

Global Service Provider for Electric Vehicle Roaming

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Abstract

Due to the rising number of electromobility business entities (electric vehicle supply equipment operators and electromobility service providers), electric vehicle users are faced with a growing complexity in the use of public charging infrastructure, especially on a greater geographical scale. The development of electromobility calls for interoperability between all electromobility entities in order to enable roaming of EV users and remove the present barriers in EV users' access to the public charging infrastructure. The paper describes the elementary processes related to EV charging (charging, reservation of charging spot, billing of charging service fee), the roles of electromobility entities in these processes, and their importance for the development of the roaming system.

ETREL has developed an integrated roaming solution introducing a new entity, the global service provider, which mediates between the electromobility entities to enable roaming. The paper discusses the architecture and functionalities of the roaming scheme which comprises the global service provider. The paper also describes individual elements of the global service provider's ICT system. The EV charging processes are explained again, this time in relation to roaming and with a focus on global service provider's role in the processes. The final section of the paper proposes further steps to expand the roaming scheme functionalities and its geographical scope, where standardization or at least an agreement on ICT interfaces, application level protocols, and software services plays the key role.

Keywords: EV (electric vehicle), charging, business model, standardization

1 Introduction

There are several entities involved in the process of electric vehicle (EV) charging. EV users are persons or legal entities using (and charging) the electric vehicle. Power producers and retailers provide electricity for EV charging while the power network system operators provide transmission and distribution of this electricity to final customers. Electromobility service providers (EMSP) are entities which have contracts with EV users for all services related to

EV charging and are the only entities that can access the EV users' personal data. Electric vehicle supply equipment operators (EVSEO) maintain and operate the charging infrastructure as a service but have no continuous contractual relation to EV users.

EV users have a direct contact only with their EMSP and with the EVSEO (in fact with the EVSE operated by the EVSEO); other entities are, at least from EV users' point of view, hidden in the background where they perform their role in EV charging processes.

For the time being, the most common business model combines the roles of EMSP and EVSEO in a single entity which is defined as the charging service provider (CSP). EV user thus has a direct access to his or her “home network” – the charging infrastructure operated by EV user’s CSP (Fig. 1, left).

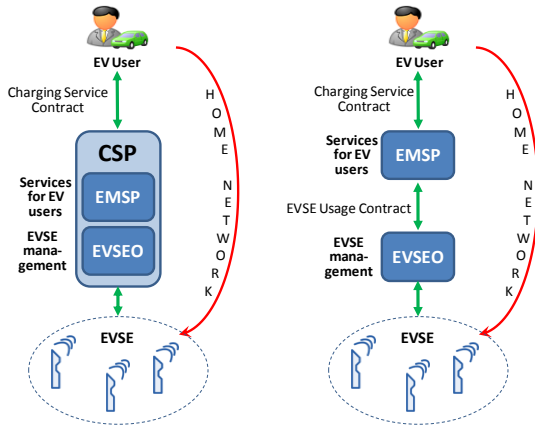


Figure 1: EV user’s home network

Even if both entities (EVSEO and EMSP) are not legally merged into one company, each individual EMSP usually has an “EVSE usage contract” with one dedicated EVSEO. The contract defines bilateral provision of services: the EVSEO enables the use of its charging infrastructure by the EMSP’s clients while the EMSP assures the payment of charging service fee to the EVSEO. In this case, the EV user’s home network is the charging infrastructure operated by the EVSEO that has an EVSE usage contract with the EV user’s EMSP (Fig. 1, right).

Deployment of electromobility will result not only in increased number of EVs and their users but also in the growth of other business sectors, especially those related to EV charging. In an open and competitive market, we can expect establishment of numerous EMSPs, EVSEOs and CSPs, many of them conducting their business on the same area.

Suddenly, the EV users might be faced with an absurd situation: the cities and roads will host large numbers of EVSE, but only a fraction of them (namely those in the EV user’s home network) will be accessible to the particular EV user.

If the EV user wants to increase the number of accessible EVSE, the obvious solution is to sign charging service contracts with several EMSPs and CSPs which operate the majority of charging infrastructure in the geographical area of EV

user’s interest. Such solution implies a handful of contracts to be signed by the EV user, a number of charging invoices received monthly from each EMSP, and a number of required identification means (such as RFID cards) issued by every individual EMSP.

Evidently, such approach is very impractical for the EV user; it resembles a fictional scenario from mobile telephony where the user would need a number of mobile phones or SIM cards, whenever he or she would leave the home mobile network.

The more practical solution lies in the implementation of interoperability between different service providers on the B2B (business-to-business) level. Such approach does not directly involve the EV user in terms of contractual issues; the EV user’s EMSP enters into EVSE usage contracts with different EVSEOs and thus enables the EV user to charge the EV also in “visited networks” (i.e. at the EVSE which is not a part of EV user’s home network). Such approach is defined as roaming and is already known from mobile communications.

2 Roaming and EV charging

In general, roaming refers to the use of service by the person which is not in direct contractual relationship with the entity providing the service. In EV charging that means (Fig. 2, left and center, solid red line):

- that the EV user can charge his or her EV also on EVSE which does not belong to his or her home network,
- that the CSP can offer the use of its infrastructure also to EV users which are not its clients (or in case of EVSEO, which are not the clients of its dedicated EMSP).

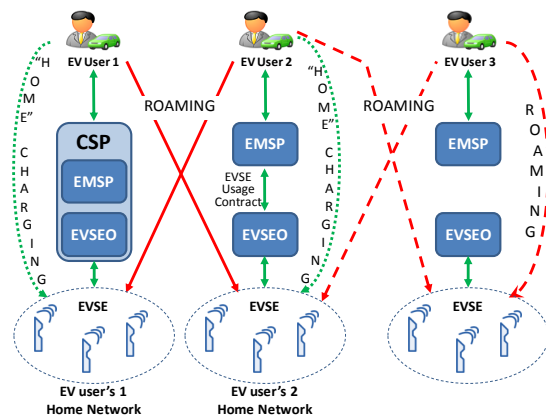


Figure 2: Roaming – CSP, EMSP and EVSEO case

If the EVSEO does not enter into an EVSE usage contract with any of the EMSPs (Fig. 2, bottom right), all charging sessions on its infrastructure are performed via roaming. Similarly, if the EMSP does not enter into an EVSE usage contract with any of the EVSEOs (Fig. 2, upper right), every charging of its clients is performed via roaming.

3 Processes in EV charging

The processes related to EV charging can be divided into two main categories:

- not related to charging session: common processes, which are not related to individual charging sessions, such as development and maintenance of charging infrastructure, transmission, distribution and retail of electricity, and management of EV users' contracts;
- charging session related: processes which are specific to each individual charging session.

The goal of roaming is to manage the charging session related processes. These processes are:

- reservation of charging spot (optional),
- charging,
- billing of charging service fee.

These processes involve the same entities and components as described above: the EV user, the CSP (or EMSP and EVSEO), and the EVSE.

3.1 Charging

The first process in each charging session is charging (if we put aside the optional reservation of EVSE). It consists of the following sub-processes: identification of EV user, authorization of charging, supply of energy to the EV battery, and termination of charging.

3.1.1 Identification of EV user

The purpose of identification is to acquire the EVSE ID (unique identification of the charging spot which the EV user intends to use for charging), and the EV user identifier.

The EV user identifier (UID) is any sequence of numbers, letters or other characters that enables the EV user to identify for charging or access to other electromobility services. It may be represented by an RFID number, credit card number, phone number, etc. Each UID is unique to the EV user, while the EV user may have several identifiers. The UID is issued or

registered by the EMSP/CSP with whom the EV user has a charging service contract.

Both pieces of data, the UID and the EVSE ID, compose the "charging request", which is transmitted to the EVSEO's centre for the control of EVSE. The charging request is communicated to the EVSEO control centre either directly by the EV user (using SMS or smart phone) or indirectly via EVSE (in cases of identification with RFID, NFC, or credit card).

3.1.2 Authorization of charging

After receiving the charging request, the EVSEO checks the conditions that need to be met to allow charging:

- if the charging spot is available, and
- if the EV user has the permission to charge.

The verification of charging spot availability is entirely under control of the EVSEO. In this step, the EVSE verifies that:

- the charging spot is not reserved by another EV user: if the charging spot is reserved (or the reservation is about to begin soon), the EVSEO compares the UID of the EV user who has required the charging, with the UID of the EV user who has reserved the charging spot;
- the charging spot is not scheduled for maintenance in the next hours.

If the verification of charging spot availability returns negative result, the EVSEO informs the EV user (with a message to the EV user's phone or on the EVSE graphic user interface) of the result of authorization (charging request rejected).

The second step of authorization is the verification if the EV user has permission to use charging services. This permission is represented by the status of the EV user's charging service contract (if the EV user's charging service contract is valid or not, has the EV user severely violated any contractual obligation, etc.). The users that are allowed to charge are on the so called "white lists" that are kept by the EMSPs.

Verification of the status of EV user's charging service contract is the process which distinguishes roaming from charging in the home network. In the case of charging in home network, the operator of the EVSE (CSP or EVSEO with an EVSE usage contract with the dedicated EMSP) knows the EV user's contractual status. In roaming, this status is unknown to the EVSEO and must be acquired in real time from the corresponding EMSP.

3.1.3 Supply of energy and termination of charging

The sub-processes that entail supply of energy and termination of charging do not depend on the relationship between the EVSE and the EV user. After a successful authorization, the charging begins automatically and can be terminated by the EV user who repeats the identification or simply unplugs the charging cable.

After the termination of charging, the charging data (including the data for the determination of charging service fee) is automatically transmitted from the EVSE to the EVSE's control centre.

3.2 Reservation of charging spot

Reservation of charging spot is executed via EUIS (End User Information Services). EUIS is an information and communications technology (ICT) tool that provides interfaces and services (web based application, mobile application, etc.) between EV users and other electromobility entities. EUIS may be operated (with different supported functionalities) either by the EVSE, by the EMSP or by any other independent entity.

The process of charging spot reservation consists of the following sub-processes: selection of charging spot, EV user's identification for reservation, authorization of reservation, and EV user's identification for charging.

3.2.1 Selection of charging spot

Within EUIS, the charging spots are usually presented on a geographical map which shows their locations, technical characteristics, and current availability. The presentation of EVSE locations is a part of public functionalities of EUIS. When the EV user selects the charging spot for reservation, he or she enters the private part of EUIS (containing user-specific functionalities), which requires EV user identification.

3.2.2 Identification for reservation

The UID may be acquired as a password used by the EV user to access the private part of the EUIS or is entered separately upon request of the EUIS.

3.2.3 Authorization of reservation

After identification, the EV user selects the time frame of reservation (date, start and end time). The purpose of authorization is the same as in the

charging process: the system verifies charging spot's availability in the given time frame and EV user's permission for charging.

The UID, the EVSE ID and the time frame of reservation compose the "reservation request", which is managed in different ways depending on the operator of the EUIS:

- if the EUIS is operated by the EVSE, the authorization procedure is the same as in the charging process;
- if the EUIS is operated by the EMSP, the EMSP verifies the status of EV user's charging service contract and, if the verification returns positive result, communicates the EVSE ID and the requested reservation time frame to the relevant EVSE. The EVSE verifies the charging spot availability and returns the result to the EMSP;
- if the EUIS is operated by an independent third party, the EUIS sends the reservation request to the EVSE (for the verification of charging spot availability) and to the EMSP (for the verification of EV user's charging service contract's status).

When the reservation is authorized, the EUIS confirms the reservation request and sends the relevant data (UID, EVSE ID and time frame of reservation) to the EVSE.

3.2.4 Identification for charging

Identification for charging is carried out as described in section 3.1.1. The use of a reserved charging spot is possible only if the EV user uses the same UID for both identification for charging and reservation of charging spot.

3.3 Billing of charging service fee

The charging service fee is determined by the EVSE based on its tariff rates for individual parameters of the charging session (duration, energy delivered, maximum load, etc.). At the end of each charging session, the EVSE sends the EMSP the charging detail record (CDR) which contains all relevant data on the charging session, including the charging service fee.

The invoice for provided charging services is issued by the EVSE to the EMSP usually on a weekly or monthly basis. The invoice contains a list of all charging sessions carried out on the EVSE's infrastructure by the clients of the relevant EMSP – recipient of the invoice.

4 Roaming schemes

The EMSP's (and also EV user's) main interest related to charging infrastructure is to enable its clients access to the largest possible number of EVSE. Similarly, the EVSEO's interest is to be able to offer its services to the largest possible user base.

The main task of the roaming system is thus to allow connectivity between the ICT systems of a large number of EMSPs (or CSPs) whose clients require charging on EVSE outside of home network and the ICT systems of a large number of EVSEOs (or CSPs) who operate this EVSE.

4.1 Bilateral roaming contracts

The connectivity can be reached by establishing bilateral EVSE usage (roaming) contracts between the EVSEOs and EMSPs and with the establishment of correspondent communication interfaces between their ICT systems.

4.1.1 Communication interfaces

In an ideal situation for all entities including the EV users, each entity would enter into bilateral contracts and establish communication interfaces with all its counterparties: each EVSEO with each EMSP, or in the CSP business model, each CSP with all other CSPs. Consequently, the inclusion of a new business entity into the roaming scheme requires the establishment of new interfaces, where the number of new connections equals the number of newcomer's counterparties.

Such approach would rapidly result in enormous increase in the number of required interfaces:

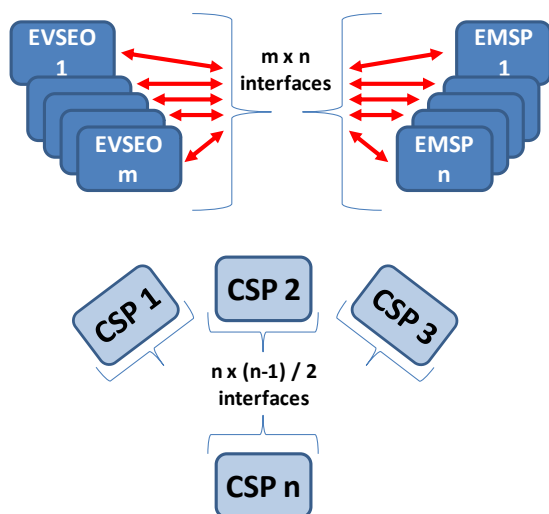


Figure 3: Interfaces in case of bilateral contracts

The extended number of interfaces, which must be able to transmit information in real time, can lead to serious technical problems for all entities, resulting in increased costs of operation and decreased quality of services.

4.1.2 Determination of EV user's EMSP

One of the most important issues in the EV charging roaming scheme is the question how EVSEO determines (based on the UID) which EMSP to contact for the verification of EV user's permission to charge (see section 3.1.2, last paragraph).

The entities (partners in the roaming scheme) may agree on the implementation of a unified structure of UIDs, which contains also information on the EV user's EMSP (EMSP ID). Typically, such predefined structures are used in RFID or NFC identification. This structure contains the EMSP ID, which is known to the EVSEO and enables the redirection of the request for verification of EV user's permission to charge to the relevant EMSP.

In case of other EV user identification methods, such as using credit cards or SMS, the UID (credit card number or phone number) does not contain the EMSP ID. The EVSEO can determine the EV user's EMSP only by means of a "UID/EMSP translation table", which associates the different UIDs with EMSP IDs. The translation table must contain all UIDs of all EV users who have a contract with any EMSP that is in the roaming scheme. The table must be updated in each EVSEO's ICT system immediately after the EV user signs a charging service contract with any of the EMSPs that are members of the roaming scheme.

4.1.3 System architecture

The entities involved in the roaming scheme can be placed on two levels:

- Level 1: physical level consisting of EVSE and EV users, and
- Level 2: service level consisting of EVSEOs' and EMSPs' ICT systems.

In this architecture the interaction between the EVSEOs and the EMSPs takes place on contractual (signing of roaming contracts and billing) and technical level (authorization and update of UID/EMSP translation tables). The interactions on technical level are carried out via direct communication interfaces between the entities.

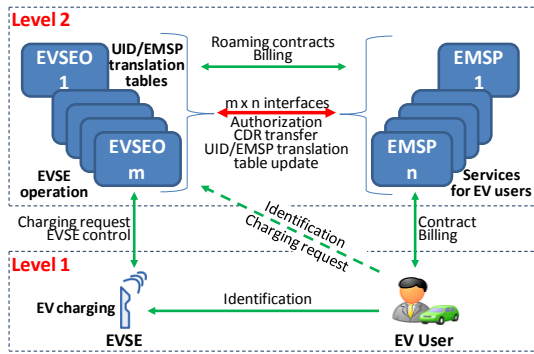


Figure 4: Bilateral contracts – System architecture

4.2 Multilateral roaming contracts

The increasing number of interfaces between the EVSEOs and EMSPs and large UID/EMSP translation tables which are required to be kept and regularly updated by each EVSEO call for a solution different from the bilateral roaming contracts model.

Connectivity between the entities can be reached also with the introduction of a higher-level entity, which mediates between the members of the roaming scheme. This new entity doesn't operate any EVSE or makes charging service contracts with the EV users; it only provides services related to roaming on the global level – therefore it is called a global service provider (GSP).

The GSP represents a “single point of contact” for the members of the roaming scheme. Each of these entities communicates only with the GSP regardless of the number of other entities involved in the roaming scheme.

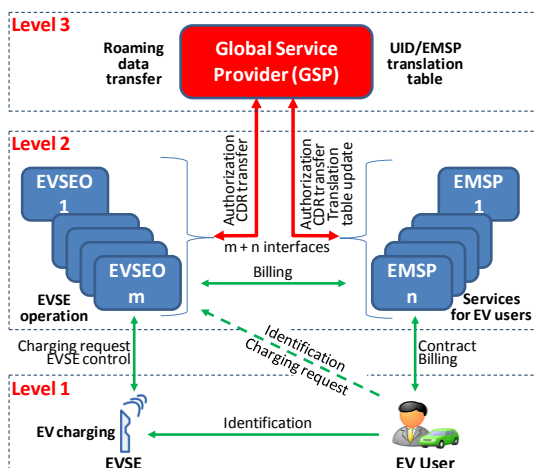


Figure 5: Multilateral contracts – System architecture

The architecture enables easy extension of the system: when a new member joins the roaming scheme, only one additional communication

interface (between the new member and the GSP) needs to be established.

The introduction of GSP simplifies the entities' business processes, decreases their operational costs and increases the quality of service provision.

In spite of the mediating role of the GSP, the EVSEOs and the EMSPs still make bilateral contracts. However, the only subject of these bilateral contracts is their mutual billing, while the EVSE usage contract is considered to be agreed on the multilateral level at the moment when a new entity joins the roaming scheme.

5 GSP's ICT system

The ICT system of the global service provider is an essential part of the EV roaming system, since it is needed to establish a valid communication of EVSEOs, EMSPs, and CSPs with the GSP. The communication solutions between these entities have to guarantee a high level of data transfer security and of data protection.

Within the ICT4EVEU project [1], Etrek developed an ICT system which enables the functionalities needed for the execution of GSP's role and fulfils the above communication requirements. The solution is currently being tested for implementation in a demonstration pilot in Slovenia.

5.1 Functionalities of the system

5.1.1 System structure

The GSP ICT system consists of:

- Contracts Management Module (CMM) for storage of data related to entities that are a part of the roaming scheme (EVSEOs and EMSPs IDs), contracts between them, and EV user's identifiers (UID/EMSP translation table);
- Roaming Management Module (RMM) for the management of information flows for the purpose of roaming (for reservation of charging spot and for charging);
- EUIS – End User Information Services, where the EV users can obtain information on EVSE (location, technical characteristics, current status) and reserve the EVSE operated by EVSEOs in the roaming scheme.

5.1.2 Roaming contracts

Members of the roaming scheme are not obliged to cooperate with all counterparties (each EVSEO with each EMSP) in the roaming scheme. Each

member may freely choose the counterparties with which it decide to enter (or not) into EVSE usage relationship. For this purpose, the GSP holds and updates the table (EVSEO/EMSP contracts) containing data on contractual relationships between individual counterparties. The table is a part of the contract management module (CMM).

When a new member decides to join the roaming scheme, it receives the list of roaming scheme members from the GSP. The newcomer selects the counterparties with which it decides to enter into EVSE usage relationship. GSP informs the selected entities about the intention of the new partner and asks them to accept or reject the newcomer's proposal for cooperation. GSP introduces a new partner into the EVSEO/EMSP contracts table and updates it according to the answers, received from the existing members of the scheme.

Any partner may freely leave the roaming scheme or change its decision of cooperation with other members. In that case, the GSP, upon member's request, modifies the EVSEO/EMSP contracts table and informs other members.

5.1.3 EV user's identifiers

The method of EV user identification depends on the functionalities provided on the level of EVSE and EVSEOs. The GSP doesn't have any influence on these functionalities; however, its ICT system supports the management of EV user's identifiers regardless whether they contain the EMSP ID code or not.

For that purpose, the GSP keeps and duly updates the UID/EMSP translation table (as a part of CMM). This table allows linking of EV users' identifiers with the corresponding EMSPs and must be regularly updated with the information on new EV user's identifiers.

5.1.4 Communication and data security

Communication in the charging process represents the exchange of sensitive business information such as user identity, charging session information and charging service costs. Business information vulnerability, data privacy, and data security are the main concerns when implementing a robust and secure ICT system.

GSP's roaming services provide secure communication and reliable information/data exchange between the roaming partners, where

all systems communicate via commonly agreed communication methods and interfaces.

All data related to roaming charging sessions are based on EV user's identifiers and not on EV user's personal data. Such approach assures the separation of charging session data from EV user's personal data: both sets of data are available only to the EMSP with whom the EV user has a contract for provision of charging services.

Whenever the EV user communicates with the EVSE or EVSEO, a dedicated user session is created. The applied information security standards and a common communication protocol provide secure information exchange, which assures that the user session is fully secure and safeguards against any unauthorized access.

Interfaces for communication between the EVSEOs and GSP and between GSP and EMSPs are based on standard, open integration technology: World Wide Web Consortium (W3C) - Open Web Platform. Entities communicate with web services using SOAP 1.2 over HTTP 1.1 and define their interfaces with WSDL 1.1.

For security and reliability the WS-I standards are used, in particular WS-Security, WS-Addressing and WS-ReliableMessaging.

For cryptography and certificate for authorization the following standards are used: WSS SOAP Message Security UsernameToken Profile 1.1 and WSS SOAP Message Security X.509 Certificate Token Profile 1.1.

5.1.5 End user information services

The module end user information services (EUIS) is composed of a mobile and a web application for end users.

Besides charging spot reservation, the EUIS enables also:

- review of EVSE properties (name of EVSEO that manages the EVSE, location, number and type of charging spots, max. charging spot power and current, charging spot availability),
- provision of general information on electromobility.

The EUIS functionalities are divided into general (review of EVSE properties, providing general information on electromobility) and user-specific functionalities (reservation of charging spot).

The EVSE properties are reviewed on the geographical interactive map with the following functions:

- search function with filters (charging station availability, socket type, managing EVSEO, identification type, payment type etc.),
- detailed overview of EVSE: detailed location and address, types and maximum current of charging sockets, current status, EVSEO contact details, payment type, user comments, instructions for use etc.,
- option to create a list of favourite stations,
- export of data for navigation devices, supporting different formats,
- option to add EVSE information: proposals for installation or upgrade of EVSE on certain locations, offers for plug sharing, and location and details on new EVSE.

In addition, the mobile application enables the EV user to search for nearby EVSE based on his or her current location.

The user-specific functionality (reservation of charging spot) is the one that requires additional data to be entered regarding the user's identification, which is handled by the EV user's EMSP. The web or mobile application provides a simplified access to the specific EMSP's communication interface where the private data can be securely entered.

5.2 Processes in roaming

5.2.1 Charging

The charging process in roaming involves the GSP, the EV user, the EV user's EMSP, the EVSE, and the EVSEO which operates the EVSE. The process is executed in the following steps (as shown on Fig. 6):

- Step 1: EV user identifies at EVSE (RFID) or at EVSEO (SMS),
- Step 2: EVSEO verifies the availability of EVSE. If the verification is negative, the charging is rejected and the session is finished,
- Step 3: EVSEO sends the charging authorization request to GSP,
- Step 4: GSP determines the EV user's EMSP (using the EMSP ID or the UID/EMSP translation table) and verifies, by means of EVSEO/EMSP contracts table, if the relevant EMSP has a contract with the EVSEO for roaming services. If the verification is negative, the charging is rejected, the GSP informs the EVSEO, and the session is finished,

- Step 5: GSP forwards the charging authorization request to EMSP,
- Step 6: EMSP verifies if the EV user has the permission to charge,
- Step 7: EMSP returns the EV user verification result to GSP,
- Step 8: GSP forwards the EV user verification result to EVSEO,
- Step 9: EVSEO issues the charging control command to EVSE (begin or reject charging).

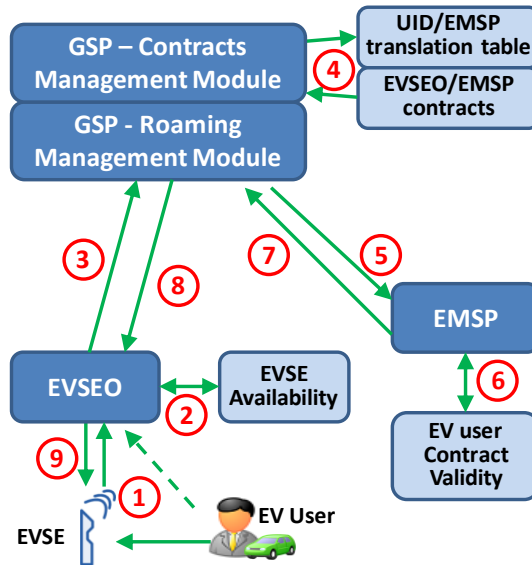


Figure 6: Roaming – Charging process

At the end of charging session, the EVSEO sends the report on charging (CDR) to the GSP, which redirects it to the EMSP. The CDR contains:

- GSP ID,
- GSP authorization code,
- EVSEO ID,
- charging session code,
- EMSP ID,
- EV user identifier (UID),
- identification type,
- start and end time of charging,
- start and end time of parking,
- energy delivered,
- maximum power of charging,
- EVSE title, EVSE ID and charging spot ID,
- time stamp.

5.2.2 Reservation of charging spot

The reservation process in roaming involves the same entities as the charging process. The main difference is that the EV user doesn't interact with the system via the EVSE but via the GSP's EUIS:

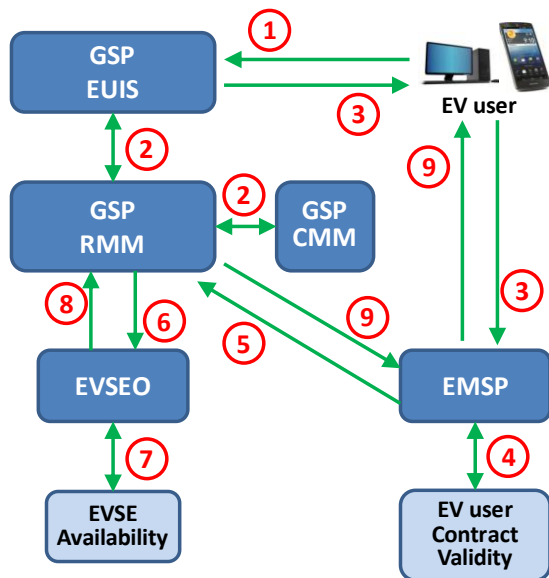


Figure 7: Roaming – Reservation process

- Step 1: EV user browses the GSP EUIS and selects the EVSE for reservation and his or her EMSP,
- Step 2: GSP verifies if the selected EMSP has a contract with EVSE for roaming services. If the verification is negative, the reservation is rejected, GSP informs the EV user and the session is finished,
- Step 3: GSP redirects the client's session to EMSP's services for EV users,
- Step 4: EMSP verifies if the EV user has the permission for reservation,
- Step 5: EMSP sends the EV user verification result to GSP,
- Step 6: GSP forwards the reservation request to EVSE,
- Step 7: EVSE verifies the availability of EVSE,
- Step 8: EVSE returns the result of EVSE availability verification to GSP,
- Step 9: GSP forwards the EVSE availability verification result to EMSP, which confirms (or rejects) the reservation request to the EV user.

5.2.3 Billing of charging service fee

The GSP doesn't deal with financial transactions between the EVSEOs and EMSPs. The responses to EVSEO's requests for EV user verification (Fig. 6, item 8) contain also the EMSP ID. This information is sufficient for the EVSEO's billing system to issue the invoices to the relevant EMSPs on a bilateral level.

The role of GSP in billing procedure is to keep records of each roaming session. These records contain information on content and time sequence of data exchange of each roaming session, and serve the members of roaming scheme in case of eventual disputes related to authorization results and invoiced charging service fees.

6 Further steps

6.1 Hierarchical structure

Implementation of pilot projects that deal with roaming in EV charging requires close cooperation between the involved entities. Therefore, the development of roaming schemes will certainly begin on the local or at most on regional level.

On the other hand, the technical development in the field of electric vehicles will soon result in a greater range of EVs – after all, extended range EVs, which are already available on the market, enable travelling across regional and even national borders. EV users will thus require ever larger geographical areas in which they will charge their EVs.

The most basic way to extend the roaming area would be to merge individual roaming schemes into larger ones, which would cover a wider geographical area. In theory, this process may continue till the roaming scheme would comprise all electromobility entities on the planet. However, such organizational scheme would result in extremely intensive data exchange towards a single common point (a single GSP), which would also represent the single point of failure and might increase the risk of system collapse.

Such system architecture is evidently unsuitable from the communication and system operational security point of view. In addition, it must be considered that even when worldwide roaming will be enabled, the majority of EV user's travels will end within regional borders.

The logical answer to the dilemma is to establish a hierarchical structure of global service providers, where the first GSP level will cover the regional area, the second GSP level (e.g. national) will only mediate between the first level GSPs, and the third (e.g. international) will only mediate between the second level GSPs. In this way, the majority of roaming sessions and related data exchange will stay within the area covered by the regional GSPs; only a small share of roaming sessions will be managed by the national GSPs and only a part of

the latter will require involvement of the international GSP.

6.2 Standardization

Services provided by GSP shall be necessarily standardized, meaning that every member of the roaming scheme must use the same service interface.

At present, the business players in the global electromobility market are cooperating in various interest groups whose scope is to provide the standardization of ICT interfaces, application level protocols, and software services. The initial focus of this collaboration is the standardization of unique identifiers, data models, and structures to enable harmonization and interoperability of services in Europe.

Besides the standardization in the field of ICT interfaces, the agreement on unique structure of EV user identifiers (UID) plays a key role in the simplification of the GSP model's operation.

If the GSP cannot extract the EMSP ID directly from the UID (in case of non-standardized UIDs such as credit card numbers or phone numbers) the UID/EMSP translation table (see section 4.1.2) must be involved on the GSP level. This table, kept by the GSP, must contain data on all non-standardized UIDs of all EV users whose EMSPs are members of the GSP's roaming scheme.

In the hierarchical structure of GSPs (see section 6.1), the UID/EMSP translation table of the regional GSP shall contain data on all non-standardized UIDs of EV users that have a contract with EMSPs in the region covered by the GSP. In the final development stage of GSP hierarchical structure, the UID/EMSP translation table of the international GSP shall thus contain data on all non-standardized UIDs of EV users all over the world.

Such approach implies that the GSPs should maintain and regularly update large databases. In case of standardization of UIDs' structure and of related identification means (e.g. RFID or NFC identification), the need for UID/EMSP translation tables disappears. The operational costs of the roaming system are thus reduced and the quality of roaming service is improved by reducing the time needed for the response to the charging or reservation requests.

Globally agreed standards for communication interfaces and unique identifiers for EV users,

EVSE, EVSEOs, and EMSPs is therefore essential in order to establish communication and exchange of information between diverse systems and enable global roaming services.

6.3 Financial clearing

In the presented solution, the billing procedures are still performed on a bilateral level with direct invoicing of individual EMSPs by each individual EVSEO. The system can be optimized if the GSP assumes also the role of the financial clearing and settlement house.

Such solution would substantially simplify the billing procedures between the increasing number of EVSEOs and EMSPs. On the other hand, the additional costs for the entities would arise due to the following requirements:

- the GSP should upgrade its legal status by obtaining the permission to perform financial activities,
- the GSP's ICT system should be upgraded with a financial clearing and settlement functions,
- the interfaces between the GSP and other entities should be upgraded for transmission of new sets of data,
- the communication would require implementation of more rigid standards related to data transfer security and safety.

Evidently, in the initial phases of implementation of roaming such solution is not economically justified, but will become more and more interesting with the massive deployment of electromobility. Therefore the development of roaming systems should consider already today the requirements and eventual consequences of the GSP's financial role and design the solutions which will enable their upgrade with new functionalities.

References

- [1] *ICT services for Electric Vehicle Enhancing the User Experience*, <http://www.ict4eveu.eu>

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