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Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communications; Part 3: Communications system for the planning and reservation of EV energy supply using wireless networks

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

The present document is part 3 of a multi-part deliverable covering the infrastructure to Vehicle Communication as identified below:

Part 1: "Electric Vehicle Charging Spot Notification Specification";

Part 2: "Communication system specification to support application requirements for Tyre Pressure Monitoring System (TPMS)";

Part 3: "Communications system for the planning and reservation of EV energy supply using wireless networks".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document specifies wireless application protocols and messages supporting the discovery of offered services (completing related discovery protocols), charging spot reservation (and possible renegotiation), pre-payment of the service reservation in the vehicle (involving pre-payment support or contract validation), and application-level logical pairing of the Electric Vehicle to a selected charging spot. Requirements regarding the underlying transport and network layer services are also defined.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ISO/IEC 15118-2: "Road vehicles - Vehicle-to-Grid Communication Interface - Part 2: Network and application protocol requirements".

[2] DIN SPEC 91286:2011: "Electric mobility - Schemes of identifiers for E-Roaming - ContractID and Electric Vehicle Supply Equipment ID".

[3] IETF RFC 5246: "The Transport Layer Security (TLS) Protocol Version 1.2".

[4] IETF RFC 6347: "Datagram Transport Layer Security Version 1.2".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 101 556-1: "Intelligent Transport Systems (ITS); Infrastructure to Vehicle Communication; Electric Vehicle Charging Spot Notification Specification".

[i.2] IEC 61851-3: "Electric vehicle conductive charging system - Part 3: Communication protocol between electric vehicle charging station and electric vehicle".

[i.3] ISO/IEC 15118-7: "Road vehicles - Vehicle-to-Grid Communication Interface - Part 7: Network and application protocol requirements for wireless communication".

[i.4] ISO/IEC 15118-3: " Road vehicles -- Vehicle to grid communication interface -- Part 3: Physical and data link layer requirements".

[i.5] ISO/IEC 15118-8: " Road vehicles -- Vehicle to grid communication interface -- Part 8: Physical layer and data link layer requirements for wireless communication".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Alternating Current (AC): AC charging through the usual grid voltage

Direct Current (DC): fast charging over high-voltage DC current provided by the recharging spot

Electric Vehicle Supply Equipment (EVSE): charging control equipment in the charging spot

inductive: inductive charging without a physical contact

quickdrop: swapping of the EV battery pack or of the trailer carrying the battery extension

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
DC	Direct Current
EIM	External Identification Means
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
HMI	Human Machine Interface
NFC	Near Field Communications
TCP	Transport Control Protocol
TLS	Transport Layer Security
UDP	Universal Datagram Protocol
UTC	Universal Time Coordinate

4 Overview of the recharging spot reservation procedure

4.1 Reservation process in the context of related electro-mobility standards

The recharging spot reservation process starts from the journey planning phase and continues during the driving phase, terminating with the approach of the reserved parking / fast recharge / quick drop area. The charging spot reservation process shall support both EVs equipped with the V2G adapter, i.e. ISO/IEC 15118-2 interface compliant vehicles [1], as well as EVs performing "mode 3" recharging based only on the IEC 61851-3 interface [i.2]. This includes support of different electrical energy provisioning modes, such as wired, quick drop or inductive recharging.

Figure 1 illustrates the scope of this protocol in the context of the EV's journey phases and in relation to other standards. This protocol is expected to be implemented either in the EV's on-board computer or on the driver's nomadic device. The reservation involves the validation of the user's payment account, in order to make sure beforehand that the user is capable of paying for the reserved services; therefore the reservation management server shall be prepared to handle such account validation.

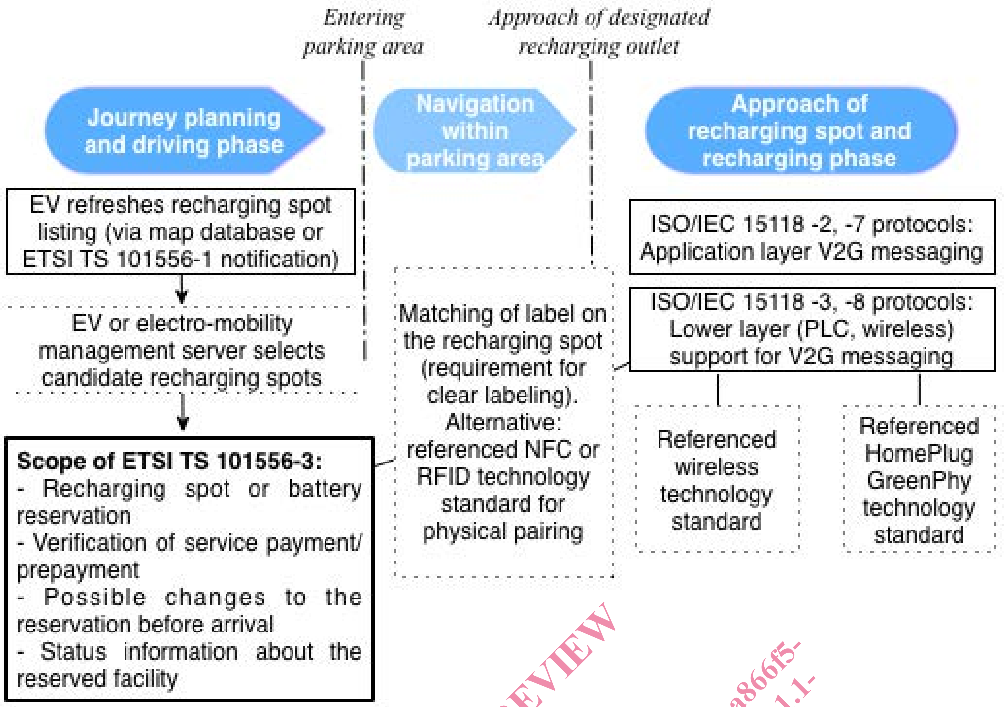
Entering parking area
Approach of designated recharging outlet
Journey planning and driving phase
Navigation within parking area
Approach of recharging spot and recharging phase
EV refreshes recharging spot listing (via map database or ETSI TS 101556-1 notification)
EV or electro-mobility management server selects candidate recharging spots
Scope of ETSI TS 101556-3:
- Recharging spot or battery reservation
- Verification of service payment/ prepayment
- Possible changes to the reservation before arrival
- Status information about the reserved facility
Matching of label on the recharging spot (requirement for clear labeling). Alternative: referenced NFC or RFID technology standard for physical pairing
ISO/IEC 15118 -2, -7 protocols: Application layer V2G messaging
ISO/IEC 15118 -3, -8 protocols: Lower layer (PLC, wireless) support for V2G messaging
Referenced wireless technology standard
Referenced HomePlug GreenPhy technology standard

Figure 1: Overview of complementing EV recharging management standards' roles

Depending on the system architecture, the recharging spot selection is done either by the EV, a nomadic device application, or an electro-mobility server/infrastructure; such architectural difference is irrelevant from the point of view of this reservation protocol. A candidate recharging spot has been selected before initiating this procedure.

As shown in Figure 1, the matching of charging spot identifier by the EV driver is complemented by the EVSE's matching of plugged-in EV with the one belonging to the reservation. When the EV supports the V2G interface, the ISO/IEC 15118-2 procedures [1] ensure that only the EVs with a valid reservation shall be able to recharge. Furthermore, the ISO/IEC 15118-2 procedures [1] may ensure that the offered charging sessions terminate by the end of the reservation period, so that there is no point for the EV to stay longer than reserved. The implementation of this concept requires appropriate system-level integration between the presently described reservation interface and the V2G interface defined in the ISO/IEC 15118-2 documents [1]; the present document defines the identification data which shall be passed between these systems.

In order to support EVs recharging without the V2G interface, the reservation process shall allow the exchange of a Pairing ID, such as RFID or NFC based identifiers, which is then used by the EVSE during the validation of physical pairing.

The complete transaction cycle begins from information gathering at the start of journey planning, and completes with the billing and accounting of utilized charging services. Figure 2 illustrates the wider view of this transaction cycle, and shows this cycle, along with the role of relevant communication standards.

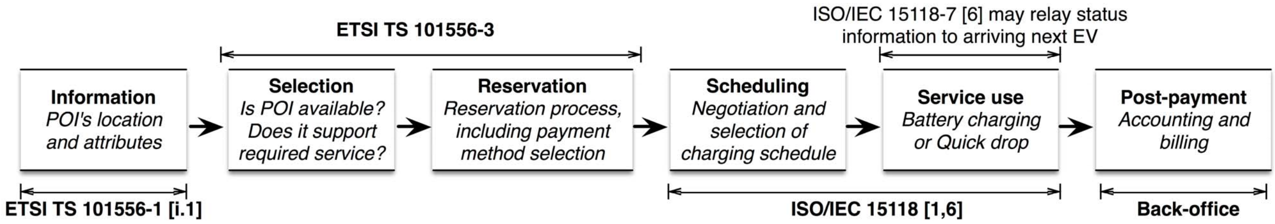
ETSI TS 101556-3
ISO/IEC 15118-7 [6] may relay status information to arriving next EV
Information
POI's location and attributes
Selection
Is POI available? Does it support required service?
Reservation
Reservation process, including payment method selection
Scheduling
Negotiation and selection of charging schedule
Service use
Battery charging or Quick drop
Post-payment
Accounting and billing
ETSI TS 101556-1 [i.1]
ISO/IEC 15118 [1,6]
Back-office

Figure 2: The EV energy management cycle

It is furthermore recognized that a trustable reservation system shall be complemented by an appropriate enforcement process to guarantee that the reserved resource shall be available. The main challenges are to ensure that the reserved recharging space is not occupied by someone else before the arrival of reserving EV and that the reserving EV departs by the end of the reserved time period. While the specification of such complementing enforcement is out of scope of the present document, the following observations are made:

- It appears that a legal enforcement is a most cost-effective solution for enforcing reservation-based EV charging spots in regions where parking itself is payment based. In that case the EVSE may detect through some sensor when a vehicle occupies a corresponding parking slot, and alert parking enforcement personnel if a valid charging session is not initiated subsequently within some timeout. Similarly, the EVSE may alert parking enforcement personnel if the recharging EV does not depart by the end of its reservation period.

- In regions where parking is for free, EV charging spots should be planned in locations of abundant parking space availability; therefore, chances for conflicting parking occupation would be minimized.

The EV charging spot reservation protocol specified in the present document is based on a request-response model based client-server architecture, where every transaction is initiated by the reserving client. There may be situations, where the EV driver should be alerted of some upcoming time limit, such as the pending expiry of reserved charging time if the EV is still plugged in. Figure 3 gives a graphical illustration of such relevant time limit alerts. The presently described protocol conveys all the needed information to the client device during the reservation process for making such alerts. It is not the responsibility of the reservation management server to make such alerts towards the EV driver; therefore, no such alert procedure is being specified. Displaying alerts as needed is the responsibility of the client device implementation, and is considered to be a design issue being out of the scope of the present document.

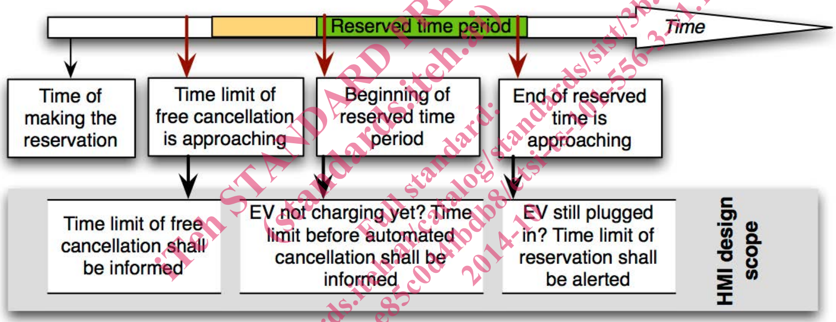

Figure 3: HMI aspects of the EV recharging management procedure

The present reservation protocol does not convey the actual pricing information of the reserved services. The reason is that the charging session is negotiated upon plugin at the start of the ISO/IEC 15118 procedure [1] and [i.3], and the final charging price may depend on the selected power and priority levels. Conveying pricing information during the reservation stage might therefore be confusing for EV users.

4.2 Identification of the reservation server

Before initiating the recharging spot reservation, the client device has the EVSE-ID which identifies the recharging spot intended to be reserved. This list of candidate EVSE-IDs is received either directly through the recharging spot notification broadcasts, or from the e-Mobility management server which plans and optimizes the recharging spot allocations. There is an IPv6 address or URL resource belonging to each EVSE-ID, which identifies the corresponding server responsible for the reservations; this information is contained in the 'Booking contact information' data element of recharging spot notification broadcasts specified in ETSI TS 101 556-1 [i.1] and shall be received by the entity making the recharging spot reservation. While the 'Booking contact information' data element is indicates as optional in ETSI TS 101 556-1 [i.1], from the perspective of the present document it is expected to be present in the recharging spot notification broadcasts.

5 Protocol procedures

5.1 Overview of the protocol operation

Figure 4 illustrates the overall flow of the EV energy supply reservation protocol procedures. The format of the involved messages and fields is described in clause 7 and clause 8.

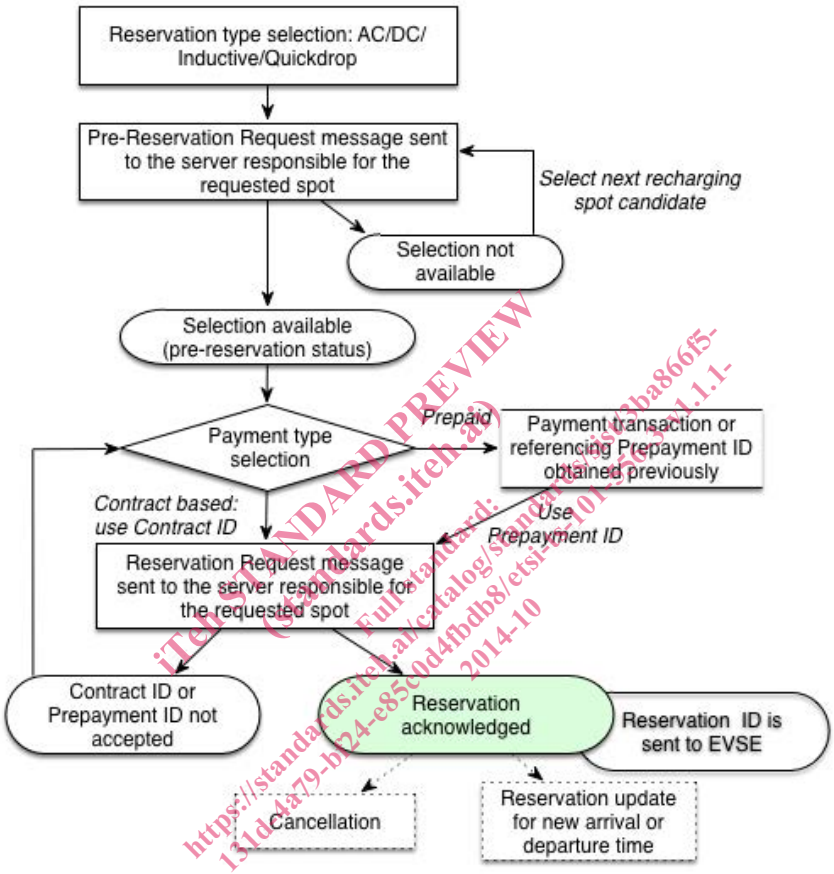

Figure 4: The EV recharging spot reservation process flowchart

Upon the completion of the reservation procedure, the charging spot reservation server shall forward to the corresponding EVSE to the assigned Reservation ID (in case of V2G based recharging) or the driver identifier (in case of recharging without V2G). The specification of such interface to the EVSE is out of the scope of the present document. It is noted that the first release of the ISO/IEC 15118-2 standard [1] does not support the transmission of Reservation ID. Therefore, such validation of the arriving EV can be based on either a future revision of ISO/IEC 15118-2 [1] or on the wireless V2G interface specified in the ISO/IEC 15118-7 [i.3] document.

The application messages described in the present document rely on IP-based network layer service, utilizing the transport protocol stack shown in Figure 5. As illustrated in Figure 5, the deployment of this service may be realized through any IP-based system, as well as through a web-based reservation interface running behind a proxy server. The access options shown in Figure 5 are examples for deployment possibilities, keeping in mind that the presently described application layer protocol is agnostic to the underlying communications technology.

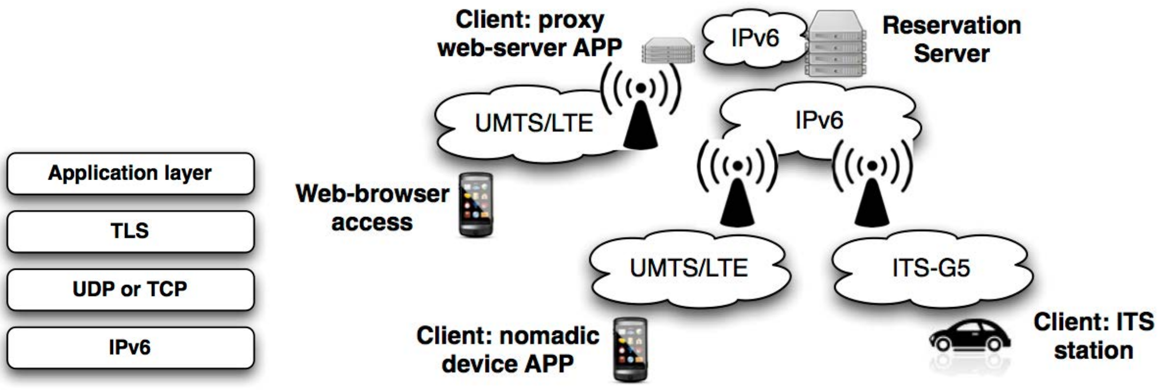

Figure 5: Deployment options for accessing the reservation service

In case of stream-based transport layer service, the messages defined in the present clause are exchanged in the same transport-layer session, which is set up by the client before sending the Pre-Reservation Request message. This transport-layer session is terminated upon the reception of the Reservation Response message, which completes the reservation procedure.

Before processing any request message, the reservation management server always authenticates the requesting client. For this security reason, the services of the underlying TLS v1.2 [3] and [4] secure transport layer shall be used. For stream-based transport services (such as TCP), the required TLS implementation is defined in IETF RFC 5246 [3], while for datagram-based transport services (such as UDP), the required TLS implementation is defined in IETF RFC 6347 [4]. Currently, TLS provides for one-way authentication of the server.

Subsequently to a completed reservation, there is a possibility to cancel a reservation or update the reservation times. The reservation update supports only later arrival time update and/or earlier departure, and not the other way around. As described in clause 6, a change of EVSE, later departure, or similar changes require making a new reservation and the cancellation of existing one. The matching Reservation ID / Reservation Password combination requirement assures the security of reservation updating process.

During the driving phase, the EV may want to poll the status of the charging spot, in order to know whether it is already available or still occupied by a preceding vehicle. Such polling procedure is not supported by the presently described service, but it may be directly provided by the wireless V2G interface of the EVSE, which is specified in the ISO/IEC 15118-7 [i.3] and document.

5.2 Pre-Reservation procedure

The client starts the reservation process by sending the Pre-Reservation Request message for reserving the preferred recharging spot. To identify the requested charging spot, the client uses the EVSE-ID in the Pre-Reservation Request message. The structure of EVSE-ID is defined in DIN 91286:2011 [2]. The server responds by informing the current status in the Pre-Reservation Response message, putting the recharging spot into pre-reservation status so that the client can trust it can safely go ahead to reserve a recharging spot which is indicated to be available. In case of a battery changing station this means the pre-reservation of the needed battery type. If the Pre-Reservation Response informs no availability at the requested recharging spot, the client can send a new Pre-Reservation Request message for the next candidate recharging spot on its list.

In case of battery replacement service, there is no indication of the needed battery type. The reason is that it may not be practical to keep track of all possible changeable EV battery types within this protocol. It is the responsibility of the recharging spot discovery procedure to keep track of possible recharging spots for a given battery type. From the point of view of this protocol, if a battery replacement station offers multiple battery types then a distinct EVSE-ID is used to indicate a recharging spot for each corresponding battery type, and the EV addresses the requested EVSE-ID.

It is needed to ensure that the requesting client is a valid one, since the recharging spot gets into a pre-reservation status upon the processing of this request. A suitable security mechanism is provided by the client authentication procedure of the underlying TLS v1.2 [3] and [4] security layer. The implementation shall take care of setting up the required client certificates for both contract-based and pre-paid procedures.