Actors Interactions and Needs in the European Electromobility Network

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***Abstract*—The standardization of services in the European electromobility network is becoming one of the main goal of researchers and practitioners. In this context, the objective of the paper is proposing a general view of the main needs and functions of the involved actors and stakeholders, and to state their interactions within the electromobility network. In particular, actors and stakeholders are grouped in so called macro-areas, and the interoperability and cooperation at both macro-areas and actors levels are provided by means of Unified Modeling Language (UML) diagrams.**

I. Introduction

Nowadays, European cities administrations are forced to deal with serious issues related to the congestion of public roads, due to the ever increasing urban population and the resulting massive usage of motor vehicles. Examples of related problems are limited parking spaces, traffic jams and pollution of the environment caused by loud noises and fuel emissions.

In order to overcome these issues one of the goals of the European Commission is to remove conventionally-fueled vehicles by 2050, also aiming at guaranteeing a better quality of life and health for european citizens.

However, switching from motor to Electric Vehicles (EVs) also calls, on behalf of the end users, for the acceptance of limited driving range vehicles which have to be used in a particular way and need to access specific charging points.

Recent literature shows an increasing interest in the analysis of the EV frameworks and markets [1] - [8]. The authors discuss in [1] the results of an interesting set of interviews which focus on the role, interests and difficulties that several actors and stakeholders encounter with the introduction of the EVs in France. The actors are then grouped on the basis of their attitude and degree of commitment to the innovations introduced by the electromobility framework.

The contribution [2] is about the RESOLVE project dealing with the introduction of Electric L-Category Vehicles in order to reduce CO_2 and other pollutant emissions. The paper proposes a thorough analysis of the main objectives of the project, how to achieve them and its expected impact.

In addition, [3] presents a regulatory framework for charging EVs: first, the agents are defined along with their peculiar features and the authors single out new agents for the electricity sector, i.e., the EV owner, the EV supplier-aggregator and the charging point manager. Hence, the specifics of the proposed framework are presented such as the grid connection, the communication and control equipment and the EV charging modes.

The authors in [4] identify several key challenges derived by the mobility systems' electrification, also proposing an ecosystem model. Some of these challenges are technical and are related to the vehicles and the battery technology, e.g. the battery life cycle for used battery and the manufacturing process. Other challenges are related to the adopted policies, taxation strategies and market conditions. One of the most important challenges is definitely the lack of a common charging infrastructure.

This paper proposes the definition of actors and their interrelations in the context of an electromobility network. Indeed, as a first step for the definition of a new common electromobility framework, it is necessary to clearly determine which actors could benefit from it and in which way they should interact and contribute to the smooth running of the network. First, we describe 9 macro-areas of actors which are grouped according to common features and/or needs. Then, we provide detailed descriptions of all the actors belonging to each macro-area. The description is performed by Unified Modeling Language (UML) class diagrams representing the interrelations between the macro-areas and the actors [9], [10].

This paper is developed in the framework of the European

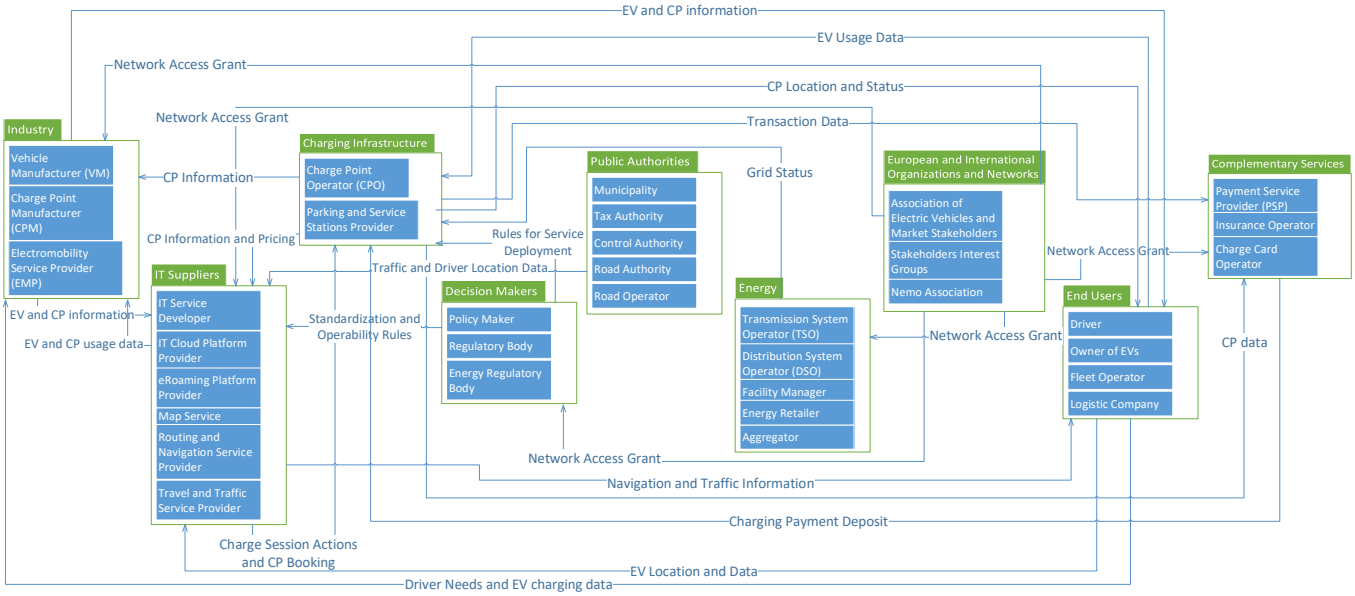

Fig. 1: The Package Diagram

Union Horizon 2020 project NeMo - Hyper-Network for electro-Mobility, which has the main objective of creating a hyper-network of new and existing tools, models and services in order to provide seamless interoperability of electromobility services and create an open and distributed ecosystem for electro-mobility [11]. All the electromobility actors should be able to interact and exchange data in order to provide more sophisticated Information and Communication Technology services. The hyper-network intends to provide new services and integrate new functionalities in existing services, relating to grid, EV drivers and EV batteries. To this aim, a common information model is designed in order to contain and describe the data required by the actors of the electromobility network.

The remainder of this paper is structured as follows: Section II describes the proposed macro-areas along with their interrelations represented by the UML class diagram and the details of the actors belonging to each macro-area; Section III presents the concluding remarks.

II. The Macro-areas and their Relationships

This section presents the identified macro-areas containing the electromobility actors (classes) and the relationships among them. More precisely, the identified 9 macro-areas are the following: Industry, Information Technology (IT) Suppliers, Charging Infrastructure, Decision Makers, Public Authorities, Energy, European and International Organizations and Networks, End Users, Complementary Services. First, the macro-areas and their main relationships are described by using the UML package diagrams shown in Fig. 1. In particular, UML packages are used to group elements of any kind. In this paper, packages represent macro-areas and group classes. Moreover, each class represents an actor of the electromobility network. In the diagram, packages are represented with boxes with the name of the package on the top and the name of the contained classes inside the box.

The Package Diagram connects different macro-areas: an arrow connecting one package to another depicts one or more actors belonging to the first macro-area sending data to one or more actors of the second macro-area. Each arrow also contains a brief description of the exchanged data.

Second, each macro-area and the corresponding relationships are described by a class diagram. In the diagrams, classes are represented with boxes that contain two compartments: the top compartment contains the name of the class and the bottom one contains the methods or operations that the class, i.e. the actor, can execute.

Due to space constraints, in this paper we report the class diagrams of the Charging Infrastructure (Fig. 2), of the European and International Organizations and Networks (Fig. 3) and of the End Users (Fig. 4). For the remaining macro-areas we present the results by tables in which the first column indicates the name of the class representing the actor, the second column shows the data sent by the actor and the last column contains the acronym of the actor recipient of the data. The acronym is composed of a letter representing the macro-area and a number which is the id of the actor, separated by a dot. If an actor sends data to all the actors belonging to a macro-area, then the acronym of the recipient is x.all where x is the letter representing the macro-area.

In the following sub-sections we provide a more detailed description of each macro-area along with the corresponding UML package representation and the description of the actors, also adapting the ISO 15118 ”Vehicle-to-Grid Communication Interface” specification [12] definitions.

TABLE I: The Industry macro-area

Actor	Data Sent	Recipient
Vehicle Manufacturer (a.1)	Technical Compatibility Data	g.1, g.2
	EV Structural Information and off-board services	b.3 h.all
	HMI Applications	a.3
Charge Point Manufacturer (a.2)	Technical Compatibility Data	g.1, g.2
	Advice on Regulations and Policies	d.all g.all
Electro-Mobility Service Provider (a.3)	Charging Authorization Response, Charge Session Action	b.3
	EV Charge Needs	c.1
	Suitable CP Finding	h.all
	EV Registrations Data	e.1

TABLE II: The IT Suppliers macro-area

Actor	Data Sent	Recipient
IT Service Developer (b.1)	IT Services	h.all
IT Cloud Platform Provider (b.2)	Cloud Platform Infrastructure	b.1
ERoaming Platform Provider (b.3)	Charging Authorization Request, Charge Detail Record	a.3
	IT Service Availability	e.1
	Charging Authorization Response, Charge Session Actions	c.1
Map Service Provider (b.4)	Map Data, CP and EV location	b.5 b.6
Routing and Navigation Service Provider (b.5)	Routing and Navigation Information	h.1
Travel and Traffic Information Service Provider (b.6)	Travel and Traffic Information	b.4, h.1
	Traffic Information	b.5, f.2

TABLE III: The Decision Makers macro-area

Actor	Data Sent	Recipient
Policy Maker (d.1)	Standardization and Interoperability Rules	b.1 b.2
	Regulations and Policies	a.2
	Mobility Policies	d.3
Regulatory Body (d.2)	Technical and Market Regulations	g.2
	Deployment Rules	c.2
Energy Regulatory Body (d.3)	Regulations and Policies	e.all
	Energy Regulations	d.2

A. Industry

The Industry macro-area groups all the actors mainly related to the production of goods. The list of the actors belonging to the Industry macro-area is reported in Table I:

- **Vehicle Manufacturer (VM)**: this actor develops, produces and sells EVs to the market. According to ISO 15118, it can be also defined as a company which builds Electric Vehicles that are different to all other products made by other companies.
- **Charge Point Manufacturer (CPM)**: it develops, produces and sells poles for charge, i.e., a company which builds Charge Poles that are different to all other products made by other companies [12].
- **Electromobility Service Provider**: according to ISO 15118 [8], this actor is a legal entity with which the customer has a contract for all the services related to the electromobility operations (for instance subscription models for charging and billing, direct-payment or navigation services to nearest available charging point, tariff schemes for end and business customers, B2C billing and invoicing).

B. Information Technology Suppliers

The IT Suppliers actors are companies providing IT services to other actors interacting in the electro-mobility network (Table II).

- **IT Service Developer**: this actor represents software companies providing back-end application or services, for example, to enable the billing and roaming or to forecast the electricity demand.
- **IT Cloud Platform Provider**: companies specialised in developing cloud platforms belong to this class.
- **Routing and Navigation Service Provider**: this public or private entity makes use of map data in order to provide routing and navigation services, based also on vehicle and driver information.
- **Travel and Traffic Information Service Provider**: this public or private entity provides a service to other actors by collecting and aggregating travel and traffic information.

C. Charging Infrastructure

This macro-area includes actors which constitute the framework necessary for the EVs to complete the charging process (Fig. 2).

- **Charge Point Operator (CPO)**: this class includes companies responsible for the management and servicing of charging stations. Its main responsibilities concern the management of the charge points by means of an IT system, the billing and invoicing.
- **Parking and Service Stations Provider (PSSP)**: this legal entity provides parking spots equipped with charging services.

D. Decision Makers

Decision Makers are actors involved in the making and supervising laws concerning the electro-mobility network (Table III).

- **Policy Maker**: this class includes member of governments responsible for making new rules and laws and public investment decisions.
- **Regulatory Body (RB)**: this actor is a public authority or government agency responsible for exercising autonomous authority in a regulatory or supervisory capacity.
- **Energy Regulatory Body (ERB)**: an organization created by governments with the purpose of protecting the interests of users and consumers, promoting competition and ensuring efficient, cost-effective and profitable nationwide services with satisfactory quality levels in the electricity sectors.

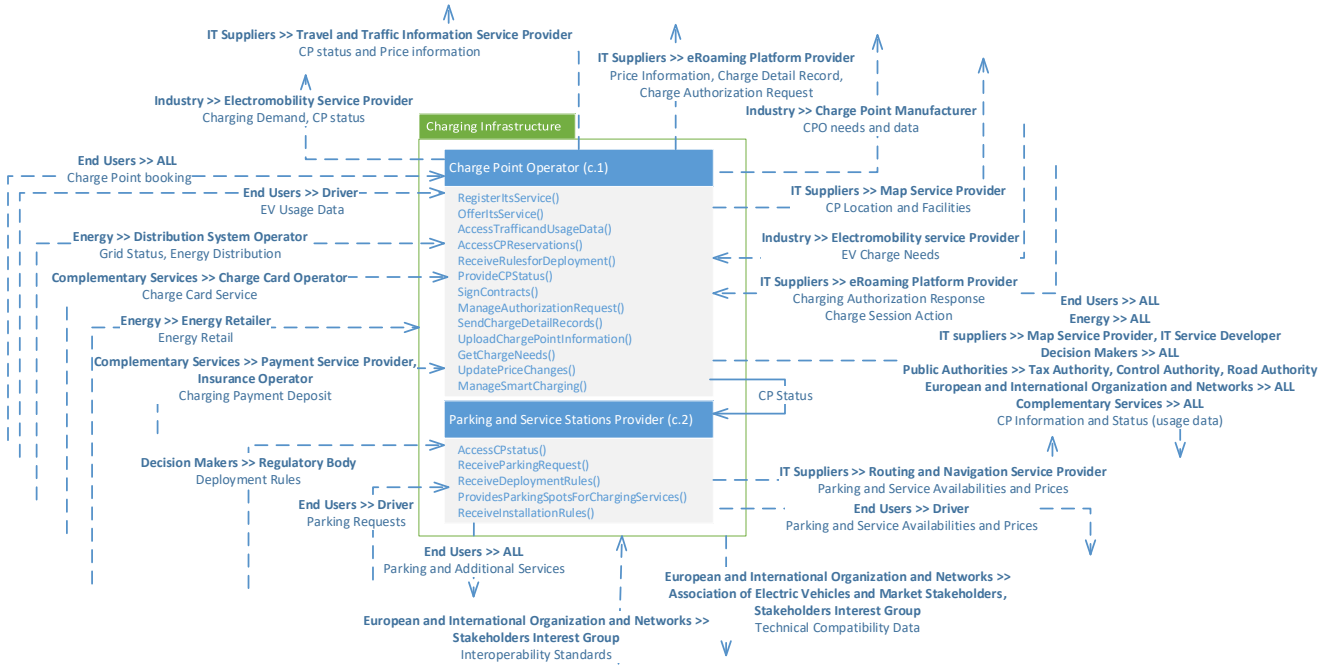

Fig. 2: The Charging Infrastructure macro-area

TABLE IV: The Public Authorities macro-area

Actor	Data Sent	Recipient
Municipality (e.1)	Mobility Constraints	d.1
	EV Registration Data	e.2
Tax Authority (e.2)	Taxes Information	e.1, e.3, h.all
	Regulations and Policies Feedback	d.all
Control Authority (e.3)	Issues and Penalties	h.all
	Control Authority Data	i.2
Road Authority (e.4)	Traffic Data	e.3
Road Operator (e.5)	Traffic Data	b.6, d.all, e.1, e.4
	Traffic and EV Usage Information	g.all
	Installation Needs	a.2

E. Public Authorities

The Public Authorities macro-area includes all the actors responsible for the government, control and tax applications in the electromobility framework (Table IV).

- **Municipality**: it is an urban administrative division with corporate status and powers of self-government or jurisdiction.
- **Tax Authority**: it is a government entity authorized by the law to assess, levy and collect taxes.
- **Control Authority**: it is a government entity authorized to guarantee the observance of the law.
- **Road Authority**: this actor is the body responsible for the administration of public roads within a given jurisdiction.
- **Road Operator**: this actor monitors, maintains and manages the road traffic and/or the road side infrastructure systems.

F. Energy

This macro-area groups all the actors involved in the management of the energy (Table V).

- **Transmission System Operator (TSO)**: this entity is responsible for operating the transmission system which transports electricity on high-voltage lines. The TSO guarantees the maintenance and, eventually, the development of the transmission system, also providing system services as balancing services, reserve capacity and power quality. It helps reducing or increasing the energy load.
- **Distribution System Operator (DSO)**: this entity is responsible for the voltage stability in the distribution grid.
- **Facility Manager**: this entity is responsible for coordinating demand and supply of facilities and services within public and private organizations. It monitors and manages building energy usage.
- **Energy Retailer**: this actor sells the electricity to customers.
- **Aggregator**: it can be called also Energy Trader and acts on behalf of groups of customers by using small volume inputs and creating saleable portfolios to be sold on different electricity markets.

G. European and International Organizations and Networks

This macro-area groups actors that cooperate and provide opinions and ideas to satisfy all kinds of users and customers of an electromobility network (Fig. 3).

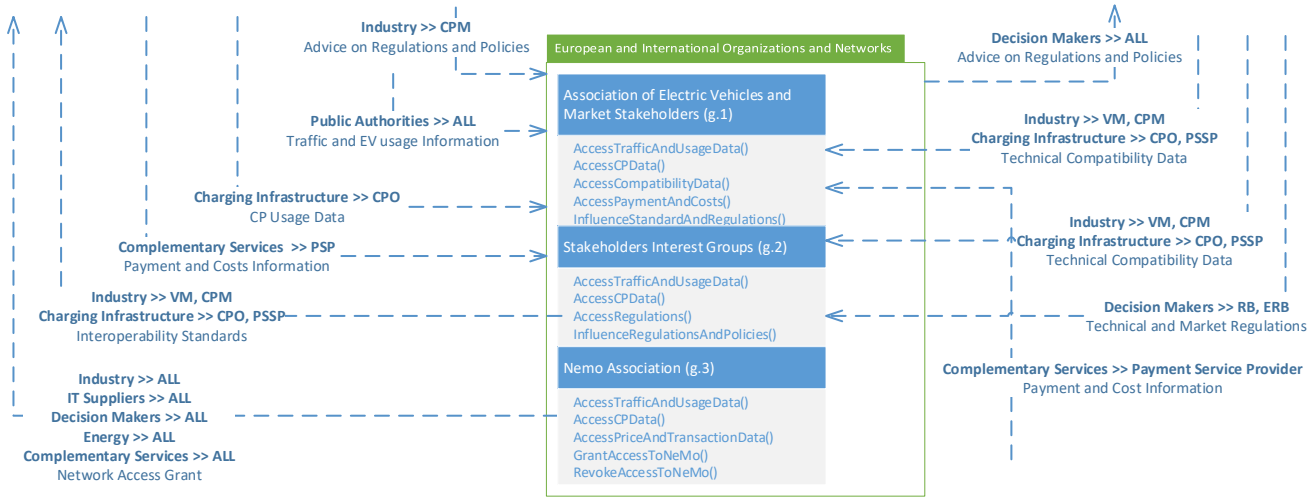

Fig. 3: The European and International Organizations and Networks Macro-area

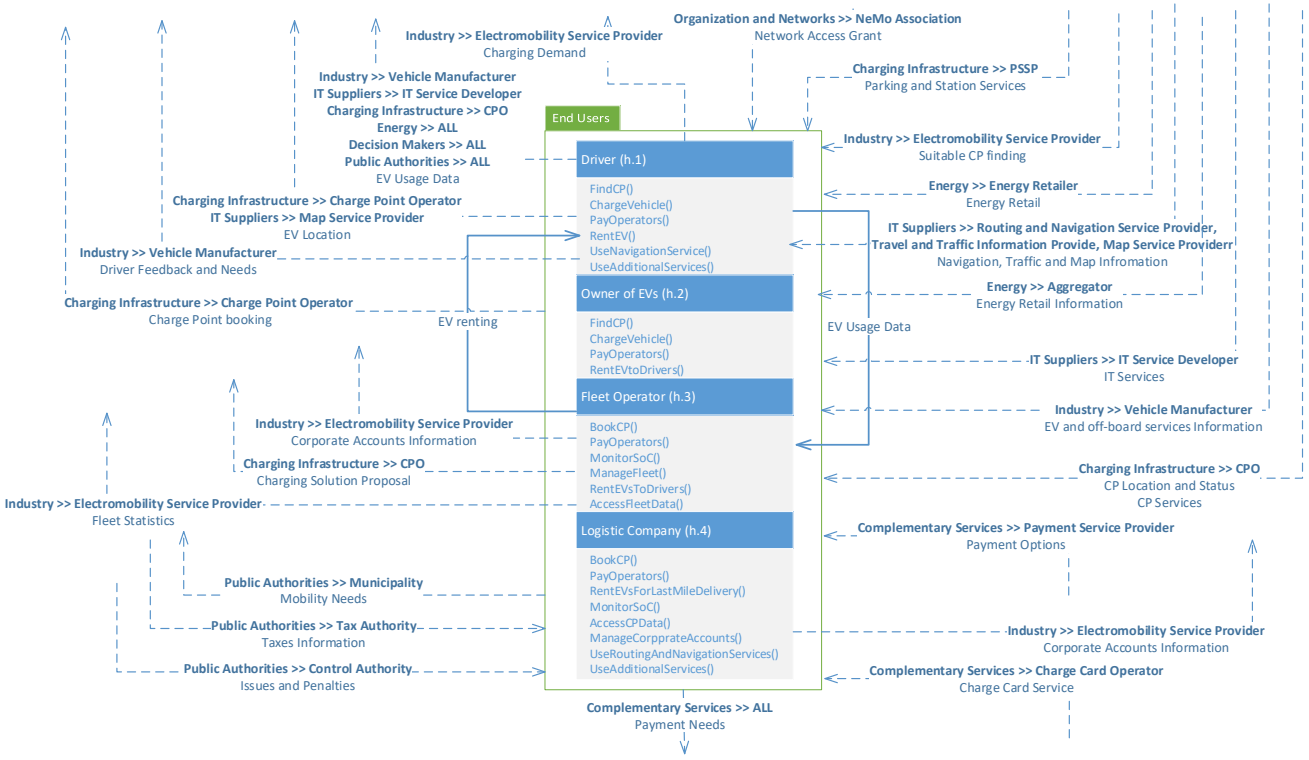

Fig. 4: The End Users macro-area

TABLE V: The Energy macro-area

Actor	Data Sent	Recipient
Transmission System Operator (f.1)	Energy Transmission	f.2
Distribution System Operator (f.2)	Demand Response Interaction	f.3
	Grid Status	c.1, f.1, f.4, f.5
	Energy Distribution	c.1
	Energy to Sell	f.4
Facility Manager (f.3)		
Energy Retailer (f.4)	Energy Retail	f.5, d.3, c.all, e.1, h.all
	Retail Tariffs	d.3, c.all, e.1, i.1
Aggregator (f.5)	Aggregated Demand Bids, Demand Response Interaction	f.2
	Energy Retail Information	h.all

- **Association of EV Market Stakeholders**: this actor is a representative body of stakeholders in the development of an EV market.
- **Stakeholders Interest Groups**: this actor is an association of actors interested in the development of the Electromobility sector and collects data and experiences of electric mobility past and present projects. Some examples include: eMobility ICT Interoperability Innovation Group (eMI3), Hydrogen Fuel Cells and electromobility in European Regions (Hyer).
- **NeMo Association**: this association grants access to the hyper-network to other actors.

H. End Users

End Users are the final users of the electromobility network (Fig. 4).

- **Driver**: a person or legal entity using the vehicle and providing information about driving needs and consequently influencing charging patterns.
- **Owner of EVs**: a person or legal entity owning the vehicle.
- **Fleet Operator**: a person or legal entity operating a fleet of EVs, eventually having contracts with electromobility service providers.
- **Logistic Company**: a company that offers logistic services using EVs.

I. Complementary Services

This macro-area groups actors offering additional services fundamental for the functioning of the electromobility network (Table VI).

- **Payment Service Provider (PSP)**: this actor offers online services for accepting electronic payments by a variety of payment mehods (e.g., credit card, direct debit, bank transfer, online banking). It manages the payment and reimbursement procedure for EV users and other operators.
- **Insurance Operator**: it is a company providing coverage in the form of compensation resulting from loss, damages, injury, treatment or hardship for EV owners and drivers.
- **Charge Card Operator**: this company provides cash-free services to EV users.

TABLE VI: The Complementary Services macro-area

Actor	Data Sent	Recipient
Payment Service Provider (i.1)	Payment and Cost Information	g.1, h.all
	Payment Deposit	c.1
Insurance Operator (i.2)	Insurance Payment Deposit	c.1
Charge Card Operator (i.3)	Charge Card Service	c.1, h.all

III. Conclusion

This paper defines the actors and stakeholders involved in the European electromobility framework, in order to group them according to specific functions and requirements and to point out their main interrelations. In the proposed framework, 9 macro-areas are identified in order to group actors according to common features and needs. Moreover, the interactions among the actors are defined and described by UML diagrams, at both macro-areas and actors level. The resulting description provides a common information model that represents a basic starting point for the electromobility network and the related services. Future research will be performed in the NeMo project framework and will be devoted to the design of the eRoaming hyper-network that will allow seamless and interoperable use of electromobility services. The proposed network will be a distributed environment with open architecture based on standardised interfaces, in which the electromobility actors will be able to interact, exchange data and provide elaborate electromobility ICT services.

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