Platone

PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

Platone

PLATform for Operation of distribution NEtworks

D2.15

PlatOne Integrated Framework Prototype (v2)

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Abstract

The Platone Open Framework aims to create an open, flexible, and secure system that enables distribution grid flexibility/congestion management mechanisms, through innovative energy market models involving all the possible actors at many levels (DSOs, TSOs, customers, aggregators). The Platone Framework is an open-source framework based on blockchain technology that enables a secure and shared data management system, allows standard and flexible integration of external solutions (e.g., legacy solutions), and is open to integration of external services through standardized open application programming interfaces (APIs).

This document accompanies the software delivery of the second prototype of the Platone Open Framework. This version of the Platone Open Framework includes all the Platone Platforms and is integrated with the physical infrastructure and external systems deployed within the three different demo architectures.

The second integrated prototype of the Platone Open Framework will be the base for the second pilots' executions during which it will be tested and evaluated under different user and business requirements and following different deployment approaches.

Keyword list

Platone Open Framework, Platform Integration, Deployment, Testing and Validation

Executive Summary

"Innovation for the customers, innovation for the grid" is the vision of project Platone - Platform for Operation of distribution Networks. Within the H2020 programme "A single, smart European electricity grid", Platone addresses the topic "Flexibility and retail market options for the distribution grid". Modern power grids are moving away from centralised, infrastructure-heavy transmission system operators (TSOs) towards distribution system operators (DSOs) that are flexible and more capable of managing diverse renewable energy sources. DSOs require new ways of managing the increased number of producers, end users and more volatile power distribution systems of the future. Platone is using blockchain technology to build the Platone Open Framework to meet the needs of modern DSO power systems, including data management. The Platone Open Framework aims to create an open, flexible and secure system that enables distribution grid flexibility/congestion management mechanisms, through innovative energy market models involving all the possible actors at many levels (DSOs, TSOs, customers, aggregators). It is an open-source framework based on blockchain technology that enables a secure and shared data management system, allows standard and flexible integration of external solutions (e.g. legacy solutions), and is open to integration of external services through standardized open application programming interfaces (APIs). It is built with existing regulations in mind and will allow small power producers to be easily certified so that they can sell excess energy back to the grid. The Platone Open Framework will also incorporate an open-market system to link with traditional TSOs. The Platone Open Framework will be tested in three European field trials and within the Canadian Distributed Energy Management Initiative (DEMI).This solution, based on a two-layer blockchain architecture, and named Platone Open Framework, allows to integrate in easy way both the data coming from the devices installed on the physical infrastructure of distribution grid, as well any other external platform.

The Platone Open Framework offers a configurable and customizable architecture, that can be exploited by the DSOs for empowering their solutions.

In particular, the second prototype of the Platone Open Framework includes:

- The second version of the Platone Blockchain Access Layer (BAL), that provides an interoperable layer for the integration of Internet of Things (IoT) devices and external Data Server, ensuring data privacy and security mechanisms.
- The second version of the Platone DSO Technical Platform (DSOTP), that allows the integration of external platforms as Distribution Management System (DMS), as well as specific DSO services as State Estimation (SE) Tool and Data Visualisation
- The second version of the Platone Market Platform, that enables a transparent and shared Flexibility Marketplace, based on blockchain technology, opened to all the market participants (TSOs, DSOs and aggregators)

The second prototype of the Platone Open Framework, described in this deliverable, will be the base for the second round of pilot executions in Italy, Greece and Germany. Each of the demos, will integrate different versions of the Platone Open Framework, exploiting different user and business requirements based on their expectations and needs.

The Italian demonstration integrated the Platone Market Platform for activating the Flexibility Market and resolving Congestion conflicts and Voltage violations within the distribution grids.

The Greek demonstration exploited the Platone BAL for metering data integration and certification and the Platone DSOTP for integrating State Estimation Tool.

The German demonstration exploited the Platone BAL for integrating and certifying data coming from Phasor Measurement Units (PMUs), as well as the Platone DSOTP for enabling services such as the balancing module, to be integrated into the Avacon Local Flex Controller (A-LFC)

The Platone Open Framework is completely modular and ready to be hosted in different way, like cloud infrastructure or on premises. Each demo is able to select the deployment approach that best suits its needs.

The second demo execution and validation phase will start in January 2023 (M41) and will end in June 2023 (M46). The feedback and the results of this phase will be exploited for the consolidation of the platforms that will be delivered at the end of the project together with the final version of the Platone Open Framework.

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1 Introduction

The project “PLATform for Operation of distribution Networks – Platone” aims to develop an architecture for testing and implementing a data acquisition system based on a two-layer Blockchain approach: an “Access Layer” to connect customers to the Distribution System Operator (DSO) and a “Service Layer” to link customers and DSO to the Flexibility Market environment (market place, aggregators, …). The two layers are linked by a Shared Customer Database, containing all the data certified by Blockchain and made available to all the relevant stakeholders of the two layers. This Platone Open Framework architecture allows a greater stakeholder involvement and enables an efficient and smart network management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems or distributed smart devices spread all over the urban area. These platforms, by talking to each other and exchanging data, will allow collecting and elaborating information useful for DSOs, transmission system operators (TSOs), Market, customers and aggregators. In particular, the DSOs will invest in a standard, open, non-discriminatory, blockchain-based, economic dispute settlement infrastructure, to give to both the customers and to the aggregator the possibility to more easily become flexibility market players. This solution will allow the DSO to acquire a new role as a market enabler for end users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone strongly contributes to aims to removing technical and economic barriers to the achievement of a carbon-free society by 2050 [1], creating the ecosystem for new market mechanisms for a rapid roll out among DSOs and for a large involvement of customers in the active management of grids and in the flexibility markets. The Platone platform will be tested in three European trials (Greece, Germany and Italy) and within the Distributed Energy Management Initiative (DEMI) in Canada. The Platone consortium aims to go for a commercial exploitation of the results after the project is finished. Within the H2020 programme “A single, smart European electricity grid” Platone addresses the topic “Flexibility and retail market options for the distribution grid”.

The Platone solution consists of a two-layer blockchain architecture named Platone Open Framework that includes a series of core components: the Platone Blockchain Access Layer, the Platone DSO Technical Platform, and the Platone Market Platform.

All these platforms were integrated in the second prototype of the Platone Open Framework described in this deliverable.

The integration phase was conducted considering the interoperability mechanisms and standards, as well as the system requirements expected for each Platone platform as result of the Use Cases described in the different demos.

The development, integration and deployment have been planned to align with the time plan designed by each demo. For this reason, this document also reports the description of the integration plan of the second version of the Platone Open Framework, within the three different demos architectures.

The second integration and deployment of the Platone Open Framework will be tested and evaluated in a second evaluation phase during the execution of the pilots.

1.1 Task 2.6

This deliverable is related to the Task 2.6 [2] that aims at releasing the Platone Open Framework prototype, following an iterative approach. Three version of the Framework integrated prototype will be delivered in an incremental way and considering the results of the testing and validation phase performed during the pilot executions.

In addition, the task ensures that Platone Platforms can communicate with each other over the framework, as indicated in the system design and the system requirements defined in D2.1 [3] and then refined and updated in D2.2 [4].

1.2 Objectives of the Work Reported in this Deliverable

The objective of this deliverable is to present the second prototype of the Platone Open Framework and its realization following the technical specification and requirements expected. The Platone Description of Action defines this deliverable as a demonstrator. This document accompanies the software release

with a more detailed architecture description, the configuration of the Platone Open Framework expected in the three demos and the status of the requirements implemented so far.

1.3 Outline of the Deliverable

The second chapter of this document describes an overview of the Platone Open Framework and some technical details on the integration phase and the release of the second prototype. It also includes the status of the functional requirements implemented so far for each Platone Platforms, as expected in Deliverable D2.2 [4], following the implementation and integration plan agreed with the demonstrations. Chapter 3 provides a detailed description on how the Platone Open Framework will be integrated within the demo architectures and how it will be deployed in the different contexts for the piloting phase. Finally, chapter 4 concludes this deliverable.

1.4 How to Read this Document

The document aims to give an overview to the Platone Open Framework second prototype release. A description of the final list of expected functional and non-functional requirements can be found in D2.2 [4]. A detailed description of the demo use cases can be found in D1.1 [5], while more details on the second technological implementations of each single demo can be found respectively in D3.4 [6] (Italian Demo), D4.1 [7] (Greek Demo) and D5.1 [8] (German Demo). This deliverable is the second out of three versions considered for the Platone Open Framework. For more information about the first prototype release and integration, please refer to the D2.14 [9].

2 Platone Open Framework – Second Prototype

The Platone Open Framework was implemented following the updated architecture specification and functional requirements described in D2.2 [4], as well as the interoperability mechanisms reported in D2.9 [10].

Following an iterative process, the second prototype of the framework was developed adapting the existing one (first version described in D2.14 [9]) accordingly to the feedback collected in the first evaluation phase.

Furthermore, the requirements not yet implemented were included in this second version of the Platone Open Framework, which can be intended as fully functional, ready to be tested and evaluated in the second execution phase within the three demos architectures. In fact, no additional requirements are expected for the final version of the Framework (M48, at the end of the project) which will consist of the release of a consolidated version of the three platforms and the integrated Framework.

Figure 1 reports the updated version of the Platone Open Framework Architecture.

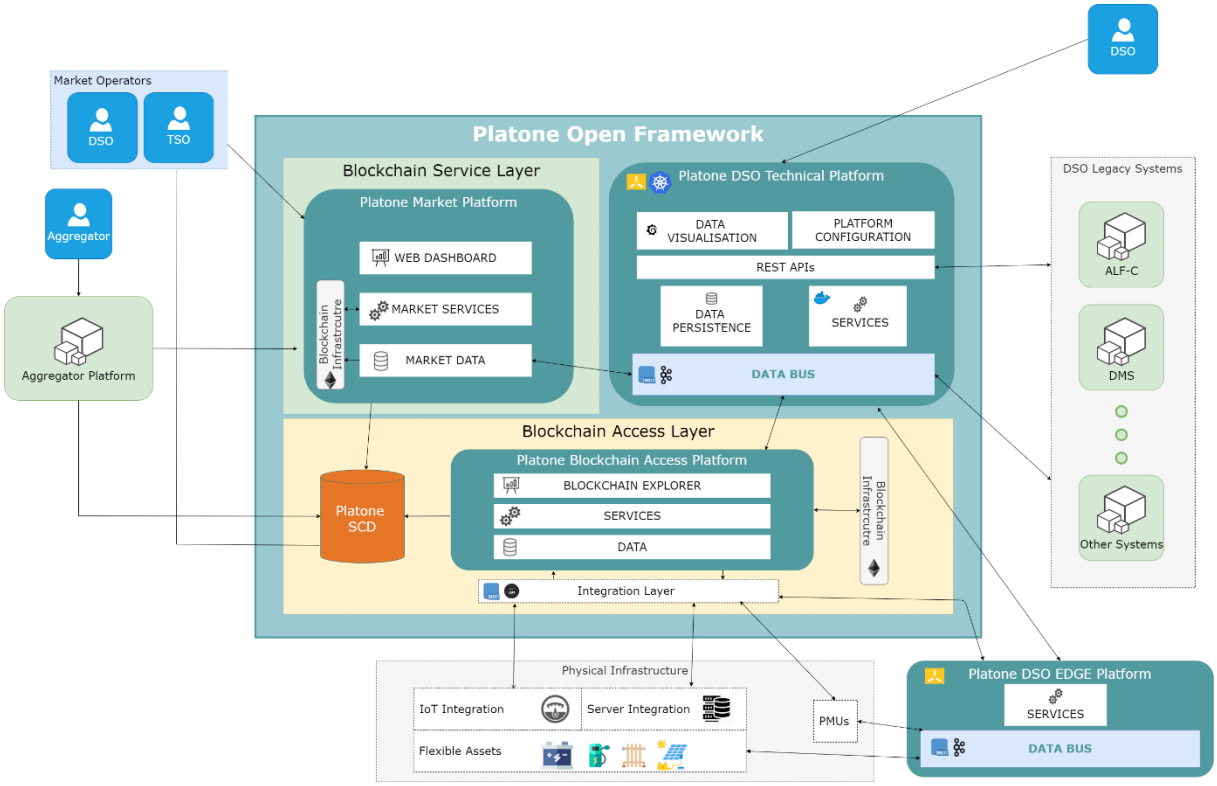

Figure 1: Platone Open Framework Architecture (v2)

2.1 Platone Platforms Integration

Starting from the output of D2.4 [11], D2.7 [12] and D2.12 [13], the main activity of this task was enabling the inter-communication of the different Platone Platforms, ensuring a secure and scalable deployment process of the entire Framework.

In particular, in this second prototype, we focussed into the following activities:

- Integration of the second version of the Platone BAL.
- Integration of second version of the Platone DSOTP.
- Integration of the second version Market Platform with the Italian demo architectural components (Italian DSOTP, Aggregator Platform and Italian BAL);
- Definition of the integration, deployment and execution plan for the Platone Open Framework within the three different demo architectures.

2.1.1 Blockchain Access Layer (v2) Integration

The Platone Blockchain Access Layer is the entry point for the data collected from the network grid. The second prototype of the BAL, described in D2.12 [13] implements two specific interoperable layers for the integration: on the one hand, the integration layer enables the integration of the physical infrastructure and allows the collection of the data, and on the other hand, the communication layer enables the integration with other systems and actors who want to use that data.

In addition to the first prototype a Representational state transfer (REST) API interface was added in order to validate the data certification within the Shared Customer Database (SCD). In particular, a new API was implemented allowing the users to check the validity of a specific transaction within the blockchain and retrieving the certified data. The new API is reported in Table 1.

Table 1: BAL REST APIs

Name	Url	Method	Parameters	Responses
Check Validation	/api/certification/getByTransaction	GET	In Params: transaction: String – Hash of the transaction saved into the blockchain	Success (200) Certified Data Error (500) Error Message - *String*

As already described in the D2.14 [9], the BAL includes a Message Queue Telemetry Transport(MQTT) broker server, based on Mosquitto [14], that allows the integration of data coming from PMUs, metering devices and Data Servers, as well as defining authentication and authorization mechanisms that allow to uniquely identify the data owner. It allows to publish data with high frequency without placing any restrictions on the data format.

The Business Layer of the BAL oversees, among other things, to manage specific data format and data models. In this second prototype JSON and XML are allowed as data format and the following data models were integrated and supported:

- PMU Data Model
- Measurement (CIM IEC 61968-9)
- Grid Topology (CIM IEC 61970-X)

Furthermore, in the second version of the BAL a complete data access management tool was implemented allowing the possibility to control the authorized access for each specific data source.

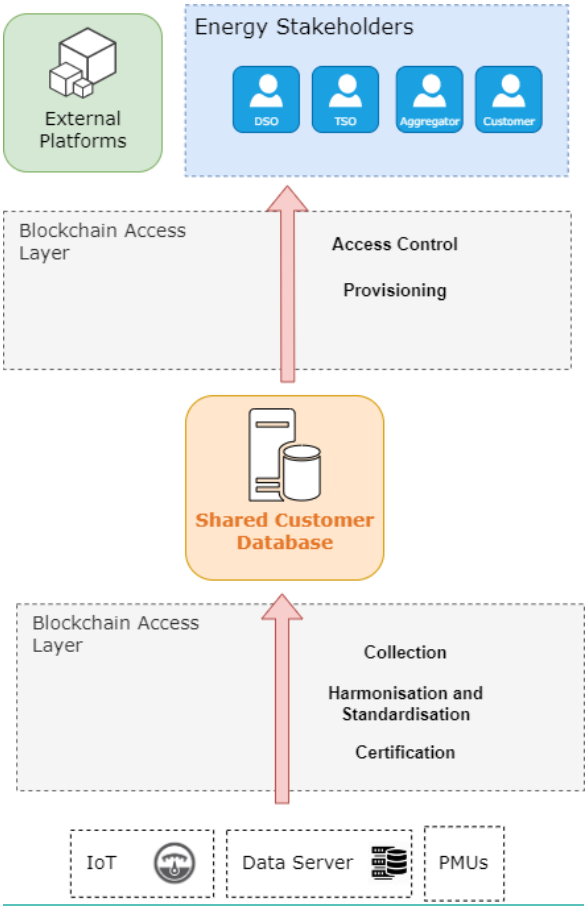

Figure 2: BAL Data Access Management Tool

In the integration scenario for the Greek and German Demo, each data provider (a Data Server or a specific data source like a meter owner) can decide how to publish data and how its own data can be available for the external system and stakeholders (e.g., the DSOTP). The BAL implements a set of configurable rules for the data access, including permission and security mechanisms.

Figure 2 represents the updated integration schema of the Platone Blockchain Access Layer:

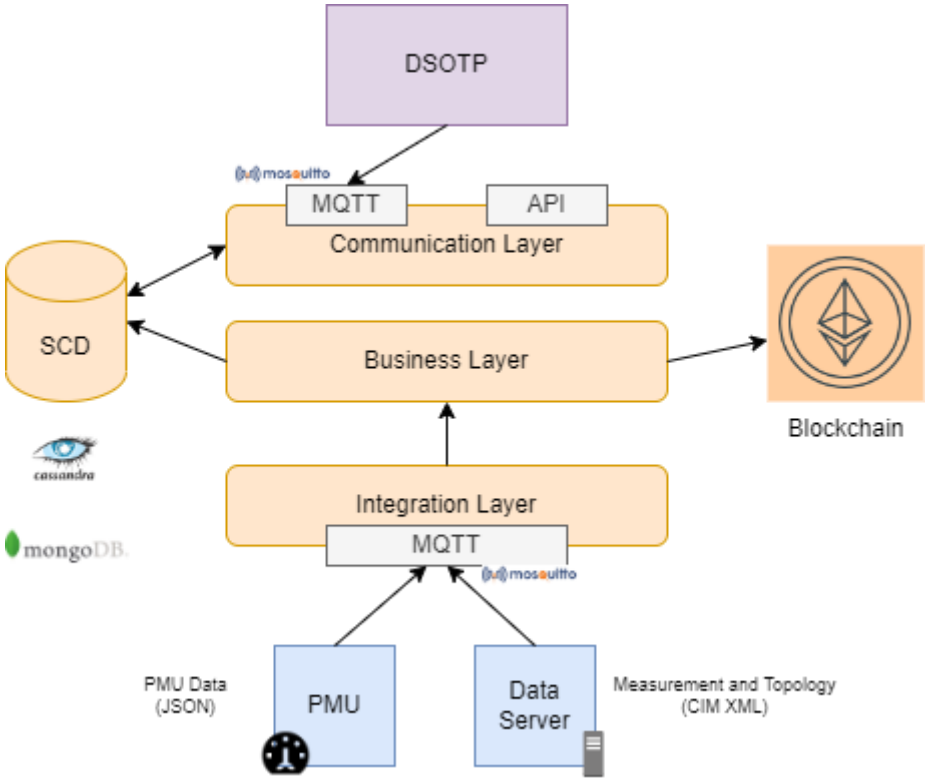

Figure 3: BAL integration and communication schema

2.1.2 DSOTP (v2) Integration

The Platone DSO Technical Platform enables distribution system operators to fulfil market requests by evaluating the current grid state and activating local flexibility requests while ensuring the reliability and operational quality of service by enlarged grid observability. The platform design builds on previous work done in the Horizon 2020 project *SOGNO [15]* and relies massively on a micro-service architecture in which a DSO can easily deploy additional services onto the platform. The first prototype of the DSOTP is described in Platone D2.6.

The second release adds a data pre-processing step to the DSOTP. For this the PMU data from the BAL is bridged to the DSOTP internal MQTT broker on the topic “raw/bal”. A microservice that calculates the active and reactive power from each PMU reading was implemented. This service is subscribed to the topic “raw/bal” and adds the calculated power the reading analogous to the measured values. The modified measurement is then published back on the DSOTP internal MQTT broker with topic processed/bal. From there it is saved to and InfluxDB. The data can then be viewed using Grafana. In addition, the processed data can also be bridged to further applications down stream using the MQTT bridge.

This version of the DSOTP also includes a balancing service that exposes http endpoints for data input and requesting the results of the last calculation. The balancing algorithm is executed when data is sent to the “<hostname>/balancing/input” endpoint via POST request and can then be requested from the endpoint “<hostname>/balancing/results” using a GET request. The complete API is documented using the OpenAPI 3.0 standard.

The current configuration of the DSOTP is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

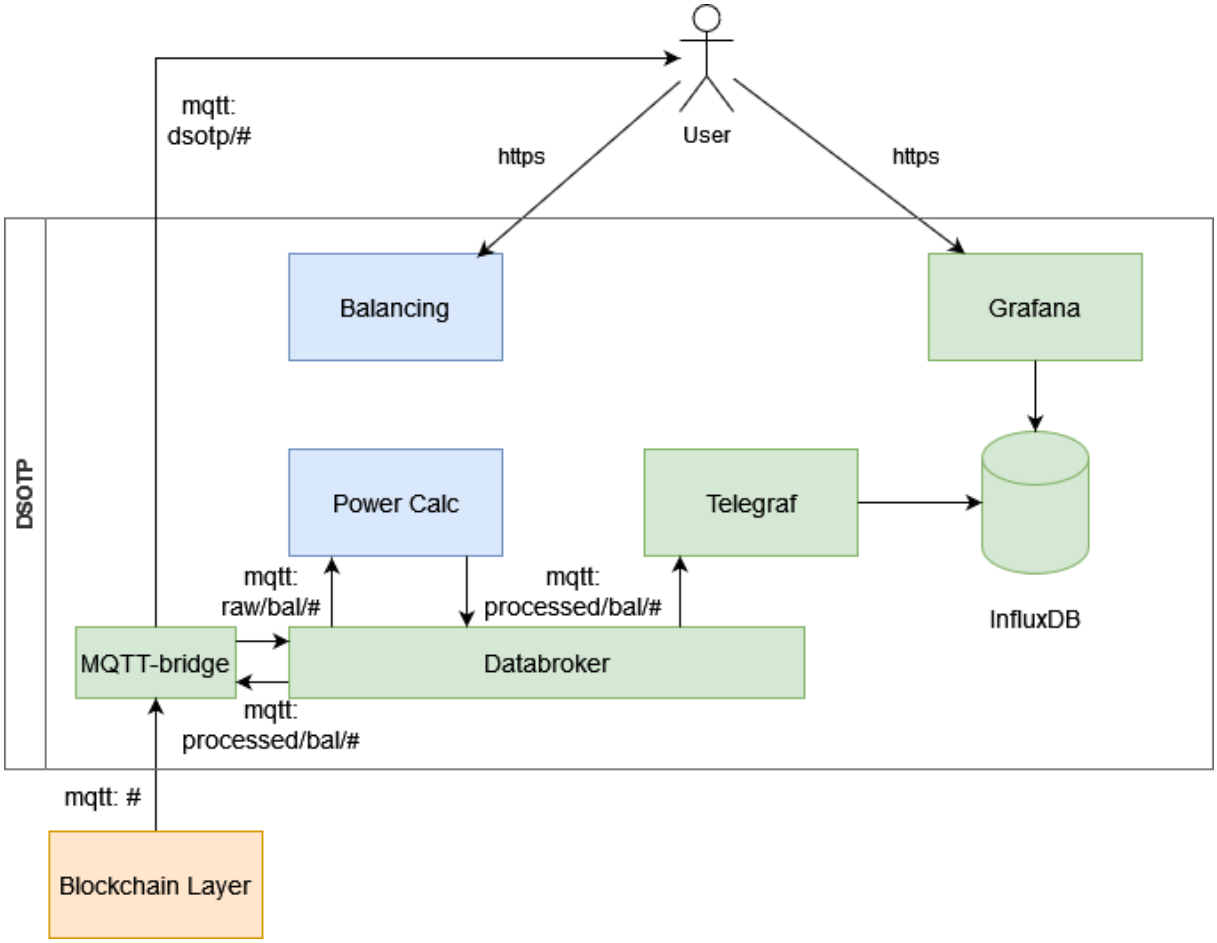

Figure 4: DSOTP integration schema

To allow an easy deployment, a Dockerfile is provided for each of the new services. Using this an image that runs the service can be easily build using Docker. In addition, a configuration for GitlabCI is provided to rebuild the Docker image on every code change to the main branch of the repository. This prevents diverging versions. The image is pushed to the projects Gitlab registry from where it can be pulled by any user with sufficient permissions.

For deployment to a Kubernetes cluster, resource definitions are provided for each service.

2.1.3 Market Platform (v2) Integration

The Platone Market Platform aims to enable a fully secure and transparent Flexibility Market, open to all the market participant, exploiting blockchain technology and smart contracts, for handling the management of flexibility services, providing market results to all the stakeholders, validating the flexibility provisioning, and performing the settlement outcome with an innovative incentivisation mechanism for improving customer engagement.

The second prototype of the Platone Market Platform, integrated in the Italian demonstration architecture, includes the following new features:

- Coordinated day-ahead and Real Time Market Flexibility Services
- Settlement outcomes and validation on Real Time results
- Certification of market results on blockchain service layer
- Settlement and Customer Incentivisation, based on two smart contracts: flexibility agreement and Platone Token
- Updated version of the Web Dashboard for market participants.

From the integration and communication perspectives, the Platone Market Platform includes a specific component, namely the Communication Layer, which supports three different interfaces for the integration of the external platforms and/or stakeholders:

- API Gateway (REST APIs)
- Message Broker (Kafka Queues)
- Graphical User Interface

Figure 5 describes the integration flows between the Platone Market Platform and the other platforms of the Italian demo architecture.

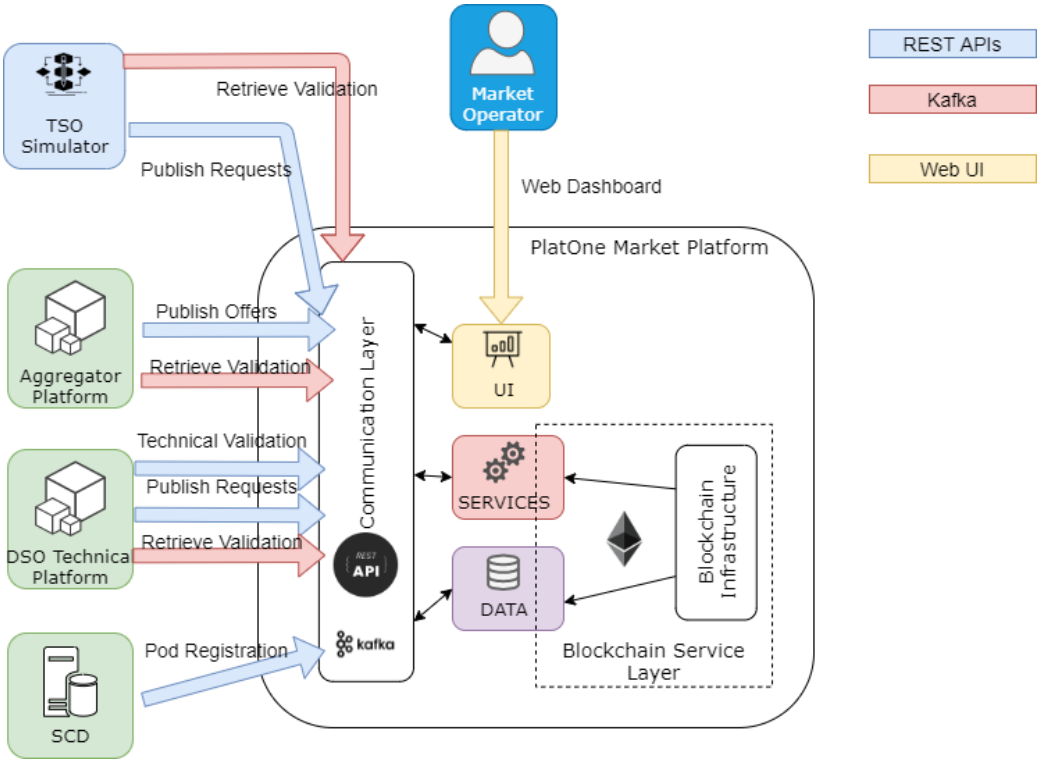

Figure 5: Integration of the Market Platform in the Italian demo architecture

All the REST APIs exposed by the Platone Market Platform implement an authentication mechanism based on Oauth2.0 over HTTPS connection and are documented as OpenAPI3.0 in the D2.4 [11] .

The second version of the Platone Market Platform implements a new authenticated API used by the aggregator for retrieving the wallet balance of a specific PoD. This information is directly retrieved from the blockchain service layer and is used for the visualisation of the Platone Token balance within the Customer app (App Flessibili), as described in D3.3 [6].

Table 2: Market Platform new REST API

Name	Url	Method	Parameters	Responses
Retrieve Balance	/contracts/transactions/balanceOf/:pod	GET	In request: PoD : String	Success (200) Wallet Balance Error (500)

				Error Message - *String*

For the exhaustive list of APIs please refer to the D2.4 [11].

All the connections to the Message Broker are secured through a mutual authentication based on Transport Layer Security (TLS).

In the first version of the Market Platform, only the Validated Outcomes were published in the Message Broker. The Validated Outcomes are filtered for each market participant (DSO, TSO, and aggregator(s)) and published in different Kafka Topics. Each consumer is authorized to read only in its own specific topic.

In the second version, a new topic was added for providing the settlement results to the aggregator. The **Fehler! Verweisquelle konnte nicht gefunden werden.** below reports the updated list of topics.

Table 3: Platone Market Platform Kafka topics

Topic	Publisher	Subscriber	Message
validated_outcome_DSO	Market Platform	DSO Technical Platform	Validated Outcome filtered by DSO
validated_outcome_TSO	Market Platform	TSO Simulator	Validated Outcome filtered by TSO
validated_outcome_[AGG_ID]	Market Platform	Aggregator(id)	Validated Outcome filtered by Aggregator (id)
Settlement_[Agg_ID]	Market Platform	Aggregator(id)	Settlement results filtered by Aggregator(id)

Another relevant aspect introduced in the second version of the Platone Market Platform is the full integration with the Blockchain Service Layer and then with the blockchain infrastructure.

In fact, as described above, the Market Platform includes now three different smart contracts for the market results certification and for the settlement phase. This update implies an adaptation in the

deployment environment that includes now a blockchain network with three nodes as well as an interface between the Platone Market Platform and the blockchain itself (the Blockchain Service Layer).

The external platforms and stakeholders are now able to interact with the blockchain through the API Gateway of the Market Platform connect to the Blockchain Service Layer interface.

Figure 6 shows the integration schema of the blockchain infrastructure, and the interfaces provided by the Blockchain Service Layer.

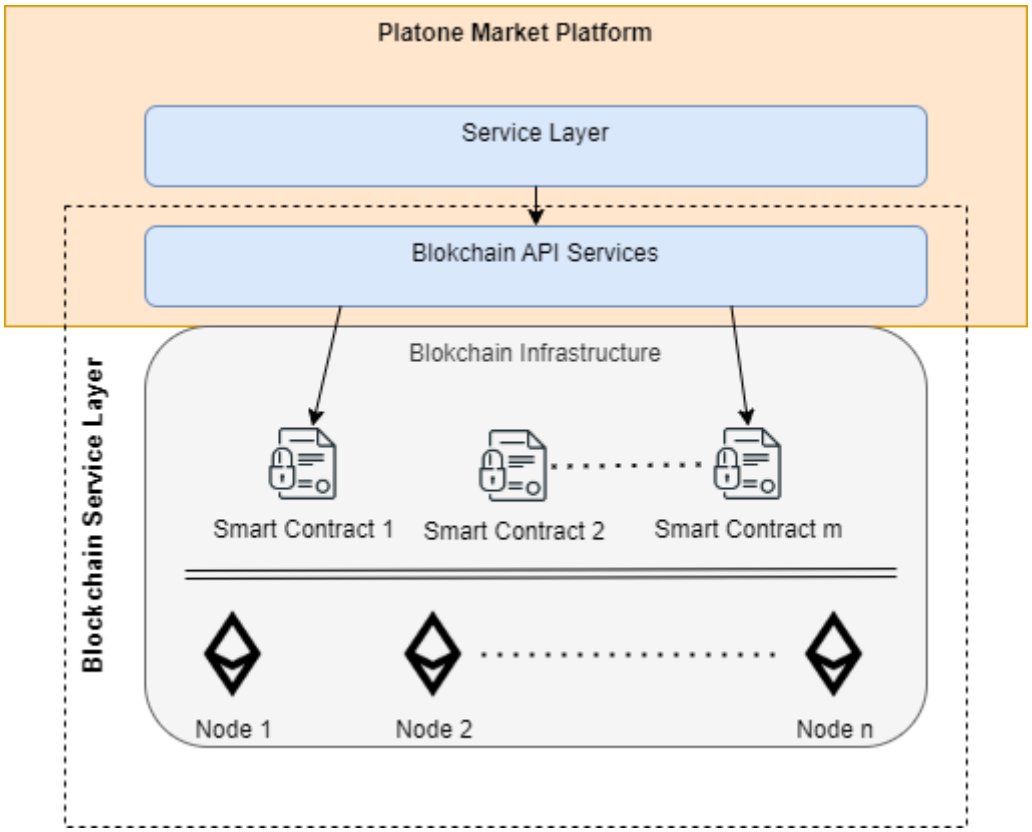

Figure 6: Blockchain Service Layer integration schema

2.2 Platone Platforms Requirements – Status

The second prototype of the Platone Open Framework implements almost all the list of expected requirements, as planned on each demo.

The new requirements implemented in this second version, will be tested, and refined in the final phase of the project. While the Market Platform and the Blockchain Access Layer already implemented all the expected requirements, a subset of the requirements of the DSOTP are still ongoing and will be included and validated in the context of the Greek demonstration, for the final version of the Platone Open Framework (expected at M48, at the end of the project).

More in detail, the following subchapters describe the status of the list of requirements implemented (functional and non-functional requirements) for each Platone Platform, as reported respectively in D2.4 [11], D2.7 [12] and D2.12 [13].

2.2.1 Platone Market Platform

Table 4: Platone Market Platform requirements

Requirement ID	Requirement name	Requirement description	Use Cases	Status	Notes
FR_MP_I_1	Initialisation	The Market Platform is able to receive PoDs information and PoM association from SCD in order to initialize a new market session	UC-IT-1 UC-IT-2	**Completed**	New in the second version
FR-MP-FSM-01	Flexibility Services Management	The Market Platform allows DSOs and TSOs to create flexibility requests in an automatic way	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-FSM-02	Flexibility Services Management	The Market Platform allows DSOs to create flexibility requests through UI	UC-IT-1 UC-IT-2	**Cancelled**	The creation of the market requests and offers is performed automatically from the external platforms (DSOTP and Aggregator Platform). UI is no longer required.
FR-MP-FSM-03	Flexibility Services Management	The Market Platform allows Aggregator Platform to create flexibility offers in an automatic way	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-FSM-04	Flexibility Services Management	The Market Platform acquires and stores all the flexibility requests and offers	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-MOMV-01	Market Outcomes Matching and Validation	The Market Platform is able to match flexibility requests and offers through market clearing algorithms	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-MOMV-02	Market Outcomes	The Market Platform is able to provide the Market Outcomes (results of market clearing)	UC-IT-1 UC-IT-2	**Completed**	

	Matching and Validation	to the DSO Technical Platform for the technical validation			
FR-MP-MOMV-03	Market Outcomes Matching and Validation	The Market Platform receives the validated market outcomes from DSO Technical Platform	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-MOMV-04	Market Outcomes Matching and Validation	DSOs, TSOs and Aggregators receive Market Day Ahead outcomes from the Market Platform	UC-IT-1 UC-IT-2	**Completed**	
FR-MP-SA-01	Services activation	The Market Platform allows to DSOs and TSOs to create service activation requests in automatic way	UC-IT-1 UC-IT-2	**Cancelled**	The service activation is not responsibility of the Market Operator and cannot be performed into the Market Platform
FR-MP-SA-02	Services activation	The Market Platform allows to Market participant to create service activation requests through UI	UC-IT-1 UC-IT-2	**Cancelled**	The service activation is not responsibility of the Market Operator and cannot be performed into the Market Platform
FR-MP-SA-03	Services activation	The Market Platform is able to aggregate the service activation requests (from DSOs and TSOs) and provide them to all the other stakeholders	UC-IT-1 UC-IT-2	**Cancelled**	The service activation is not responsibility of the Market Operator and cannot be performed automatically into the Market Platform
FR-MP-BC-01	Blockchain certification	The Market Platform is able to register on the blockchain all the market data trough Smart Contracts based functionalities	UC-IT-1 UC-IT-2	**Completed**	New in the second version
FR-MP-BC-02	Blockchain certification	The Market Platform allows to Market participant to verify all the market data registered in the blockchain	UC-IT-1 UC-IT-2	**Completed**	New in the second version

FR-MP-SET-01	Settlement	The Market Platform allows to Aggregator to create new smart contracts with settlement mechanisms via UI	UC-IT-1 UC-IT-2	**Completed**	New in the second version
FR-MP-SET-02	Settlement	The Market Platform provides to Aggregator Platform a list of available Smart Contracts with settlement mechanisms	UC-IT-1 UC-IT-2	**Completed**	New in the second version
FR-MP-SET-03	Settlement	The Market Platform is able to read meters measurements from SCD	UC-IT-1 UC-IT-2	**Completed**	**Renamed from** FR-MP-S-01
FR-MP-SET-04	Settlement	The Market Platform performs the settlement comparing the metering data and BSP baseline	UC-IT-1 UC-IT-2	**Completed**	Renamed from FR-MP-S-02. BSP replaced BRP.
FR-MP-SET-05	Settlement	The Blockchain Service Layer is able to provide tokenization system for the settlement through Smart Contracts functionalities	UC-IT-1 UC-IT-2	**Completed**	Renamed from FR-MP-S-03. New in the second version
FR-MP-SET-06	Settlement	The Market Platform allows to DSO, TSO and Aggregator to read the settlement outcomes	UC-IT-1 UC-IT-2	**Completed**	FR-MP-S-04
Market Platform – Non-Functional Requirements					
P-MP-01	Communication protocols	The Market Platform exposes REST APIs for collecting flexibility requests and flexibility offers	UC-IT-1 UC-IT-2	**Completed**	
P-MP-02	Communication protocols	The Market Platform provides a message broker for communicating market results	UC-IT-1 UC-IT-2	**Completed**	
T-MP-01	Communication Protocols, Timing	The Market Platform is able to receive measurements from SCD Kafka Broker every 15 minutes	UC-IT-1 UC-IT-2	**Completed**	

T-MP-02	Timing	The Market Platform is able to schedule day ahead and real time Market sessions at prefixed times and in automatic way	UC-IT-1 UC-IT-2	**Completed**	
S-MP-01	Security	Market Platform must expose all its REST APIs under Oauth2.0 authentication and client credentials	UC-IT-1 UC-IT-2	**Completed**	
S-MP-02	Security	Market Platform must identify all the Kafka clients using two-way authentication and server/client certificates	UC-IT-1 UC-IT-2	**Completed**	
S-MP-03	Security	All the Market Platform interfaces must be exposed using TLS connections	UC-IT-1 UC-IT-2	**Completed**	

2.2.2 Platone DSO Technical Platform

Table 5: Platone DSO Technical Platform requirements

Requirement ID	Requirement name	Requirement description	Use Cases	Status	Notes
FR-DSOTP-DA-01	Data Acquisition	The DSOTP is able to receive measurements that reflect the network state from DSO Data Server	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	**Completed**	
FR-DSOTP-DA-02	Data Acquisition	The DSOTP is able to receive data coming from State Estimation Tool	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	**Completed**	
FR-DSOTP-DA-03	Data Acquisition	The DSOTP is able to receive PMU measurements that reflect the network state	UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	**Completed**	
FR-DSO-TP-DA-04	Data Acquisition	The DSOTP is able to receive certified measurement from BAP	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	

FR-DSO-TP-DA-05	Data Acquisition	The DSOTP is able to receive setpoints from EMS	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	After an internal technical evaluation it was decided to avoid sending the Setpoints through the DSOTP since is too complex to be implemented during the project phase.
FR-DSOTP-SE-01	State Estimation	The DSOTP is able to trigger the State Estimation Tool via REST API.	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4	**Completed**	The State Estimation Tool is deployed inside the DSOTP and can be triggered via REST APIs
FR-DSOTP-SE-02	State Estimation	The DSOTP provides DSO with the estimated state vector resulting from the State Estimation Tool.	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	Completed	
FR-DSOTP-PMU-01	PMU Data Integration	The DSOTP is able to integrate PMU and conventional measurements into a unified measurement set, to be processed by the State Estimation Tool.	UC-GR-2 UC-GR-3 UC-GR-4	**Expected in V3**	

FR-DSOTP-T-01	Tariffs retrieval	The DSOTP sends to the DSO/Aggregators tariffs that reflect the expected state of the network	UC-GR-3 UC-GR-4	**Expected in V3**	
FR-DSOTP-T-02	Tariffs retrieval	The DSOTP is able to receive data coming from the Algorithm for DER Control and Algorithm for ancillary services	UC-GR-3 UC-GR-4	**Expected in V3**	
FR-DSOTP-AS-01	Data to DER control and Ancillary Services	The DSOTP is able to send the output of the state estimation to external tools (DER control and Ancillary Services tools)	UC-GR-3 UC-GR-4	**Expected in V3**	
FR-DSOTP-DER-01	Optimal DER dispatching	DSOTP is able to trigger the Algorithm for DER Control via REST API	UC-GR-3	**Expected in V3**	
P-DSOTP-01	Communication protocols	DSOTP is able to receive data from PMUs via MQTT protocol	UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	**Completed**	
P-DSOTP-02	Communication protocols	DSOTP is able to receive data from DSO Data Server via TCP/IP protocol	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5	**Completed**	
P-DSOTP-03	Communication protocols	DSOTP is able to receive setpoints from A-LFC via MQTT and/or HTTP protocol	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	After an internal technical evaluation it was decided to avoid sending the Setpoints through the DSOTP since

					is too complex to be implemented during the project phase.
T-DSOTP-01	Timing	DSOTP is able to receive measurement every 10 seconds from sensors	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	
T-DSOTP-02	Timing	DSOTP is able to receive measurement every 15 minutes from Data Management Backend	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	
T-DSOTP-03	Timing	DSOTP is able to receive setpoints every 10 seconds for CBES and every 15 minutes for HBES	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	After an internal technical evaluation was decided to avoid sending the Setpoints through the DSOTP since is too complex to be implemented during the project phase.

2.2.3 Platone Blockchain Access Layer

Table 6: Platone Blockchain Access Layer requirements

Requirement ID	Requirement name	Requirement description	Use Cases	Status	Notes
P-BAP-01	Communication protocols	The BAP is able to receive data from sensors via MQTT protocol	UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	Completed	
FR-BAP-DM-01	Blockchain Data Management	The BAP is able to acquire Measurements from network	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	Completed	
FR-BAP-DM-02	Blockchain Data Management	The BAP certifies Measurements via Smart Contracts	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	Completed	
FR-BAP-DM-03	Blockchain Data Management	The BAP provides certified measurement in a secure way to DSOTP	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1	Completed	

			UC-GE-2 UC-GE-3 UC-GE-4		
FR-BAP-NC-01	Network Control	The BAP is able to receive set points from DSOTP	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	Not Implemented
FR-BAP-NC-02	Network Control	The BAP certifies set points via Smart Contracts	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	Not Implemented
FR-BAP-NC-03	Network Control	The BAP is able to send certified set points to Data Management Backend	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Cancelled**	Not Implemented
P-BAP-02	Communication protocols	The BAP is able to integrate data coming from external server via TCP/IP protocol	UC-GR-1 UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	
T-BAP-01	Timing	BAP is able to receive measurement every 10 seconds from sensors	UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	
T-BAP-02	Timing	BAP is able to receive measurement every 15 minutes from Data Management Backend	UC-GE-1 UC-GE-2	**Completed**	

			UC-GE-3 UC-GE-4		
S-BAP-01	Security	All the external interfaces of the BAP must be under TLS connection	UC-GR-2 UC-GR-3 UC-GR-4 UC-GR-5 UC-GE-1 UC-GE-2 UC-GE-3 UC-GE-4	**Completed**	

3 Platone Demo sites Integration and Deployment

3.1 Italian Demo

The Italian demonstration aims to manage grid congestion and voltage violation issues through an open and transparent Flexibility Market.

Within the Italian Demo architecture, parts of the Platone Framework (Italian SCD, Italian DSOTP and Italian BAL) were specifically implemented for the Italian Demo site, following the Platone Open Reference Architecture specification. The Platone Market Platform developed within the Framework was instead integrated in this architecture as one of the core platforms.

The second integration phase in the Italian demonstrator was anticipated and a preliminary execution was already performed at the end of 2022. In this second demo execution, the day-ahead market life cycle was integrated with the intra-day market and the activation and settlement phase were enabled at the end of the intra-day session. More details can be found in D3.4 [16] and D3.8 [17].

Focusing on the integration of the Platone Market Platform, the integration steps and sequence diagram which describe the day-ahead market full cycle were already described in D2.14. Below are reported the steps for the integration of the two markets (day-ahead and intra-day) as well the activation and settlement phase with the integration of the Blockchain Service Layer.

3.1.1 Integration steps

Real Time sessions

1. Market Platform creates 6 real-time market sessions, covering the full day.
2. For each real time market session, the Market Platform receives flexibility requests from the Italian DSOTP and TSO Simulator via REST APIs, under TLS connection and Oauth2.0 authentication.
    - The aggregator can optionally update the offering of the day-ahead in the real-time market, otherwise the day-ahead offers are confirmed.
3. Market Platform closes the active Market Session
4. Market Platform matches requests and offers (already accepted in the day-ahead market and new ones) and produces a market outcome.
5. Market Platform sends market outcome to DSOTP for technical validation via REST APIs under TLS connection and Oauth2.0 authentication.
6. DSOTP performs technical validation and sends technical outcome to the Market Platform via REST APIs under TLS connection and Oauth2.0 authentication.
7. Market Platform produces the final validated outcome (market validation and technical validation) and communicates it via Kafka Broker. Each platform authenticate itself using two-way authentication mechanism.
8. Market Platform certify all the validated outcomes using smart contract and the blockchain service layer interface.

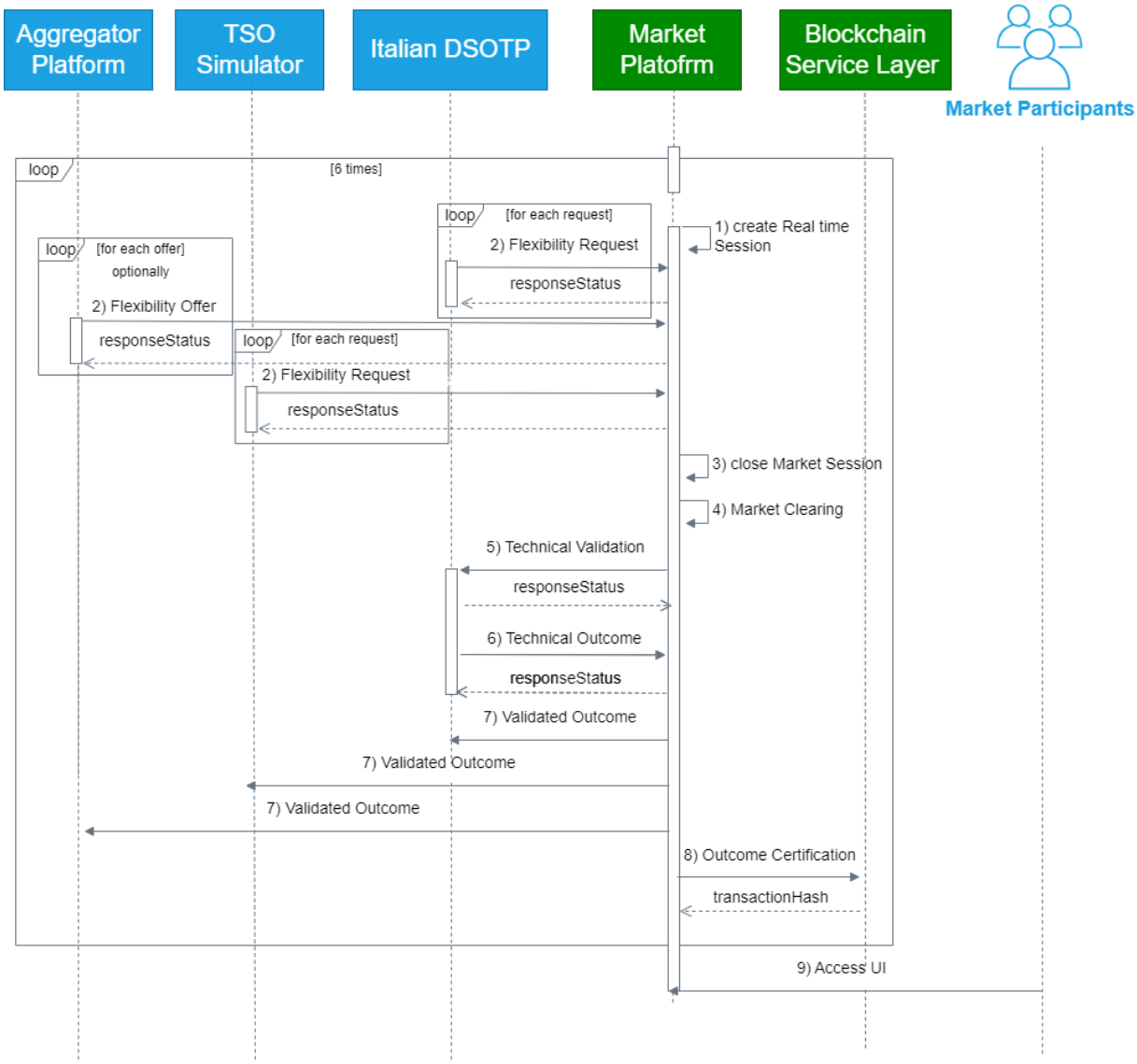

Figure 7: Italian Demo - real-time session sequence diagram

Settlement

1. Market Platform receives measurements for market data verification and settlement.
2. Market Platform verifies on the blockchain services layer the agreement between Aggregator and Customer
3. Market Platform performs settlement based on measurement, market outcomes and agreements.
4. Market Platform assigns the Platone tokens to the respective customers.
5. Market Platform shares the settlement data to all the market participants (with specific access permission)
6. Aggregator, TSO, and DSO can visualise all the data via web User Interface (UI).

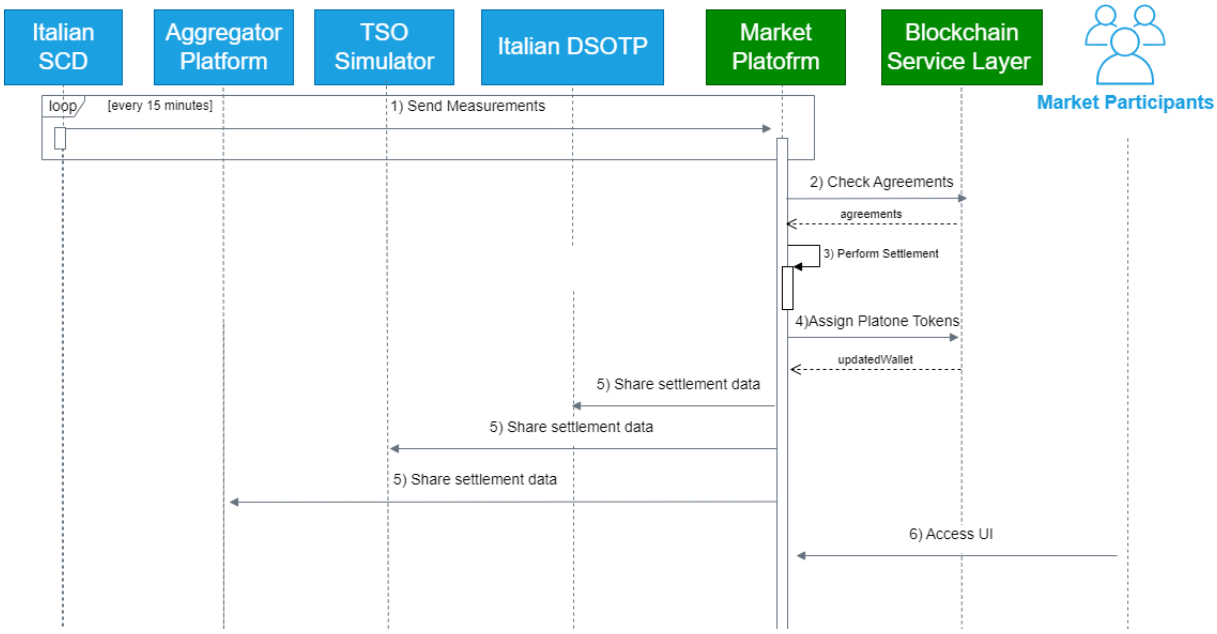

Figure 8: Italian Demo - Settlement sequence diagram

3.1.2 Deployment

The Platone Market Platform is hosted in cloud in ENG infrastructure, together with the blockchain infrastructure and Blockchain Service Layer. Platone Market Platform is able to communicate with Aggregator Platform, Italian Shared Customer Database and Italian DSOTP hosted in other cloud infrastructures, following secure authentication mechanisms (Oauth2.0 for REST APIs and two-way certification for Apache Kafka).

The source code of the integrated version of the Platone Market Platform is public available in the project Gitlab Repository [18].

3.2 Greek Demo

The main objectives of the Greek demonstration are to economically optimize the use of distributed energy sources to provide ancillary services and balancing market participation to the transmission system operator, advanced observability, automation and controllability in the distribution network fault-detection, self-reconfiguration and self-healing for increased security and resilience of the distribution system and optimal control of distributed energy sources both in the day-ahead and real-time time frames for market participation, mitigation of congestions and voltage limit violations, and minimization of losses.

All these objectives, will be pursued, integrating the Platone Open Framework, that allows to manage easily the integration and the certification of the data coming from the grid and at the same time, makes these data available in real time to the DSOTP that enables DSOs to exploit a several innovative services as evaluating the current grid state, activating local flexibility requests, as well as ensuring the reliability and operational quality of service by enlarged grid observability.

In this second integration within the Greek Demo architecture, the integration of the State Estimation Tool was improved.

Compared to the first version, in which only the measurements were integrated and certified and the State Estimation tool was used as-a-service outside the DSOTP, in this second integration phase, metering data and grid model data coming from DSO Data server, will be collected and used into the DSOTP for the State Estimation Tool, which is completely integrated into the DSOTP itself.

The Grid model data can be optionally certified into the BAL or provided directly to the SE tool within the DSOTP.

Figure 9 shows a draft integration schema of the State Estimation Tool and the data collected within the DSOTP and the BAL.

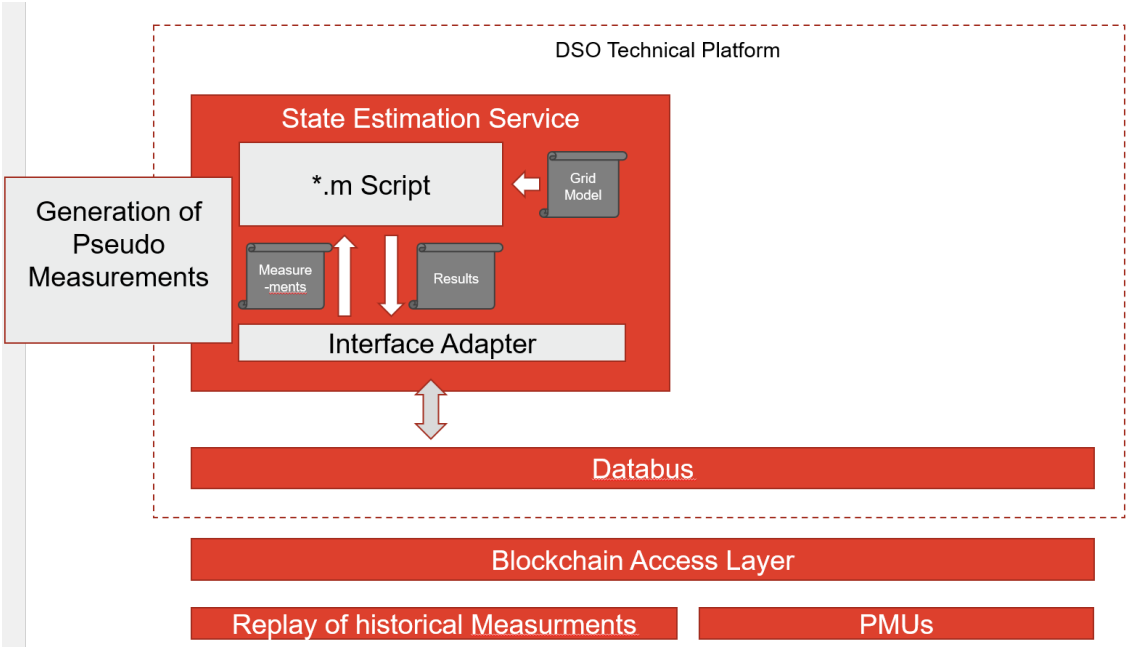

Figure 9: State Estimation Tool Integration

For releasing the second version of the integrated Platone Open Framework within the Greek Demo architecture, the following integration steps were implemented.

3.2.1 Integration steps

1) MQTT Broker of the BAL receives metering data from DSO Data Server, every 15 minutes, in CIM standard model, in authenticated way and under TLS connection.
   a) Optionally, MQTT Broker of the BAL receives grid model data from DSO Data Server, every day in CIM standard model, in authenticated way and under TLS connection.
2) BAL stores data into SCD and certify aggregated data into BAP.
   a) BAL updates data with certification hash into SCD
3) BAL provides metering data and grid model data (optionally) to DSOTP via MQTT bridging.
4) DSOTP makes selected topics available on its internal message bus for processing by services.
5) The DSOTP use collected data for running the SE Tool and providing useful outcomes to the DSO.

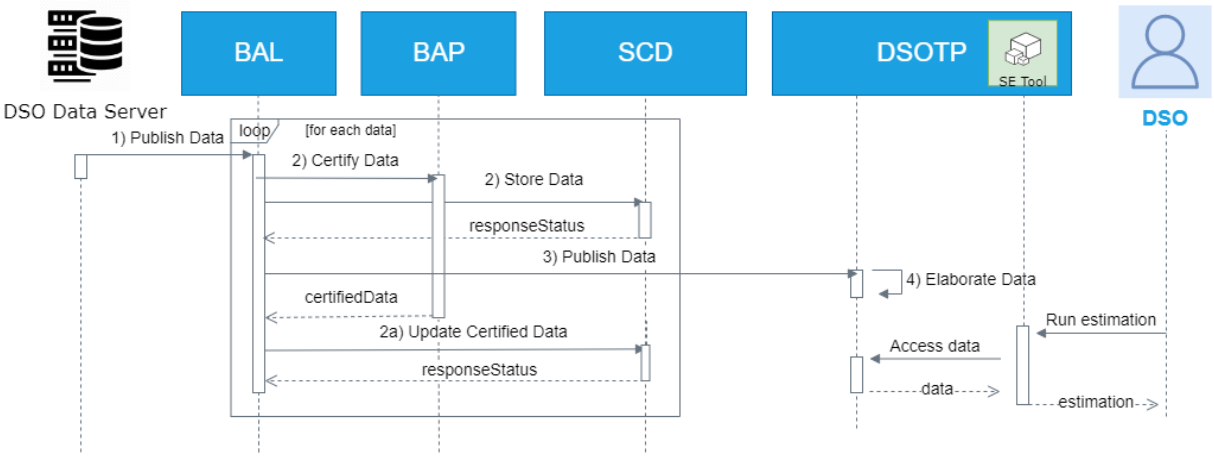

Figure 10: Greek Demo Integration v2 – sequence diagram

3.2.2 Deployment

The entire Platone Open Framework was already packaged as Docker Container and released to the partner of the Greek demo, in its own infrastructure.

The updated version of the platforms and the integrated Platone Open Framework will be released following the same approach upgrading existing previous versions.

3.3 German Demo

The main objectives of the German demonstration are the coordination between local balancing mechanism and centralized grid operation and the allocation of flexibility in local networks between the local network and higher-level networks. A further objective is an effective informational and temporal uncoupling of low and medium voltage networks by handling energy supply and export in bulk packages rather than a real time exchange.

All these objectives, will be pursued, integrating the Platone Open Framework, that allows to manage easily the integration and the certification of the data coming from the grid and at the same time, makes these data available in real time to the DSOTP that enables DSOs to exploit a series of innovative services as evaluating the current grid state, activating local flexibility requests, as well as ensuring the reliability and operational quality of service by enlarged grid observability.

In this second integration within the German Demo architecture, PMU data coming from the PMU devices, already integrated during the first integration phase will be used for implementing two different services within the DSOTP: the Balancing Service and the Power Calculation Service.

As described in Ch. 2.1.2, the two new services were implemented and integrated in the second version of the DSOTP and are available through REST APIs for the external actors and platforms. In the case of the German Demol, these services will be integrated with the A-LFC for providing new feature and services to the DSO.

3.3.1 Integration steps

1. MQTT Broker of the BAL receives data from PMU, in authenticated way and under TLS connection every seconds. Every device can only write in its dedicated topic.
2. BAL stores data into SCD
3. BAL provides data to DSOTP via MQTT bridging.
4. DSOTP makes selected topics available on its internal message broker for processing by services.
5. Within DSOTP, PMU data are stored in a timeseries database and usable for implementing services.
6. DSOTP provide Power Calculation service via REST API to the A-LFC using PMU data collected from BAL.
7. DSOTP provide Balancing module via REST API to the A-LFC using PMU data collected from BAL.
8. BAL periodically request aggregated Data to SCD
9. BAL send aggregated data to BAP for data certification.
10. BAP certify data.
11. BAL update data into SCD

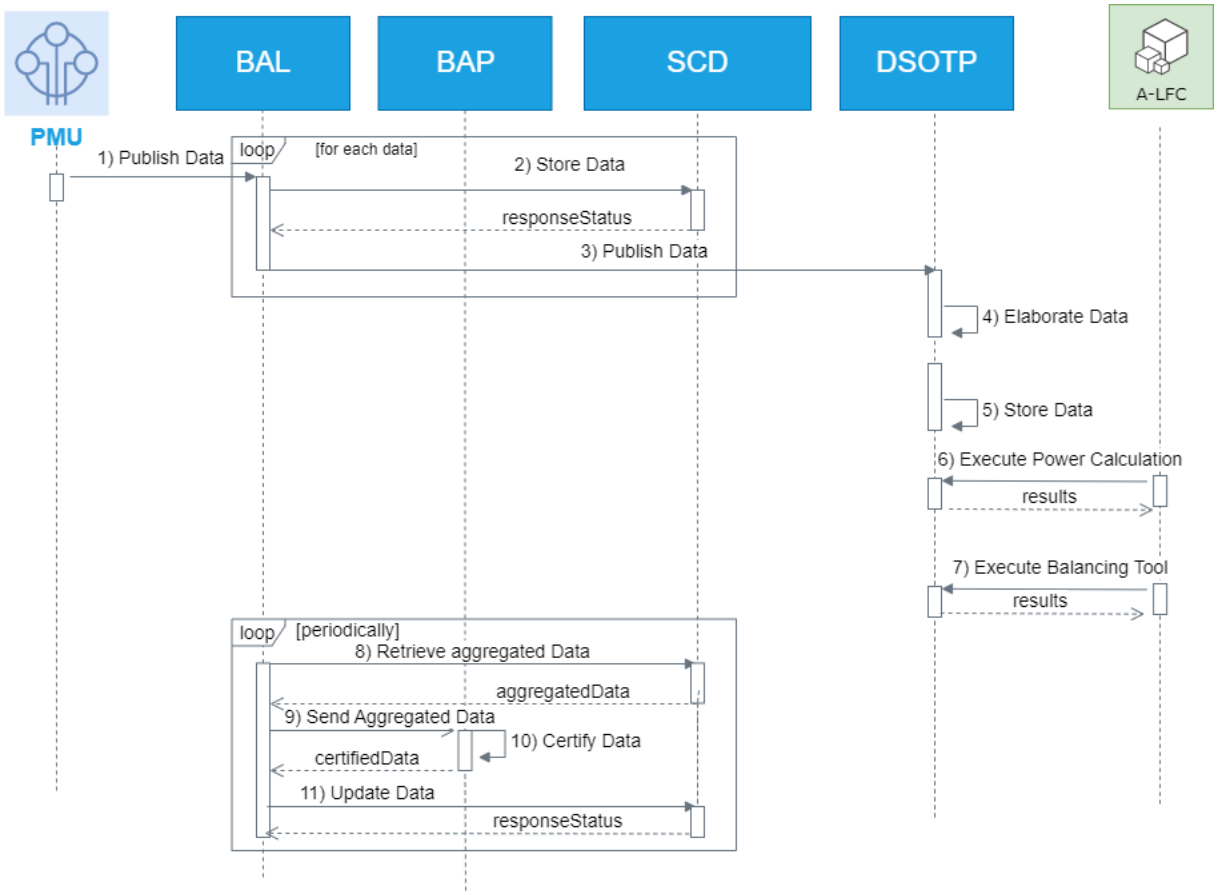

Figure 11: German Demo Integration – sequence diagram

3.3.2 Deployment

The second version of the Platone Open Framework will be integrated in the German Demo cloud infrastructure based on MS Azure.

The first version of the Framework was already deployed in the German Demo infrastructure, using Docker for the packaging of the software, Kubernetes for the deploying and the orchestration of the services and CI/CD pipelines for managing the evolution of the software.

This deployment approach will allow an easy upgrade of the Platone Open Framework from the first version to the second one.

4 Conclusion

Starting from the first integrated prototype of the Platone Open Framework, all the Platone Platforms were improved and enhanced in a second version. The integration of these platforms conducted to the release of the second integrated prototype of the Platone Open Framework.

This second prototype implements almost all the expected functionalities and will be intensively tested and validated during the second evaluation phase within the three different demo environments: Italian, Greek and German.

The three environments represent three different contexts with three different configurations of the Framework, emphasizing the concept of modularity as one of the key elements of the solution.

During this second phase, all the new functionalities will be tested in order to be refined and stabilized in the final version of the Platone Open Framework, expected for the end of the project.

In addition, scalability and performance test will be performed, for ensuring a high reusability and flexibility of the Platone Open Framework itself in more realistic and extended contexts.

5 List of Tables

6 List of Figures

7 List of References

[1] European Commission, "2050 long-term strategy", [Online]. Available: https://ec.europa.eu/clima/policies/strategies/2050_en

[2] *Grant Agreement No. 864300 – Platone.*

[3] "D2.1 Platone platform requirements and reference architecture (v1) ", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M12_D2.1.pdf

[4] "D2.2 Platone platform requirements and reference architecture (v2) ", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M30_D2.2.pdf

[5] "D1.1 General functional requirements and specifications of joint activities in the demonstrators", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M12_D1.1.pdf

[6] "D3.3 Delivering of technology (v1)", Platone EU Horizon 2020 Project, 2021

[7] "D4.1 Report on the definitions of KPIs and UCs", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M12_D4.1.pdf

[8] "D5.1 Solution design and technical specifications", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M6_D5.1.pdf

[9] "D2.14 PlatOne Integrated Framework Prototype (v1)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M20_D2.14.pdf

[10] "D2.9 Specification of the interoperability and standard communication protocols (v1)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M28_D2.9.pdf

[11] "D2.4 PlatOne Market platform (v2)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M38_D2.4.pdf

[12] "D2.7 PlatOne DSO Technical Platform (v2)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M38_D2.7.pdf

[13] "D2.12 PlatOne BlockChain Customer Access Layer (v2)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M38_D2.12.pdf

[14] "Mosquitto," [Online]. Available: https://mosquitto.org/.

[15] "SOGNO H2020 Project – Service Oriented Grid for the Network Of the future", [Online]. Available: https://www.sogno-energy.eu/About/H2020

[16] "D3.4 Delivering of technology (v2)", [Online]. Available: https://www.platone-h2020.eu/data/deliverables/864300_M38_D3.4.pdf

[17] "D3.8 Report on first integration activity in the field (v2)"

[18] « Platone Public GIT Repository » [Online]. Available : https://git.rwth-aachen.de/acs/public/deliverables/platone

8 List of Abbreviations

Abbreviation	Term
A-LFC	Avacon Local Flex Controller
API	Application Programming Interface
BAL	Blockchain Access Layer
DMS	Distribution Management System
DSO	Distribution System Operator
DSOTP	DSO Technical Platform
IoT	Internet of Things
MQTT	Message Queue Telemetry Transport
PMU	Phasor Measurement Unit
PoD	Point of Delivery
REST	REpresentational State Transfer
SE	State Estimation
TLS	Transport Layer Security
TSO	Transmission System Operator