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Responsible:	Organisation:	Contributing WP:
Tsatsakis Kostas	SUITE5	WP3

Authors (organisation):
Diego Garcia-Casarrubios, Alberto Zambrano (ETRA), Tsitsanis Alexandros, Tsatsakis Kostas (Suite5)

Abstract:

The scope of the document is to provide the details about the development of the SERVIFLEX tool that will facilitate the management of local flexibility profiles in order to forecast and decide upon optimal flexibility utilization strategies, while satisfying the goal of reduced complexity that comes from organizing profiles into clusters of homogeneous behaviour. This is the 1st version of the SERVIFLEX platform development as the 2nd version will follow and be reported in D3.6.

Keywords:
SERVIFLEX tool, Flexibility Aggregator, SERVIFLEX DSS

Revision History

Revision	Date	Description	Author (Organisation)
V0.1	01.03.2021	TOC and allocation of work	Tsitsanis Alexandros, Tsatsakis Kostas (Suite5)
V0.2	12.04.2021	1st version – Design overview	Tsitsanis Alexandros, Tsatsakis Kostas (Suite5)
V0.3	15.05.2021	Feedback on 1st version	Diego Garcia-Casarrubios, Alberto Zambrano (ETRA)
V0.6	03.08.2021	2nd version ready	Tsitsanis Alexandros, Tsatsakis Kostas (Suite5)
V0.7	01.09.2021	3rd version of the tool and document for review	Tsitsanis Alexandros, Tsatsakis Kostas (Suite5)
V0.8	15.09.2021	Review of the document	Chloe Fournely (UL), Simeon Parcharidis, Aristoklis Karamanidis (SLS), Diego Garcia-Casarrubios, Alberto Zambrano (ETRA), Lola Alacreu (ETRA)
V1.0	30.09.2021	Version ready for submission	Tsitsanis Alexandros, Tsatsakis Kostas (Suite5), Lola Alacreu (ETRA)

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Executive Summary

The scope of the document is to provide the details about the development the SERVIFLEX tool that will facilitate the management of local flexibility profiles in order to forecast and decide upon optimal flexibility utilization strategies, towards satisfying the business objectives of the energy stakeholder.
The first prototype of the SERVIFLEX tool has been developed over the period of six months (from M19 to M24) following the work performed in T3.5 – "Design and Development of the SERVIFLEX tool for Flexibility Forecasting, Clustering and Management", where the design specifications of the SERVIFLEX tool are defined. In addition, the detailed modelling and software development of the different flexibility profiling modules as delivered in D3.2 – "DER Flexibility Modelling", D3.3 – "P2X Flexibility Modelling and Specifications for an Intelligent P2H component" and D3.4 – "Design of the SERVIFLEX tool for Flexibility Forecasting, Clustering and Manage" are also considered as part of the SERVIFLEX tool.

Overall, the development details are reported in the document, namely:

a) The definition of the data management layer of the SERVIFLEX tool
b) The incorporation of the different flexibility profiling agents as developed in the project
c) The development of the SERVIFLEX analytics layer incorporating clustering and aggregation techniques
d) The delivery of the SERVIFLEX optimization layer for the management of optimal flexibility utilization strategies
e) The development of the SERVIFLEX User Interface (UI) as the visualization layer of the tool

This document describes the technical details of the implementation of the different modules, including the general architecture of the tool, the communication methods used, the data models, and libraries used by each module.
Regarding infrastructure, the prototype of the SERVIFLEX developed in WP3 will be deployed as a dedicated service in the cloud. A Kubernetes cluster running Docker will be used for its deployment and maintenance. Due to their nature, these technologies will enhance the flexibility and scalability of the tool, and will allow the future integration of further pilots and new field infrastructure.

List of Figures

List of Tables

1 INTRODUCTION

1.1 Purpose and scope of the document

The scope of the document as stated in the Description of Actions (DoA) [1] is to provide the details about the development the SERVIFLEX tool that will facilitate the management of local flexibility profiles in order to forecast and decide upon optimal flexibility utilization strategies, while satisfying the goal of reduced complexity that comes from organizing profiles into clusters of homogeneous behaviour. It complements the work of T3.5 Design and Development of the SERVIFLEX tool for Flexibility Forecasting, Clustering and Management as reported in D3.4 where the focus was about reporting the design specifications of the SERVIFLEX tool.

All in all, the SERVIFLEX tool embeds all functionalities pertaining to the tool chain for collecting local flexibility profiles (as specified in D3.2 [3], D3.3 [4] and D3.4 [5] -1st part), managing them in order to establish optimal Virtual Power Plant (VPP) composition for the delivery of grid services. Its main innovation is that the SERVIFLEX tool clusters, and segments flexibility sources based on their actual, locally estimated flexibility, enabling the configuration of dynamic Virtual Power Plants as means of aggregation and disaggregation entities of disparate multi-type Distributed Energy Resources (DERs), rather than matching the assumed flexibility profile of a specific asset to a generic class and then extracting flexibility estimations. In addition, an intuitive UI is made available to the business stakeholder for the management of the different types of DERs.

We have to point out that this is the 1st version of the SERVIFLEX development documentation reporting the status until M24 of the project. The 2nd and final version of the SERVIFLEX development documentation reporting the full SERVIFLEX solution will be made available in M36 through D3.6- SERVIFLEX tool Development v2.

1.2 Structure of the document

The document is the short report about the development of the SERVIFLEX. It complements the detailed design specifications of the SERVIFLEX solution as reported in D3.4 Design of the SERVIFLEX tool for Flexibility Forecasting, Clustering and Management. Therefore, the focus of the work is:

- In Chapter 1 the purpose and the scope of this document are presented.
- In Chapter 2, the back-end development activities are reported focusing also on the early validation of the different algorithmic processes incorporated in the platform. Also, some development details about the front-end implementation are presented.
- In Chapter 3, some technical details about the implementation and the deployment of the solution are reported.

In the last chapter, the key remarks and summary are provided.

2 SERVIFLEX TOOL DEVELOPMENT IMPLEMENTATION

2.1 Architecture Overview

The design specifications of the SERVIFLEX tool were presented in detail in D3.4. In this document, a brief summary is provided to link the design specifications with the development activities performed during the reporting period. The overall architecture of the SERVIFLEX tool is presented.

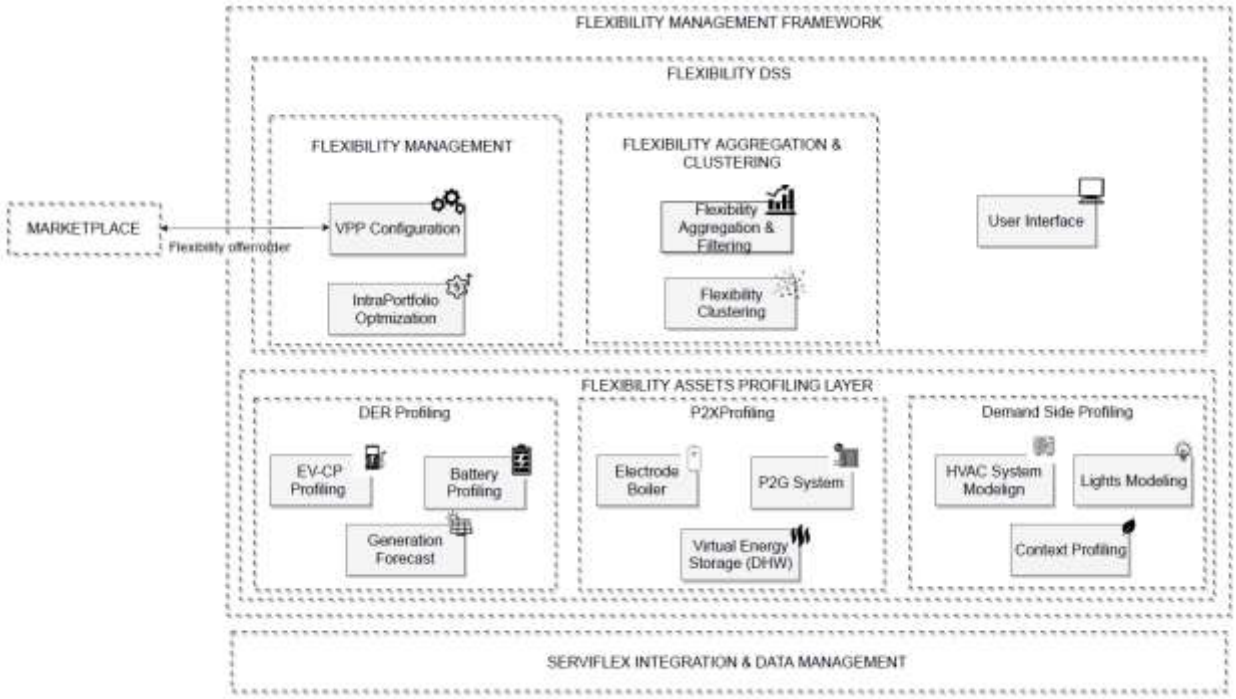

Figure 1 SERVIFLEX Tool Conceptual Architecture

The core of the architecture of the tool is formed by a set of modules in the form of microservices: each module expects a specific input—either from an external source or from another module of the tool—and use them to perform some kind of analysis to generate an output, which is further utilized by another module. This loose coupled approach is promoted to ensure scalability and flexibility of the SERVIFLEX application.

The different components that consist of the SERVIFLEX tool are:

- The **SERVIFLEX integration and data management layer**: responsible for integration with the X-FLEX platform and the storage of the data for further exploitation. SERVIFLEX strongly relies on the X-FLEX platform communication capabilities in order to perform these operations, taking advantage of the different services and technologies it provides for communication purposes. These technologies include Kafka and RESTful web services, among others. Its storage service is used as well, both to maintain the real-time status of the elements managed by SERVIFLEX, and to store and retrieve time series of data
- The different **Flexible asset profiling layers** as presented in D3.2, D3.3 and D3.4- 1st part. The different modelling approaches are incorporated in software bundles, setting that way the different microservices for the management of the different flexible assets' technologies in place, namely:
    - **DER profiling layer** covering generation, battery and EV charging point assets

- **P2X profiling layer** covering P2G and P2H solutions
- **Demand Side Flexibility profiling** layer covering demand side assets

In association with the different micro-modules, a unified common semantic layer is defined to ensure that the output of each modelling approach can be easily integrated to the common modelling framework of SERVIFLEX Tool.

- A **flexibility aggregation & clustering layer** responsible to aggregate the available flexibility from the different flexible sources, further making it available to the Aggregator or 3rd party business entities. As presented in D3.4, this component split into two modules:
  - **Flexibility Aggregation & Filtering Engine**
  - **Flexibility Clustering Engine**
- A **flexibility management layer** responsible to optimize the utilization of the different flexible sources taking into account the business and operational requirements and constrains. As presented in D3.4, this component split into two modules:
  - **VPP Configuration Engine**
  - **Intra portfolio optimization Engine**
- The **SERVIFLEX User Interface** (UI) is provided as the front end of the application, on the way to provide an intuitive visualization for the system stakeholders, the aggregators.

Note: The development details for the different flexibility profiling layers (DER profiling layer, P2X profiling layer, Demand Side Flexibility profiling) were presented in the associated deliverables D3.2-D3.4. In this document, the focus is about the core of the SERVIFLEX tool, namely: the data management layer, the analytics (and optimization) layer and the visualization layer.

2.2 SERVIFLEX Back-End Modules

The scope of this section is to provide the development details of the SERVIFLEX back-end modules. As stated in the previous chapter, this section is first covering the integration and data management layer, and then the data analytics and optimization layer of SERVIFLEX.

2.2.1 SERVIFLEX Integration and Data Management Layer

The scope of this section is to provide the development details of the SERVIFLEX Data Management Layer. In D6.2 “Architecture of the flexible and scalable integrated platform” & D6.3 “Flexible and scalable integrated platform”, the integration details with the X-FLEX platform as the data management layer of the XFLEX platform as a whole were provided. In this document, the way these data are handled by the SERVIFLEX tool is specified.

There are three main processes considered at the SERVIFLEX Data Management Layer with the respective modules to set the SERVIFLEX data management layer, namely:

- The SERVIFLEX Data Integration Module, responsible for the management of integration methods with X-FLEX platform.
- The SERVIFLEX Data Transformation Module, towards the semantic alignment of heterogeneous data sources in the SERVIFLEX data model.
- The SERVIFLEX Data Storage Module, responsible for the storage of the data following the SERVIFLEX data model principles.

A visual representation of the SERVIFLEX Data Management Layer is presented in the following figure.

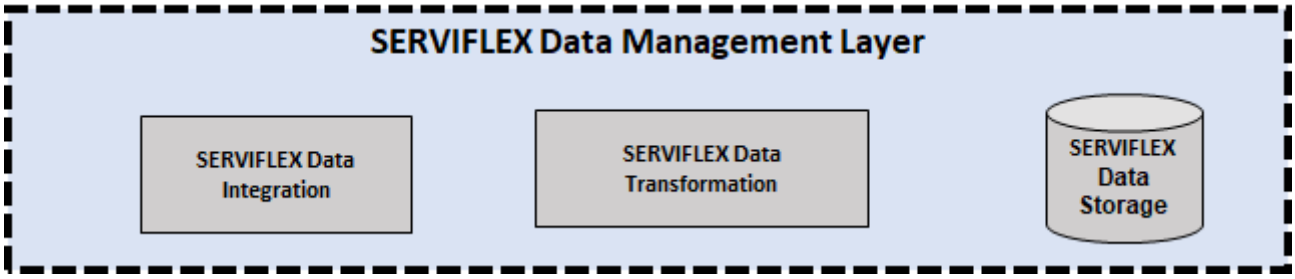

Figure 2 SERVIFLEX Data Management Layer Overview

Some technical details of the different modules that consist of the SERVIFLEX Data Management Layer are provided.

SERVIFLEX Data Integration Module

The role of this module is to ensure integration with the X-FLEX platform, providing the necessary functionality for the timely and successful retrieval of data. Data can be generally retrieved through the different data integration methods defined at X-FLEX platform. More details about these methods are provided in D6.2 – "Architecture of the flexible and scalable integrated platform".
By taking into account the available methods and the SERVIFLEX tool requirements as expressed in D2.2 – "Use cases and requirements definition", SERVIFLEX will interface with the X-FLEX platform through API data retrieval methods that have been exposed by the platform (or any other 3rd party source). The list of parameters to be considered for the retrieval process are handled by the SERVIFLEX tool; customized based on the project needs and requirements.
In addition, and in order to ensure real time connectivity and message exchange among the different applications, a message broker client is delivered at SERVIFLEX data management layer. Real time data streams are accessible from SERVIFLEX via Kafka topics as exposed by the X-FLEX platform or any other 3rd party platform. In addition, the SERVIFLEX Data Integration Module host the appropriate Kafka topics in order for 3rd party entities to publish their data to the SERVIFLEX tool.

SERVIFLEX Data Transformation Module

The role of this module is to ensure semantic interoperability among the different modules that form the SERVIFLEX tool. Considering that the SERVIFLEX tool supports integration with heterogeneous data sources, a common semantic model is needed also at SERVIFLEX level. This semantic alignment of the ingested data to the SERVIFLEX data model does not apply only for the raw data which follow X-FLEX Common Information Model (CIM) principles rather on the processed data that interchange among the different SERVIFLEX modules that should also comply with the SERVIFLEX internal data model. Apart from data mapping to the SERVIFLEX data model, different transformation rules may be applied over the data, e.g., measurement units that apply to their numerical data. The most important part of the data mapping process is the definition of the SERVIFLEX Internal data Model which is presented in the following section 2.2.2

SERVIFLEX Data Storage Module

The role of this module is to act as the data repository of the SERVIFLEX tool, responsible for data persistence and archiving of the volumes of data generated. Following data transformation, the data is stored in a non-relational (NoSQL) database in the Data Storage component. The NoSQL approach has been preferred over a relational database, as it is scalable by default and thus allows optimized management of heterogeneous datasets. In addition to the permanent data storage, a data indexing engine is employed to facilitate the analytics services execution to follow.
We presented above the key components that set the SERVIFLEX Interoperability and Data Management Layer. Apart from the technical details as provided above, it is worth presenting the SERVIFLEX data model (as the internal data model of the SERVIFLEX tool).

2.2.2 SERVIFLEX Internal Data Model

As stated above, the definition of the SERVIFLEX data model is a key step towards the development of the SERVIFLEX tool. Considering that different microservices consist of the SERVIFLEX tool, the definition of the lingua franca for the different modules is an anchor point at the development phase. Overall, the SERVIFLEX data model is a subset of the X-FLEX information model, as presented in D6.2 and D6.3, further enhanced with specific data attributes defined explicitly within the context of SERVIFLEX tool. An overview of the SERVIFLEX model is provided in this section.

Towards defining the SERVIFLEX data model, the typical entity-relationship model approach is adopted. The key terms that describe the definition of the SERVIFLEX data model are:

- Concept: An abstraction of the entity in the modelling work. The definition of concepts needs to be performed on the basis of the analysed requirements and SERVIFLEX modules. A taxonomy of the different concepts is performed taking into account the different modules, namely
    - Generation & Battery - DER related concepts
    - Power-to-X (P2X) - DER related concepts
    - Demand Side related concepts
    - Aggregator/VPP related concepts

  Additional concepts related to the Flexibility of the different DERs as well as generic model concepts that facilitate the modelling task in SERVIFLEX are also incorporated to the model.
- Field: Concept characteristics are captured via fields, also incorporated in the SERVIFLEX data model.

A first analysis of data specifications was provided in the X-FLEX data model. This analysis contributed to the definition of the specific domains; these domains are taken under consideration to guide the targeted analysis for the SERVIFLEX tool. With this assessment performed, the rest of the steps towards defining the SERVIFLEX model are delivered, namely: (a) the definition of extra concepts needed within the context of SERVIFLEX tool and (b) the definition of extra fields to better specify the SERVIFLEX related concepts.
Overall, the list of all concepts that are defined for the needs of the SERVIFLEX data model are presented in the following table.

P2X Concepts	**Flexibility Related Concepts**
BuildingThermalMass	FlexibilityOffer
DomesticHotWaterSystem	FlexibilityOrder
DomesticHotWaterSystemControlAction	FlexibilityProfile
ElectrodeBoiler	FlexibilityRequest
ElectrodeBoilerControlAction	FlexibilitySettlement
Electrolyzer	LoadControlEventData
ElectrolyzerControlAction	LoadControlEventDataAction
FuelCell	LoadControlStateData
FuelCellControlAction	
HydrogenTank	**Generation & Battery Concepts**
	BatteryControlAction
Demand Side Concepts	BatterySystem
AirCondition	ElectricVehicle
AirConditioningSystemControlAction	EVChargingStation
BuildingAsset	EVChargingStationControlAction
ComfortPreferences	GenerationMeasurements
DemandMeasurements	PVSystem
Device	RES
Gateway	StorageMeasurements
LightingDevice	WindTurbine
LightingDeviceControlAction	
SensingMeasurement	**Generic Model Concepts**
Sensor	Duration
SmartDevice	Event
SmartMeter	KPI
	KPIValue
Aggregator Business Concepts	Measurement
Aggregator	Schedule
Area	Status
Retailer	WeatherMeasurement
VPP	WeatherStation

Table 1 SERVIFLEX List of Data Model Concepts

In addition, the conceptual view of the relationships among the different concepts is presented in the following figure. We have to point out that the detailed list of relationships is incorporated in the model.

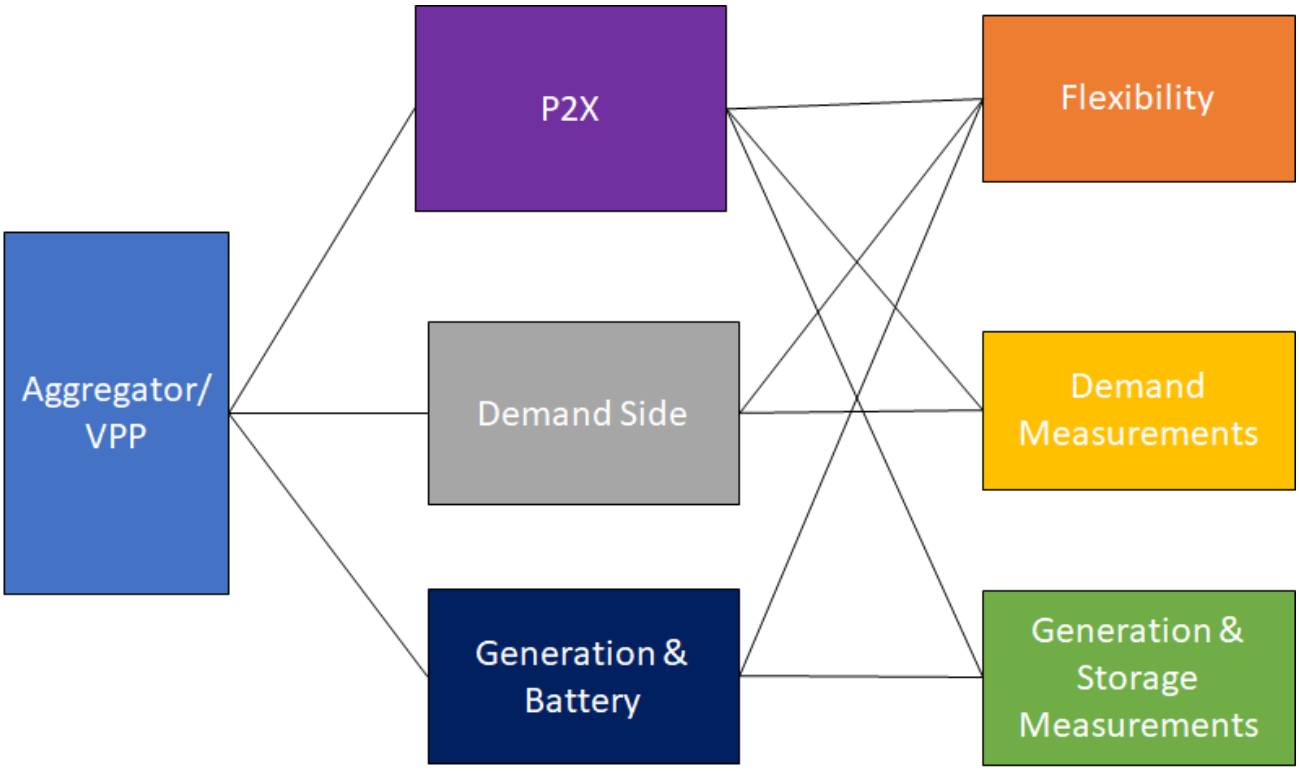

Figure 3 Conceptual relationships among concepts

Having defined the concepts that form the SERVIFLEX Internal Data Model, the modelling (as part of the methodology) of the fields per concepts is provided. An indicative example of the PV concept with the associated fields is presented in the following table.

Concept	Fields
PV	brandName, code, deratingFactor, description, efficiency, id, lifetime, manufacturerName, manufacturerName, maxPowerPoint, maxPowerPointCurrent, maxPowerPointVoltage, model, name, nominalCapacity, nominalVoltage, openCircuitVoltage, panelsCount, shortCircuitCurrent, temperatureCoefficient, temperatureCoefficientPercent, type

Table 2 Photovoltaics Information Model

It is important to anticipate changes and be ready to address them in the most efficient way; the initially created version of SERVIFLEX Data Model should be able to evolve based on the stakeholders needs and project use cases. Towards this direction, the Entity Relationship based approach has been adopted in order to be able to have a fully expandable model with new concepts and fields to be inherited in the model. In order to ensure the sequence of the model, it is important to note that new versions of the SERVIFLEX Data Model

need to be backwards compatible with the previous ones, to ensure the consistency of the data that have been already ingested in the SERVIFLEX Tool.

2.2.3 SERVIFLEX Analytics Layer

The functional details of the SERVIFLEX Analytics Layer were reported in D3.4 providing an overview of the algorithmic framework supported by the platform. As presented also in the introductory section, there are different types of analytics features supported by the application, namely:

- Flexibility Aggregation & Filtering Module to enable search over the flexible assets available at the portfolio of the aggregator and further aggregation of flexibility profiling data (from the flexibility sources) to support the business services of the aggregator
- Flexibility Clustering module to provide fine grained analytics techniques for the management of the flexibility sources available at the portfolio of the aggregator
- VPP Configuration module to facilitate the optimal placement of the flexibility sources to 3rd party business campaigns. These business campaigns are triggered by the MARKETFLEX tool as the innovative flexibility marketplace layer established in the project
- Intra portfolio optimization module to facilitate the optimal management of the flexibility sources withing the portfolio of the business stakeholder of the tool.

In this section some technical details of this implementation are provided. In line with the different functions that form the business analytics layer of the SERVIFLEX tool, there are four software bundles that incorporate the functionalities considered.

SERVIFLEX Flexibility Aggregation & Filtering Module

The SERVIFLEX Flexibility Aggregation & Filtering module is responsible for searching over the portfolio of the aggregator and filtering with specific criteria in order to set groups of flexibility assets with similar characteristics. As specified in D3.1 and D3.4 there are different parameters (both technical and business) that characterize the flexibility assets and on the basis of these parameters appropriate segments may be defined in order to set groups of flexible assets which are of interest for the business stakeholder (Aggregator). On top of this filtering functionality, an aggregation functionality should be incorporated in order to aggregate flexibility profiling information, which is again of interest for the business processes of the business stakeholder.

SERVIFLEX Flexibility Clustering Module

The SERVIFLEX Flexibility Clustering module is responsible for the execution of simple and advanced analytics processes over the flexibility data streams (as presented in D3.4, the tool will enable the execution of simple and ML based analytics over the data streams). More specifically, the module complements the filtering functionality as presented above and support the quick access on the filtered data, as well as the execution of the respective analytics services: some generic simple algorithms (i.e. aggregations, KPI calculations etc…) and advanced algorithms (i.e. ML-based algorithms such as classification, clustering, regression, etc. targeting the

energy domain applications as presented in D3.4) are incorporated in the module in order to extract the requested outcomes.

SERVIFLEX VPP Configuration Module

The SERVIFLEX VPP Configuration Layer module is responsible for the execution of the optimization of the portfolio flexible assets taking into account 3rd party requests triggered by MARKETFLEX. More specifically, the module incorporates the optimization algorithm for flexibility management as presented in D3.4 as well as the interface details with the MARKETFLEX tool. In addition, the module is responsible for the calculation of the flexibility performance KPIs; results intended to be shared at the SERVIFLEX front end for visualization. More details about this process are provided in the following section.

SERVIFLEX Intra Portfolio Optimization Module

The SERVIFLEX Intra portfolio optimization module is responsible for the execution of the optimization of the portfolio assets taking into account intra -portfolio business objectives as defined in the project. More specifically, the module incorporates the optimization algorithms for assets management as presented in D3.4 addressing both stakeholder cost minimization as well as self-consumption optimization. In addition, the module is responsible for the calculation of the intra -portfolio performance KPIs; results intended to be shared at the SERVIFLEX front end for visualization. More details about this process are provided in the following section.

We presented above in brief some technical details about the different analytics processes to be executed at SERVIFLEX DSS layer. As stated above, there are also the analytics services that are executed at the Flexible Asset Profiling Layer of SERVIFLEX with the technical details to be presented in D3.2, D3.3 and D3.4.

2.3 SERVIFLEX Front End User Interface

The SERVIFLEX User Interface is the front-end view of the system related to SERVIFLEX visualization; the visualization is made available to the business actors (aggregators) for the prompt management of the flexible sources which are part of their portfolio. There are different views provided by the SERVIFLEX UI web-based tool to support the back-end functionalities as presented in previous section (and in line with SERVIFLEX requirements as reported in D2.2). More specifically, the different modules that consist of the SERVIFLEX Front End User Interface are:

- **Portfolio Filtering Visualization Dashboard:** associated with the filtering functionality provided by the SERVIFLEX tool; the aggregator can set specific groups of flexible assets by applying appropriate filters over the flexibility data. These input parameters are further available to the filtering back-end component presented above. In addition, the results of the search and filtering process are available for visualization.
- **Portfolio Analytics Visualization Dashboard :** associated with ML-based analytics applied over the flexible assets to dynamically set groups of flexible assets with similar characteristics. The input parameters defined by the user of the tool are further available to the analytics back-end component presented above. In addition, the results of the flexibility analytics process are available for visualization.
- **Portfolio Optimization Visualization Dashboard :** associated with configurations that apply at the optimization process as described in previous section. The input parameters defined by the user of

the tool are further available to the analytics back-end component as presented above. In addition, the results of the portfolio optimization process are available for visualization.

- **Portfolio Performance Visualization Dashboard:** associated with the visualization of portfolio performance related information via the UI.
- **Portfolio Settings Visualization Dashboard**: to enable additional settings (e.g., optimization objective, etc.) that apply over the assets of the portfolio of the aggregator. These are parameter values manually provided by the user of the tool.

Indicative design mock ups for the different views were presented in D3.4 as part of the design specifications of the SERVIFLEX tool. The development details of the SERVIFLEX User Interface will be made available in the 2nd version of the SERVIFLEX tool Development (D3.6: SERVIFLEX tool Development v2)

By presenting the details about the different modules that consist of the SERVIFLEX development, we proceed with more details about the technical implementation, highlighting the different technologies and development frameworks considered at the development of the SERVIFLEX tool.

3 SERVIFLEX TECHNICAL IMPLEMENTATION AND DEPLOYMENT

Following the functional documentation of the SERVIFLEX development, some details about the technical implementation are reported in this section. As there are different modules composing the SERVIFLEX tool, we present the development details and licenses considered for each of the different services.

3.1 SERVIFLEX Integration and Data Management Layer

SERVIFLEX Data Integration Module

The Data Integration Module acting as the communication layer for the different data sources. There are two different types of communication means supported.
A periodical data retrieval via APIs containing:

- the business logic for Data Integration Module based on the Flask [8] micro web framework
- the data repository for the Data Interface Module on MinIO [9] (as the data intermediate database)

A real-time data exchange mechanism through:

- The core development of the application is performed in Apache Kafka [10] as the most widespread open-source stream-processing software platform.
- On top of the Kafka implementation, a ZooKeeper [11] installation is running to manage the Kafka cluster.

The different versions of the tools used for the development of the Data Interface Module along with their licensing are reported in the following table.

Name of the Library	Version	License
Flask	1.1.1	BSD 3-Clause
Flask RESTful extension	0.3.8	BSD 3-Clause
Flask CORS support	3.0.8	MIT
MinIO (part of the Data Storage services bundle, but included here for completeness)	-	Apache License 2.0
Apache Kafka	2.7.0	Apache License 2.0
ZooKeeper	3.6.2	Apache License 2.0

Table 3 Technologies and libraries used in the Data Interface Module, along with their licenses

SERVIFLEX Data Transformation Module

This is the module responsible for performing the background data processing operations to ensure that the related data from the different endpoints that have been ingested in the platform are appropriately harmonized, mapped, and aligned with the SERVIFLEX internal model. Again, the layers of software are:

Name of the Library	Version	License
Flask	1.1.1	BSD 3-Clause
Flask RESTful extension	0.3.8	BSD 3-Clause
Flask CORS support	3.0.8	MIT

Table 4 Technologies and libraries used in the Data Transformation Module, along with their licenses

SERVIFLEX Data Storage Module

The Data Storage module is responsible for storing the amount of data, along with their associated metadata, acting as the repository for the SERVIFLEX tool. The Data Storage is based on state-of-the-art data storage and indexing technologies including: MongoDB [12] as the NoSQL database, Elasticsearch [13] as the search optimization and indexing engine. Also, a lightweight storage required for storing the configuration files based on PostgreSQL [14]. The tools and licenses used for data storage are presented in the following table:

Name of the Library	Version	License
MongoDB	4.4	Apache License 2.0
Elasticsearch	7.10	Elastic License
PostgreSQL	12.2	PostgreSQL License (similar to BSD/MIT)

Table 5 Technologies and libraries used in the Data Storage Module, along with their licenses

3.2 SERVIFLEX Analytics Layer

In this section, the development details for the modules that consist of the analytics layer of SERVIFLEX tool are presented. There are two software bundles to incorporate the different functionalities as presented in previous section. The details of these software bundles are provided.

SERVIFLEX Aggregation & Filtering Module

The Aggregation & Filtering software bundle address the functionality of the SERVIFLEX Aggregation & Filtering module responsible for applying filtering over flexibility profiling data by taking into account the criteria defined by the end users of the platform (business application developers). In addition, aggregation over the flexibility profiling data is supported by the software module. The layers of software are:

- the business logic for data search-based on Nest [15] framework.
- the lightweight storage required for storing the search configuration files based on PostgreSQL

The related tools and licenses are presented in the following table:

Name of the Library	Version	License
Nest NodeJS Web Framework	12	MIT License
PostgreSQL (part of the Data Storage services bundle, but included here for completeness)	12.2	PostgreSQL License (similar to BSD/MIT)

Table 6 Technologies and libraries used in the SERVIFLEX Search and Filtering Module along with their licenses

SERVIFLEX Flexibility Analytics Software Bundle

The flexibility analytics software bundle of the SERVIFLEX analytics Layer offers all functionalities around flexibility profiling analysis with the aim of insights' extraction from these data. Simple and advanced analytics techniques are incorporated in the flexibility analytics Layer in order to enable the provision of the different services (namely the SERVIFLEX Flexibility Clustering, the SERVIFLEX VPP Configuration and the SERVIFLEX Intra Portfolio Optimization as presented above) to the business stakeholders.

The layers of software used for the development of this software bundle are:

- the business logic for data analytics-based on Nest and Flask with the usage of, Pandas [16], Scikit-Learn [17] for the execution of analytics services

- the lightweight storage required for storing the analytics configuration files based on PostgreSQL

The related tools and licenses are presented in the following table:

Name of the Library	Version	License
Nest NodeJS Web Framework	12	MIT License
Pandas	1.1.1	BSD-3-Clause
Scikit-Learn	0.23.2	BSD-3-Clause
Flask	1.1.2	BSD 3-Clause
PostgreSQL (part of the Data Storage services bundle, but included here for completeness)	12.2	PostgreSQL License (similar to BSD/MIT)

Table 7 Technologies and libraries used in the SERVIFLEX Analytics Layer along with their licenses

SERVIFLEX Tool Visualization Layer

Complementary to the data management and analytics layers, the SERVIFLEX Tool Visualization Layer is responsible for assisting the business stakeholders with the management of their portfolio, by applying the appropriate configuration settings as part of the business process. The front-end User interface is based on Vue JS [18] with Vue Query Builder[19] and custom UI template incorporating Tailwind CSS [20].

The related tools and licenses are presented in the following table

Name of the Library	Version	License

Vue.js	2.6.11	MIT
Vue Query Builder	0.8.2	MIT
TailwindCSS	1.9.0	MIT

Table 8 Technologies and libraries used in the SERVIFLEX Tool Visualization Layer along with their licenses

SERVIFLEX Tool Platform Orchestrator

The SERVIFLEX Tool Platform Orchestrator is responsible for the orchestration and execution of all services for data management storage and analytics along with the visualization. Its main subcomponents include:

- Kubernetes [21] for the Orchestration Engine, for automating deployment, scaling, and management of services for data ingestion, data handling and data storage.

- The Business Logic Layer focusing on task and event management based in Nest (NodeJS) web framework and implements the scheduling functionality which is facilitated through a RabbitMQ [22] message broker. TypeORM [23] is used for the development of the connectors with the Data Storage.

The tools and licenses are presented in the following table:

Name of the Library	Version	License
Nest NodeJS Web Framework	12	MIT
TypeORM	-	MIT
Kubernetes	1.18	Apache License 2.0
RabbitMQ	3.8.2	Mozilla Public License

Table 9 Technologies and libraries used in the SERVIFLEX Tool deployment management, along with their licenses

Taking into consideration the different licenses and tools that are utilized for the development of the SERVIFLEX Tool, it is evident that the overall development is a complex task requiring integration and configuration of different technologies and further customization in accordance with the needs of the project. In addition, we have to point out that no commercial versions of the different tools were considered; the whole development was instead performed on the basis of open source and “plain” versions of the different software tools, as presented above.

When it comes to the deployment of the different components that consist of the SERVIFLEX tool, detailed instructions for the installation and deployment of these components are provided in the related private code repository (to point out also that the overall development of the different components is performed as closed source implementation). In order to use the alpha release of the SERVIFLEX tool, an instance of each component needs to be created. To facilitate the installation process components are provided as Docker containers and can be run by the related docker compose command. In any case, for the demonstration

activities of the project, the deployed version of the services bundle is made available through the integrated SERVIFLEX platform.

4 CONCLUSIONS

In this version, the 1st alpha version of the SERVIFLEX tool is presented. The starting point for this 1st version of the SERVIFLEX tool is the delivery of the detailed design specifications as reported in D3.4, specifying the main objectives and work of the SERVIFLEX component.

Overall, the SERVIFLEX tool consist of the system to facilitate the management of local flexibility profiles in order to forecast and decide upon optimal flexibility utilization strategies, while satisfying the goal of reduced complexity that comes from organizing profiles into clusters of homogeneous behaviour. The SERVIFLEX embed all functionalities pertaining to the tool chain for collecting local flexibility profiles, managing them in order to establish optimal VPP composition for the delivery of grid services. Its main innovation is that rather than matching the assumed flexibility profile of a specific asset to a generic class and then extracting flexibility estimations, the SERVIFLEX tool cluster, and segment flexibility sources based on their actual, locally estimated flexibility, enabling the configuration of dynamic Virtual Power Plants as means of aggregation and disaggregation entities of disparate multi-type DERs.

The back-end system is the backbone layer for the functionalities supported by the App. The integration and data management layer is defined to incorporate the different data types defined in the project. Towards this direction, a non-exhaustive list of interfaces with multiple system components was defined and delivered, increasing that way the complexity of the development of the SERVIFLEX tool. In addition, a non-exhaustive list of features is supported taking into account the project use cases and the design specifications as reported in D3.4. To further support the exploitation of the application, the development was delivered in frameworks (Python and JavaScript based) that further enable the scalability and the expandability of the main functionalities, while the deployment as a container app is in line with the requirement for a plug and play and fast deployment in different working environments.

The front-end is the visualization and user interaction layer in order to (i) monitor, (and partially manage) portfolio performance; (ii) provide analytics over flexibility potential on the way of VPP formation; and (iii) enable end users to actively participate in energy marketplaces offering their potential of flexibility. The App front-end is constructed using web-based standard tools. To support an enriched and intuitive information visualization, state of the art (JavaScript based) visualization technologies and framework are considered for the development process. As stated above, the front-end visualization will be made fully available in the following months and thus the documentation of the user interface will be made available in the 2nd version of the document, at M36 - D3.6 SERVIFLEX tool Development v2.

Following the development and deployment specifications of the SERVIFLEX tool, the customization of the application to the different demo sites will follow. This customization will be made more evident in WP7 activities where the details of demonstration planning are reported.

Overall, the 1st version of the SERVIFLEX tool may be described as a test ready application to support not only the project requirements but also generic requirements about DERs management. The lab testing of the SERVIFLEX tool will follow and the feedback gathered during the testing period, along with the remaining set of design specifications will be considered for the delivery of the final version of the SERVIFLEX tool at M36 - D3.6 SERVIFLEX tool Development v2.

5 REFERENCES

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6 ACRONYMS

Acronym List	
ICT	Information Communication Technologies
DER	Distributed Energy Resource
DHW	Domestic Hot Water
DoA	Description of Actions
P2G	Power-to-Gas
P2H	Power-to-Heat
P2X	Power to Heat
RES	Renewable Energy Sources
VPP	Virtual Power Plant
HVAC	Heating, Ventilation and Air Conditioning
UC	Use Case
WP	Work Package
CSS	Cascading Style Sheets
KPI	Key Performance Indicators
ML	Machine Learning
UI	User Interface
IM	Information Model
EV	Electric Vehicle
EV-CP	Electric Vehicle Charging Point