D4.8 - Initial USM Extensions for Storage Systems

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Document History

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0.1	2017-06-23	UPB	First draft of TOC
0.2	2017-07-07	UPB	New template for first draft of TOC
0.9	2017-08-21	UPB	Version Ready for internal review
1.0	2017-08-31	UPB	Final version, ready for submission to the EC

Internal Review History

Review Date	Reviewer	Summary of Comments
2017-08-28 (v1.0)	Vasco Delgado-Gomes (UNINOVA)	Approved: • Needs proper formatting, complying with the official prototype template • Acronyms table needs to be completed • Missing the Executive Summary • Needs improvement for better readability on the marked sections • Comments on Figure 1 and on the ER section.
2017-08-28 (v1.0)	Riccardo Tomasi (ISMB)	Approved with minor comments: • Minor corrections (typos, style) • Minor suggestions for harmonization with overall architecture.

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Executive Summary

D4.8 describes the "Initial USM Extensions for Storage Systems" details of the prototype, developed by the Storage4Grid project. The deliverable describes the extension connectors which are needed to be developed in the Unbundled Smart Meter (USM) to support the S4G functionalities. Similarly to other prototypes, this document provides minimal technical documentation necessary to understand the functionalities and structure of USM prototype with its extension connectors needed to support the S4G system at the filed level. The document will be revisited in the subsequent D4.9 and D4.10 deliverables (updated and final USM extensions).

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1   Introduction

D4.8 describes the "Initial USM Extensions for Storage Systems" prototype, developed by the Storage4Grid project. Similarly to other prototypes, this document provides minimal technical documentation necessary to understand the functionalities, structure and deployment instructions for the prototype of interest. More detailed information can be retrieved from related documents summarized in Section 1.2.

1.1   Scope

This prototype deliverable has been developed by Task T4.4 – "Unbundled Smart Meter Extensions for Storage Systems". Further updates of this prototypes are expected to be released as D4.9 (M21) and D4.10 (M33).

1.2   Related documents

ID	Title	Reference	Version	Date
D1.1	Project Quality and & Risk Management Plan	[1]	1.0	2016-12-23
D2.1	Initial Storage Scenarios and Use Cases	[2]	1.1	2017-06-08
D3.1	Initial S4G Components, Interfaces and Architecture Specification	[3]	1.0	2017-08-31

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2 Unbundled Smart Meter Architecture. Prototype Overview

The USM is composed by a Smart Metrology Meter (SMM) i.e. a certified smart meter suitable to measure energy consumption using a trusted/certified method and an SMX Box, hosting the SMX Core and one or more SMX extensions i.e. a modular software, running on a dedicated small-form Personal Computer (PC) (namely the SMX hardware), which can host plug-in components providing added-value services

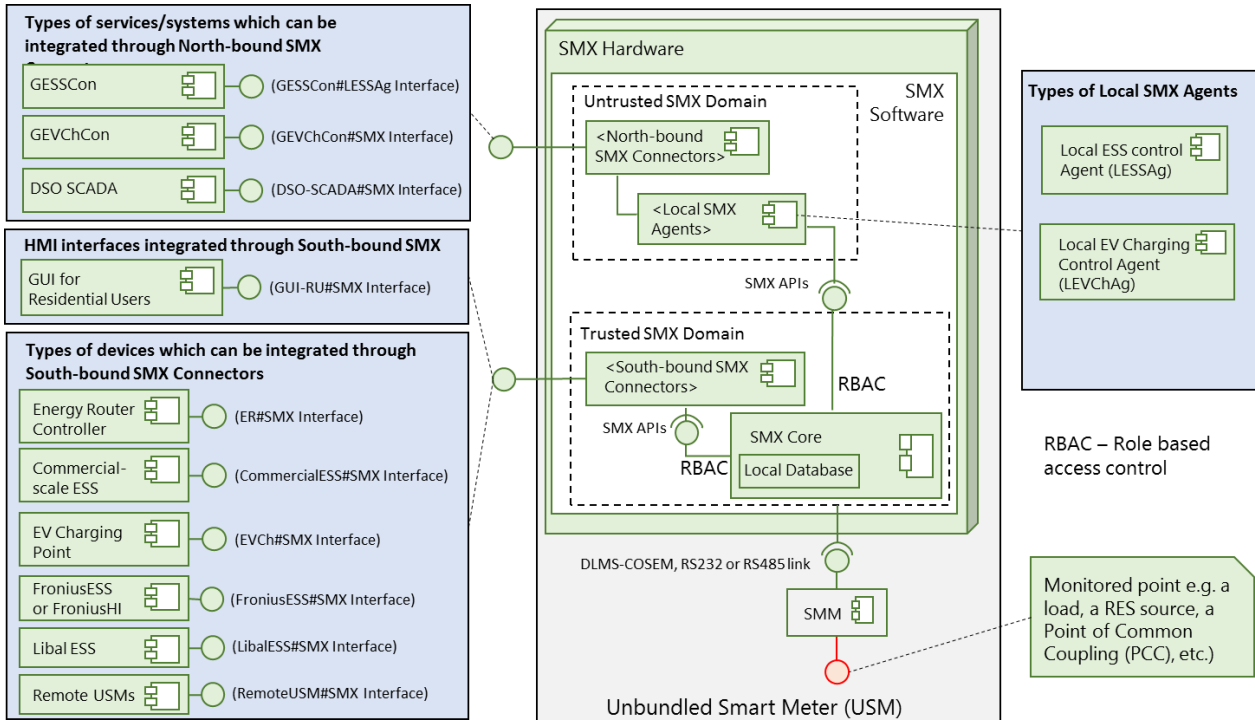The overall, high-level structure of prototype USM Architecture is summarized in Figure 1.

Figure 1 – The USM prototype structure (source: Storage4Grid D3.1)

The sub-components of the prototype are shortly summarized in the following sections.

2.1 Smart Metrology Meters (SMM)

2.1.1 Billing values in SMM

Electricity meters are deployed for their main functionality: billing. This is usually made either by reading
- a meter index at a-priori specified intervals of time (e.g. each beginning of month), in case of single tariff or
- by reading meter indexes associated with different tariffs.

In case of active energy meters, the so-called "billing values" can be reported in digital form and read remotely. These values are usually made available in one or more of the following forms:

 - Indexes of active energy: these are usually indexes which only increase their value until the index recirculates, meaning that it overpasses its maximum value, e.g. 999999.99

There can be separate indexes for each direction of the transfer of active energy during the PCC where the meter is installed (to/from the customer installations), meaning separate IdxA+ and IdxA- , measured in [kWh] or [MWh]

 - Indexes of reactive energies; these are also usually indexes for each direction of reactive energy, meaning separate IdxR+ and IdxR- , measured in [kvarh] or [Mvarh]

- Indexes associated with each tariff, in case of multiple tariffs;
- A list of these indexes stored at specified moments, usually at the beginning of a new month.

2.1.2 Instrumentation values in SMM

Mandatory instrumentation values to be obtained directly (without additional calculations) from the SMM (also from market existing meters which have some Smart Meter functionalities) are:

- Voltage value on each phase – U(t) for mono-phased meters and U1(t), U2(t), U3(t) for three phased meters, where U(t) or Ux(t) represents the RMS value of the voltage available on the communication interface. To be noted that usually the time window Tw for calculating this value is not specified by the meter manufacturer. Usually these values are obtained in secondary values and are in volts [V]. Meters with indirect connection (voltage connected with a voltage transformer and current connected through a current transformer) may give the voltage level either in secondary values (specific to the standard 57 V range which correspond to 100 V phase-to-phase voltage) or in primary values, which means secondary values multiplied by the voltage transformer ratio.
- Current value on each phase – I(t) for mono-phased meters and I1(t), I2(t), I3(t) for three phased meters, where I(t) or Ix(t) represents the RMS value of the voltage available on the communication interface. Meters with indirect or semi-direct connections may give the voltage level either in secondary values (specific to the standard 57 V range which correspond to 100 V phase-to-phase voltage) or in primary values, which means secondary values multiplied by the voltage transformer ratio.

- Active power value on each phase – P(t) for mono-phased meters and P1(t), P2(t), P3(t) for three phased meters. To be noted that usually the time window TW for calculating this value is not specified by the meter manufacturer. In case that the SMM has values to be calculated from other values, the following P(t) can be used in real time, with the condition that the meters provide these vales:

- Reactive power value on each phase – Q(t) for mono-phased meters and Q1(t), Q2(t), Q3(t) for three phased meters. To be noted that usually the time window Tw for calculating this Q value is not specified by the meter manufacturer.

- Frequency f of the network;

2.2 S4G Instrumentation Components

Similar with the main meter used for billing, presented as SMM, other components of the local system involving storage resources need also specific instrumentation values. However, the additional instrumentation values may be not necessary enforced by metrology, as being sub-metering information, thus not relevant for the point of common coupling between the local system and the DSO. Sub-metering is provided by the devices which are integrated in the South-bound part, as presented in Figure 1.

2.2.1 Sub-metering local ESS

Similar with the SMM, local ESS need its instrumentation values to be acquired by SMX through specific interface. A commercial or vendor specific ESS can be integrated by using either a special SW extension which can read the instrumentation values or another USM having as main role the provision of the electrical data. In S4G project are considered to be used USMs, which bring the same type of data to be read for all these points. The "Remote USM" are then the preferred devices to be connected to the south-bond connector in the main USM.
The following data are needed for the S4G project:
- The active power P(t) on each phase of the meter
- The voltage U(t) in the metered point

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- Active energy A+ and A- (in both directions)

To be noted that the exact details of the extension will be presented in the next phase of development, namely in D4.9.

2.2.2   Sub-metering EV

EVs charging parameters need also to be read by the S4G system, to help the optimisation of using the storage resources. For this purpose, in S4G project are considered to be used also USMs, bringing the same type of data to be read for all these points. The extension is reading the "Remote USM" in the main USM.
The following data are needed for the project:
- The active power P(t) on each phase of the meter
- The voltage U(t) in the metered point
- Active energy A+ and A- (in both directions)

2.2.3   Sub-metering ER

The ER will measure its electrical data and make it available through the ER adapter. The following data is available in the ER:
- The active power P(t) on each phase;
- The voltage U(t) in the metered point
- Active energy A+ and A- (in both directions)

More information about the available data is provided by D4.1.
Please note that in cases where the ER energy needs to be billed (or any other reason) an USM will be considered.

2.2.4   Sub-metering PV

PV production is present in all pilot sites and is considered to be paired with the storage resources. PV are separate resources which are difficult to be interfaced with SMX, therefore the project is considering the use of an USM, as it is a common solution in previous cases.
The following data are needed for the project:
- The active power P(t) on each phase of the meter
- The voltage U(t) in the metered point
- Active energy A+ and A- (in both directions)

2.2.5   Sub-metering Fronius

The Fronius devices used in the project need to be also monitored also in terms of electrical data. Instead of USMs, the SMX extension connectors developed by Storage4Grid will provide instrumentation values directly the measured internal data of the Fronius devices. The needed data is separated for each type of Fronius equipment

2.2.5.1   Sub-metering Fronius Simo (hybrid)

The Fronius hybrid controls both local PV and storage resources. The following data are needed for the project:
- The active power P(t) on each phase of the AC interface towards the DSO network
- The voltage U(t) on each phase of the AC interface towards the DSO network
- Power Ppv, for the PV production

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- Power Pess, for the storage part
- Active energy A+ and A- (in both directions)

For the situation that A+ and A- are not directly available, an integration module which uses P(t) will be implemented as extension connectors for USM, in order to obtain similar information.

The exact data available through the extension connectors will be based on the data availability from the Fronius hybrid inverter (FronoiusHI).

2.2.5.2 Sub-metering Fronius for Storage

The Fronius inverter equipment controls the storage resources needed to provide the following data:
- The active power P(t) on each phase of the AC interface towards the DSO network
- The voltage U(t) on each phase of the AC interface towards the DSO network
- Active energy A+ and A- (in both directions)

For the situation that A+ and A- are not directly available, an integration module which uses P(t) will be implemented as an extension connector for USM, in order to obtain similar information.

The exact data available through the extension will be based on the data availability from the Fronius inverter.

3 Smart Meter eXtensions – SMX. Prototype Overview

3.1 Extensions for integration of local EV charging station (HLUC – 2)

A dedicated extension, namely the "EV Charging Point Connector", has been developed to integrate controllable charging points compatible with the OCPP open standard.

Such controllable charging points are normally deployed in public charging stations, but within the S4G project one of such charging points is also planned for deployment in a residential scenario.

In order to preserve operation of pre-existing EV SCADA systems, this extension works as a "transparent proxy", allowing in-bound connection from the EV SCADA systems, which are transparently forwarded to the charging point. The "transparent proxy" mode has been introduced because many commercial charging point implementation only allow one single in-bound connection.

The deployment schema for the extension is depicted in Figure 2. It has to be observed the the picture does not represent the full list of components involved in this type of scenarios (e.g. the Event Broker, the DataWharehouse, etc.), but it is only provided to highlight the main remote components to be deployed when the "EV charding Point Connector" extension is used.

![STORAGE 4 GRID]

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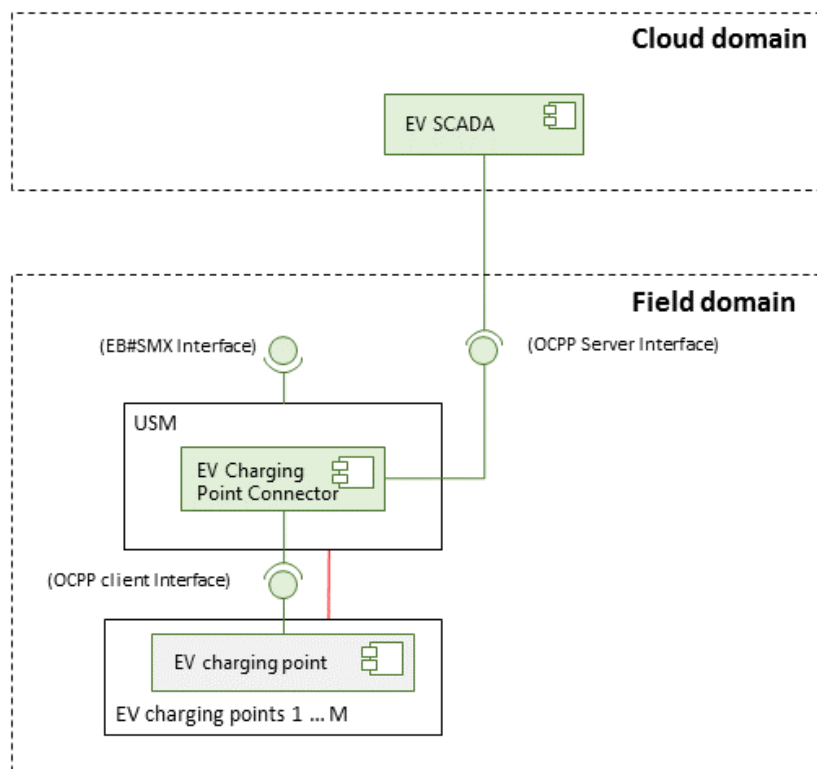
Figure 2 - EV Charging Point Connector

There are three interfaces designed for this extension which is named as EV charging point connector. They are OCPP client interface, OCPP server interface and EB#SMX interface as shown in Figure 2 - EV Charging Point Connector . For this version, only OCPP client interface and OCPP server interface are defined. EB#SMX will be defined in the next version.

3.2 Extensions regarding the inter-connection with local GUIs for residential users (all HLUCs)

This extension is described in D6.7.

To be noted that in Figure 1 the GUI interface is considered to be connected to the South-bond part of SMX, which is considered to be a trusted domain.

Even if it is possible that remote or local GUI can be available from the untrusted SMX domain, the basic implementation is foreseen to be related to the trusted zone, as the professional or residential user has anyhow the right to access all the local data, which belongs to the user.

3.3 Extensions for integration with Grid-side ESS (HLUC – 3)

3.3.1 GESSCon#LESSAg Interface

The interface for the storage controls at user premises are given in D3.1 Section 4 Information View. The GESSCon will send a recommended load profile (DC Power) to the user side ESS Control. The user side ESS control will prioritize the charge and discharge of the battery locally with recommendation from the GESSCon.

3.3.2   GESSCon#SMX Interface

If a USM is needed without storage controls this interface shall be used only measuring active and reactive power as well as grid voltages. This interface is detailed in D3.1.

3.4   Extensions for integration with Residential ESS (HLUC – 2 and HLUC – 3)

A dedicated extension, namely the "Fronius ESS connector", has been developed to inter-connect the USM to pre-existing Fronius Hybrid inverters (and the associated storage systems) available both in the residential parts of both the Fur and Bolzano test sites.

The deployment schema for the extension is depicted in Figure 3.

Such extension is typically deployed on-board a dedicated USM (USM1), which is in-term acting as a slave of the main USM (0), hosting the LESSAg.
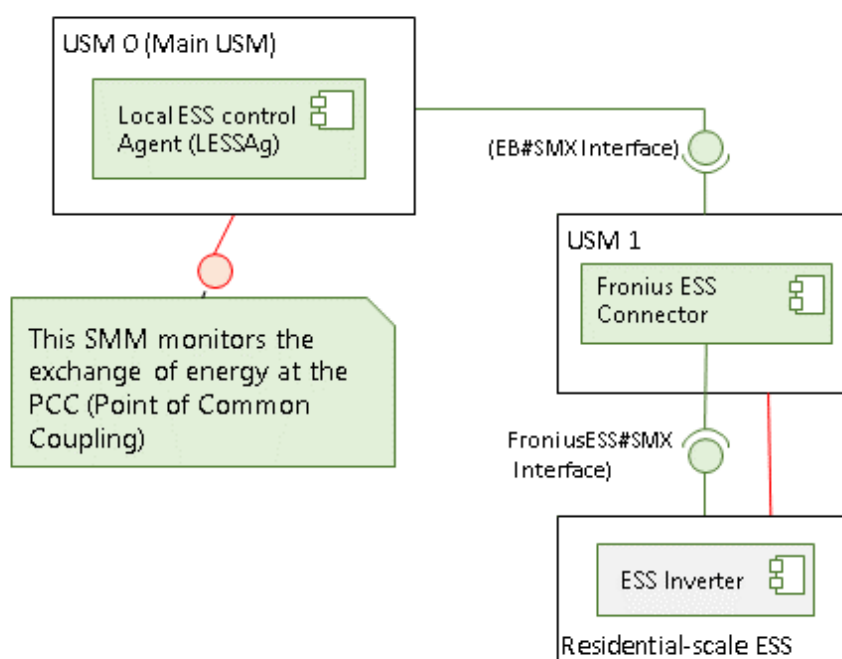

Figure 3 Fronius ESS connector

Alternatively, the connector implements one of the interfaces available on-board the Fronius system e.g. the solarweb API or the Fronius Modbus specifications.

3.5   Extensions for integration with ER (HLUC – 1)

The extension to connect USM with the energy router is special designed to value all data an setpoints available in the ER.

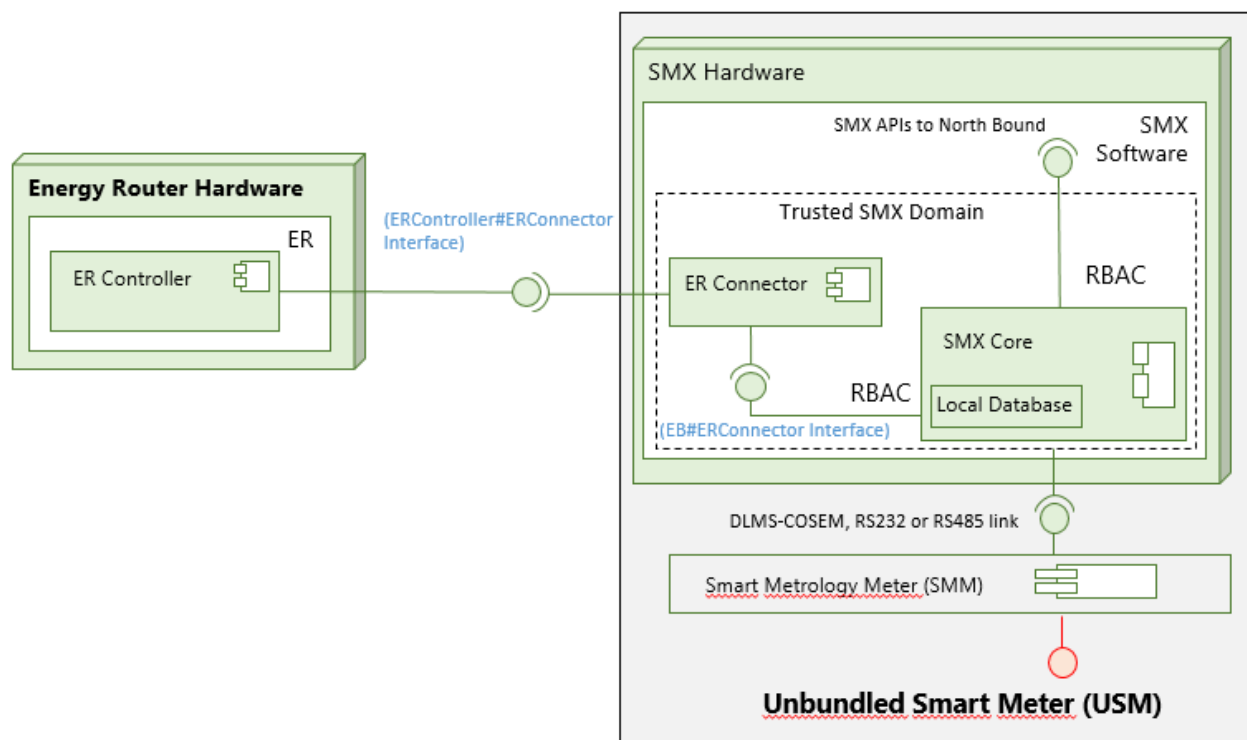The deployment schema for the extension is depicted in Figure 3.

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Figure 4 - ER extension

The ER Connector is implemented in the trusted SMX domain and the communication is made through the local database of SMXCore. A specific RBAC (permissive) will be considered for the ER communication and a strong RBAC focused on the needed data is considered for the North-bound connection, where the LESSAg will be installed.

4   SMX communication and information exchange with high level application. Prototype Overview

The communication with the cloud components will use MQTT messaging to exchange data between SMX and the GESSCon / EVChCon applications, as presented in Figure 5.
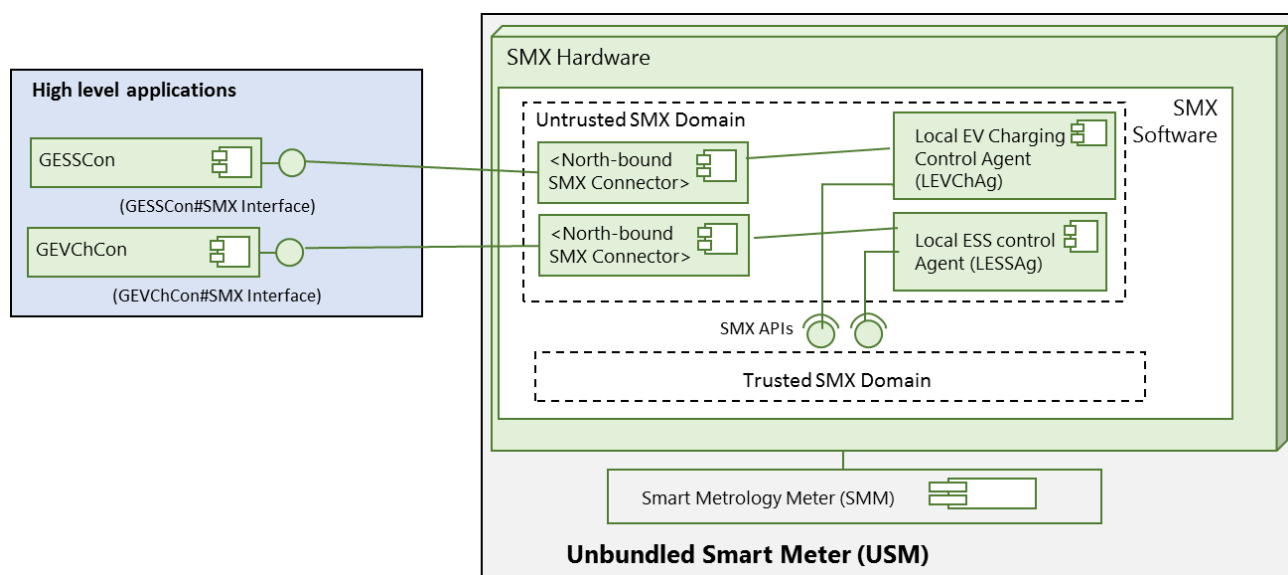
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Figure 5 High level applications connectors

The information exchanged with the trusted domain is based on precise RBAC configuration, allowing that only necessary data is sent to the agents running in the untrusted domain.

5   Software dependencies and requirements

5.1   Minimal requirements for SMX

SMX is a Linux platform which need to run on a compact Single Board Computer (SBC). The Raspberry Pi3 SBC has been chosen due to its quad-core architecture running at 900 MHz, its memory capacity of 1 GB of RAM and its storage capacity of up to 32 GB on SD-Card. In the S4G project, it is considered as sufficient a 16 GB SD-Card, which allows the installation of the Linux operation system and of the project related applications, while still allowing the recording of a high-resolution log of different variables.

5.2   Software dependencies

Table 1 summarises the main dependencies known at this stage of development.

Table 1 – Software Dependencies

Dependency	License	Role
Java-OCA-OCPP[1]	MIT	A client and server library of Open Charge-Point Protocol from openchargealliance.org. Used in the "Extensions for integration of local EV charging station"
Java Modbus Library[2] (Jamod)	Apache v2	Library used to support Modbus communication in the Fronius ESS connector.
SMXCore	GPL	Open source Core application running in the trusted domain, implementing the real-time

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[1] https://github.com/ChargeTimeEU/Java-OCA-OCPP
[2] http://jamod.sourceforge.net/

		database, the communication with SMM and with all extensions running around SMXCore, by using also a RBAC system to preserve security and privacy for the used data

6   API Reference

6.1   API for Extensions for integration of local EV charging station (HLUC – 2)

This extension implements the JSON-over-WebSocket specifications foreseen within the OCPP specifications since version 1.6. According to such specification, the OCPP client (i.e. the charging point) will initiate a bi-directional WebSocket connection through an OCPP-J (HTTP UPGRADE) request as in the following example. The details of the implemented protocol can be found in the OCPP JSON v1.6 Specification and OCPP protocol v1.6 Specification[3].

6.2   API for Extensions for integration with Residential ESS (HLUC – 2 and HLUC – 3)

The extension implements the Fronius open specifications for Fronius Solar API and Modbus[4].

6.3   API for Extensions for integration with Energy router (HLUC – 1

The extension implements the Energy Router specifications developed and described in D4.1 and further deliverables.

7   Conclusions

D4.8 describes the "Initial USM Extensions for Storage Systems" prototype, developed by the Storage4Grid project. Similarly to other prototypes, this document provides minimal technical documentation necessary to understand the functionalities, structure and deployment instructions for the prototype of interest.
The document presents the main extensions needed in the SMX for implementing a complete chain of functionalities to support efficient and optimized used of storage resources.
More detailed information based on the implementation of the extensions will be presented in the following deliverables D4.9 and D4.10.

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[3] http://www.openchargealliance.org/protocols/ocpp/ocpp-16/
[4] https://www.fronius.com/en/photovoltaics/products/home/system-monitoring/open-interfaces/fronius-solar-api-json-

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Acronyms

Acronym	Explanation
DSO	Distribution System Operators
ESS	Energy storage system
ER	Energy router
EV	Electrical Vehicle
GUI	Graphical user interface
MQTT	Message Queue Telemetry Transport
OCPP	Open Charge Point Protocol
PCC	Point of common coupling
PV	Photovoltaic
RBAC	Role based access control
RMS	Root mean square
SBC	Single Board Computer
SCADA	Supervisory control and data acquisition
SMM	Smart Metrology Meter
SMX	Smart Meter eXtensions
SW	Software
USM	Unbundled Smart Meter

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