service using the third field. Here, service provider and developer can input the name of function, the type of function, target device, the method of API, rule, and the URL of targeted service domain platform.

The name of function is represented as an individual of class ServiceModel according to the type of function (i.e, controlling or measuring). Targeted device is represented as an individual of class Device. The method of API is represented as an individual of class ServiceGrounding according to CRUD type (i.e., PUT, GET, POST, and DELETE). Finally, rule is represented as a datatype. Hence, it has a relationship with an individual of class ServiceModel using "useAPI".

Finally, the IVSP is developed using Java, Jena APIs, and Jena TDB on the Apache Tomcat 8.0. In the IVSP, we developed RESTful API in order to connect with vehicles and the web-based registration tool. To this end, we use the spring framework provided by Apache foundation. We also developed various semantic functions in order to create and update the ontological model using Jena APIs. And we developed service repository using Jena TDB and queries for discovering semantic data using SPARQL.

4. Performance Evaluation

In this section, we show feasibility of the IVSP by building a prototype service for the connected car. Here, we evaluate the performance of some functions: (1) dynamic creating and updating ontological model corresponding to service information; (2) performing service controlling or monitoring via interworking with domain service platform. In (1), we evaluate the ontological model focused on schema and its individuals according to the service information added by registration tool. Finally, to evaluate (2), we show some experimental results of a connected car service scenario (i.e., home appliance controlling). In particular, we focus on interworking with domain service platform.

4.1. Service Scenario

The detail service scenario includes: (1) a vehicle measures outside temperature value while it is being driven; (2) if the temperature value is more higher than pre-set value (29 degree) defined by a user, the vehicle requests the home appliance control service to IVSP; (3) After receiving the request from the vehicle, IVSP discovers a matched service using the semantic function; (4) Finally, IVSP sends information to control the service to the vehicle, and then the vehicle requests the control home appliance to domain service platform.

4.2. Evaluation of IVSP

In this section, we describe the evaluation of the IVSP by applying the prototype service (i.e., home appliance controlling). For the evaluation, we develop an experimental vehicle using the Smart video kit [22] with temperature sensor as shown Figure 6. The Smart video car kit allows to embed software into the Raspberry pi and to add diverse sensors into the vehicle. To use Mobius, we download the install software from the OCEAN, and build our testbed service [23]. OCEN is a website and it provide the install software of Mobius via downloading service. The evaluation is composed of three steps according to service scenario: (1) register home applicant to Mobius; (2) register service (i.e., web-based service registration tool); (3) compare the hierarchy of the updated ontological model of IVSP; and (4) verify the results of the experimentation.

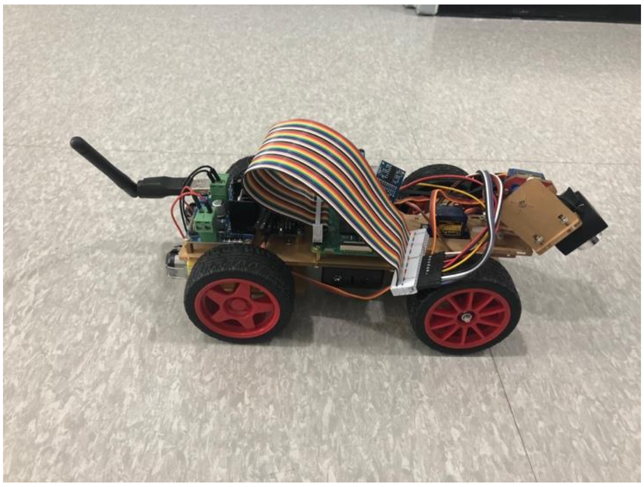


Fig. 6: Experimental vehicle using Smart video kit with a temperature sensor

- Step 1: Register home appliance to Mobius:
  We first perform registration of a fan with smart socket to Mobius. Mobius is an IoT service platform that comply with oneM2M standard. The platform has implemented by KETI. It enables to manage and store the data and virtual devices. Mobius also provide open APIs to control and monitor various IoT devices.

- Step 2: Register service
  We register a home appliance controlling service using the web-based service registration tool. In this step, we input service domain, function, and type of function, rule, API, and targeted service domain platform as shown Figure 7.

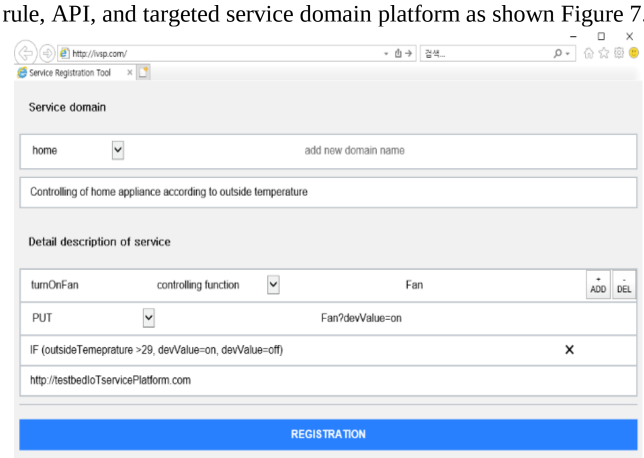


Fig. 7: Snapshot of registration service using registration tool

- Step 3: Compare the hierarchy of the updated ontological model of IVSP
  We compare the hierarchy of the updated ontological model of IVSP using protégé. In this step, we evaluate the first item (dynamic creating and updating an ontological model corresponding to service information). To do this, we focus on a schema of the ontological model and its individuals. Figure 8 shows results of service information added in the ontological model with individuals by type.
  In Figure 8, the red line box denotes new created individual in the ontological model. The value of service profile inputted from the registration tool is created as an individual of class HomeDomain. Accordingly, we can notice that the value of first field of the tool is used to distinguish matched domain. Likewise, the detail service information is created as individual classes of Device, ServiceGrouding, and ServiceModel, respectively, as explained in Section 3.3.

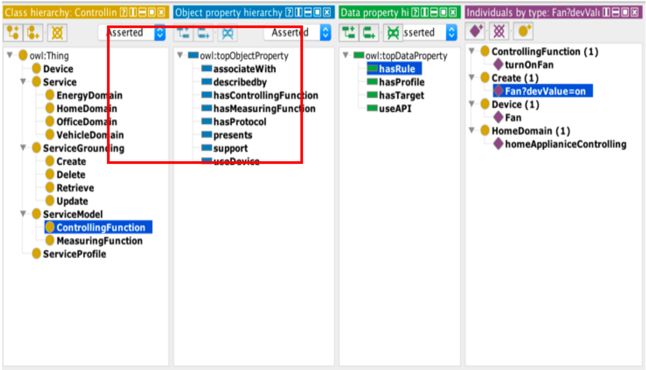


Fig. 8: Results of service information added in the ontological model (red line)

Consequently, we can know that the service information inputted from the registration tool is correctly added in the ontological model and the IVSP allows to dynamically create and update the ontological model corresponding to inputted information.

- Step 4: Verify the results of experimentation

  In this step, we evaluate second item (performing service controlling or monitoring via interworking with domain service platform). We first run the experimental vehicle in our testbed as shown Figure 9, and then we periodically check current temperature as shown Figure 10-(a). We also monitor the fan device registered in the Mobius as shown Figure 10-(b).

  From experimentation results, we can confirm that the IVSP enables fan controlling according to predefined rule through working with Mobius.

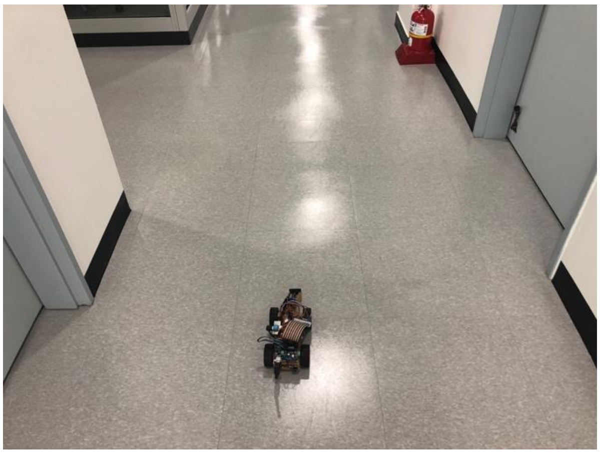


Fig. 9: Snapshot of experimental vehicle running

(a) (b)

Fig. 10: Results of (a) the current temperature value and (b) Fan device control function

5. Discussion

As we have explained a way of integrating services for connected car services in this paper, there might be consider additional practical issues.

To integrate existing services, we use an ontological model which allows to understand and interpret meaning of specification regarding the services as mentioned in Section 3. However, in practical, a service has its own business logics. Accordingly, in order to integrate services, a platform should support business logic of the services. Although we use OWL-S in the proposed platform, this could not support various business logics. Consequently, we consider an efficient way to support various business logics according to requirements of service using OWL-S, which is a challenging task.

Another issue is to consider employing deep learning and reinforcement learning in connected car services. Those technologies enable to predict and decide autonomous actions. For example, the technologies would compose different services according to driver's behaviors. Likewise, the technologies can adaptably react to new situations on roads. Accordingly, this is our next challenging task.

6. Conclusion

In this paper, we have presented an integrated vehicle service platform (IVSP) to provide service system infrastructure in connected car environments. In order to integrate existing connected car services, we developed a web-based service registration tool. Accordingly, service providers and developers can add their services into the IVSP without installation of another software. We have also developed an ontological model based on OWL-S to understand and interpret meaning of service resources Furthermore, to support dynamic creating and updating the ontological model according to inputted service information, we applied OntoLearn to semantic functions.

To show the feasibility of the proposed IVSP, we have developed a prototype service for connected car, which can provide remote control of a home appliance according to temperature value. We also have developed an experimental vehicle using Smart video car kit. Through the evaluation, we have shown that the IVSP can enable the prototype service to perform integration of existing service, semantic discovery, and eventually interworking with another service platform. Accordingly, we can conclude with confidence that the IVSP can eventually contribute to providing people in connected car services.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2016R1D1A1A09917662).

References

[1] Kevin Dennehy, "5G Technology Will Spur Autonomous Vehicle's Growth", Available online: http://insideunmannedsystems.com/5g-technology-will-spur-autonomous-vehicles-growth/ (last visit: 19.06.2018)
[2] Zhu Zhiqiang, Zhao Taifang, and He Chao, "5G shits Connected Vehicles up a gear", available online: http://www.huawei.com/en/about-huawei/publications/communicate/84/5g-shifts-connected-vehicles-up-a-gear (last visit: 19.06.2018)
[3] Weiß, Christian, "V2X communication in Europe–From research projects towards standardization and field testing of vehicle communication technology," Computer Networks (2011), pp. 3103-3119.
[4] Quinn, Casey, Daniel Zimmerle, and Thomas H. Bradley, "The effect of communication architecture on the availability, reliability, and economics of plug-in hybrid electric vehicle-to-grid ancillary services," Journal of Power Sources, Vol. 195, No.5, (2010), pp.1500-1509
[5] Park, Yougho, Chul Sur, and Kyung-Hyune Rhee, "Pseudonymous authentication for secure V2I services in cloud-based vehicular networks," Journal of Ambient Intelligence and Humanized Computing, Vol. 7, No. 5, (2016), pp. 661-671.
[6] Liu, Nianbo, et al, "When transportation meets communication: V2P over VANETs," Distributed Computing Systems (ICDCS), 2010 IEEE 30th International Conference on. IEEE, (2010)
[7] Pillar, Duane R., and Bradley C. Squires, "Equipment service vehicle with network-assisted vehicle service and repair," U.S. Patent No. 6,993,421, (2006)
[8] W3C, "OWL Web Ontology Language for Services (OWL-S)," available online: https://www.w3.org/Submission/2004/07/ (last visit: 4.09.2018)
[9] Sheik Mohammad Mostakim Fattah, Nak-Myoung Sung, Il-Yeup Ahn, Minwoo Ryu, and Jaeseok Yun, "Building IoT Services for Aging in Place Using Standard-Based IoT Platforms and Heterogeneous IoT Products," Sensors, Vol. 17, No. 10, (2017), pp. 1-29.
[10] Saravanan Kannan, Arunkumar Thangavelu, and RameshBabu Kalivaradhan, "An intelligent driver assistance system (i-das) for vehicle safety modelling using ontology approach," International Journal of UbiComp, Vol. 1, No. 14 (2010), pp. 15-29.
[11] Simone Fuchs, Stefan Rass, Bernhard Lamprecht, and Kyandoghere Kyamakya, "A model for ontology-based scene description for context-aware driver assistance systems," In Proceedings of the 1st international conference on Ambient media and systems, ICST, (2008).
[12] Navigli, Roberto, Paola Velardi, and Aldo Gangemi, "Ontology learning and its application to automated terminology translation," IEEE Intelligent systems, Vol. 18, No.1, (2003) pp-22-31
[13] Kim, J., Lee, J.-W., "OpenIoT: An open service framework for the Internet of Things," In Proceedings of the 2014 IEEE World Forum on Internet of Things (WF-IoT), Seoul, Korea, 6–8 March, (2014), pp. 89-93.
[14] Auto connected car news, "Definition of Connected Car-What is the connected car? Defined," available online: http://www.autoconnectedcar.com/definition-of-connected-car-what-is-the-connected-car-defined/ (last visit: 19.06.2018)
[15] Haberle, Tobias, et al., "The connected car in the cloud: a platform for prototyping telematics services," IEEE Software, Vol. 32, No.6 (2015), pp.11-17.
[16] C. Fehling, F. Leymann, and R. Retter, "Your Coffee Shop Uses Cloud Computing," IEEE Internet Computing, vol. 18, no. 5, (2014), pp. 52–59.
[17] Abid, Hassan, et al, "V-Cloud: vehicular cyber-physical systems and cloud computing," In Proceedings of the 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies. ACM (2011).
[18] Ryu, M., Kim, J., and Yun, J., "Integrated semantics service platform for the Internet of Things: A case study of a smart office," Sensors, Vol.15, No.1 (2015), pp. 2137-2160.
[19] Feld, Michael, and Christian Müller, "The automotive ontology: managing knowledge inside the vehicle and sharing it between cars," In Proceedings of the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications. ACM, (2011)
[20] W3C, "OWL-S: Semantic Markup for Web Services," available online: https://www.w3.org/Submission/OWL-S/ (last visit: 19.06.2018)
[21] Protégé, available online: https://protege.stanford.edu/ (last visit 19.06.2018)
[22] Smart Video Car Kit, available online: https://github.com/sunfounder/Sunfounder_Smart_Video_Car_Kit_for_RaspberryPi (last visit 18.01.2018).
[23] OCEAN, available online: http://iotocean.org/main/ (last visit 19.06.2018)