Standardised travel information for electric vehicle users

A hybrid service via broadcast and Internet

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***Abstract*— IRT specified and developed a novel application as part of the international travel information standards' family TPEG (Transport Protocol Experts Group): EMI (Electromobility charging Infrastructure). With TPEG EMI a user can be provided with real-time information about suitable and available Charging Stations where he may charge his electric vehicle. This allows him to plan his journey energy-efficiently and to optimize the usage of the vehicle's battery. TPEG EMI is a "hybrid" application: information services based on this specification foresee a distribution of information via broadcast, complemented by a transmission of data via Internet. In the context of the R&D project e-GAP in the municipality of Garmisch-Partenkirchen, IRT also developed an Android-App based on TPEG EMI, which was provided to the local end-users for field testing.**

Keywords—TPEG; travel information; electromobility; charging infrastructure

I. INTRODUCTION

Mobility becomes more and more important in our society. To live up to this development and to simultaneously strengthen the region of Bavaria as a center of the automotive industry, the Bavarian parliament in the year 2010 had selected Garmisch-Partenkirchen as one of Bavaria's model municipalities for electromobility. Because of its location Garmisch-Partenkirchen is particularly suited to investigate integrative solutions for the existing challenges: the model community has a large touristic footprint, which – in addition to investigating electromobility at a whole in the region – also allows an intense communication of the sustainable mobility options to the region's visitors.

In the R&D project "model municipality electromobility" (this overall project is called "e-GAP") holistic mobility concepts have been developed. The partners involved in the project addressed exemplary solutions for future challenges and tested the required innovative technologies with respect to their functionality, suitability for daily use and appeal to the end-user. The cooperative sub-project "Intelligent Charging Infrastructure" (in brief "e-GAP IL") comprised investigating, installing, integrating, operating and field testing various types of novel Charging Stations in an intelligent power grid.

For the evolution of electromobility it is crucial to allow the end-user to plan his route and his overall journey as energy-efficiently as possible. In addition to route information (e.g. distance, altitude profile) and accurate real-time traffic information, also information about the charging infrastructure is essential (e.g. location and current status of the available Charging Stations). The appropriate data should be provided in real-time and be continuously updated, to allow a user to plan his journey based on information about the charging possibilities along the route as well as at the destination.

In the scope of e-GAP IL the Institut für Rundfunktechnik GmbH (IRT) has investigated, how a charging management backend system (which handles information about Charging Stations) and a travel information system can be optimally combined. IRT has many years of experience in the area of traffic and travel information distribution: the R&D institute was significantly involved in the development of RDS-TMC[1] and with its technical expertise still supports broadcasters in their TMC service provisioning. Beyond that, IRT, in close cooperation with many international partners, develops solutions for the delivery of traffic and travel information via digital transmission channels, e.g. digital radio. In this process, the envisaged applications are tuned to the broadcasters' editorial requirements. Additionally, IRT has developed its own software tools to prototypically implement and test the overall transmission chain.

IRT has deployed this knowhow in e-GAP IL to design and develop new applications for users of electric vehicles.

II. TPEG INSTEAD OF TMC

Already for a long time traffic telematics experts have seen the provision of real-time traffic information for navigational devices, in addition to spoken traffic alerts in radio programs, as crucial. Such information strongly increases road safety and allows a dynamic routing, e.g. to circumnavigate traffic jams. During the rapid growth in the navigational market in the years 2004/2005 only a single well-proven technology was available: TMC. TMC had been developed during the years before and was specifically designed for transmission via FM radio.

[1] Radio Data System - Traffic Message Channel

However, already at that time the limitations of this technology were apparent.

For localizing traffic events TMC uses so-called "location lists". The end-user device contains a copy of the location list, which must be adapted based on changes in the road network and regularly synchronized with the location list at the service provider (e.g. in Germany new versions are published each year). Moreover, TMC messages cannot describe the location of the accident or traffic jam accurately enough and they are limited to basic traffic information. For these and other reasons the EBU (European Broadcasting Union) already in the year 2000 had started to draft a novel traffic information specification format: TPEG (Transport Protocol Experts Group).

Using georeferencing mechanisms based on latitude and longitude coordinates, TPEG offers a much more accurate localization for traffic events and at the same time is independent of location lists. As in TMC, traffic information (regarding accidents, traffic jams, etc.) plays a central role in TPEG; the TPEG application Traffic Event Compact (TEC) was specifically developed for this use case. However, TPEG potentially can provide a large variety of multimodal travel information services to the end-user: time tables for public transport, parking information, weather forecasts, fuel prices, to name a few. In contrast to TMC, TPEG has been designed as a construction kit: the TPEG format is extendable and applications at any time may be enhanced or even redesigned if required. For the implementation of these advantages, TPEG understandably needs more transmission capacity than TMC and also is not compatible with FM radio: TPEG applications target a delivery via digital transmission channels such as DAB/DAB+ or alternatively the Internet.

In the year 2007 the Traveller Information Services Association (TISA[2]) was founded as a market-driven membership association with worldwide scope, established as a nonprofit company focusing on the implementation of traffic and travel information services and products based on existing standards, primarily including RDS-TMC and TPEG[3] technologies.

III. A NEW USE CASE: TPEG EMI

TPEG primarily is an end-user oriented format: information that may be beneficial on the road, when travelling or when planning a journey is provided to the end-user by means of the appropriate TPEG applications. This is the main focus when requirements for new TPEG applications are being defined. For a user of an electric vehicle it is crucial that he can find available and suitable Charging Stations within a charging infrastructure, especially in the early days, when there is no nation-wide coverage of charging facilities. This use case was not yet covered by any TPEG specification; we had to verify if and how the TPEG standards' family optimally could be enhanced to support the specific requirements with respect to electromobility and charging infrastructures.

[2] http://tisa.org/

[3] http://tisa.org/technologies/tpeg/

In e-GAP IL we therefore collected the end-user requirements with respect to an electromobility information service offer, focusing on information about the charging facilities. First we developed several use case descriptions which consider the end-user as well as other actors related to charging procedures. For the realization in TPEG we have also considered extensions to existing TPEG specifications.

A. *Charging is different from fuelling (and also from parking)!*

It may be well-known to the reader, that charging an electric vehicle takes more time than fueling a conventional car. What's more, also the billing models are entirely different from the ones we know from petrol stations: typically the end-user is not billed by the operator of the infrastructure or by the Energy Provider. Instead, he has a contract with a so-called "Electromobility Provider" (EM-Provider). The EM-Provider sees to it, that his customers can charge their vehicles at as many Charging Stations as possible and enters into agreements with other providers to accomplish this (similar to "roaming" agreements between mobile network operators). He is also the one who bills the end-user (see Fig. 1 and Table I, which describe the actors that are involved in charging procedures – an actor can also be looked at as a role, whereas multiple roles can be combined by a single actor). Rather than paying cash or by means of cash card, the customer typically authorizes the charging procedure with a smart card he obtains from his EM-Provider (or alternatively from a Charge Card Issuer) for this purpose. The respective billing models currently show a large variety and may incorporate any model between "flat rate" and "charge your vehicle for free when you shop here". At the time of writing it is not clear in which direction the billing models may develop or consolidate.

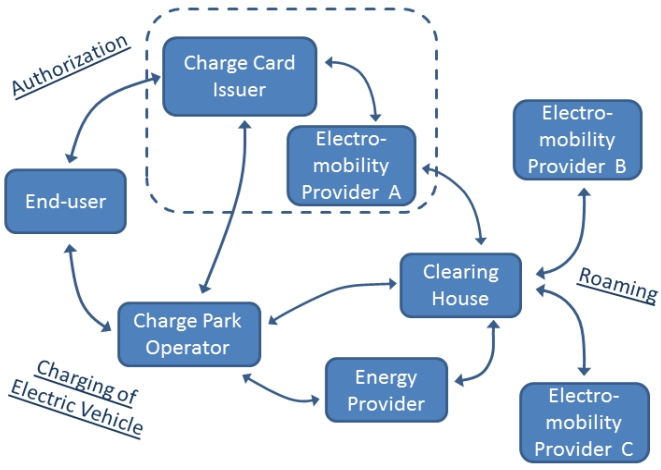

Fig. 1. Overview of actors and roles related to charging procedures

TABLE I. ACTORS AND ROLES RELATED TO CHARGING PROCEDURES

Actor/Role	*Description*
Energy Provider	Provides energy to the Charge Park Operators.
Charge Park Operator	Manages one or more Charge Parks (a Charge Park consists of multiple Charging Stations that technically belong together and that are being operated together, e.g. in a car park). He maintains the charging site(s) and is a business partner to the Energy Provider. He typically bills the Electromobility Provider or Clearing House(s).
Electromobility Provider (EM-Provider)	Is the business partner for the end-users who charge their electric vehicles. He sees to it that his customers can charge their vehicles at as many Charging Stations as possible and bills the customer accordingly.
Clearing House	Mediates charging orders and billing data between Charge Park Operators and EM-Providers. By doing so, charging orders from all EM-Providers who have a business relationship with a Clearing House can be processed at all Charging Stations from Charge Park Operators who have a business relationship with that Clearing House.
Charge Card Issuer / Publisher	Typically an RFID smartcard will be used to allow end-users to access the charging infrastructure. Such smartcards are produced, printed and signed by specialised manufacturers. The role of card publisher can also be carried out by an EM-Provider.
End-user / Electric Vehicle owner	After having parked his Electric Vehicle and before starting the charging procedure, the end-user first must authenticate himself. Typically authentication takes place by means of an RFID-based smartcard. The card number is verified and in case the user is authorized at this Charging Station, the charging order is generated and the charging procedure is carried out.

The charging infrastructures that are currently being implemented also are organized quite differently than the chains of petrol stations operated by the large oil companies. This specifically holds for public charging infrastructures, like the one that has been deployed for e-GAP IL. The existing TPEG FPI (Fuel Price Information) specification is based on a data model that is strongly oriented along the organization of common petrol stations and therefore cannot easily cover for the charging times and the billing models in the new use case. Furthermore, the TPEG FPI data model was specifically designed to support the delivery of information about a large number of petrol stations and petrol prices using only a low transmission data rate. To achieve this, TPEG FPI combines information components for several petrol stations, based on the assumption that e.g. the price for each petrol type is the same for a group of petrol stations operated by the same company. The variety in billing models targeted by EM-Providers cannot be covered by this mechanism.

During the charging procedure the electric vehicle occupies a parking spot; thus, comparisons to parking can also be drawn. The TPEG PKI (Parking Information) specification foresees a distinction between static information (e.g. location, opening hours, number of parking places, height of entrance gate) and dynamic information (e.g. current availability, tendency) which is basically also applicable for the charging infrastructure use case. However, a closer look at the specification revealed that the TPEG PKI data model is not efficient enough, so that many other adaptations (e.g. to cover charging time and billing models) would have been required.

Because of (amongst others) the aforementioned reasons, the existing TPEG FPI and PKI specifications could not be easily enhanced to support the new use case. Moreover, almost certainly backward compatibility with previous versions of these specifications would not have been possible.

B. Current information services are not sufficient

At the time of our analysis (early 2013) already plenty information offers were available regarding Charging Stations, either via the website of the respective operator or in the form of an App. Most of them only offered static information to the end-user and they were very heterogeneous with respect to the types of information they offered. Moreover, they predominantly lacked real-time information about the availability of the Charging Stations. Additionally, all service offers used proprietary data formats – an open standard for such services did not yet exist.

C. A novel, open, hybrid specification is required!

Because of the issues mentioned above, a novel TPEG application was developed under the auspices of IRT within the scope of e-GAP IL: EMI – Electromobility charging Infrastructure. The respective TISA-specification was finalized in 2014; at the time of writing, the standardization process in ISO (International Organization for Standardization) is in its final stage.

By means of TPEG EMI a service provider can provide users of electric vehicles with comprehensive information, that can be aggregated at different levels. The service provider may choose to distribute information about single Charging Stations but he can alternatively do so for so-called Charge Parks, which summarize the information of several Charging Stations that logically belong together (this could e.g. be useful in a future car park with charging possibilities at multiple parking spaces). TPEG EMI distinguishes between information that is relatively constant on the one hand and information that changes frequently on the other. Whereas the former contains information such as address and capacity of a Charge Park, contact information of the Charge Park Operator or payment options, the latter ("dynamic") information specifically comprises of the current availability of a Charge Park (or Charging Station) and potentially the momentary waiting time. This classification allows a service provider to appropriately adapt the transmission mode: dynamic data are predestined to be regularly distributed via broadcast; "static" data may be sent less frequently, or could even be downloaded by a TPEG receiver via Internet at irregular intervals (e.g. when the vehicle is parked in the garage at home using the home WLAN).

TPEG EMI is a truly hybrid TPEG specification: the possibility to combine the distribution of information via broadcast with an Internet-based transmission already shows

this. Moreover, a backchannel (via Internet) is indispensable for a user who wishes to make a reservation for a Charging Station when planning a journey, a feature which is specified in TPEG EMI as a request/response procedure. Obviously, for realizing such a hybrid service, an end-user device is required which combines broadcast (digital radio) reception with Internet access.

IV. TPEG EMI IMPLEMENTATIONS

After the TPEG EMI specification had been established, we have implemented corresponding implementations within the e-GAP IL project. Based on these implementations, end-users can be provided with up-to-date information about the Charging Stations that are embedded in the charging infrastructure, either via digital radio (DAB+) or alternatively via Internet. Firstly, we have developed a TPEG-Converter & Playout platform, which retrieves raw data about the Charging Stations from the Backend / Charging Management System, transforms them into the TPEG EMI data format (Charge Park operators typically use proprietary data formats in their backend systems) and cares for regular information updates, see Fig. 2. Specification conformant, each TPEG application includes two data formats – a binary and an XML format – both of which are being generated continuously by the converter.

Second, for usage by the end-users on location in Garmisch-Partenkirchen, we have implemented an Android App within e-GAP IL. With the App, a user can find an available Charging Station that is suitable to his electric vehicle, in real-time. The App accesses the TPEG EMI data in XML format via the Internet and presents the Charging Stations and their current availability on a map (see Fig. 3). The Charging Station colors have following meaning: green – at least 50% of the charging points on the Charging Station are free, yellow – 50% or more of the charging points on the Charging Station are occupied, red – the Charging Station is completely occupied. Additional information about the Charging Station is provided when it is selected. Furthermore, the App provides the search for available Charging Stations within a certain radius with respect to the current location, filtering of the results e.g. according to connector type as well as a link to route planning or a navigation App. Within the scope of e-GAP the App could be downloaded and used freely. In March 2015 the App was made available to the end-users in Garmisch-Partenkirchen and has been in operation since then.

The second – binary – data format output by the converter is intended for the distribution via digital radio. The appropriate information is being broadcast in the IRT DAB test multiplex in München Freimann, received and decoded by means of IRT's DAB test and reference receiver DAB-Scout.2 and (similar to the TPEG App) presented on a map with the respective details (see Fig. 4). In the same way TPEG EMI information could be transmitted to future navigational devices in electric vehicles in order to relieve drivers from an eternal search for an available Charging Station.

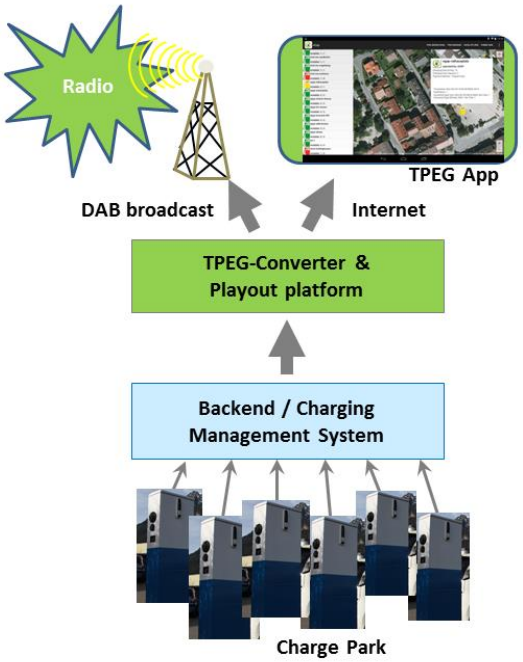

Fig. 2. Block diagram of the TPEG transmission chain realised for e-GAP IL

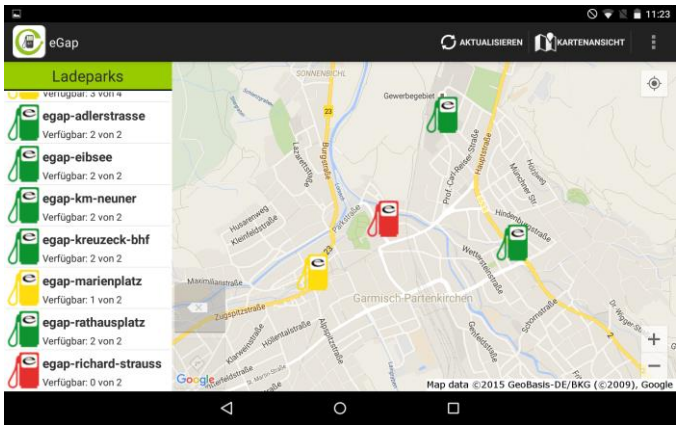

Fig. 3. TPEG EMI App for Android devices

V. TRAVEL PLANNING: MAKING A RESERVATION FOR A CHARGING STATION

In the course of a complementary project (e-GAP IL-Plus) we have implemented a reservation option based on the respective feature in TPEG EMI. At the time of writing, the extensions to the system are being integrated; during the first half of 2016 the implementations will be evaluated with end-users in Garmisch-Partenkirchen. The extensions to the overall system with respect to e-GAP IL (depicted red in Fig. 5) mainly consist of:

- a reservation system, which has been specifically developed by an e-GAP IL-Plus project partner. This system handles reservation requests from the end-user, verifies these accordingly with the Backend / Charging Management System and gives the end-user an appropriate response;
- additions to the TPEG EMI App, to allow an end-user to authenticate himself at the reservation system and to place an appropriate reservation request.

VI. Outlook

The developments described in this article should be seen as a proof of concept for applications providing relevant travel information to users of electric vehicles. Other realizations, based on TPEG EMI, are surely possible, e.g. provision of a "charge guide system", that similar to car-park routing systems in cities shows the way to available Charging Stations. Based on future use cases, extensions to TPEG EMI can be imagined as well.

In addition to the developments in the e-GAP project IRT continues to investigate possibilities to merge travel information from various data sources and/or TPEG applications to so-called multi-modal traffic and travel information services. To accomplish this goal, the institute closely cooperates with other market players, notably traffic editors of the ARD (the Association of Public Broadcasting Corporations in the Federal Republic of Germany), ORF (the Austrian national public service broadcaster) and SRF (Swiss Radio and Television, the largest Enterprise Unit within public-service broadcaster SRG SSR (Swiss Broadcasting Corporation)).

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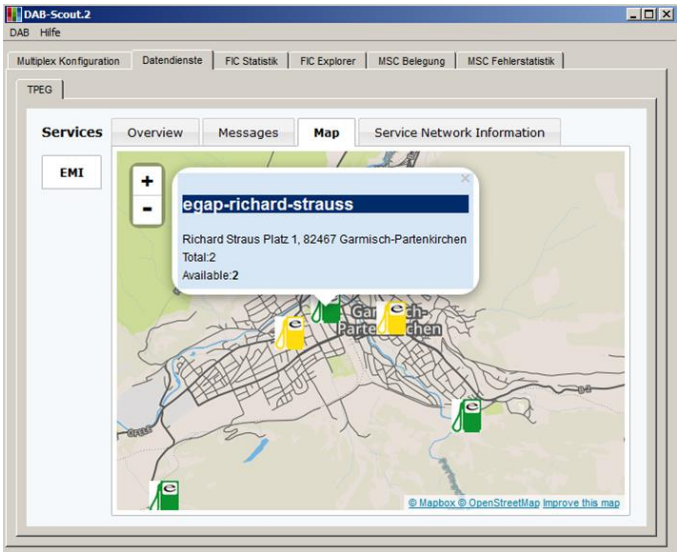

Fig. 4. TPEG EMI implementation as integrated in the DAB-Scout.2, IRT's test and reference receiver for DAB and DAB+

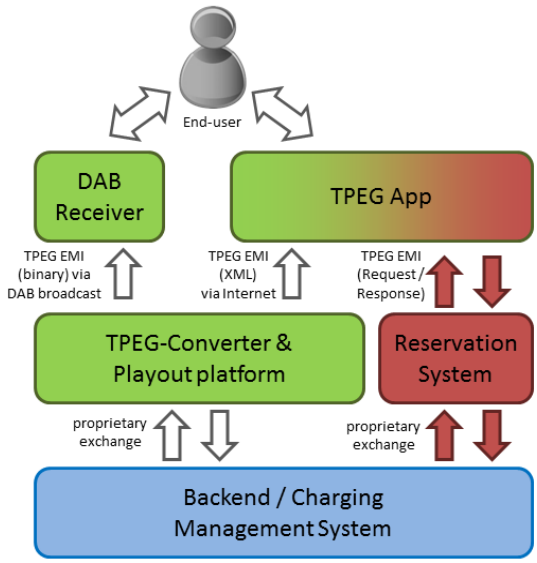

Fig. 5. Overview of integrated system for e-GAP IL-Plus (extensions for reservation functionality marked red)