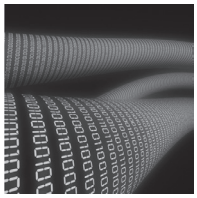

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Standardization of ADAS functionalities for fully electric vehicles

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ABSTRACT

EcoGem Project was conducted in scope of ICT Green Cars Initiative under the Seventh Framework Program, during 2010-2013 period. EcoGem Consortium's aim was to provide ICT-based solutions increasing the mobility of Fully Electric Vehicles (FEV). A FEV-dedicated Advanced Driver Assistance System was developed in scope of the Project. It included suitable monitoring, analysis, reasoning and management capabilities, which increased the autonomy and energy efficiency of FEVs.

One of the Project's goals was to deliver a significant contribution into standardization activities concerning management of external information provided to ADAS systems. During the project development, a contact with various standardization organizations was established. We contributed to the standard development activities of OGC and TISA. The article presents the proposed solutions with regard to EcoGem functionalities. Described in the article standardization contribution includes new FEV oriented propositions of specifications for transmission of multi-modal traffic and travel information as well as the attributes defining charging stations.

KEYWORDS: electric vehicles, advanced driver assistance system, driver information systems, standards

1. Introduction

Throughout the last few years a significant increase in Fully Electric Vehicles technology could be seen. Not only the vehicles themselves were a subject of development and upgrade, but also the recharging infrastructure and popular ICT solutions had to be adapted for the needs of electric cars.

EcoGem project answered these needs by designing Advanced Driver Assistance System for the electric vehicles. The EcoGem approach was to integrate intelligence and learning functionalities to on-board systems for fully electric vehicles increasing the level autonomy as well as interactive real-time learning through V2X communications based on experience gathered both autonomously and through exchange via V2V/V2I interactions, EcoGem vehicles are able to learn the energy profile and the traffic behaviour of the various segments in road network., and thus to predict and avoid congested and poorly energy-efficient routes. This capability, coupled with the enhanced ability to optimally plan the vehicle recharging strategy (based on battery monitoring), optimized scheduling of recharging processes and real-time booking of recharging points, ultimately leads to increased energy efficiency of travelling and enhanced vehicle range.

The successful delivery of EcoGem could not do without the development of an enhanced traffic prediction and recharging platform at the infrastructure side, nor the exploitation of existing V2X technologies, as well as definition and development of new FEV-oriented protocols and interfaces. That is why three main innovative project macro-areas included in-vehicle functionalities, central platform functionalities and V2X communication. In-vehicle functionalities aim at providing FEVs' drivers with the highest possible degree of autonomy and confidence. Central platform plays role of a main repository for the data gathered by EcoGem-enabled vehicles, both collected from an external

traffic information providers and accumulated by the vehicles themselves.

The project itself was partially funded by the European Commission under the Seventh Framework Program, ICT Green Cars Initiative (grant agreement no. 260097). The Consortium consisted of 10 European partners, including Motor Transport Institute and lasted for 30 months, from January 2010 until March 2013.

Contribution into development of Intelligent Transport Systems can be assessed, besides the other terms, through the perspective of standardization activities. Main standardization bodies working in scope of European ITS community are ISO/TC 204, CEN/TC 278, ETSI TC ITS as well as TISA A.S.B.L., organization working in liaison with WG10 of ISO/TC204. During the project development phase, EcoGem Consortium established contact with a few standardization organizations in order to identify standards capable of extension and provide a contribution for their documentation. Profiles of the organizations were different due to complexity of the Project and different aspects of ICT systems developed. Yet, each of the working groups contacted was related to Intelligent Transport Systems issues. In scope of ISO TC204 the relevant elements of the EcoGem were described and sent in a form of structured document to WG1 (Architecture), WG11 (Route guidance and navigation systems) and WG16 (Wide area communications/protocols and interfaces). The same document was sent to ETSI TC ITS WG1. Relevant elements of the projects were also presented during a meeting with SAE organization members.

The specific cooperation was established with two standardization organizations – Open Geospatial Consortium (OGC) and Travel Information Services Association (TISA). The identification of possible standard extension was provided by several phone conferences. Documents introduced to these organizations were based on contribution brought in the deliverables.

This article introduces the standardization work provided by EcoGem Consortium. Second chapter provides information on standardizational organizations which EcoGem established contact with and describes the standards which were identified as capable of extension aiming at needs of electric vehicles. Third chapter highlights the proposals of extension of the standards and thoroughly explains causes of introducing each amendment.

2. Open geospatial consortium approach

Open Geospatial Consortium is an international industry consortium which gathers 480 members – both companies and national goverments' entities. It's main goal is to develop publicly available interface standards related to geolocation services as well as to serve as a global forum for the developers and users of spatial information services in order to provide standards which could help in establishing full geospatial interoperability between various systems. State-of-the-art standards of this organization cover mainly linking the data provided by the Internet, wireless and location-base services to geographical information compatible with GIS technology. EcoGem contacted the Chairman of Energy & Utilities Domain Working Group, as it was found as the most thematically relevant to the innovative solutions provided in the project. The group focuses on specific needs of organizations engaged in providing the geospatial aspects of the planning, delivery and managements of fossil fuels and electric energy services.

Taking into account the FEV-related OGC standards, the most promising scope for EcoGem contribution was identified in topics strictly related to charging infrastructure location and its characteristics. Regular contacts with members of the Open Geospatial Consortium led to focusing the work on contributing to one of the OGC Web Feature Service extensions introduced by BALLADE Project, i.e. e-Mobility Application Profile.

BALLADE Project itself was provided by Austrian companies specializing in management of charging infrastructure dedicated for the electric vehicles. Project aimed at developing a cost efficient, safe and intelligent charging station for FEVs as well as dedicated ICT system enabling fast implementation of a demonstration charging network in consideration of charging infrastructure grid future aspects, traffic and parking management. Results of the project helped in integrating the entire e-mobility supply chain, i.a. provider-end-client communication, payment, authorization, control modules and are available in form of a web-based online system showing a real-time status of a charging station.

The part of the e-Mobility Application Profile, which EcoGem Consortium took into further research was called e-Mobility GML Charging station Data Model and contained the attributes of charging stations defined in GML language, a XML language modification used exclusively for geolocation purposes. EcoGem focused on comparing its approach in scope of defining the attributes with the ones provided by the BALLADE and made its official comment in form of a White Paper document.

In EcoGem project two different data objects were identified in order to provide a full information about the specific recharging point. Recharging Points Data included list of attributes describing the location of the RP, while RP Provider Data referred to the address and contact info of the infrastructure provider. Following tables show all of the attributes designed in scope of the aforementioned data objects:

Table 1. Content of Recharging Point data object [1]

Data item no.	Information content
1	ID
2	COUNTRY
3	ZIPCODE
4	CITY
5	CITYDISTRICT
6	STREET
7	HOUSENUMBER
8	X
9	Y
10	CONNECTORTYPE
11	RPTYPE
12	NO_RECHARGING_SPACE
13	StartAvailability
14	EndAvailability
Update frequency	Every 10 minutes

Table 2. Content of Recharging Point Provider data object [1]

Data item no.	Information content
1	ID
2	COUNTRY
3	ZIPCODE
4	CITY
5	CITYDISTRICT
6	STREET
7	HOUSENUMBER
8	X
9	Y
10	CONNECTORTYPE
Update frequency	On demand

BALLADE's approach for describing the recharging attributes attributes was identified as different from ECOGEM, especially in terms of complexity of the provided information. BALLADE focused on integrating all aspects of recharging point management for both mobile and stationary end-users, while EcoGem was dedicated for a end-user who is willing to book a recharging point while being on the road. This is why the amount of EcoGem attributes was restrained to required minimum, while more broad context of BALLADE contribution resulted in providing three categories of information for a single recharging point, i.e. Recharging Point Provider (geolocation data of the Provider), Recharging Point (geolocation data of a specific RP) and Recharging Point's Characteristics (features of an RP, current and historical data). Following tables show the attribute division between these three categories:

Table 3. Recharging Point Provider - list of attributes [1]

Attribute no.	Information content
1	PROVIDER_ID
2	P_ADDRESS
3	P_POSTAL_CODE
4	P_CITY
5	P_EMAIL
6	WEBSITE
7	PHONE
8	LOGO_URL
9	EXT_PARTNER_ID

Table 4. Recharging Point - list of attributes [1]

Attribute no.	Information content
1	ID
2	EXT_XP_ID
3	ADDRESS
4	POSTAL_CODE
5	CITY
6	COUNTRY
7	WEBSITE
8	LOCATION_IDENTIFIER
9	STREET
10	HOUSENUMBER
11	EXT_NUMBER_ID
12	BUILDING_STOREY
13	GEOMETRY PROPERTY TYPE INFORMATION

Table 5. Recharging Point Characteristics - list of attributes [1]

Attribute no.	Data object contains information on recharging point attributes
1	STATUS
2	CONNECTOR_TYPE
3	MANAGED
4	SPECIAL_RESTRICTIONS
5	RENEWABLE_ENERGY
6	LOAD_MANAGEMENT
7	LAST_CHANGE
8	PAYMENT_METHOD
9	CHARGING_CAPABILITIES
10	SERVICES
11	CAR_ACCESSIBILITY
12	COUNTRY_ISO
13	OPENING_TIME
14	RESERVATION_URL
15	RESERVATION_AMOUNT

Despite the complexity of provided information and different names of the attributes, many of them were implemented in order to deliver the same or a very similar information to the end-user. Following comparison points out the similar attributes provided in scope of both projects:

Table 6. Comparison of EcoGem and BALLADE similar attributes [1]

EcoGem attribute (data item)	BALLADE equivalent	Comment
X coordinate	GeometryProperty Type Information	BALLADE attribute is found to be more accurate, yet EcoGem coordinates fulfill their aim.
Y coordinate		
Start availability	LAST_CHANGE, MANAGED, STATUS	EcoGem provides info on a booking RP time-frame, while BALLADE gives an overview on current and historic data of its occupation.
End availability		
RPTYPE	CHARGING CAPABILITIES	Attributes provide practically the same information, yet BALLADE attribute seems to be more accurate

Additionally, both lists provide exclusive attributes which fulfill the needs of end-users, according to the emphasis put on different aims of both projects.

EcoGem included implementation of the attributes found to be desired in terms of providing relevant contact information to the provider responsible for the recharging point – MANAGER NAME and CITYDISTRICT. Additionally, attribute CITYDISTRICT included in Recharging Point data object enables easy localization of the a charging station in large urban areas.

In comparison, BALLADE Project introduced a significant amount of attributes, which are found to be convenient in terms of geolocation, recharging infrastructure provider information, online and mobile booking services, as well as provision of data to external services. Many of the following attributes were also identified by

EcoGem during the standardization works as valuable in terms of making a quick booking decision while being on the road.

Table 7. Recharging Point - list of attributes [1]

No.	BALLADE exclusive attributes (affiliation to the category)
1	location_identifier (Recharging Point)
2	status (Recharging Point)
3	building_storey (Recharging Point)
4	special_restrictions (Recharging Point)
5	renewable_energy (Recharging Point)
6	load_management (Recharging Point)
7	payment_method (Recharging Point)
8	services (Recharging Point)
9	car_accessibility (Recharging Point)
10	countryISO (Recharging Point)
11	opening_time (Recharging Point)
12	reservation_url (Recharging Point)
13	reservation_amount (Recharging Point)
14	website (Provider)
15	logo_url (Provider)
16	ext_partner_id (Provider)

3. TISA approach

Traveller Information Services Association is a worldwide association, which gathers more than 100 international members and cooperates closely with other research and standardization entities by providing formal liaison agreements on mutual cooperation in scope of projects and fora. It was established as a non-profit organization, with membership open to all public and private organizations which express an interest in supporting the objectives of the association. TISA's approach is to implement RDS-TMC and TPEG standardization solutions desired by the market, especially in terms of travel information services and products based on existing standards. It also supports standards that provide elements or a framework for services covering public transport, points of interest, weather and environmental data.

TPEG (Transport Protocol Experts Group) itself is a set of specifications for the transmission of independent language for multi-modal traffic and travel information purposes. The protocol is based mainly on RDS-TMC, yet it's content is human understandable and machine readable. Particularly, TPEG does not assume any large scale location or pre-coded phrase databases in any client receiving device.

TPEG standard can be represented in two types called "flavours", differing with the way of representation of the data and transmission channel. The TPEG binary data format is designed for transmission over DAB (Digital Audio Broadcasting) or DMB (Digital Media Broadcasting), while tpegML is the XML implementation of the standard designed for the use in editing systems and delivery via the Internet and DVB (Digital Video Broadcasting).

During the standardization work EcoGem Consortium identified several TPEG application specifications, which were found to be most relevant in terms of EcoGem context and provision of targeted contribution. Following descriptions reveal the aim of the contribution-targeted applications.

TPEG-TEC (Traffic Event Compact) is an application providing machine and human readable incident information in a compact form with defined structured content. It is an aimed on dynamic route guidance navigation systems which gathers information in form of specified events. TPEG-TEC can also be used to recommend route diversion, determined by different factors. EcoGem found special interest in implementing traffic situation and safety/weather-related messages into its system.

TPEG-PKI (Parking Information) is an application in development, which is identified as crucial element in providing travel-related information in urban areas. Two message types were identified. The first one, of relatively static nature, gives information about the parking facilities of general nature. The second one is the dynamic information providing information of still available parking space. TPEG-PKI enables binding TPEG information and events, in order to provide information adapted to the needs of the specific end-user, e.g. number of free parking space for motorcycles on parking lots reachable by a certain public transport line. EcoGem Consortium designed a mechanism for booking recharging point in scope of its project, that is why it was found valuable to share the experience and contribute to TPEG-PKI application.

TPEG-FPI (Fuel Price Information) is an application gathering information about types of fuel and it price on different fuel stations in local area or along the route. According to a certain number of petrol stations and recharging points around the local area it provides efficient solutions for data coding structure limiting required bandwidth. The TPEG-FPI specification faces generic issues, such as price, availability and type of fuel, which also includes the electric type.

TPEG-RMR (Road and Multi-Modal Route) is currently developed application which concentrates on providing real-time route suggestions based on information gathered from other TPEG applications as well as different external sources. It addresses electro-mobility in two use cases, which are related to EcoGem. The first is providing alternative routes to the traveler by suggesting a transfer to another mean of transport, e.g. to use public transport by using P+R and second – providing alternative routes for the traveler.

4. EcoGem contribution

During the analysis of aforementioned content provided by Open Geospatial Consortium and TISA, EcoGem Consortium found some important shortages in range of different standards and applications, which are going to be thoroughly described in this chapter.

In scope of BALLADE e-Mobility Application missing data was identified in the range of Recharging Point data provision. Desired missing attributes were distinguished between five different groups: Pricing, Station name, Usage category, Special message and Landmarks.

Recharging infrastructure providers set prices for using recharging point services. The fee itself often reaches a certain amount of complexity due to provider's policy on point location, time of day, station type, recharging pace etc.. EcoGem believes

that drivers should be fully provided with this information, as it may be important in choosing whether to book a recharging point. That is why following list of attributes were suggested to be added as 'Pricing rules' element of e-Mobility Application Profile schema:

Table 8. Proposal of attributes for presenting pricing of certain recharging point [2]

No.	Attributes in scope of XML element
1	NAME
2	FEE
3	TARIFF BASIS
4	PRICE VARIES
5	PER-HOUR FEE
6	DISCOUNT
7	RATE OPERATING HOURS

Attribute 'NAME' stands for introducing the name of an active pricing rule/rate, while 'FEE' and 'TARIFF BASIS' are to describe elementary information about what is the principle of a recharging fee and how much does it cost. Attribute 'PRICE VARIES' should inform about limitations of the current tariff (time of day, day of week, vehicle model etc.). 'PER-HOUR FEE' should describe the conditions in which the fee is charged (only when charging or the entire time when the vehicle is plugged in). Attribute 'DISCOUNT' should describe the level of cost reduction together with the reduction conditions. Finally, 'RATE OPERATING HOURS' is found to be important according to possibility of implementing time-of-day-based tariffs by the Provider.

Regarding the 'Station Name' group EcoGem encourages both BALLADE project and OGC to provide a clear distinction between IDs of certain recharging points and their full names. Operators frequently provide the ID number of the station in a representation of code, which may be unclear to an average user. At the same time, the full names of recharging stations are also in use. This is why EcoGem finds it important to consider which element should be passed to the end-users of the services.

In scope of 'Usage category' group EcoGem considered a consistently enlarging group of companies getting into recharging business and becoming providers, as well as private households, which are also in position to charge the electric vehicles in case of having the infrastructure installed. Due to this situation, EcoGem believes that the type of access and any possible limitations should be provided to the drivers. The following table shows proposed attributes, gathered in 'Usage category' XML element:

Table 9. Proposal of attributes describing recharging points access limitations [2]

No.	Attributes to be specified in USAGE CATEGORY element
1	Commercial (Restricted Access)
2	Commercial (Unrestricted Access)
3	Public
4	Private

'Special message' attribute group may be very useful, especially in large urban areas. It should provide a brief, yet accurate information on how to find a recharging point. Such message could also contain various information considering seasonal discounts or other user-dedicated information from the provider.

According to the description according previous element, search for a recharging point in a specific location may be difficult due to its look, shape or color. This is why it could be useful from driver's point of view to be provided with an URL of the picture with the specific recharging point and its near proximity, in a form that could be seen on an onboard navigation module.

Regarding TPEG applications, EcoGem issued recommendations to each of them in a form of a detailed proposal or general remarks aiming at upgrading the application for the specific needs of electric vehicles.

The analysis of TPEG-TEC specification showed that the usage of the "VehicleRestriction" mechanism allows disseminating distinctive vehicle type specific information. Still the modelled VehicleType table (tec010) doesn't support a distinction based on the engine type (e.g. electric vehicles). In order to support possible specialized routing types (e.g. electric vehicles oriented energy saving) EcoGem proposes to extend the table tec010 by introducing multiple engine type codes.

In scope of TPEG-PKI EcoGem pointed out that despite the fact the application already includes the indication of areas dedicated to specific vehicle types, it does not involve the information on capability for battery recharging. Within the specification, two fields mainly deal with specific parking allocation: pki001:VehicleType (indicating if parking is offered to special vehicles) and pki004:FuelType (indicating if the parking is dedicated to special fuel type engines). While pki001:VehicleType does not specifically address electro-mobility, pki004:FuelType includes fuel code 009:electric. EcoGem underlined the need for designing specific proposal, to provide sufficient information for identifying the parking space dedicated for the electric vehicles.

The specification of TPEG-FPI provides information about electric type station in type015 'electric' in scope of fpi003:FuelKindType event. Nevertheless, in the specific context of EcoGem, more information is required, in order to make sure the candidate charging station is compatible with the specific vehicle type. According to this, EcoGem proposes to introduce application's capability for providing information about code plug type and charging level coding (e.g. by extending fpi003:FuelKindType), by describing two standardised plug types (NEMA 5-15R, SAE JI772/3) and :5 different charging level coding, including AC, DC and CHAdeMO charging.

The existing draft of TPEG-RMR application does not enable specific requests or route recommendations for electric vehicles. This is why EcoGem proposes to introduce a mechanism in the request protocol to enable a specific route requests, according to engine type, as well as to enable engine type specific re-routing suggestions. The functionality of the mechanism should resemble to energy-driven routing functionality introduced in scope of the project.

5. Conclusion

Both international and national reseach projects in scope of ICT and electro-mobility solutions provide innovative and often very demanded services and technologies. Regarding the experience of EcoGem Consortium such outcome is expected and well welcomed by majority of the stakeholders, but may not be enough in terms of satisfying all ot them. Standardization is one of the aspects which is often neglected by research project providers and replaced with strong dissemination activities. Yet, the fact is that standardization organizations are highly adjusted at the cooperation, because contributions provided form the external entities are their main source of gaining relevant data for further work. According to this, EcoGem highly encourages to establish contact with relevant standardization entities, as the possible cooperation may be fruitful for both sides, especially in terms of providing significant extensions in the state-of-the-art standards.

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