Transforming Vehicles into e-government 'Cloud Computing' Nodes

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Abstract. Nowadays sophisticated vehicles can become autonomous e-government service providers by viewing them as “G-Cloud computing” nodes. By using web services technologies vehicles can offer e-government cloud computing services.

Keywords: vehicular, G-Cloud, e-government, web services, registry, discovery.

1 Introduction

Vehicles have evolved from basic assets into sophisticated devices produced by a conjunction of sciences such as architecture, mechanical and electronic engineering, telecommunications and computer science [1]. This kind of technological invocation continues seeking ways to transform vehicles into autonomous service providers.

Cloud Computing is giving us a new trend and form of technological resources and enterprise services of the Web [2]. Several efforts are being made by the automotive industry to exploit the cloud computing concept on vehicles [3] in order to provide end-users with new kind of services.

In this paper an architecture with which vehicles become Vehicular Service Providers (VSP), acting as G-Cloud Computing Nodes, is proposed utilizing Web Services and Cloud Computing technologies to provide and deliver e-government services whether they are public order vehicles (e.g. police vehicles, ambulances, fire trucks units) or commercial vehicles. This paper is structured as follows: Second section there is an introduction to the concept of cloud computing vehicular services; the third section presents an adaptation of Cloud Computing terms into vehicular terminology; the fourth section proposes a vehicular service discovery mechanism in order for vehicles to become cloud computing nodes. The paper concludes with future research directions.

2 Situation Awareness

Vehicle vendors focus in new technological developments addressing vehicular network requirements in order to enhance vehicular services [3]. Nowadays, web

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enterprises applications utilize in high extend the Web Services technologies over the "Cloud". Several efforts are being made by the automotive industry to exploit the "Cloud Computing" concept on vehicles in order to provide end-users with new kind of services. A powerful example is the partnership for research and development of Ford, Microsoft and Intel with the University of Michigan in order a vehicle to access Windows Azure "Cloud" Platform [4].

Such kind of services can be utilized to enhance e-government service information strategy. The combination of Cloud Computing and Web Services can provide government agencies with innovative creations of new set of services and applications, addressed to citizens, third party application developers and the automotive industry as a whole. Web Services technology can reduce the cost of integration and produce immediate financial advantages with the integration of new systems for deploying services. Additional functionality can be composed using Web Service messages mechanisms [5, 6]. The roles in the operational model of Vehicular Web Services (Fig. 1) are defined as follows: The VSP provides the environment for the deployment and operation of Web Services defines the vehicular services and publishes them.

The Vehicle Service Requestor (VSRq) refers to a Vehicle Client program, which invokes Web Services. The Vehicle Service Registry (VSRg) is responsible for the vehicular service registration.

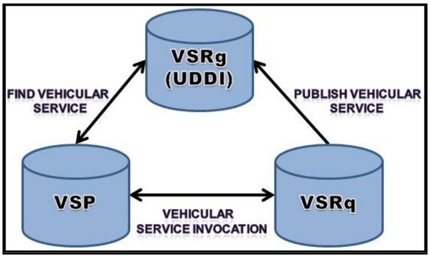

Fig. 1. Operational Model of Vehicular Web Services

The VSRg lists the various types, descriptions and locations of the vehicular services. During the publish service operation, the VSP registers Web Services information in VSRg. The VSRq finds in the Registry information such as service description, interface description and access point. Finally, the vehicle requestor finds the required vehicular service and executes it from the VSP.

This mechanism is a key to overcome actual implementation and standardization issues now that vehicles are becoming intelligent platforms and possess tremendous computational power, capable to host complex applications. Taking vehicles to the next level, is to consider them as computation "Clouds" providing services to other vehicles and various in-vehicle network-capable "terminals". This paper proposes a web service-based model, for offering vehicular services over the G-Cloud.

3 "Cloud Computing" Vehicular Services

In this paper, the term "services" in a vehicle computation G-Cloud, describes how a vehicle or any other network-capable electronic device can use on demand computation assets provided by other vehicles. Vehicles can provide the following Vehicular Cloud Services:

Hardware - Infrastructure as a Service: Is a type of service that can be available in a Vehicle Cloud Computing or G-Cloud. This kind of services offers the hardware infrastructure of a vehicle (e.g. on-board memory, GPS receiver), to users that do not have in their vehicles the same hardware capabilities.

Platform as a Service: A vehicle may provide more than infrastructure. A fully networked vehicle [3] could deliver an integrated set of software and hardware that a developer needs in order to build an application for both software development and runtime.

Software as a service: While vehicle applications are stand-alone applications, companies who want to offer portfolio of next generation, vehicle applications will increasingly rely on shared services between vehicles (e.g. governance, account management, workflow, single-sign-on, social networking).

Network - Internet as a Service: Vehicles with internet access can be used by vehicle users to obtain internet service (e.g. e-mail, RSS feeds) or even be the gateway for users to gain access to any other network or the Web.

Treating traditional vehicle services (e.g. such as navigation, traffic, warning and weather information), as vehicle cloud services, there will be an enhancement in terms of functionality, interoperability and cost effectiveness. Specifically this new view can enhance the notion of e-government such as traffic information and management (cooperative traffic information & forecasting, dynamic free parking space information, location based information and warning), safety and security (e.g. hazard warning, theft recovery, tracking and trace, emergency calls) or comfort (e.g. future adaptive cruise control systems and infotainment systems with music/video on demand or business information) enabling them to offer innovative next generation services. Cloud computing and web services can offer technological and financial advantages in government agencies.

4 Vehicular Service Registry Mechanism

The combination of cloud computing services and vehicles, state that a vehicle with less capabilities than others, could be able to request a service from vehicles that already are equipped with. In the various modes of Vehicle-to-Anything (V2X) communication, network capabilities are under consideration to support new applications and services.

In this paper a high level implementation mechanism that can be used by the contracting parts, is described for the exposure of various governmental vehicular services. These services are provided by the "G-Cloud" vehicles and their discovery is made by the client vehicles. Technologies used in Web Services play a key role to this operational model.

A Web Services Description Language (WSDL) document is used by the side of the service vehicle provider in order to describe the functional characteristics of its Web Service [5, 6]. The UDDI ver.3 protocol (Universal Description, Discovery and Integration) is an XML-based registry that is used to register and locate the services provided by the "cloud" vehicles. UDDI v3 protocol introduces the function of a service subscription. In this case, the service subscription function provides the service requestor vehicle with the ability to subscribe interested service information in the UDDI and receive notification of adding, updating and deleting operations [5, 6].

There can be three implementation mechanisms for service discovery over a high mobility cloud. In all service discovery mechanisms SOA Protocol (SOAP) messages are being exchanged between all vehicle-counterparts. SOAP is utilized for exchanging information between the VSP and the VSRq. The three secure discovery mechanisms are described as follows:

4.1 Case 1: Decentralized Service Discovery over a Vehicle (DSDV)

A Decentralized Service Discovery over a Vehicle (DSDV) (Fig. 2) can be applied in an environment where no centralized service infrastructure exists. A client node that requests services search for existing connections with other available online nodes.

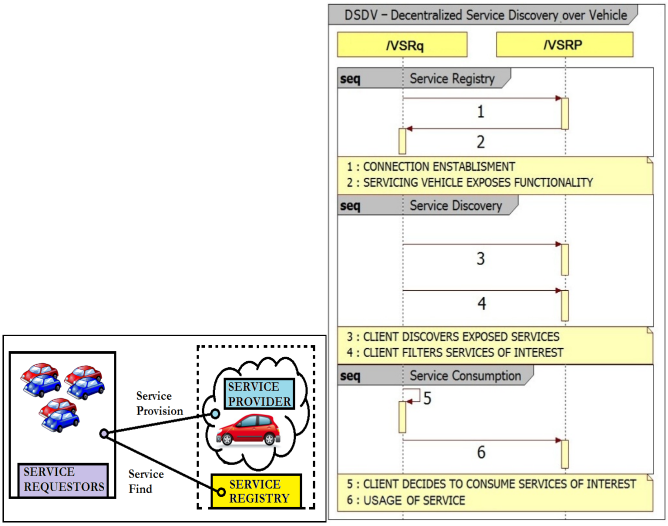

Fig. 2. Case 1- DSDV Overall

This action occurs until the client node finds another node capable to provide the required vehicular services. Every time that a VSRq node connects to another node always checks if a UDDI with registered vehicular services exist. If a UDDI exists the VSRq will filter the provided exposed vehicular services, to find and use a service of its interest. More specific DSDV takes place after the network communication between the VSP and the VSRq is established. A servicing vehicle having its services functionalities exposed is being discovered by the client by the exchange of SOAP messages. The VSRq filters the services that interests it and decides to use them. A connectivity status check process can be utilized, during all phases of nodes communication of DSDV.

4.2 Case 2: Centralized Service Discovery over Infrastructure (CSDI)

In the second case of a CSDI implementation mechanism a local region based dynamic UDDI infrastructure (Fig.3) holding all services is utilized.

After the registration of the service takes place the local UDDI infrastructure provides the VSRg with a security token. This security token is provided for authentication reasons once a connection between the VSP and the VSRq nodes is established. A client requesting services in that specific region will search the local UDDI for a VSP. The infrastructure will provide the client with a security token after the identification of the service occurs. This security token will be used by the client in order to be authenticated by the VSP. A connection will then be established with the VSP.

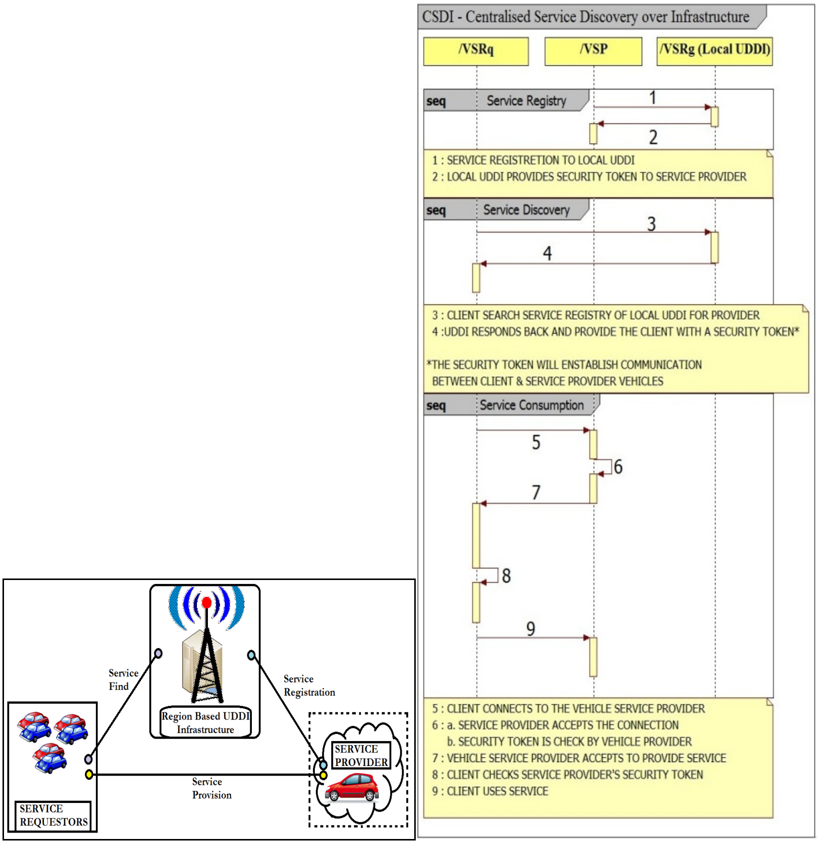

Fig. 3. Case 2 - CSDI Overall

For authentication reasons the VSP will check the VSRq security token in order to provide services. The VSP sends its security token for authentication by the client. Finally, the VSRq will authenticate the VSP and will use the service.

In CSDI, a connectivity status check process can be utilized during all phases of vehicle node communication.

4.3 Case 3: Centralized Service Discovery a Vehicle (CSDV)

The CSDV implementation mechanism is utilized due to the lack of a centralized region based infrastructure holding a UDDI. A number of vehicles capable to provide services are forming a group and decide which one will hold the UDDI. Once this phase is completed the rest of the CSDV mechanism is the same with the CSDI mechanism (Fig. 4). All VSPs will register their services to the vehicle holding the UDDI. The vehicle UDDI will generate a security token that will provide to each VSP.

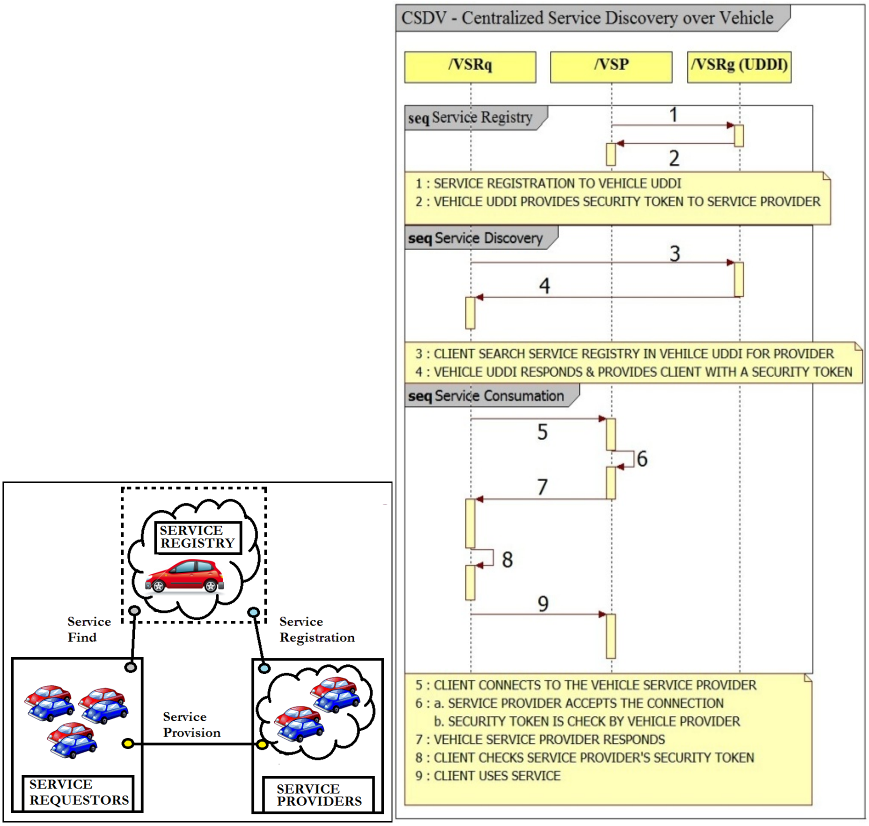

Fig. 4. Case 3 - CSDV Overall

When a VSRq establishes a connection with the vehicle UDDI will find that a UDDI exists and will search and find the desired vehicle service. If the services are not provided locally by the vehicle UDDI, the VSRq will receive a security token in order to be authenticated by the VSP. The VSRq will then establish a connection with the VSP. For authentication reasons the VSP will check the VSRq security token in order to provide services. After the authentication of the VSRq, the VSP will send its security token to the client vehicle. Finally, when the VSP's authentication is completed, the VSRq will consume the service. During all phases of CSDV mechanism a connectivity status check process can be utilized.

In addition, the vehicles, regardless of their role, are capable for transmission through an onboard or external network capable device. This way vehicle will be updatable and upgradeable.

5 Conclusions – Future Directions

Three implementation mechanisms for vehicular service discovery over a governmental cloud are presented in this paper. These mechanisms can be applied in cases that a client vehicle or a group of client vehicles request services. Provided on demand generic services such as navigation information, points of interests, road warnings and weather condition information via a computation cloud, next generation services are offered in vehicles.

Moreover, the second implementation mechanism can also be used in cases where the services are consumed from already existing road infrastructures that can host in the future the UDDI. This case of implementation also helps the appliance of cloud computing in vehicles in order to become stand alone cloud nodes.

Nowadays vision regarding vehicles is to be able to operate over functional oriented architectures and information-based services over packet based networks. Cloud computing in vehicles can not only offer new generation services, but also can provide system efficiency in high mobility environments, such the one that vehicles are operating.

Vehicular Safety also can be increased via a Vehicular G-Cloud Computing cooperative environment. In addition, a cloud computing notion, fully adopted in a high mobility environment such as the one that vehicles are operating, a vehicular service discovery mechanism plays a key role when applying the notion of cloud computing in vehicular services.

The presented Vehicular Service Discovery Mechanisms is a functional approach of a service finding model. A future enhancement approach for this implementation will be the construction of a more dynamic vehicular invocation framework. This framework can be specialized in vehicular high mobility environments along with new security mechanisms such as an embedded vehicular firewall.

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