An IoT Approach for the Connected Vehicle

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Abstract. This paper will showcase the iCore Project approach for instantiating an Internet of Things (IoT) Service Enabling Architecture to support the Connected Vehicles (Transportation in the Smart City).

Keywords: Connected vehicles · Internet of things · Virtual objects · Composite services · Context awareness · Connected infotainment systems

1 Introduction

In modern cities, roads and motorways an increasing amount of circulating vehicles are equipped with more and more sophisticated infotainment devices and systems, also capable of communicating through WAN 3G/4G connections, bringing the promise of an always-connected driving experience.

Nevertheless, a concrete ICT architecture is still lacking for enabling a safe and efficient connection of such equipment with the huge volume of information and services which could be potentially provided by many actors to the drivers while they are on trip.

Thanks to the efforts of the Industry and Academic Research in the field, the Internet of Things (hereon "IoT") paradigm and technologies are rapidly growing maturity, creating an ideal environment for enabling the concept of "Connected Vehicles". Like any other "thing" in the IoT, every vehicle will provide standard network interfaces and APIs towards in-the-cloud, service-enabling ICT platforms, realizing a vehicle "virtualization" which will allow service providers to reach different vehicles drivers through a uniform interface.

In the domain of Connected Vehicles, the service provider role could be potentially played by many actors like road infrastructure managers, city managers, tourist agencies and organizations, car insurance companies.

This short paper will showcase the iCore Project [1] approach for instantiating an IoT architecture to support the Connected Vehicle paradigm. In the following we will briefly introduce the key concepts and novelties of the iCore Project architecture for IoT, then the Smart City – Transportation Use Case will be described.

B. Mandler et al. (Eds.): IoT 360° 2015, Part II, LNICST 170, pp. 158–161, 2016.
DOI: 10.1007/978-3-319-47075-7_19

2 The iCore Project

In the context of the IoT landscape, the iCore Project proposes a multi-level architecture based on cognitive technology, aiming at reducing the complexity of creating and deploying services in different IoT domains (transportation, logistics, healthcare, home and office automation). The iCore Architecture defines three levels for and IoT platforms: the Service Level, the Composite Virtual Object Level and the Virtual Object Level.

The **Service Level** lays at the topmost level of the iCore IoT architecture. The Service Level is responsible for processing the end user requests (in the context of this use case, the end user is the car driver) and detecting the best way to process the service request. This is accomplished exploiting techniques belonging to the Cognitive Science and Knowledge Based Reasoning, leveraging the big amount of data from the real world objects collected by the lower levels of the architecture, and it results in the selection of the most suitable Composite Virtual Object (hereon, "CVO") to be executed, according to the available Real World Knowledge.

The **Composite Virtual Object Level** is the "composition" layer of the iCore Architecture. This level provides the Execution Engine for processing the data coming from the virtualized objects/sensor and for controlling the virtualized objects/actuators, and the unit of work to be executed is defined as a Composite Virtual Object (CVO). In the context of this use case, the role of the Execution Engine has been played by a highly scalable event-based composition engine, which allows to define the CVO logic based on an "event/action" paradigm. The CVOs available for execution are published in a common CVO Repository.

The **Virtual Object Level** is the "virtualization" layer of the iCore Architecture. This level provides the Virtual Object Container which hosts the Virtual Objects and allows the exposure of a "virtual" and common interface from a real object (either a sensor or an actuator) towards the upper levels of the architecture. This approach has the great advantage of "decoupling" the real object from the other parts of the architecture, allowing the reuse of the same "virtual" interface whenever the "real" object hardware implementation is changed. The available Virtual Objects are registered in a common VO Registry, alongside with metadata (e.g. geographic location). The VO Registry provides query facilities based on RDF/SPARQL [2] in order to identify the VO that best suites a given context/situation.

3 The Smart-City Transportation Use Case

The iCore project Architecture for IoT has been instantiated to showcase the value of the architecture for deploying a Service Platform for the Connected Vehicles. The specific demonstrator, described in the following, has been called "Smart City - Transportation Use Case Demo".

3.1 The Storyboard

The Driver is driving her "Connected Car": the Connected Car is equipped with an advanced Infotainment System, exposed as a Virtual Object towards the iCore platform. The advanced infotainment system sends data to the platform (GPS position, speed), receives and displays messages/alerts about services availability, allows the driver to activate available services on demand and receives and displays informative messages sent by the services being executed.

While on trip, the driver is notified that the service "Parking Around Me" is available. As soon as he/she activates the service through the Infotainment System, the service provides to the Infotainment System an information message with the real-time availability of places in the parking lots nearby the current location of the driver.

While the driver proceeds, the platform is able to detect that he/she is driving towards a recurrent destination for such a user because the iCore system is increasing its own Real World Knowledge each time the user activates the service. In this case, the platform informs the Driver about the availability of the new service "Parking at Destination", and as soon as the Driver activates the new service the Infotainment display shows the availability of places in the parking lots nearby the final destination of the driver.

3.2 The iCore Architecture Instantiation

The following figures describes the instantiation of the iCore Architecture for the Smart City – Transportation Use Case.

3.3 Behind the Scenes: Playing the Storyboard

The Advanced Car Infotainment System is connected to the iCore Platform in two ways: (i) it interacts with the Service Management Unit shown in Fig. 1 for being notified of available services and request services and (ii) as a Virtual Object because it can send GPS/speed information messages and it can receive and display "generic" information messages and alerts from the services executed on the platform.

While driving the user activates his/her Infotainment System which interacts with the Service Management Unit to discover the available services. If no recurrent destination is recognized by the system, the Service Management Unit proposes to the Driver the "Parking Around Me" Service.

When the driver generates a new service request, the Service Management Unit creates a CVO execution request to the CVO Container; the requested CVO exploits the Parking System Virtual Object for interfacing an Open Data service made available by the City which provides real-time parking data.

It is worth noting that the CVO Container does not bind to a VO directly, but it is instructed to use a specific Parking System Virtual Object based on the location of the Driver (e.g. the Parking Open Data of a specific city). This feature allows the CVO to have a context-aware behavior.

While the Driver progresses on his/her trip, the Destination Learning and Detection system becomes aware that the Driver is on a recurrent trip, towards a recurrent

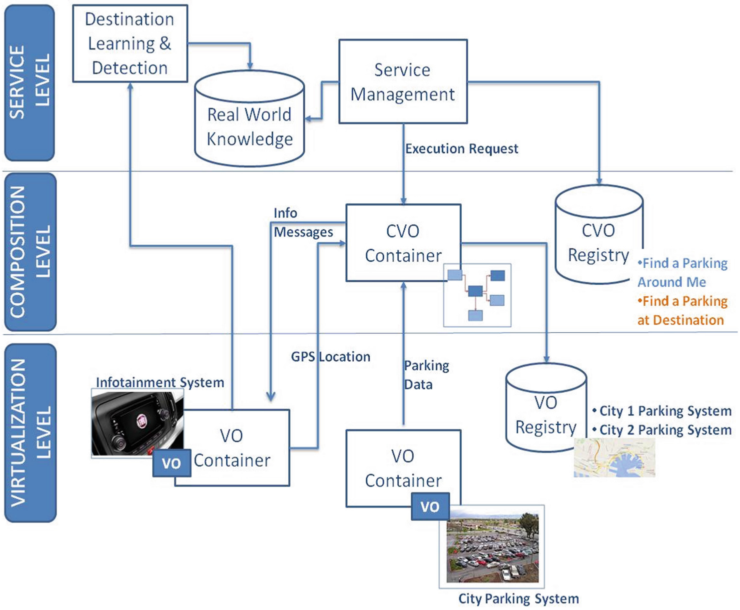

Fig. 1. The smart city transportation use case architecture

destination. This is achieved exploiting knowledge on user behavior obtained applying learning techniques to previously acquired data from the Car Virtual Object, and it allows the platform to identity a different CVO that can be executed. This CVO will provide a different parking suggestion, exploiting both the current position and the final destination, and possibly taking into account predicted traffic flows and situation.

Both the "Parking Around Me" as well as the "Parking at Destination" services will deliver the parking information to the Driver through the Car Display Virtual Object, and the Infotainment System will display it to the Driver. This architectural choice of having a Virtual Object Level allows (i) to decouple the Infotainment interface (Virtual Object) from the actual implementation (Real Object), and (ii) to retain the low level details of the Infotainment functions in the hand of the Car Maker/Car Maker Provide, who can be aware of specific constraints (e.g. avoid to show messages in particular conditions).

Acknowledgments. The work described in this paper has been carried on in the context of the iCore Project [1], partially funded by the European Commission in the context of the 7th Framework Program. Parts of this work (concepts, ideas, artifacts and architectural components) are due to the efforts of the partners belonging to the iCore Project Consortium

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