Hyper-Network for electroMobility

D2.3 Standards and protocols

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Task	Task 2.4: ICT Standards and protocols for Hyper-Network integration
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Glossary of Terms

Term	Description
BAEM	The Business Alliance for Electro-Mobility (BAEM) as the non-profit association that will take over the management of the Hyper-Network and endure its sustainable operation as well as promote electromobility after the project ends.
Electro mobility or e-mobility	The use of electric-powered drivetrains for road vehicles designed to shift vehicle design away from the use of fossil fuels and carbon gas emissions.
e-roaming or eRoaming	A market model in electro mobility whereby EV drivers may charge their vehicles at all charging stations, regardless of any contracts concluded with operators. The billing then takes place via the customer's own contractual partner.
Hyper-Network	A distributed environment with open architecture based on standardised interfaces, in which actors (physical or digital) can connect and interact seamlessly, exchange data and provide integrated and interoperable ICT services.
Hyper-Network Business Partner	A user of the Hyper-Network that NeMo or the BAEM has accredited as being compliant with the relevant protocols and procedures. Potentially a "label" that could be used by the organisation concerned.

List of abbreviations and acronyms

Abbreviation	Meaning
B2B	Business to Business
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardisation
CPO	Charging Point Operator
DIN	German Institute for Standardization
DSO	Distribution System Operator
eMobility	Electromobility
EM(S)P	Electromobility (Service) Provider
eMI³	eMobility ICT Interoperability Innovation group
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
EVSEO	Electric Vehicle Supply Equipment Operator
HMI	Human Machine Interface
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
NSP	Navigation Service Provider
OCHP	Open Clearing House Protocol
OCPI	Open Charge Point Interface
OICP	Open Inter Charge Protocol

Abbreviation	Meaning
OCSP	Open Certificate Status Protocol
OEM	Original Equipment Manufacturer
SOC	State of Charge
TPEG	Transport Protocol Experts Group
TSO	Transmission System Operator
V2G	Vehicle to Grid

Executive Summary

The NeMo project developed a Hyper-Network of tools, models and services in order to enable interoperable and seamless electromobility services provision across Europe. Consequently, the Hyper-Network is supporting the creation of an open, distributed and widely accepted ecosystem for electromobility (eMobility) by enabling increased accessibility to charging infrastructure, ICT services, and wider B2B interconnectivity. NeMo facilitates increased service availability, better planning and more secure electric grid operation, by making backend data and services accessible to the right actors and bringing down digital (interfaces) and physical (location) barriers.

This deliverable is a public report on communication protocols and standards for the NeMo Hyper-Network integration and it provides an evaluation of the existing communication protocols and standards that support the Hyper-Network use cases in order to discover whether the particular standards, protocols or a specific combination of both are mandatory to support the deployment of the Hyper-Network. Part of this is to investigate protocols and standards and their relations to specific business scenarios, services, and involved actors/interfaces. Another part was to provide recommendations for supporting project interoperability and standardisation activities. The process included several expert analysis and feedback from NeMo partners.

The key findings include a summary of standards and protocols which are important to be considered by NeMo to support the Hyper-Network and main guidelines for further standardisation activities. The standards and protocols were analysed according to their functions for different services of several business cases.

This work also includes non-communication standards in form of hardware standards regarding the vehicle and eMobility infrastructure, such as safety requirements and testing of the Hyper-Network which are required to be fulfilled by eMobility original equipment manufacturers (OEMs).

1. Introduction

Nowadays charging an electric vehicle (EV) is more complicated than refuelling a combustion engine vehicle, one reason being that many and diverse actors are participating in the eMobility ecosystem. This leads to several specific interoperability requirements, where interoperability is defined as the ability of different systems or software to share, exchange and make use of information. Often, there is no interoperability among different charging point operators (CPOs) in Europe and no access to other CPOs' services such as the reservation of charging stations. Avoiding national and regional technological borders for EV charging is important for the development of eMobility. Having a common payment method, harmonized legislation, and international collaboration on the infrastructure installation are necessary to realize interoperability. Using internationally uniform protocols and standards is a key factor for enabling interoperability across countries, actors and services.

The vision of the NeMo project was to enable seamless interoperability of eMobility services and for this reason it has created a Hyper-Network of new and existing tools, models and services. In this context, the main goal of the work presented in this deliverable was the creation of a continuous standardization and protocol framework, so that the final NeMo solution is usable by all eMobility actors. It was anticipated from the start of this work that existing standards would cover part of the requirements for the Hyper-Network development and that adaptations and extensions would be required in order to accommodate the results emerging in other tasks and WPs of NeMo. Activities included the identification and selection of relevant existing standards, the provision of guidelines and tools for project interoperability, and the provision of guidelines for future standardization activities. The standards and protocols from different existing standardization groups, initiatives and standardization bodies, such as ISO, DIN or IEC, were analysed to find out which standards and protocols are important to be applied in NeMo. They were analysed according to their function for different services of several business cases.

The present work was based on the identified Hyper-Network business scenarios, the extracted services or requirements needed to achieve the business scenarios, and determination of the involved actors. These business scenarios, services and actors were then mapped to the existing standards and protocols to refine their selection for NeMo.

This deliverable is organized as follows. After the introduction, basics on standards and standardization are presented in Chapter 2. Chapter 3 describes the methodology and workflow, while Chapter 4 describes the requirements for standardization by NeMo. Following, Chapters 5 and 6 present different ways of classifying standards. In Chapter 7 missing standards and protocols are identified and guidelines for future standardisation work are presented.

2. Introduction to Standards, Protocols and Standardization Groups

Before the analysis of the list of standards and protocols relevant for NeMo, it is necessary to provide basic information on the standards classification and groups as well as on the communication protocols.

2.1 Standards and Standardization groups

De jure and de facto Standards

A *de jure* standard is a technology, method or product that has been officially endorsed for a given application. De jure, from medieval Latin, means from law. The term refers not only to legally protected or enforced standards but also to those that have been endorsed by an official standards organization.

A *de facto* standard is a custom or convention that has achieved a dominant position by public acceptance or market forces (i. e., by early entrance to the market). De facto is a Latin phrase that means in fact (literally by or from fact) in the sense of "in practice but not necessarily ordained by law" or "in practice or actuality, but not officially established", as opposed to de jure.

The term de facto standard is used in contrast with de jure standards or to express the dominant voluntary standard, when there is more than one standard available for the same use.

Open Standards

An open standard is a standard that is publicly available and has various rights of use associated with it. Also, it may have various properties of how it was designed (e.g. open process). There is no single definition, and interpretations vary with usage.

Open Source Standards

We refer to open source standards as standards, which are accessible, usable and can be implemented on a royalty-free basis.

Proprietary Standards

Proprietary standards are typically developed by private companies with limited public or even industry participation.

Standards and specifications can be developed by standardization groups, initiatives, and bodies including a number of organizations from various countries and at various levels (national, European, international). To provide a better understanding an overview of the various standards organizations and their interrelations, together with their regulatory bodies, is given in the figure below.

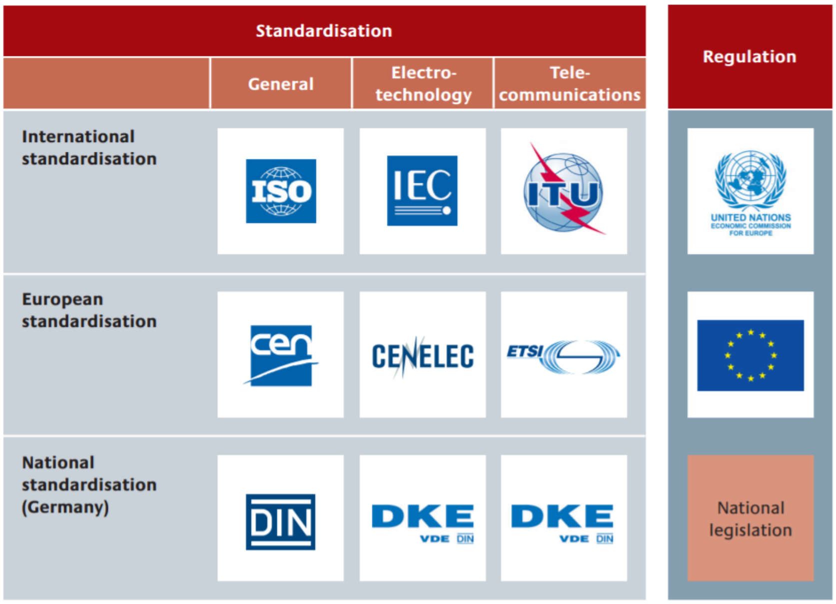

Figure 1: Main elements of standardisation landscape and their relationships with their regulatory bodies[1]

In terms of full consensus-based standardisation, ISO, IEC and ITU-T are the authoritative standards organisations. The corresponding standards organisations at a European and national level are CEN and DIN (including NAAutomobil, the Road Vehicle Engineering Standards Committee), and CENELEC, ETSI and the DKE. The respective national standards organisations are members of ISO, IEC, CEN and CENELEC.

Below an overview of the standardization bodies that are relevant to Nemo is presented.

Standardization group	Scope
DIN	Deutsches Institut für Normung (DIN) develops norms and standards for rationalization, quality assurance, environmental protection, safety and communication in industry, technology, science, and government, as well as the public domain.
ETSI	The European Telecommunications Standards Institute (ETSI) is an independent, not-for-profit standardization organization in the telecommunications industry (equipment makers and network operators) in Europe, headquartered in Sophia-Antipolis, France, with worldwide projection.

[1] https://www.din.de/resource/blob/77456/4407b11ea3d0ad1ac1a8889eab8e6b15/nr-3-0-en-data.pdf

Standardization group	Scope
IEC	The International Electrotechnical Commission (IEC) is an international standards organization that prepares and publishes international standards for all electrical, electronic and related technologies – collectively known as "electrotechnology".
ISO	The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations.
SAE	SAE International, initially established as the Society of Automotive Engineers, is a U.S.-based, globally active professional association and standards developing organization for engineering professionals in various industries.

Table 1: Standardization groups

Specifically, the standardization work relevant to electromobility is presented in the figure below.

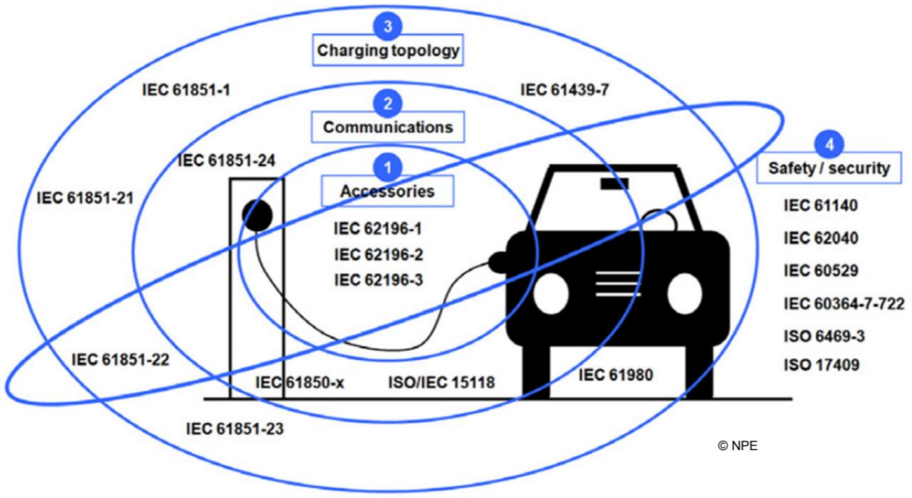

Figure 2: Overview of electromobility standards[2]

Special mention needs also to be given at the following work: The IEC 61850-90-8, a document that is not a standard in itself but a technical report which describes an object model for electric mobility. It models Electric Vehicles as a specific form of Distributed Energy Resource according to the paradigms defined in IEC 61850. While the IEC 63119 is a standard that is currently being developed upon: Information exchange for Electric Vehicle charging roaming service. It contains of four parts: Part 1: General – aimed publication date August 2019, Part 2: Use Cases,

[2] https://www.din.de/blob/71592/8f14594082a9ec0dab86e7e6b1d0d4b0/overview-emobility-standards-data.pdf

Part 3: Message structure, Part 4: Cybersecurity and information privacy. All last three parts have aimed for a publication date in March 2022.

2.2 Communication protocols

Communication protocols are, in short, sets of hardware/software rules and guidelines that communication end-points must follow in order to share and exchange information and enable relevant processes.

In the table following, an overview of electromobility protocols relevant to the EV market and NeMo is presented.

Initiatives	Initiatives description	Protocols
CHAdeMO Association	Industrial association / alliance promoting one or more protocol(s)	CHAdeMO
Gireve	Company maintaining and promoting their protocol(s)	eMIP (eMobility Inter-Operation Protocol)
Open Charge Alliance (OCA)	Industrial association / alliance promoting one or more protocol(s)	OCPP (Open Charge Point Protocol) OSCP (Open Smart Charging Protocol)
Hubject	Company maintaining and promoting its protocol(s)	OICP (Open Intercharge Protocol)
eMI3	Industrial association / alliance promoting one or more protocol(s)	eMI3 Business Objects
G3-PLC Alliance	Industrial association / alliance promoting one or more protocol(s)	PLC (Powerline Communication)
PRIME Alliance	Industrial association / alliance promoting one or more protocol(s)	PLC (Powerline Communication)
Innogy (ex. RWE)	Company maintaining and promoting their protocol(s)	LG2WAN
Nobil	Company maintaining and promoting their protocol(s)	Nobil-API

Initiatives	Initiatives description	Protocols
Now!Innovations	Company maintaining and promoting their protocol(s)	Now!Innovations Protocol
E-Clearing	Company maintaining and promoting their protocol(s)	OCHP (Open Clearing House Protocol)
The Netherlands Knowledge Platform for Charging Infrastructure (NKL)	Industrial association / alliance promoting one or more protocol(s)	Open Charge Point Interface (OCPI)
PlugSurfing	Company maintaining and promoting their protocol(s)	OIOI
RHTW Aachen University	Academy maintaining and promoting their protocol(s)	SteVe
European Broadcasting Union (EBU)	Regional standards organization based in Europe	Transport protocol exchange group (TPEG)
GraphDefined GmbH	Company maintaining and promoting their protocol(s)	World Wide Charging Protocol (WWCP)

Table 2: EV market communication and charging protocols

More specifically, the following protocols, as described in detail, enable the charging processes and the exchange of charging data among different electromobility actors. [1]

The Open Charge Point Protocol (OCPP) has been designed and developed to standardize the communications between an EV charge point and a central system, which is used for operating and managing charge points. The communication protocol is open and freely available to ensure the possibility of switching from charging network without necessarily replacing all the charging stations or significant programming, including their interoperability and access for electric grid services. The protocol is intended to exchange information related to transactions and for operating a charge point including maintenance. It can also be used for schedule-based EV charging. For Roaming, OCPP provides technical access to the charge point and facilitates forwarding of transactions to the E-mobility Operator/ Mobility Service Provider.

The Open ADR – Open Automated Demand Response Standard / OpenADR Alliance is a protocol aiming at automating demand response communication; it supports a system and/or device to change power consumption or production of demand-side resources. This can, for example, be done based on grid needs, either by means of tariff and/ or incentives or emergency signals that are intended to balance demand to sustainable supply.

The Open Smart Charging Protocol (OSCP) communicates forecasts of the available capacity of the electricity grid to other systems. The protocol is based on a budgetary system where client systems can indicate their needs to a central system, which guards against overuse of the grid by handing out budgets per cable. If a system requires more it can request more, if it requires less it can hand back part of its budget, to be available for other systems.

OCPI is an independent roaming protocol that makes it easy to exchange data. It can be used both by companies (peer-to-peer) and via a roaming hub or platform. The protocol is supported internationally. With OCPI EV drivers get an insight into the availability and costs of charging points. OCPI protocol is publicly available at no cost, and its development is co-funded by the projects evRoaming4EU and ECISS, which receive EU and NL subsidies.

The Open Clearing House Protocol (OCHP) is a protocol which is meant for exchanging authorization data, charging transaction and charge point information data for roaming via the e-clearing.net platform. The protocol consists of 2 parts: i) A part that is specifically for communication between market parties and an EV clearing house; ii) A part that is for peer to peer communication between market parties, this is called OCHPdirect. The OCHP is publicly available at no cost.

The eMobility Interoperation Protocol, called eMIP, is provided by GIREVE as part of its main business objective: “open access to vehicle charging stations”. eMIP targets two goals: 1. enabling roaming of charging services by providing a charge authorisation; 2. a data clearing house API and providing access to a comprehensive charging point database. The eMIP protocol is publicly available at no cost.

The Open InterCharge Protocol (OICP) is a roaming protocol which can be used to communicate with the Hubject B2B Service Platform. This platform enables exchanging roaming messages between an EMSP and a CPO. The protocol consists of two parts that together create the protocol: a separate part for the EMSP and a separate part for the CPO. The OICP protocol is publicly available at no cost.

3. Methodology for creating a continuous standardisation and protocols framework

In the initial project phase, potential electromobility business scenarios to support the Hyper-Network were identified. There are 7 business scenarios, as described in D1.1 *" Consolidated Version of the Use Cases and Actors' Requirements",* that have been considered in the present work, which are smart charging, itinerary planning, cross-provider authorization and payment management, NeMo service development environment, horizontal services (actors monitoring and profiling, service brokerage, service finder and optimiser), eMobility report, and vehicle preparation for drive-off. Following, specific services were determined which are required for the business scenarios. For instance, the smart charging business scenario would require each connected actor to interact for information exchange through services such as predictive analysis of the battery status and EV data secured access.

To have a seamless information exchange among the different eMobility actors, standardized processes and protocols would be needed. Therefore, after the determination of business scenarios and services, related standards and protocols were further identified and analysed. To identify the necessary standards and protocols, or their combination, that based upon the functionalities they cover, enable actors communication with each other so that they realize certain required processes and enable provision of interoperable services, it was important to track the actors' communication flows (i.e. CP to Backend or Backend to roaming platform), which take place in the business scenarios or within the services queries and responses. An actor is any entity who must send, receive, or request information, including companies responsible to provide electricity (DSOs, TSOs, energy aggregators). Identifying the actors helps determining who will control the power flow during each use case, and how it will be controlled. This is influenced by whether the power flow is controlled at the electric vehicle supply equipment (EVSE) and/or within the EV itself.

NeMo recommends a framework for the continuous discussion of the Standardisation initiatives and developments of communication protocols for enabling of the Hyper-Network. This is done by firstly, making a requirements analysis on the standardization work needed for the NeMo identified actors and their interfaces, as well as services and their communication processes. Afterwards, a detailed overview of the existing standards and protocols that do find force within NeMo is performed, so that all the standards and protocols are mapped according to the requirements of the involved services and actors. Once this is completed, based upon the analysis for services and processes that do not have related standards nor protocols from existing standardization bodies and initiatives, the missing standardization work and protocols has been identified and proposed. Further standardization is proposed by discussion with relevant standardization groups and associations. The process is visualized in the following figure.

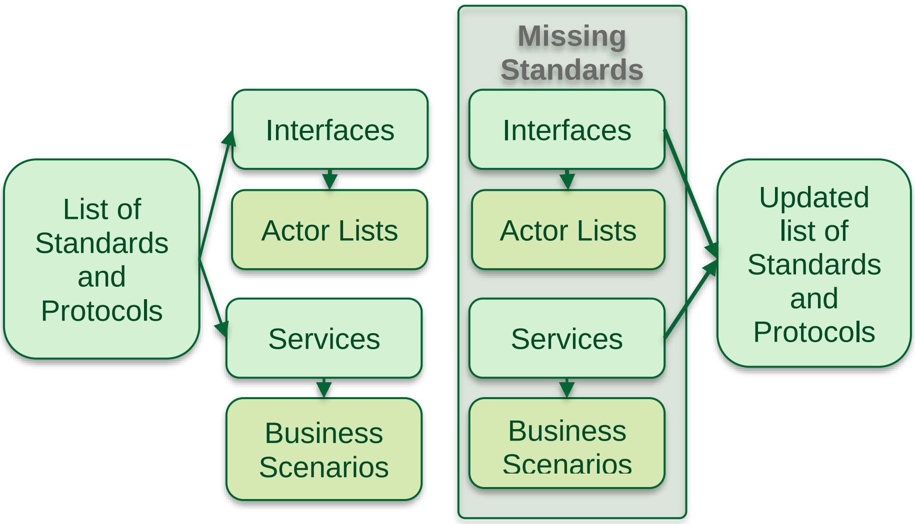

Figure 3: NeMo Standardization and Protocol Framework methodology

NeMo Hyper-Network is facing the interdisciplinary nature of the electromobility domain, with its complex communication processes that are fastly and continuously evolving among a great variety of actors, as well as the variety of possible services that could be offered and consumed on the marketplace, and as such worked to establish common models and standardized processes to enable interoperable and seamless service provision. The actors' interfaces, the services categories and the standards categories can be summarized on the following figure**Error! Reference source not found.** that is further discussed in the following chapters.

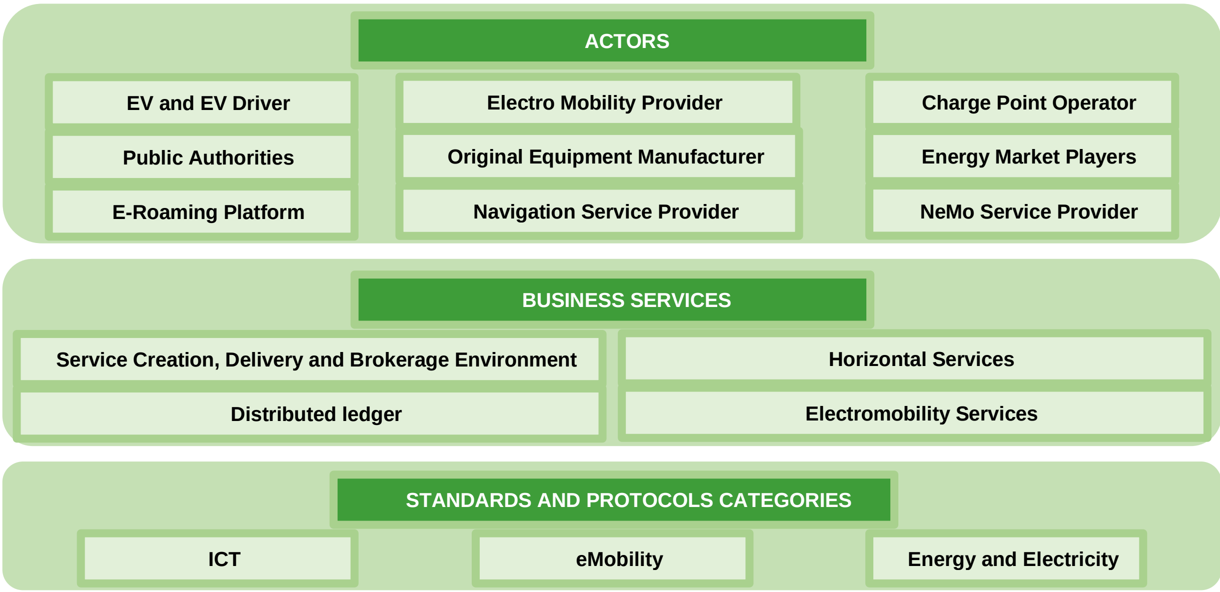

Figure 4: Actors interfaces, services and standards & protocols categories in NeMo

4. Standardization Requirements in Nemo

4.1 General Requirements

Standards and protocols in Nemo should fulfil the following requirements to enable seamless interaction between each actor category:

1. Interoperability between regulatory bodies
   a. Avoiding conflicts between national and transnational standardization and regulation
   b. Trying to establish international standards from the beginning
   c. Deployment of normal charging points should be simplified

2. Interoperability between the regulatory and contracted frameworks
   a. National authorities should enable the market-selection to take place, regarding the following points
      i. The development of charging points at places with high demand
      ii. Standards and regulations through allowing the co-existence of different standards and regulations
      iii. Non-standardized private charging solutions

3. Interoperability between business models of the involved players
   a. Harmonized process of handling data and meter-data
   b. Standardized payment methods
   c. Secure transparent information about pricing, services etc.

4. Semantic interoperability
   a. Ensure the interoperability for interface-based standards
   b. Unified way of identification and authorization
   c. Establishment of transnational data bases and tools

Each identified standard and protocol in this deliverable fulfils several of these requirements.

4.2 Special Requirements by Business Scenario

Business scenarios, their data flows and interfaces, have been specified in D2.1 *"Consolidated version of technical specifications for NeMo development and integration"*. The interoperability between actors requires standardized data flows and commonly described interfaces for creating interoperable services and an optimum business scenario environment that would allow actors interaction in a structured and normalized way. The upcoming different business scenarios have been analysed as a starting point for the identification of requirements for standards and protocols.

Business Scenario 1: Smart Charging

The term smart charging describes an intelligently controlled charging process which considers several factors such as grid stability, load flow management, power generation, frequency regulation and dynamic pricing/demand response. Taken these factors into account, the available power and energy are distributed in an efficient but also flexible manner both at local and national market level. As a result, different parties benefit economically from smart charging. EV drivers benefit from the fact that their EV is charged when the electricity price is low while CPOs can benefit (instead of being negatively affected) from energy costs fluctuation.

A standardized communication is essential to implement smart charging since data is exchanged between the charging infrastructure, electrical network, energy market, electric vehicle supply equipment operator (EVSEO) and EV. Therefore, the different eMobility actors rely on common standards and communication protocols to communicate with each other.

Key roles in the ecosystem of smart charging are the Energy Aggregator, who can propose different charging schedules to the CPO/EV owner based on dynamic pricing related dispatching markets. The CPO (in case of a pool of public charging points for example) or the EV driver (with his own domestic charging and car) will always have the possibility to decide whether or not to participate and offer their flexibility on the market. As per EU indication, the DSO role in local procurement of flexibility to manage directly congestions/problem on their networks will improve in the following years.

The smart charging business scenario includes also vehicle-to-grid (V2G) standards to enable bidirectional sharing of electricity between EV and the grid.

Business Scenario 2: Itinerary Planning

In order to offer different services to fleet management companies for an efficient monitoring and management of their EV fleets, factors that can affect traveling mode of EV need to be analysed and monitored. Best routes in terms of electric power consumption, road topology information, weather conditions, vehicle characteristics, driver profile, traffic conditions and electric charging stations positions are required to enable EV itinerary planning that helps reduce range anxiety.

Standardized information exchange between EV and smart grid is required for seamless EV usage. Information about the state of charge (SoC), destination, and available charging stations on the road are covered in this business scenario.

Business Scenario 3: Cross-provider authorization and payment management

The EV must be authenticated by the charging station before the charging process can get started. A communication protocol between the CPO and electromobility provider (EMP) needs to be implemented to authenticate each other but also to enable the payment after the charging session is completed. The secure information exchange to authorize transaction and payment needs to be regulated and follow the existing standards. A facilitated authentication payment process improves the EV driver’s experience and thus leads to a higher eMobility acceptance.

Business Scenario 4: NeMo Service Creation Development

NeMo enables a seamless and interoperable use of eMobility services throughout Europe to allow a continuous and uninterrupted provision of data and services. Therefore, enabling users to search and register for required services is important. The seamless and secure information exchange within businesses and between actors needs to be standardized in order to enable the exchange of data and services between actors' systems, wherever their physical connection may be.

Business Scenario 5: Horizontal Services (actors monitoring and profiling, service brokerage, service finder and optimiser)

Part of the NeMo project was the development of horizontal services which are namely a CP finder and optimiser, a service broker, and actors' monitoring and profiling services. They are designed and developed to be integrated and add intelligence to other eMobility services. Again, a secure information exchange between actors needs to be standardized to enable the exchange of data and services among them.

Business Scenario 6: eMobility Report

Extensive information about eMobility activities are required for understanding the improvement possibilities. Analysis of EV activity data, e.g. charging session, power consumption or dynamic status, is useful to identify the trends within eMobility. The report is also important to show the impact of eMobility on sustainable mobility. For example, showing the impact on climate change, new markets, lower dependency on fossil fuels, and energy transition.

Business Scenario 7: Vehicle Preparation for Drive-Off

The optimal preparation of an EV before the drive-off maximizes the battery capacity. This business scenario includes the prediction of the energy need for the possible next trip of a specific EV but also the notifications for the preparation of vehicle functionalities so that the battery is at the maximum SoC and the vehicle is optimally ready to start. Furthermore, also proposals on how to operate vehicle functionalities, such as heating, AC or ventilator, before the vehicle drive-off can be provided.

5. Existing Standards and Protocols mapped per NeMo requirements

Based upon the identified requirements as described previously and the creation of an extensive list of existing standards and protocols, the results upon the mapping to the existing standardization work and their relevance is presented below divided in three sections: NeMo services, NeMo actors' interfaces and market categories.

5.1 Services

After the description of the Hyper-Network business scenarios, services to achieve these business scenarios have been defined.

5.1.1 Service Creation, Delivery and Brokerage Environment

Each of the actors involved in these services needs to fulfil certain standards to enable communication for the charging process. Communications between vehicle to infrastructure, such as charging points, needs to follow ETSI TS 101 556-3. Therefore, CPO, EMP and vehicle should adapt the same communication standard to avoid obstacles in charging processes. Every CPO also needs to follow a certain standard called DIN SPEC 91286 to name their EVSE. So, every service provider or aggregator in Europe can have only one database for their customer. It is also important for EMPs to have a common standard for RFID cards which is widely used for authorizing a charging process.

Services brought by the EMP such as service activation, subscription, and registration are connecting the EV driver and the CPO. Thus, the security of the telecommunication process also needs to be regulated by the same standards. There are several entities that provide protocols for the communication between the EV and the CPO for billing, payment, finding a service, or communication between plug-in vehicle and CP. Open Clearing House Protocol (OCHP), Open Charge Point Interface (OCPI), Open InterCharge Protocol (OICP) and Open Certificate Status Protocol (OSCP) are some protocols that provide these services. CPO and EV should use these protocols, which need to adapt the same standards such as SAE J2931 to have a seamless communication for charging processes.

Service Creation, Delivery and Brokerage Environment
• **DIN SPEC 91286** EVSE ID German standard • **ETSI TS 101 556-3** Infrastructure to vehicle communications • **ISO 25001** Quality criteria and the evaluation of digital software products • **ISO 7816** RFID Card requirements • **ISO 8583** SMS payment requirements • **SAE J2931** Digital Communications for Plug-in Electric Vehicles • **WWCP** Secure internet protocol to connect market actors in e-mobility field

Table 2: Examples of standards relevant to the Service Creation, Delivery and Brokerage Environment

5.1.2 Horizontal Services

The CPO and EMP need to follow certain processes for communication to provide horizontal services. Having the same standards for translating data with IEC 60870-5-104 will enable a seamless communication process. The security of transmitting the data between CPO and EMP follows a set of standards for data security with IEC 27001, integrity with IEC 27002, and quality with IEC 25001.

Some entities provide protocols to enhance the horizontal services such as optimization algorithms for the forecasting of events and predictive analysis for eMobility charging events. OSCP and TPEG (Transport Protocol Exchange Groups) are examples of protocols that can be adapted by CPO and EMP for predictive analysis and forecasting.

Horizontal Services
• **IEC 25001** Systems and software quality requirements • **IEC 27001** Management System for information security • **IEC 27002** Information security • **IEC 60870** DSO-EV transmission protocol • **TPEG** Data Protocol for the transmission of traffic and travel information

Table 3: List of standards relevant to NeMo Horizontal Services

5.1.3 Distributed Ledger

As mentioned before, a seamless and secure information exchange of data between different actors is for different services of great importance in the eMobility market. The distributed ledger technology is characterized by its Peer2Peer communication which leads to a decentralization. This enables a direct exchange of data between actors without a central institution. An immediate communication is hereby ensured which can be i.e. used in the context of charging processes. The adaption of IEC 27001 is important to have the standardized management system for information security.

Distributed Ledger
• **ISO 8583** Electronic transactions initiated by cardholders using payment cards • **IEC 27001** Management System for information security • **GOSSIP** Protocol to ensure data integrity and consistency

Table 4: List of standards on Distributed Ledger

5.1.4 eMobility Services

There are several services provided by the CPO to make their customer comfortable with having an EV. As an EV driver, being able to search charging points, reserve a timeslot, and compare prices can be facilitated by the CPO who adapts communication protocols such as OCHP, OCPI, OICP and OSCP.

These protocols provide different services that a CPO can choose according to the needs of their customer and their business model. OSCP is a protocol supporting grid balancing that allows EVs to feed the grid when the grid has too high usage and allowing EV users to charge when the renewable energy production is on peak such as during high wind and sun exposure.

OICP provides services for EMP and CPO to extend their reachability by providing eRoaming protocols so that EV drivers can charge anywhere unlimited by their subscription condition. OICP enables further functions for the CPO and the EMP such as the reservation of charging stations. The protocols also should follow certain standards for the communication between vehicle and infrastructure. One example is ETSI TS 101 556-3 for EV charging spot reservation. By adapting the same standards for charging spot reservation, the EV driver can have a similar reservation process independent which EMP they subscribed to.

Sending the vehicle data to the CP enables a seamless process neglecting authentication devices such as RFID card or mobile application app. By adapting ISO 15118, EV drivers just plug their vehicle to a CP and it not only can transfer the electricity to the car, but also authenticate the EV and conduct a payment process. Another useful standard in this context is DIN SPEC 70121:2014-12 which can send a remote command from EV to CP.

The energy market and the CPO also need to communicate in the future to enable EV users having a renewable energy source. Monitoring energy grid constraints by the CPO and the energy market, tariff levels can be done by following SAE J 2847 which is regulating the communication between plug-in vehicles and the utility grid. Furthermore, the standard SAE J 2931 is regulating the advanced metering infrastructure while IEC 60870 is regulating the transmission network using standard transport profiles.

eMobility Services
• **EMIP** Communication protocol between CPO and Gireve platform • **DIN SPEC 70121** Electric vehicle for controlling DC Charge • **IEC 61970** Application program interfaces for energy management system • **IEC 62325** Standards to deregulated energy market communications • **IEC 60870** DSO-EV transmission • **ISO 8583** Electronic transactions initiated by payment cards • **ISO 15118** Vehicle to grid communication standard • **Nobil-API** Database of charging stations in Norway • **Now! Innovations Protocol** Industry standard for various hardware platform • **OCPP** Communication between CP and central system • **OICP** Communication standard between EU EMP and CPO

Table 5: List of standards relevant to eMobility Services

5.1.5 Standards for all services

Some standards can only be applied to one specific service but some others are applicable to a range of services. The following table lists standards which can be used for all services.

Standards for all services
• **SAE J2847** Communication between plug-in vehicles and the utility grid • **SAE J2931** Digital communications for plug-in electric vehicles • **ISO 14443A** RFID Card communication to proximity coupling device • **IEC 62831** User identification in EVSE • **DIN 91286** EVSE ID German standard • **CHAdeMO** DC charging standard for EV • **OCHP** Protocol for service providers to connect to infrastructure providers • **OCPI** Protocol between CPO and EMP • **OSCP** Protocol for smart charging for CPO, energy management, and DSO

Table 6: List of standards for all services

5.2 Actors' Interfaces

For the identification of necessary or optional communication pathways that could satisfy certain requirements, partners considered the actors involved in accomplishing each use case. An actor is any entity who must send, receive, or request information, including companies or persons who will be starting and stopping the flow of electricity. Identifying the actors also helps determining who will control the power flow during the use case, and how it will be controlled. This is influenced by whether the power flow is controlled at the EVSE and/or within the EV itself.

To have a seamless information exchange among each actor, standardized communication systems and interfaces are required. Multiple pathways are available, including using combinations of currently available communication standards and protocols that are specialized for different purposes, to achieve communication among each actor. There are a variety of combinations of standards and protocols that can meet the service requirements and exchange messages between actors.

5.2.1 CP and Vehicle Interface

The CP interface is highly important to enable a seamless charging process. A hardware level standard specifies the physical connection of the vehicle and the charging point (IEC 61851) or the safety requirements for the energy transfer. On a software level the interface between the vehicle and the charging point may include the identification and authorization for charging by ISO 15118 or DIN SPEC 70121 and 70122.

CP and Vehicle Interface
• **IEC 61850** Communication protocol for electronic devices at electrical substations • **IEC 62196** Plugs, socket-outlets, vehicle connectors and vehicle inlets • **IEC 61851** Electric vehicle conductive charging systems • **SAE J1772** North American standard for connectors for electric vehicles • **IEC 62893-4** Charging cables for electric vehicles • **ISO17409:2015** electric safety requirements for conductive connections • **DIN SPEC 70121/2** Conformance tests for digital communication EV and EVSE • **ISO 15118** Vehicle to grid communication interface • **IEC 61980** Vehicle wireless power transfer • **ISO 19363** Requirements wireless power transfer • **IEC 62840** Electric vehicle battery swap system

Table 7: List of standards for CP and Vehicle Interface

5.2.2 EV Driver (HMI)

The EV Driver demands information about the technical specifications of the charging infrastructure (CEN/TC 301) and about the price for a charging session. The EV driver must authorize the charging process e.g. by using a smart card (IEC 62831) or use direct payment methods.

EV Driver Interface (HMI)
• **ISO/IEC 14443** NFC Technology • **IEC 62831** User identification at EVSE using a smartcard • **CEN/TC 301** symbols for the charging stations • **DIN SPEC 91286:2011-11** Schemes for identifiers

Table 8: List of standards for EV Driver Interface (HMI)

5.2.3 EMP, CPO and eRoaming Platform Interface

The CPO is responsible for managing and maintaining the CP. The CPO interface supports the management and retrieving of status information from charge points. Most of the CPOs use the OCPP for operating their charging points. The EMP is the only actor who is able to connect the EV user's ID number with EV user's personal data. Schemes for identifiers in the eMobility markets are specified by DIN SPEC 91286:2011-11. The eRoaming interfaces are used for the identification, authorization, data transfer and payment of charging processes at CPs where the EV driver has no subscription for the services of the respective CPO. The eRoaming platform provider connects eMobility players internationally using protocols that can be adapted by the CPO and EMP, i.e. OICP and eMIP. These protocols provide a standardized communication between the CPO and EMP so that data can be transferred based on a clear and uniform data format.

EMP, CPO and eRoaming Platform Interface
• **DIN SPEC 91286:2011-11** Schemes for identifiers • **OCPP** Open charge point protocol • **OICP** Open intercharge protocol • **OCPI** Open charge point interface • **OCHP** Open clearing house protocol • **eMIP** eMobility interoperation protocol

Table 9: List of standards for EMP, CPO and eRoaming Platform Interface

5.2.4 Navigation System Provider Interface

The navigation service provider (NSP) interface enables the communication between the NSP and built-in navigation systems in the vehicle or on drivers' personal devices. To locate a CP or for itinerary planning according to travel schedule and battery status, the TPEG protocol will be useful to transmit needed information between vehicle, CP, EMP and NSP.

Navigation System Provider Interface
• **TPEG** Protocol on traffic data

Table 10: List of standards for Navigation System Provider Interface

5.2.5 Energy Market Actors' Interface

Energy market actors are selling electrical energy to consumers in compliance with regulations for market organization. The consumer can purchase the electricity for its EV charging directly from the energy provider or indirectly by buying the charging service from the EMP respectively from the CPO who purchases the electricity on behalf of the EV user. Exchanging information about energy, i.e. due to a metering system, the communication from energy provider to energy supplier and CPO can be conducted by applying IEC 61970. The communication of standardized data from energy market for supplying energy should follow IEC 62325.

Energy Market Actors Interface
• **IEC 61970** API for energy system management • **IEC 62325** energy market communication (common information model) • **ISO 15118** Vehicle to Grid • **ETSI TS 101 556-3** Vehicle-to-grid communication interface • **SAE J2847** Communication between plug-in vehicles and the utility grid • **OSCP** Open smart charging protocol

Table 11: List of standards for Energy Market Actors' Interface

5.2.6 Public Authority Interface

This interface is used for the exchange of information about traffic situations from the road authority to driver and charging infrastructure. E.g. the travel route and traffic condition from the current position to the CP is important for the itinerary and charging planning. Adapting TPEG and ISO 17425 can support exchanging information about traffic provided by municipality, road authority or road operator.

Public Authority Interface
• **TPEG** Protocol on traffic data • **ISO 17425** Intelligent transport systems data exchange specification

Table 12: List of standards for Public Authority Interface

5.3 By market category

The standards can be divided into the following 3 categories: ICT, eMobility and Energy and Electricity.

5.3.1 ICT

The communication standards in information and communication technology (ICT) between actors consist of data transfer security and authentication. Several standards are existing for these processes. For the communication between driver and CPs, standards as DIN SPEC 91286:2011-11, which specifies the requirements for the payment with the RFID card, or ETSI TS 101 556-3, which specifies the requirements for the reservation of a CP via an EMP application, are needed. Another example is IEC 27001 which is important to build a standardized management system for information security.

Energy integration also needs ICT to connect different parts of the energy system with the players on the eMobility market. Therefore, the information exchange about the dynamic network, management of electricity producers, storage facilities, consumers, grid installations, and infrastructure needs to be standardized. In this context, ISO 15118 can be a solution for the seamless connection between vehicles, CP and grid. By following the standards listed in the upcoming table, eMobility players will be able to intelligently communicate with each other, allowing smart grid system to be incrementally expanded with the addition of new services and products.

ICT standards
• **ISO 15118** Vehicle to grid communication interface • **ISO 8583** SMS Payment requirement • **IEC 61850** Communication network and systems in substations • **IEC 62831** User identification in EVSE • **IEC 60870** DSO-EV transmission protocol • **DIN EN 13757-1:2002** Communications systems for meters • **SAE J2847** Communication between plug-in vehicles and utility grid • **ETSI TS 101 556-3** Infrastructure to vehicle communications • **OICP** Communication protocol between EMP and CPO • **OCPP** Communication solution between CP and central system

Table 13 Examples of standards in ICT

5.3.2 eMobility

OEMs need to apply standards for hardware and security/safety regarding every aspect. For example, a safe charging process needs to follow IEC 61851 and ISO 17409 for the right connection to an external power supply.

Charging station standardization is also important in this part. This includes suitable metering technologies that can be guaranteed by adapting SAE J2931 and a standard for the connected charging of a light EV by IEC 61851. The new technology of wireless charging for EVs also needs to follow IEC 61980 to have a safe and secure charging technology.

The EV user safety must be adapted by the OEM by having a standardized crash test behaviour with SAE J1766 and a test requirement with ISO 21782. Actors that need to adapt these standards are car/automotive OEMs and CP manufacturers.

eMobility (manufacturers and infrastructures)
• **IEC 61851** Connected charging of light electric vehicle • **IEC 61980-2-3** Wireless power transmission systems for EVs • **IEC 62840** Security requirements for battery replacement systems • **IEC 60364** Requirement for low-voltage electrical installation • **ISO 6722** Requirements for power lines in the vehicle • **VDI 2166** Planning of electrical installations in buildings e.g. charging station

Table 14 Examples of standards in eMobility

5.3.3 Energy and Electricity

In this category are standards for electricity and energy requirements for the vehicle battery and electricity demand listed. The IEC 61980 manages the requirements for electronic components of the EV battery. Battery systems, which consist of cells, battery management systems, cell monitoring, electrical and sensor systems, safety elements, cooling periphery, and housing, are essential to determine the vehicle efficiency. Several standards for battery systems need to be followed by OEMs, for example IEC 62840 for battery swaps and ISO 17409 for safety requirements for EVs.

Standardized ways of connecting EVs to the power grid are essential for the development of the eMobility market. To meet this challenge, an intelligent grid charging infrastructure needs to be set up. Therefore, energy providers need to transmit information about minimum and maximum electric flows to support the charging stations according to the electricity demand by EVs and the grid stability. The energy provider also needs to fulfil a range of requirements according to existing standards, such as IEC 61970.

Energy and electricity

- **IEC 61980-1** General requirements for electronic components for EV charging
- **IEC 62840-1** Charging/battery swap modes and types
- **IEC 61970** Energy management system and distributed energy resources
- **IEC 62325** Reference architecture for electric power systems
- **ISO 17409:2015** Safety requirement to an external electric power supply
- **ISO 6469-3:2011** Protection of persons against electric shock
- **SAE J1766** Recommended practice for EV crash integrity testing

Table 15: Examples of standards in energy and electricity

6. Guidelines for standardization

NeMo has identified from the initial phases of the project as well as during the project course and within this task, gaps in standardization or needs for harmonized modelling or protocols, relevant to the project activities. As such, NeMo contributed with its results in the identified standardization gaps by developing, extending, or facilitating and merging of existing formats or protocols, in order to accommodate for standardized data and information exchange models, common APIs and structured ways to integrate all electromobility actors addressing their needs.

6.1 Common Information Models (CIM)

The NeMo Common Information Models are one of the pillars for unifying the data structures and the information exchange, as well as charging infrastructure, among all connected NeMo actors. All objects, physical or digital, which are relevant for the selected electromobility business scenarios were modelled, defining common formats for all electromobility objects, such as the vehicle, the charge point, the vehicle users/owners, etc., and have been constantly updated during the project lifetime, a process that greatly contributes to the interoperability of electromobility services.

CIM have been designed based on the specifications template of the eMI3 group, of which several NeMo partners are members. The eMI3 specifications describe the charging infrastructure business objects and the charge detail record business object only. NeMo has proposed models for all objects which are relevant for its business scenarios and thus is proposing updates to the eMI3 specifications according to the needs identified in its WP1 work, as justified in the descriptions of the Charge Detail Record and of the charging infrastructure business objects.

In order to better improve the harmonisation of the ICT data definitions, formats, interfaces, and exchange mechanisms, the models are continuously updated based on the needs that arise not only during the project development but also from the feedback of electromobility forums, as this has been presented to NeMo Stakeholder Forums and as being submitted for further consideration to the eMI3 group as well as liaising with other groups (ISO/IEC), since NeMo members are closely working on respective standardization groups.

Tools offered by NeMo like Data translators are responsible for creating these unified interfaces. These agents that are configured at the initial service registration to the Hyper-Network, have a dual role: transformation of data messages between platform specific data models to the NeMo CIM, as well as appropriate data modification, where necessary, in order to ensure security and privacy compliance to the NeMo Policy Model, verifying in this way the service from privacy and security aspects. NeMo offers also the tools, under its Service Creation domain to describe in CIM consistent format these services, so the new services to be built using the Hyper-Network functionalities will generate and exchange data according to CIM via the use of Data Translators as presented in D3.1.

CIM has already released its second version by September 2019 incorporating all the changes as proposed by the development needs or by stakeholders' groups, and are openly accessible for further consideration and update as will be needed, aspiring to support the creation of a common standard covering all electromobility needs, a task that will be taken over by the Business Alliance for Electromobility that will be founded to take over the NeMo results and manage the Hyper-Network operation. Standardized approaches as incorporated are described in the following sections.

6.1.1 Identifiers according to ISO 15118 and DINSPEC 91286

The topic of unification of eMSPs and CPOs identifiers was one of the standardisation gaps identified and in need of a proposed relevant approach. As operator aggregators, the eRoaming platforms reduce the risks related to this IDs conflicts, and their interconnection as part of NeMo by the Inter-Roaming protocol is further contributing to this regard, but resulting from the initiative for ICT for electrical mobility, the need for the establishment of unique identifiers for all electromobility was evident. In this scope and defined in the DINSPEC 91286, the following identifiers have been defined:

- Identifiers derived from the first scheme identify the contract between an E-Mobility Operator and its customer.
- Identifiers derived from the second scheme identify an EVSE of an EVSE Operator.

According to the DINSPEC 91286, the following IDs have been identified:

- **Electric Vehicle Supply Equipment ID (EVSEID) -** unique identifier of an EVSE, consisting at least of Spot Operator ID and Power Outlet ID
- **Identifier (ID)** - a sequence of characters embodying the information required to distinguish what is being identified from all other things within its scope of identification (see RFC 3986)
- **Power Outlet ID** - unique identifier of a power outlet to the vehicle
- **Provider ID -** unique identifier of an E-Mobility Operator
- **Spot Operator ID** - unique identifier of an EVSE operator

Four countries have defined a specific association responsible for these IDs assignments, France with AFIREV, Germany with BDEW, Netherlands with eViolin and Austria with AMP, while in other countries, CPOs and eMSPs assign themselves their operator IDs, creating a risk, as there is no central entity ensuring the uniqueness of the identifiers. The above mentioned entities have tried, via the eMI3 working group, to address this topic and presently this has been transformed into a relevant support action programme, the IDACS project: ID AND DATA COLLECTION FOR SUSTAINABLE FUELS IN EUROPE, where all ID issuing bodies from countries that these do exist are participating with the directive that each member state needs to set up one official authority taking care of ID issuing. The results of this action will meet and support the standardized data models update.

6.1.2 V2G Wireless authentication solution and test framework

Within the NeMo developed smart charging solution, an approach for the novel method of EV authentication via wireless processes upon the newly introduced ISO15118 on authentication over WLAN, consisted of the development of a test framework with prototypical implementation of parts of ISO 15118-2 2nd edition/ISO 15118-8, based upon certificate-based authentication and customized test control notation scripts. The developed test framework validated the

Wireless Authentication Solution that uses standardized messages enabling the seamless authentication without driver actions and produces a standard for international authentication interoperability.

The proposed novel standardized structures for the messages required for the above processes have been incorporated and proposed in the Common Information Models.

6.1.3 Extended Vehicle standard implementation

A set of services that enable add-on functionalities as regards managing vehicle information sharing and data exchange via NeMo using the Neutral/Trustee Server connection to the OEM’s backend, are another NeMo contribution to standardization.

The project use case was based upon the itinerary planning service developed within NeMo, enabling sharing in-vehicle data to third party service providers, like the navigation service providers. The architecture developed for secured sharing of in-vehicle data to any third-party service providers by the consent of the EV driver, was developed upon the Extended Vehicle standard (ISO 20078) and was demonstrated live in ACEA working group, showcasing its first real implementation by 3 OEMs (CRF, Renault and Honda) by having all three systems harmonized by complying with the NeMo Common Information Models. The integration of the OEMs backend was realized via the NeMo Trustee Services and the Extended Vehicle standard, fulfilling the EU guiding principles and the data privacy via the double consent approach.

CIM objects, such as vehicle and battery, etc., along with their attributes, were further updated as a result.

6.2 Open Inter-Roaming Protocol

The eRoaming platforms and partners of the NeMo Project have worked on a development of a solution for integrated information flow between different eRoaming platforms using different communication protocols.

As described in the D3.2 “*The NeMo Inter-Roaming protocol is a functional protocol that enables the direct communication between eRoaming platforms, as regards the four interfaces of authorisation, static and dynamic information about charge infrastructure and CDRs.”.* The analyses of different protocols and the merging of the information flows enables the exchange of data directly with another eRoaming platform as well the exchange of data with the NeMo Hyper-Network. The proposed open Inter-Roaming protocol allows the integration of any eRoaming platform that in turn allows access to all Charging Point Operators connected under them and provides the authorization mechanisms for any of their connected users.

The concept and functional architecture of the Inter-Roaming protocol is shown in the following figure.

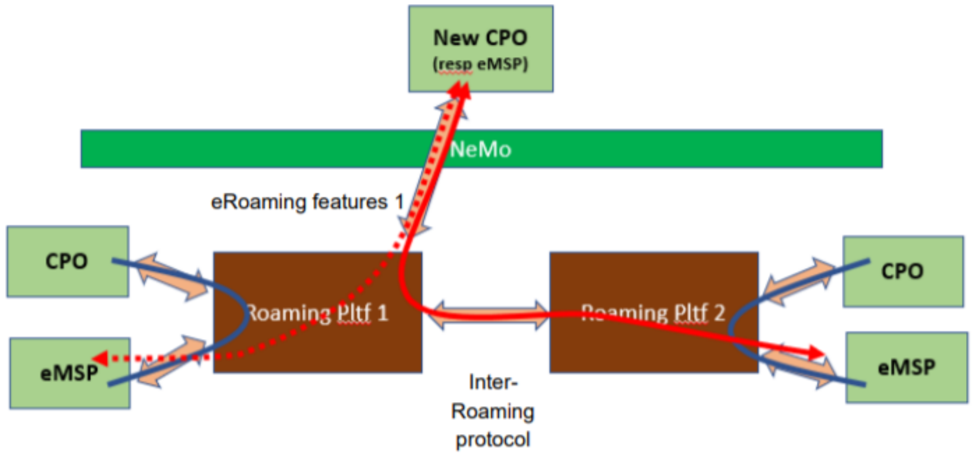

Figure 4: NeMo Open Inter-Roaming Protocol concept

In detail, the NeMo Open European Inter-Roaming Protocol, provides the functional protocol for eRoaming platforms to communicate and exchange data between themselves, and to expose their data to the NeMo Hyper-Network. It describes all necessary services and interfaces to assure the interconnection between different eRoaming platforms and between an eRoaming platform and NeMo. The interfaces served by the Inter-Roaming protocol are the exchange of static and dynamic charge point information, authorisation data and charge detail records. For each of the four interfaces, web services by each of the platforms who are NeMo partners, Gireve and Hubject, have been defined. These eRoaming features are compliant to the Common Information Models (CIM). The mapping of the Common Information Models attributes against the proprietary Gireve's eMIP protocol and the Hubject's OICP protocol were configured for these services' data Translation in order for eRoaming features to be published to the NeMo Hyper-Network.

Any other eRoaming platform can connect with all other already connected platforms either directly or via NeMo. For connection via NeMo, the new platform can provide its eRoaming features, like any other NeMo service, through NeMo, making itself visible to all other connected actors. For direct connection to a connected platform, the new platform has to implement the Inter-Roaming protocol, as a generic functional protocol, and it is only needed to further specify the exact technical implementation. The new platform does not need to connect to all other platforms, it is enough if it only connects to one of them.

In this way the base for the creation of virtual pan-European eRoaming framework has been set in a structured and consistent way, and can further expand to any other European eRoaming platform or initiative (e-clearing, etc.), thus creating a standard of e-roaming interconnection.

6.3 Discussion with standardisation groups and initiatives

During the project a number of consortium partners have been active in discussions with a number of standardisation groups and initiatives, contributing on ICT standardization work, including:

- BDEW – Bundesverband der Energie- und Wasserwirtschaft
- VDE – Verband der Elektrotechnik, Elektronik und Informationstechnik
- eMI3 - eMobility ICT Interoperability Innovation
- AVERE – the European Association of eMobility
- CharIN – Charging Interface Initiative
- ISO 20078, ISO20077, ISO 20080 – Contribution on extended Vehicles in TC22 SC31 WG6

6.4 Further work and suggestions for improvements

After mapping the existing standards and protocols according to the services, actors, and work undertaken within the project, missing standards were outlined. Firstly, there are missing standards for some identified services. For example, the services that do not have standards in place are: service composition testing, creating a demo service, or converting mobility needs into charging needs. Other examples include the service of partner registration and partner search or the aggregation of services of the same type to support usage of multiple similar services within one request from a service requester.

Aside from services, missing standards in some of the communication paths between actors could also be identified. One example is the communication pathway between the charge point and the energy system. In detail standards are necessary, which guarantees the uniform and secure exchange of information between the backend of the charging points and the IT-systems of the energy grid operator. The standardized exchange of information might even be required between the charging point backend and the IT-systems of the energy provider. These communication pathways and interfaces are crucial for all services in the field of smart charging. Furthermore, and more general is the standardization on the communication between the charge point and the charge point backend – OCPP is a de facto Standard.

The general need for standardization can also be found according to new technologies and different components. One of these new technologies is the distributed ledger technology. A challenge for standardization is related to the component battery and the prediction of the actual state of charge, which is needed for the services smart charging and trip planning. Even the hardware of charging points is lacking standards concerning DC-meter and the new field of inductive charging. The interfaces to different vehicles like buses and other heavy-duty vehicles on the one side and light and ultra-light vehicles on the other side have not been fully standardized yet.

Generally, a clear, uniform and universal terminology must be identified in the field of the e-mobility market. A common understanding of terms, roles and role models builds the fundament for developing the different areas of standardization.

7. Conclusions

This deliverable is a public report providing an overview on communication protocols and standards relevant for the NeMo Hyper-Network integration, and provides an evaluation of the existing communication protocols and standards that support the Hyper-Network business scenarios.

Protocols and standards and their relations to specific business scenarios, services, and involved actors/interfaces were investigated and recommendations for supporting project interoperability and future standardisation activities were described. The process included several expert analysis and feedback from NeMo partners as well as external stakeholders and initiatives.

The key findings include a summary of standards and protocols which were important and have been considered in NeMo, the work performed within the project to identify standardisation gaps, as well as main guidelines for future standardisation activities.

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