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E-Roaming in Germany and the EU:

From isolated charging stations to a nation and European Union wide network

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Abstract

From 2011 on the first charging stations in Germany were installed Many of them were part of projects of the so-called “Modelregions” and the “ICT for electric mobility” RnD Programs. These first charging stations had a connection the CPO’s IT backend but these were not designed to work with each other, which led to over 20 isolated charging solutions all over Germany. With the emergence of two commercial E-Roaming platforms and the “Showcase Electric Mobility” Programme things began to change and a connected interroaming network started to spread across Germany and its neighbouring countries. This paper will address the technical, regulatory/legal, political and economic challenges that had to be faced and the possible solutions to these challenges.

1 Introduction

In late 2013, an initiative was launched within the promotional programme "Electromobility showcase", with strong support by the respective project coordination agencies, designed to harmonise the ICT structures between the four showcases. It intends to implement e-roaming in such a way that customers can charge their e-vehicles based on a single car charging contract across different providers and regions.

The E-Roaming initiative presented its first result in a joint showcase at the eCarTec trade fair in Munich in autumn 2014, using prototypes to demonstrate the successful implementation of an e-roaming method featuring charging columns and access media from all the four showcases.

With their commitment, the partner companies of this initiative for the interconnection of platforms support the political and customer-friendly target set forth by the European Parliament and the Council of the European Union in its directive on the "Deployment of Alternative Fuels Infrastructure" which states: "The operators of recharging points shall be allowed to provide electric vehicle recharging services to customers on a contractual basis, including in the name and on behalf of other service providers. All recharging points accessible to the public shall also provide for the possibility for electric vehicle users to recharge on an ad hoc basis without entering into a contract with the electricity supplier or operator concerned[1]."

2 Status Quo

By October 2014, there were some 950 charging columns with about 2,000 charging points in the four showcase regions2. They are owned by different charging station operators. Thanks to its project ICTP (Standardised, Open Platform for e-Mobility Data3), the Lower Saxony showcase has a central ICT structure at its disposal, which provides access to the charging infrastructure available in the showcase. The partner companies directly involved in this project are T-Systems, Volkswagen, the German Aeronautics and Space Research Centre (DLR), and komola. In the Berlin-Brandenburg showcase, access to the public charging infrastructure of RWE and Ebee is implemented by Hubject GmbH. In addition, Bosch Software Innovations GmbH and the DAI laboratory at the Technical University of Berlin in cooperation with Hubject are carrying out a field trial related to e-mobility designed to ensure access to the charging columns at Ernst Reuter Square. Bavaria-Saxony has also presented heterogeneous solutions. While access in Dresden, East Saxony, and Leipzig is provided by the local utilities DREWAG / ENSO and Leipzig Municipal Utilities via the so-called "StromTicket"4 (electricity ticket) and additionally in Leipzig by Hubject, the fast-charging columns installed along the A9 motorway are operated by E.ON, Siemens, and Hubject.

In the Baden-Württemberg showcase, the public charging infrastructure of EnBW AG with over 600 charging points and the additional semi-public charging stations of Bosch Software Innovations GmbH are also operated by Hubject GmbH. Outside the showcase regions, three providers are currently offering platforms to access the charging infrastructure in Germany[5]:

- Hubject GmbH offers its business partners a bilateral connection, supplemented with a standardised framework agreement, which provides all the participants with easy market access through the so-called "intercharge network".
- E-clearing.net pursues an open market model for bilateral and cross-functional contractual relations between the participating partners.
- Tesla Motors, Inc. prefers the approach of supplying their own customers with an adequate charging infrastructure.

In the following illustration of the status quo, each charging column is assigned to only one participating platform. There are numerous access possibilities within these networks. However, they can be roughly divided into two categories:

- Local authorisation (card readers at the charging columns, mostly RFID)
- Remote activation (mostly by the user via app, SMS etc.)

It must be noted that, particularly with local authorisation, the charging columns are not always integrated into an ICT infrastructure. But even if authorisation is effected through a request made to the central IT infrastructure, the column itself is not necessarily connected to it, as shown in the "StromTicket" (electricity ticket) example[6].

Integration into a modern energy infrastructure, however, requires a link to back-end systems and corresponding data connections. The easiest access to a charging column would undoubtedly be a cash-based system that releases a certain amount of electricity after the customer has inserted coins. In reality, however, neither cash nor credit or EC cards have become popular with charging infrastructure operators. One of the reasons for this is the fact that these solutions entail transaction costs for the operators which bear no relation to the low proceeds gained from individual charging processes. This is why operators still require their customers to provide specific access media, such as an RFID card or an app.

Substantial technical and organisational efforts by the various parties involved are still required to implement the vision of establishing e-roaming using compatible ICT interfaces, similar to the mobile telephone system. The first important step in this process is to ensure compatibility between the showcase regions.

3 User Requirements and Use Case Descriptions

The heterogeneity of the status quo described above makes it necessary to define the minimum requirements a charging column has to fulfil in order to be included in the design of e-roaming use cases.

These minimum requirements are:

- The charging column has an ICT (internet) connection.
- If these conditions are met, the following use cases should be made possible:
- The charging column is compatible with OCPP 1.5 or offers similar features (Open Charge Alliance, 2012).
- The charging column has a local RFID card reader and/or a function for remote activation.

If these conditions are met, the following use cases should be made possible:

- Every customer of platform A should receive access to all charging columns of platform B.
- To this end, the customers of platform A should be able to:
    1. Find charging columns of platform B via an app or a website and determine their status based on dynamic Point-of-Interest (POI) data sent to platform A by platform B.
    2. Activate platform B charging columns using an RFID card ("MIFARE DESFire EV1" or "MIFARE Classic").
    3. Activate platform B charging columns using an app.
    4. Receive a bill of the charging process, based on a Service Detail Record (SDR[7]), which is sent from platform B to platform A.

These criteria will subsequently be used as a reference when checking the implementation. In the process, potential technical extensions of the charging infrastructure, for instance to OCPP 2.0, must be considered in order to meet future standards.

4 Describing the Solution within the Framework of the Showcase Interconnection

The aim of the E-roaming showcases was to implement a compatible charging solution for the four showcase regions and to demonstrate its interoperability. The solutions were based on the four use cases mentioned above:

4.1 Finding a Charging Column of Platform B and Determining its Status for Users of Platform A

Exchanging POI data to find a charging point (EVSE = Electrical Vehicle Supply Equipment) is a prerequisite for using charging stations of different providers. The exchange of data between the platforms used in the showcase was based on a common data and interface definition to make sure identical information was exchanged between all market partners. Figure 1 illustrates the exchange of POI data between the platforms and the systems of their partners.

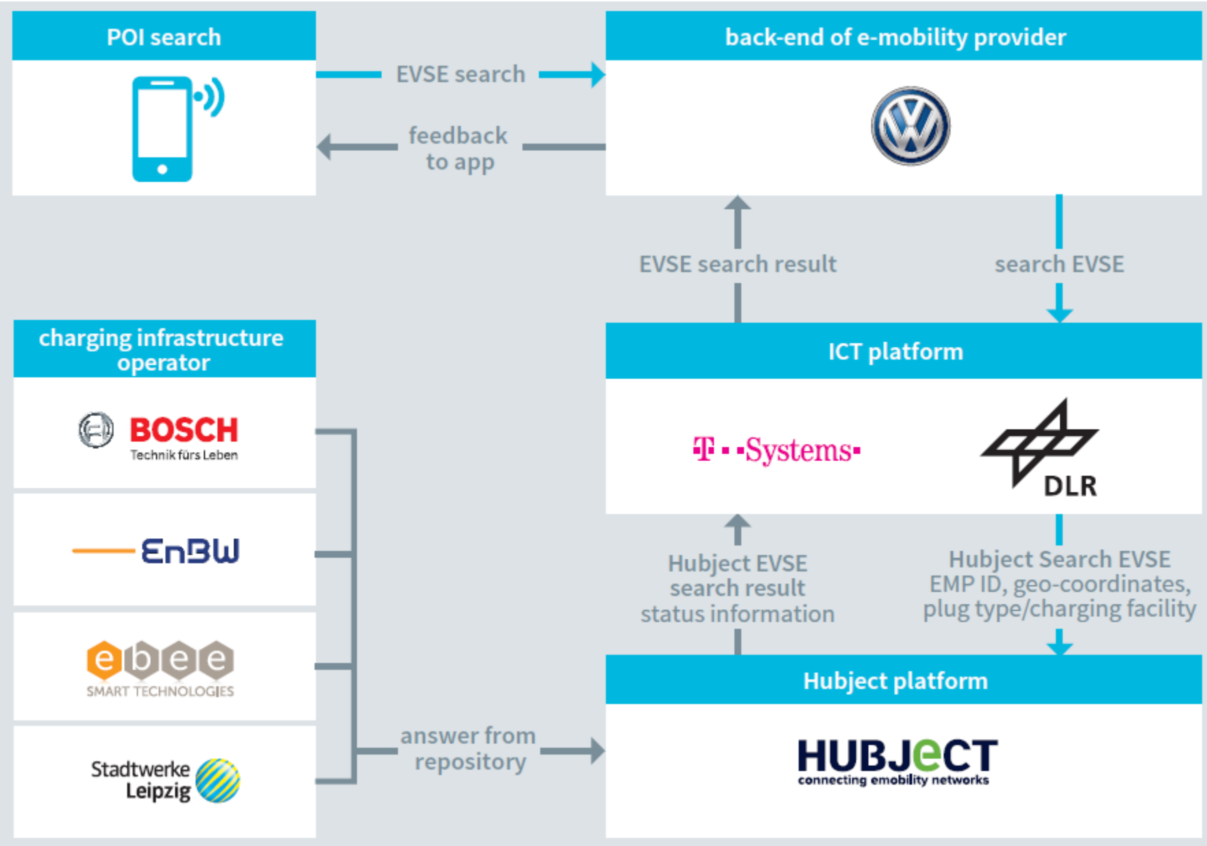

Figure 1 Illustration of a search for a POI

4.2 Activation of Platform B Charging Columns by Platform A Users by means of an RFID card ("MIFARE DESFire EV1" or "MIFARE Classic")

Activation with an RFID card via a card reader installed at the charging station was selected for the showcase because this function did not require any changes to the existing charging infrastructure. If a platform A user registers at a platform B charging column with his mobility card which is not known there, the charging station sends the card number to its IT system for identification. If the system is unable to identify the number, platform B forwards the request to the IT system of the roaming provider, which asks all the other platforms connected to it whether any of them can identify that card. In a positive scenario, the mobility provider that knows the card number replies and signals assent to the activation of the charging column.

For the inter-regional showcase, this request was extended to connect - for the first time - two independent roaming providers, the ICTP platform granting access to the charging infrastructure in Lower Saxony and the Hubject platform granting access to the charging infrastructure of the three other showcase regions. The OICP protocol of the Hubject GmbH formed the basis of this approach.

The request triggered by an RFID mobility card issued by Volkswagen (pilot project) at a charging column in Baden-Württemberg was forwarded by the local provider EnBW to the roaming provider Hubject and from there on to the ICTP platform used in Lower Saxony. From there the request was sent to Volkswagen, the responsible e-mobility provider, where the number was authorised and the charging column in Baden-Württemberg was activated.

A similar information chain was used to activate an RFID mobility card issued by BMW at a charging column operated by enercity in Hannover. The request was sent to Hubject via the ICTP platform and from there on to BMW, the responsible e-mobility provider. In total, the showcase of the four regions implemented the technical integration of four providers of mobility cards and six providers of charging infrastructures, demonstrating that it was possible to tap the charging infrastructure in Baden-Württemberg, Bavaria, Berlin, and Lower Saxony with a single card (e. g. the Volkswagen mobility card).

4.3 Activation of Platform B Charging Columns by Platform A users with an App

This use case was similar to the RFID card scenario in many aspects. The only difference was that the authorisation request was not triggered at the card reader of the charging column, but with a customer's app, which initiated the activation via the e-mobility provider's back-end. Therefore, it is not specifically illustrated here.

5 Technical Implementation of the Showcase Interconnection

The task of interconnecting different charging infrastructures presents the parties involved with technical obstacles that can be overcome using various options.

5.1 Relevant Roles in E-Roaming[8]

The user drives an electric vehicle and wants to use the charging infrastructure in the public and semi-public space. Typically, he has a contract with an e-mobility provider facilitating this use.

Based on this contract, the **e-mobility provider (EMP)** gives the user the opportunity to use charging infrastructures via a service that includes the detection and activation of charging stations.

The **charging point operator (CPO)** operates the charging infrastructure or a part of it with legal responsibility and may issue invoices for its use. A charging point operator may draw on other providers for his business, such as network operators, electricity providers, and charging station manufacturers.

The **e-roaming provider** connects the services offered by the EMPs and CPOs that cooperate with him across regions. Along with the technical interconnection, he provides other services for his partners, supporting them, for instance, with billing procedures.

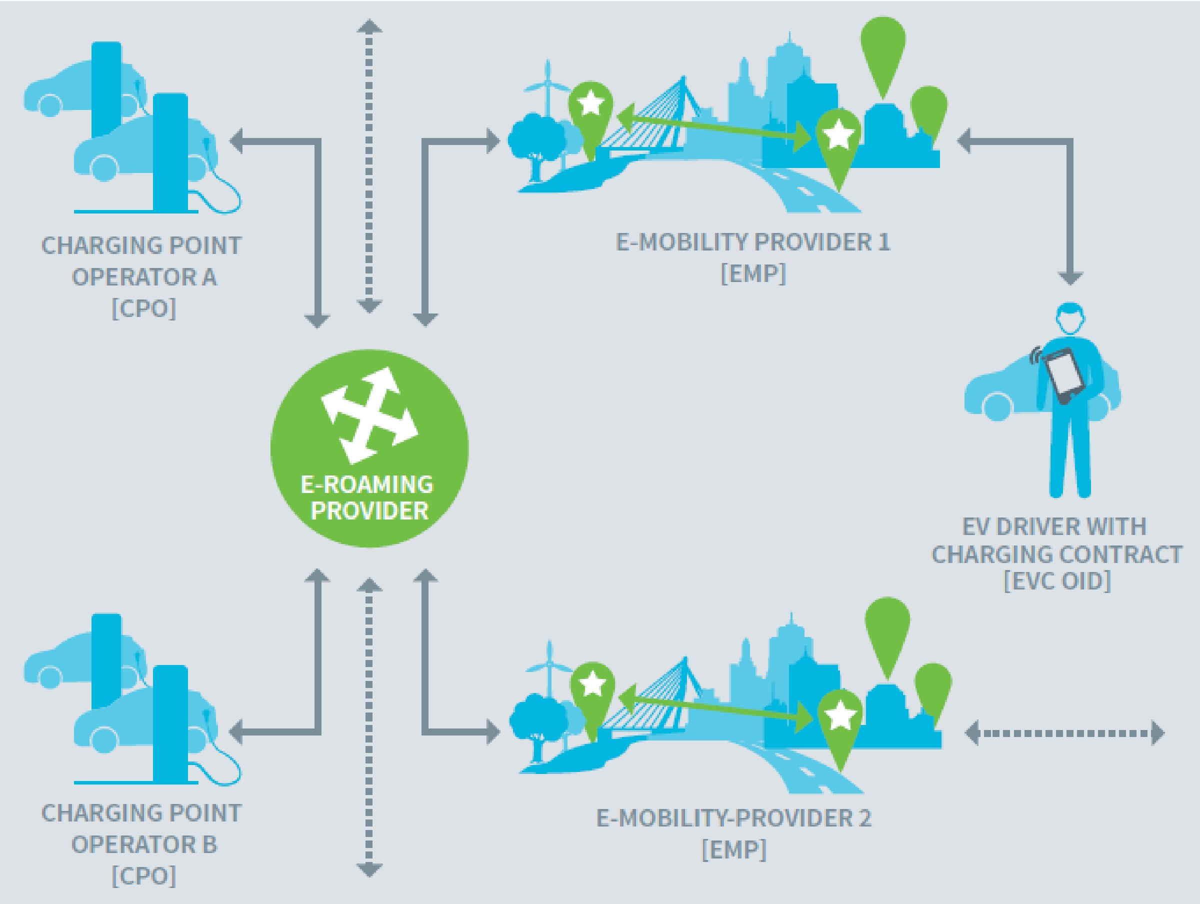

Figure 2 Relevant Roles in E-Roaming

In practice, these roles overlap. Many charging point operators let their customers use charging infrastructures, which means that they are providers of e-mobility at the same time. The five large German electricity providers are a good example. They operate a charging infrastructure to which they also provide access for their customers. On the other hand, there are providers of e-mobility that operate their own charging points. Among others, this refers to car manufacturers that either install charging boxes for their customers on private property or even operate public charging stations like Tesla.

5.2 Unique Identification of EVSE and User

Since a charging point is the only object that can actually be uniquely assigned to a charging process, its clear identification is essential. This is the purpose of the so-called EVSE ID. It consists of several sections, similar to the IP address of computers in the internet. The format of the following two examples is taken from older standardisation initiatives:

*DE*ABC*EABC123BDC456* (ISO 15118-2:2014 – Appendix H (ISO, 2014)[9]

*+49*123*123456789* (DIN SPEC 91286 (DIN, 2011))

The first two sections of the EVSE ID refer to the charging point operator, uniquely identifying him in a country. If an operator is active in several countries, it is advisable to use different operator IDs. In Germany (country code "DE"), the administration of operator IDs was mandated to the Federal Association of the

Energy and Water Industry (Bundesverband der Energie- und Wasserwirtschaft e. V., BDEW) according to ISO15118, which assigns a unique ID to each legal person.

The third section can be freely assigned by the charging point operator, even though there are differences between the standardisation proposals by ISO and DIN. For example, the ISO standard demands that the third section should always start with "E" for better recognition as an EVSE ID related to electro mobility. Other differences include the accepted symbols and the length of the third section. See the BDEW website for more information.

Since 01 March 2014, every charging point of an operator is assigned a worldwide unique EVSE ID. For this purpose, the existing DIN format mentioned above is replaced by a new ISO format with the following syntax:

*DE*A23'*E45B*78C*

This syntax consists of the country-specific operator ID (here: DE*A23'), followed by the charging point ID [https://bdew-emobility.de/▪. The separator,*' in the syntax is mandatory.

Along with every charging point, every user must be uniquely identified as well. Only this makes the assignment of a charging process to a user and the correct billing of the charging process possible. The user is identified through the contract ID, which is also called EMA ID (e-mobility account identifier) or EVCO ID (electric vehicle contract identifier). For this number as well, BDEW clearly assigns the first section (= provider ID) to an e-mobility provider in Germany, as stipulated by ISO 15118. For the customer ID, a "C" is prepended to the number instead of an "E" to emphasise that it is a contract number. As an alternative, identification according to DIN SPEC 91286 is also used on the market.

5.3 Models of Cooperation in E-Roaming

The public infrastructure should be made available not only to local charging point operators and providers of e-mobility, but also to regional and national providers of e-mobility services like car manufacturers, car-sharing companies, and fleet providers. This requires a comprehensive approach to cooperation, which was also taken in the showcase initiative, granting principally every potential market participant access to e-roaming. Charging station operators must open their charging points for other market players, thus maximising the number of users of their charging infrastructure.

Instead of interlinking a large number of bilateral user contracts and different interfaces for communication between proprietary systems in a meshed network, a joint framework agreement with a technical interface like in a hub and spoke model is recommended for this process. Additionally, an extended spoke model permits linkage and interaction between hubs on the basis of defined framework agreements, if in line

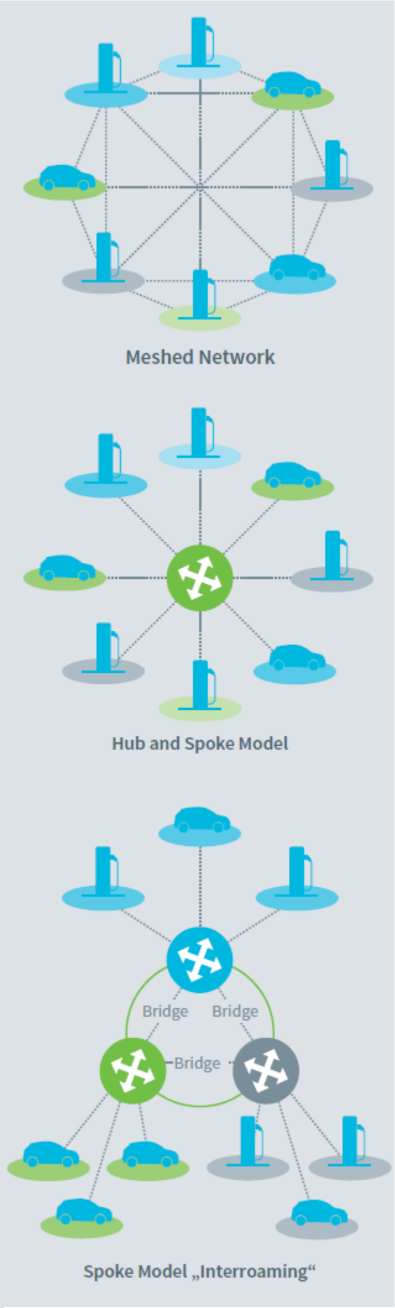

Figure 3 Illustration of cooperation models for e-roaming.

with the corporate strategy. This enables municipal utilities and private businesses to efficiently participate in an e-roaming scheme.

The benefits of a spoke model or a hub and spoke model in terms of reducing complexity, costs, and non-transparency have already become evident in the telecommunications and finance industries. Overall, these models allow for efficient, uninhibited, and sustainable market growth, provided that efficiency factors like system security, fees, and speed are taken into account.

For this reason, the spoke model was chosen as the basis for cooperation between Hubject and T-Systems in the showcase. The technical communication between the platforms and their connected systems was based on the OICP protocol. The showcase partners suggest the same approach for any interconnection beyond the scope of the showcase.

5.4 Models for Technical Communication between E-Roaming Providers

E-Roaming providers can be connected with each other in various ways. The basic requirement in all these cases is that every e-mobility provider and every charging point operator can be connected via a coordinated IT interface.

The main target of the initiative "Interconnecting the four showcases" was to use the promotional programme "Electro mobility showcase" to demonstrate that it is technically feasible to connect e-roaming providers with each other. Therefore, a method was chosen that permitted a fast and simple technical implementation without the need to make major changes to the systems that existed in the showcases.

In this model, the e-roaming partners set up a direct link with each other, which is implemented via a single communication protocol, to which the participants have to agree. The showcase selected the Open Intercharge Protocol (OICP) for this purpose.

With card-based authorisation at a charging station, however, no information on the target provider of e-mobility is available. This is due to the unstructured format of the RFID card number because RFIDs are assigned without structuring sections that indicate the country or e-mobility provider. Since neither the target e-roaming provider nor the associated e-mobility provider can be determined from the ID, a broadcast similar to a radio broadcast has to be sent to every connected e-roaming provider. This broadcast, however, must be in the language of the respective provider. This simple model also has limitations when it comes to remote activation since this feature requires broadcasting as well, if more than two e-roaming providers are connected. Current technologies do not yet offer a clear and publically available assignment for charging point operators and e-roaming providers. To be sure, this simple type of technical communication is practical within the narrow scope of the showcase initiative, but every additional e-roaming provider would make it more complex.

The requirements for higher complexity are met by the multi-platform model in Figure 4. The single most important factor for the efficiency of this model is the information indicated by the text boxes next to the nodes. They symbolise so called routing tables that state which player can be addressed via which roaming platform. E-roaming providers use this information to avoid broadcasts and to target the corresponding player via his provider (unicast). This helps avoid data scattering and unnecessary system requests and is, therefore, a very desirable objective.

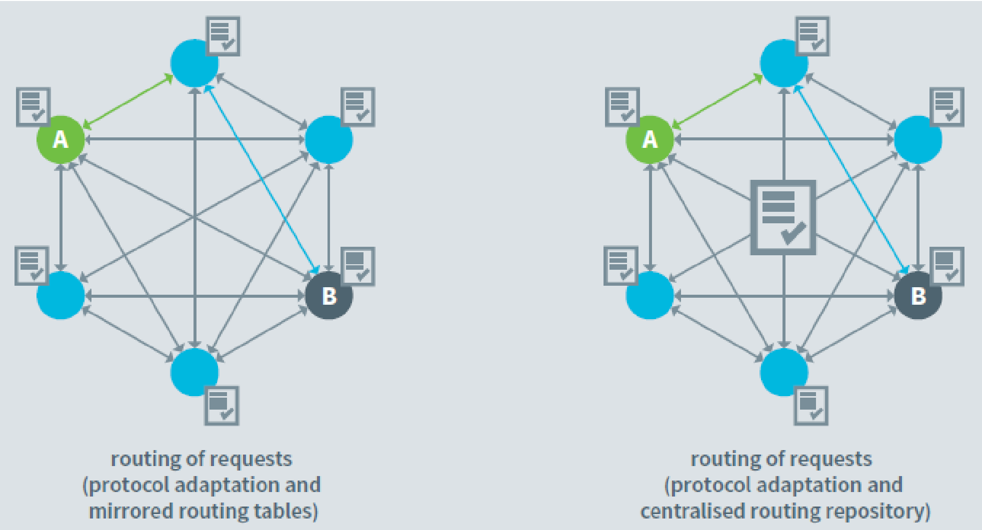

Figure 4 Multi-platform approach via routing tables and protocol adaptations

In the diagram on the left, the routing tables are stored with all e-roaming providers in the same manner and must be mirrored between them. This may seem complicated to organise, but is, in fact, quite easy to implement.

The diagram on the right, in contrast, shows the centralised administration of the routing table by a single provider. While this scheme keeps the amount of effort for communication required by each provider almost on the same level, synchronisation of the routing information becomes easier. Coming to an agreement with respect to such a centralised administrative entity, however, is a political challenge in view of the numerous regional, national, and European initiatives.

In addition, both models still require the messages to be converted into the language of the respective e-roaming provider. This drawback can be overcome by aligning the communication protocol between all providers, along with introducing routing tables. Figure 5 shows these models with decentralised and centralised routing table administration, respectively.

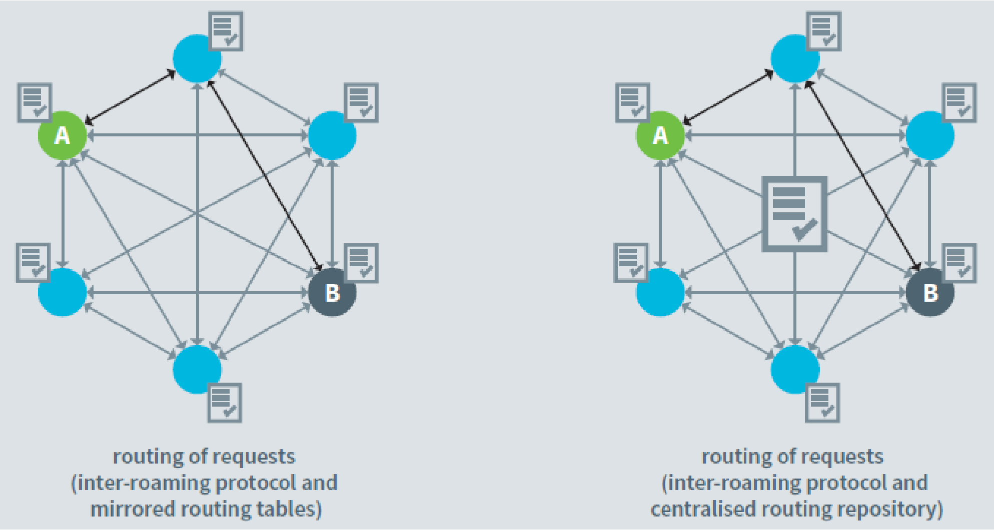

Figure 5 Multi-platform approach via routing tables and an inter-roaming protocol

These models no longer require protocol adaptations, at least not between e-roaming providers. Rather, all providers involved define and use a so-called "inter-roaming protocol" that transmits essential information such as:

- Charging point and contract ID
- Status information on charging points
- Charging process data (amount of electricity, duration)

One of the most important forums where options for harmonising this exchange are discussed is the eMI3 group (http://emi3group.com/).

An inter-roaming protocol can have different levels of sophistication. On the first level, the exchange of charging point information can be harmonised, including real-time status, exchange of authorisation messages and of information after the charging process has been completed. This makes both card-based and remote authorisation (e. g. via smartphone) possible. The joint protocol can subsequently be extended in many ways to facilitate, for instance, the reservation of specific charging points (e. g. at fast-charging columns along motorways) or grant access to parking spaces.

Another important requirement for an inter-roaming protocol - along with its modular expandability - is its high technical flexibility, so that it does not have to explicitly take special features of individual providers into account. Other important factors for the quality of such a protocol are its reliability and open availability. At the same time, the cost of its development (shared by several partners) and implementation in various systems play a major role for its viability and acceptance. Another interesting factor is the communication technology selected for the exchange of data. In this context, approaches like REST or SOAP are available for implementation. Both systems are well established in internet communication. REST stands for Representational State Transfer and is a method for the location-based access to web resources with unchanging syntax and semantics. Today, REST is often mixed with other methods like SOAP, for instance when describing methods for the access to web resources. The SOAP protocol is a standard of the World Wide Web Consortium (W3C) used for exchanging predefined data via the internet.

6 Conclusion and recommendations

On the basis of the E-Roaming showcase and findings of other projects in the Showcase Electric Mobility" Programme, the following recommendations are given:

1. The parties involved in interconnecting the charging infrastructure should organise their cooperation in an extended Spoke model. This model combines different platforms ("hubs") to which the regional market partners are connected by using defined frame agreements ("hubbing the hub"). The result is a substantial reduction in both the complexity and cost of trans-regional cooperation.
2. A multi-platform approach, using integrated routing tables and a jointly defined inter-roaming protocol, can simplify the technical communication between e-roaming providers. The routing tables indicate the platform address(es) of all the parties involved. The joint protocol eliminates the need for adaptations between platforms, and systems tied to specific e-roaming providers can continue to use the platform-specific protocol if necessary.
3. The inter-roaming protocol used between the various e-roaming providers can be extended on a modular basis. It should also be mandatory, freely available, as well as clearly defined with respect to communication technology and data format, without incurring excessive cost.

4. In order to successfully integrate different IT systems into e-roaming, all types of software tests should be conducted, including black box, white box, and grey box tests.
5. E-roaming platforms must ensure a high level of security, high robustness, and quick reaction times to fulfil the needs of inter-regional interconnection. Customer-friendly support processes are also helpful.
6. Online authorisation is desirable, even though it may lead to increased running times of authorisation requests to the back-end. This makes e-roaming easier and facilitates ad-hoc access and payment via a smartphone app.
7. Charging points, providers and end users must be bijective identifiable to ensure easy reservation, authorisation, and billing at charging stations. The corresponding IDs have meanwhile been assigned throughout Germany. This is a milestone on the path to a national charging infrastructure.
8. A bijective transaction ID that cannot be altered is necessary to trigger, process, and document charging processes in a consistent manner.
9. End users should be able to quickly find and reliably reserve the charging points, all of which must be clearly marked so that their interoperability is easily recognizable.
10. All charging points and their providers should provide dynamic POIs to enable users to plan their routes according to the status of charging points.
11. In addition to providing interoperability, all charging stations should offer ad-hoc access for users without a contract.
12. An industry standard for the human machine interface (HMI) is desirable in order to provide a uniform and understandable status indicator on the charging columns.

Author

Sven Lierzer was born on June 2nd 1982. Following his studies of political science and sociology at the University of Tubingen, he started to work at BridgingIT GmbH.

In the last five years he has been engaged in issues of several industries mainly utilities. He worked on innovations such as Smart Grids, new mobility concepts e.g. electric mobility and smart cities, both on national and international level. At this, Sven Lierzer advises large companies and corporations as well as governmental organizations on aligning their strategy.

Sven Lierzer is a member of several expert circles including:

- *Representative of BridgingIT GmbH at the BEM e.V. and the Smart Grids BW e.V.*
- *Project manager and electric mobility expert in the leading edge cluster Electric Mobility South-West projects SGI and IMEI*
- *Expert at the parallel research into effectivity within the German federal program "Electric mobility Showcase"*
- *and author/co-author of various publications plus expert in various special topics as:*
  - *Research program "Horizon 2020" of the European Union*
  - *Electric Mobility E-Roaming, Smart Charging and Smart Grid*

Within the scope of innovation and business development Sven Lierzer is engaged with the current trend topic of Digitization – from Big Data, Industry 4.0 and demographic change through to issues of the whole transformation of industries.

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1 Source: Directive 2014/94/of the European Parliament and of the Council of 22 October 2014 on the Deployment of Alternative Fuels Infrastructure, article 4, (8–9), URL: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&qid=1415713803036&from=EN

2 Source: http://schaufenster-elektromobilitaet.org/

3 Source: http://schaufenster-elektromobilitaet.org/

4 "StromTicket" facilitates ad-hoc access to the charging infrastructure using codes sent via an app or SMS.

5 See also NPE (National Platform Electromobility) 2014 Progress Report, 2014, p. 31f.).

6 In this scheme, an authorisation command is sent to a centralised system via app or SMS and the user receives an mTAN (activation code) in response, which is to be entered at the charging column. (KEMA IEV – Ingenieurunternehmen für Energieversorgung GmbH, 2013).

7 Service Detail Record; a record used to transfer selected data related to the charging process for subsequent billing. This record is also called "charge detail record".

8 This role model can be found in a similar way in various sources. It is derived from illustrations of BDEW (Bundesverband der Energie und Wasserwirtschat e. V. = Federal Association of the Energy and Water Industry), the protocol specifications of OCHP (OCHP Open Clearing House Protocol), OICP (Hubject GmbH), and activities of the Green eMotion project (see for example: http://www.greenemotion-project.eu/upload/pdf/deliverables/D3_2-ICT-Reference-Architecture-V1_2-submitted.pdf, last access on 26 February 2015).

9 The ISO currently consists of eight parts, but only "part 1" and "part 2" are assigned the status "published". All other parts are still in process.