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# D7.5 Version 1.0

## *Consolidated Analysis of Generic Enablers and Domain Specific Enablers Integration*

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**Abstract:**

This report is a consolidated final report on the integration of GEs and DSEs into the FINESCE trial site infrastructures.

**Keyword list:**

Generic Enabler, Domain Specific Enabler, FIWARE, Smart Energy, API

**Disclaimer:**

All information provided reflects the current status of the trial site testbeds at the time of writing and may be subject to change.

# Executive Summary

This is a report on the integration of GEs and DSEs into the FINESCE trial site infrastructures and on FINESCE's GE evaluation.

FINESCE is the Smart Energy project in Phase 2 of the FI-PPP. FINESCE is performing field trials of the use of FIWARE Generic Enablers (GEs) in the smart energy sector and providing Domain Specific Enablers (DSEs) and an Application Programming Interface (API) which will allow third-party clients (such as SMEs involved in the FIWARE Accelerator Programme) to develop applications which access the trial infrastructures, thus supporting the creation of a network of Smart Energy application developers.

The FINESCE trials comprise seven trial sites developed by five vertical work packages (WP) covering Smart Energy areas where Information and Communications Technology (ICT) can beneficially be applied:

- development of demand side response and demand-side management solutions for mixed-use buildings in a city district;
- efficient grid utilisation through demand-side management of prosumers;
- industrial demand side response interworking with a cross-border Virtual Power Plant (VPP);
- development of an energy marketplace to provide demand side response to varying energy production from Distributed Energy Resources (DER);
- controlling electrical vehicle charging to balance DER supply and improved utility communications.

FINESCE has performed an extensive selection of GEs to determine whether they can be used in the trials and has performed a formal evaluation of the selected GEs. This report gives an overview of the results of this GE selection and evaluation activity. In performing the GE evaluation, requirements on the GEs have been defined and the degree to which the GEs fulfil the requirements has been assessed. The result from the GE evaluation process is that the GEs have generally given satisfactory results in terms of compliance with the FINESCE requirements.

FINESCE is developing fifteen DSEs. These are components from the trial sites which have been developed to help integrate the GEs towards trial site equipment or to perform particular Smart Energy domain-specific functions not already covered by GEs. The FINESCE DSEs are published as open-source code.

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# 1. Introduction

This is a report on the integration of GEs and DSEs into the FINESCE trial site infrastructures and on FINESCE's GE evaluation. It is an output of the GE and DSE Integration task (M4-M24) where GEs and DSEs have been integrated into the trial infrastructures, which are ready for trial experiments to be performed (Trial Implementation task, M10-M26).

Each FINESCE trial site cover widely different Smart Energy use cases. Due to this diversity, FINESCE adopted a bottom-up architectural approach where each individual trial site offers Smart Energy data over an API, with the WPs' individual APIs being unified through the FINESCE API which offers a single point of access to the data available from the seven trial sites. Overviews of the individual trial sites' integration architectures with explanations of the purpose of their various components and how GEs have been used are presented in Chapter 2.

FINESCE has performed an extensive process of selection and evaluation of GEs, culminating in a detailed formal evaluation of the GEs which have been integrated into the trial sites. The selection and evaluation methodology is explained in Chapter 3 and an overview of the results of this formal evaluation is given in Chapter 4. Detailed GE evaluations are presented in ANNEX 3. Formalised evaluation results are presented only for the GEs in the FIWARE Catalogue[1].

An overview of the DSEs that FINESCE is publishing are presented in Chapter 5.

[1] http://catalogue.fiware.org/

# 2. Integration Architectures of FINESCE WPs

The sub-chapters below give an overview of the FINESCE trial site functional architectures. The intention is to outline where the DSEs, GEs and other trial-site components fit into the trial sites.

In the FINESCE trial sites, FIWARE GEs have been integrated along with other software and hardware components, some of which have been defined by FINESCE as DSEs. DSEs are open source, software components which are considered to be potentially re-usable by developers in the Smart Energy domain. In order to be re-usable, code and specifications must be made available, thus allowing a developer to make his own implementation of the DSE. A reference DSE implementation must exist; in FINESCE the reference DSE implementations are in the FINESCE trial sites, or associated cloud infrastructure, hosting the respective DSEs.

FINESCE is organised with seven independent trial sites. Although independent, there are broad similarities in their use of GEs. The predominant pattern is that the sites gather data from remote equipment in buildings or vehicles, process the data and make it available over a WP-specific API. These WP APIs are used by the FINESCE API mediator and also, in some cases, directly by FINESCE partners or internally in the trial site.

In FINESCE, GEs from the FIWARE IoT chapter are typically used for data gathering, GEs from the Data/Context Management chapter for data handling and GEs from the Security chapter for controlling access via the WP's API. This typical GE usage pattern is shown in Figure 1 for the different trial sites; the letters (A-E) used for the GE groups in Figure 1 is referred to in the per-WP descriptions in the sub-chapters below to show which GE groups are used in particular trial sites; if a GE group is not mentioned below then it is not used by the given trial site.

Please note that Figure 1 is meant as a simplified overview only. It shows the broad pattern of GE usage, but it does not show all GEs used (some WPs use GEs from FIWARE chapters which are not indicated).

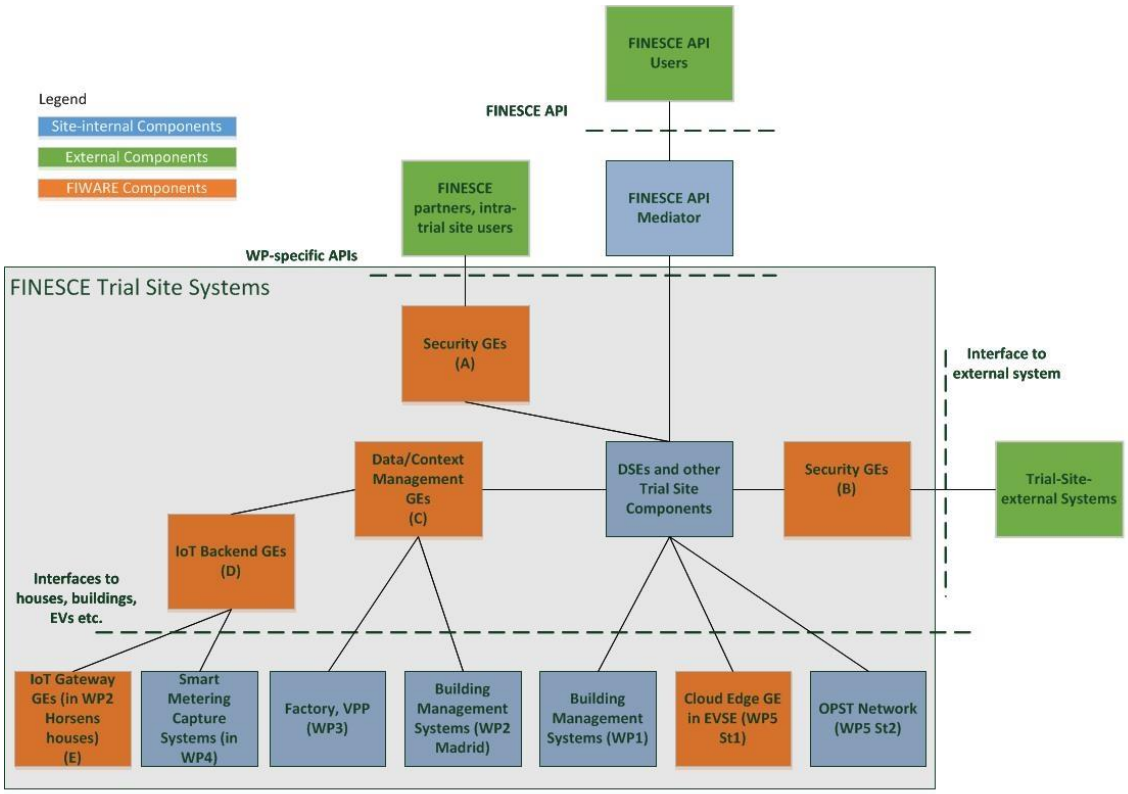


**Figure 1 – Broad Pattern of GE Usage Across FINESCE Trial Sites**

## 2.1 WP1 Integration Architecture

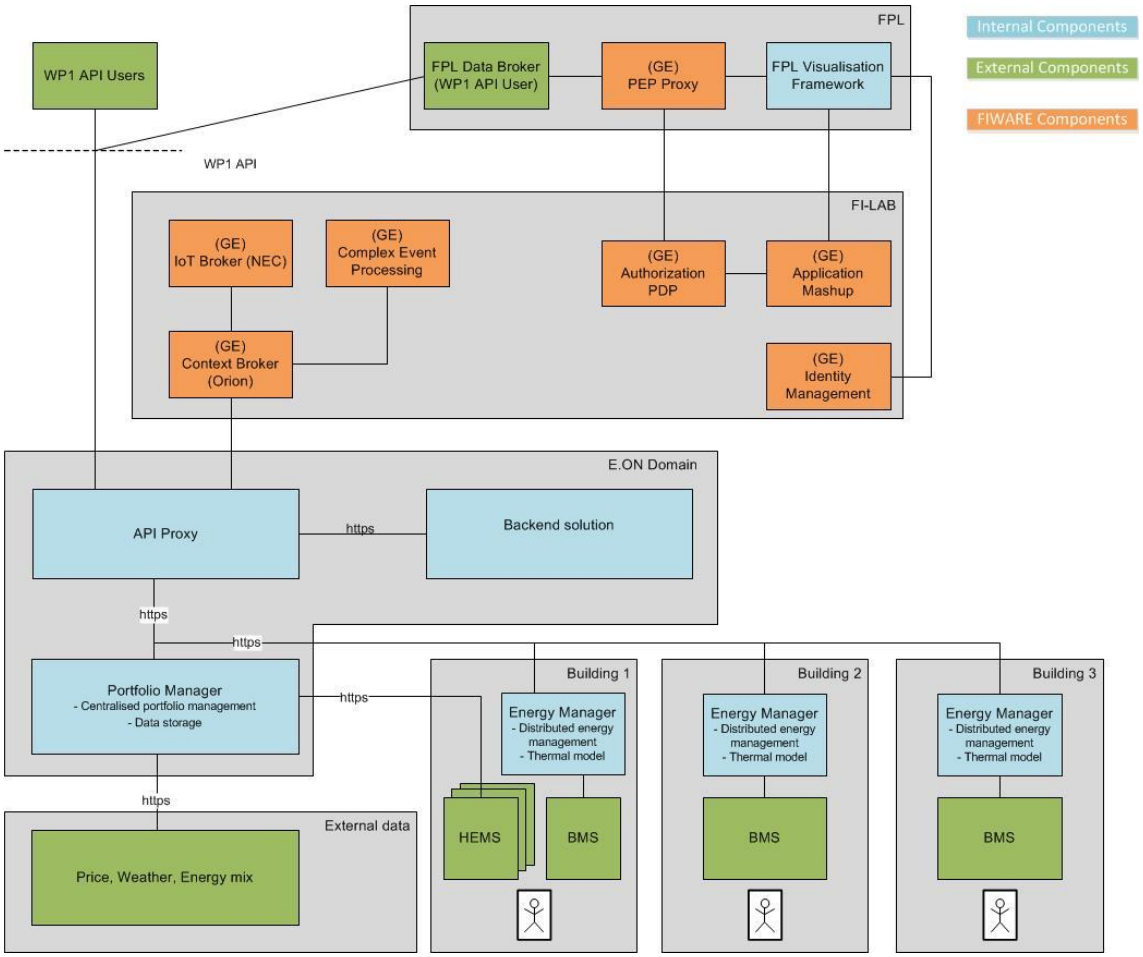


**Figure 2: - WP1 Integration Architecture**

WP1's functional architecture, shown in Figure 2, comprises a distributed energy management function and a centralised energy portfolio management function. Figure 2 shows the following components which have been integrated into the WP1 trial site:

- *Backend solution,* handles WP1 API user access rights and roles towards E.ON IT systems;
- *API Proxy:* Provides the WP1 API, acting as a frontend integrator towards FI-Lab and E.ON systems;
- *Portfolio Manager:* back-end server platform for centralised portfolio management;
- *Energy Manager*, present in each building in WP1, performs distributed energy management;
- *Building Management System (BMS)*, present in each building in WP1, computer based control system monitoring and steering the heating supply and ventilation;
- *Home Energy Management System (HEMS)*, present in all apartments in the first building in WP1 (Roth Fastigheter), computer based control system monitoring and steering the heat usage;
- *GE Integration Kit* is a documented process for integrating GEs, with examples from WP1, to help others in such implementations; it is not a component in the architecture shown in Figure 2 above;
- *FINESCE Presentation Layer (FPL):* cloud-based visualisation app working towards WP1 and WP3 trial systems. It interworks with a graphical web app which FPL users run in their browsers. FPL uses *Identity Management (Keyrock), Authorization PDP* and *PEP Proxy* GEs for user identity management and authentication and the *Wirecloud Mashup GE* for testing the graphical web app.

WP1's GEs are integrated via the API Proxy and the FINESCE Presentation Layer (FPL) , as depicted Figure 2, where the *Context Broker* GE has a very central position.

Note: the letters in brackets e.g. "Security (A)" refer to the GE Groups illustrated in Figure 1 above.

Security (A)
*Identity Management (Keyrock),Authorization PDP (AuthZForce)* and *PEP Proxy (Wilma)* are used for a single-sign-on to the FPL.

Data/Context Management (C)
*Big Data Analysis (Cosmos)* and *Publish/Subscribe Context Broker (Orion)* GEs have been integrated.. The "Cygnus" module is used to notify changes from Orion to Cosmos.

IoT Backend (D)
An IoT backend based on the *Backend IoT Broker (NEC)* to enable handling larger numbers of Energy Managers is under study. WP1's IoT Backend will be fed from the *Publish/Subscribe Context Broker (Orion)*, i.e. not directly from the buildings.

## 2.2 WP2 Integration Architecture

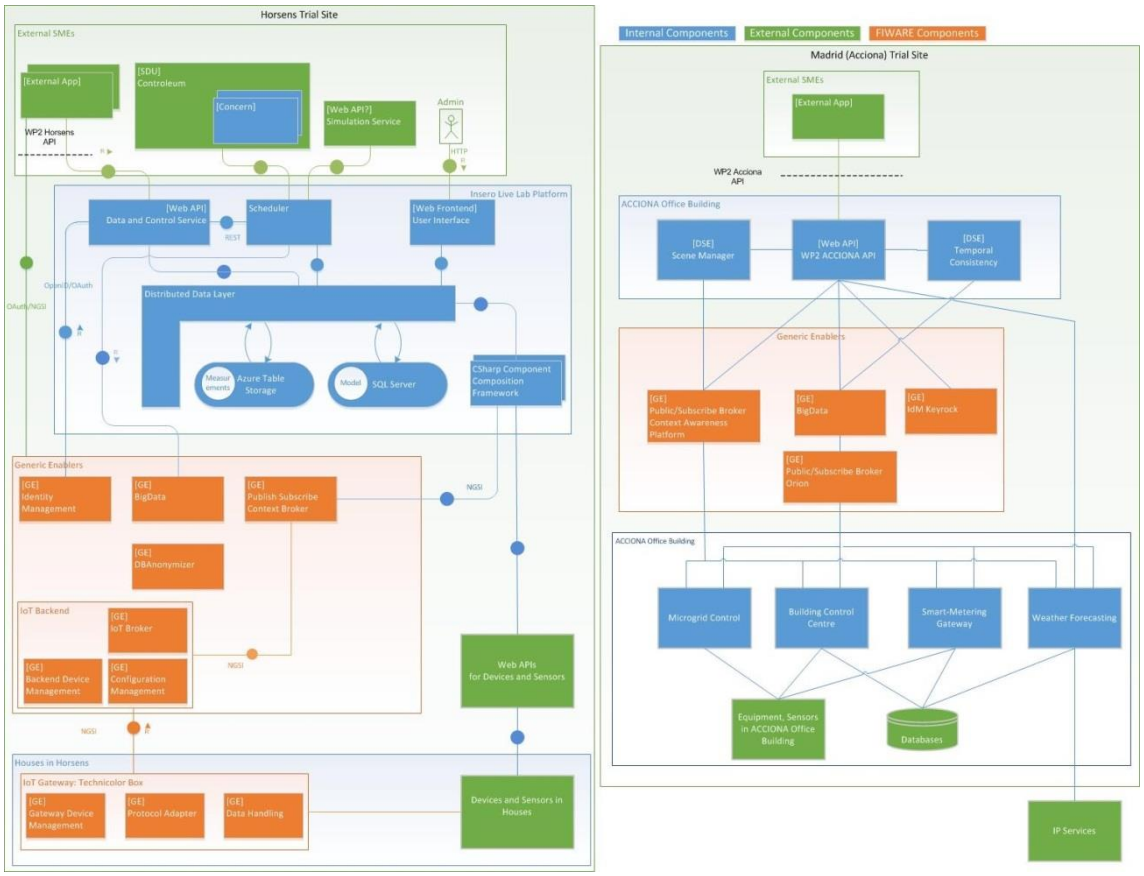


**Figure 3 –WP2 Integration Architecture**

WP2 consists of two trial streams being implemented and executed independently but with the possibility to share data. The first trial stream consists of 20 single family houses in the Horsens area, Denmark. The houses are equipped with energy producing and energy consuming components. In Madrid, Spain, a second trial stream consists of an office building equipped with a Building Management System, components for electricity production as well as electricity storage. Figure 3 depicts the functional architecture of the WP2 Horsens and Madrid trial sites.

It shows the following components which have been integrated into the Insero Live Lab Platform on the Horsens trial site:

- *User Interface (web service):* administrator's system management portal, used to manage everything that can be configured in the system and visualise some of the data that is being collected.
- *Data and Control Service* (formerly *Control Service and Historic Data Service*): exposes the API that all external services will use. Provides the historic data services to get raw measurements and aggregate measurements. Includes OData querying syntax for retrieving the sources of the measurements and the different types of measurements that exist. Provides API for the control services for the devices in the houses.
- *CSharp Component Composition Framework* DSE*:* mediates the different APIs exposed from the web services that gather the data from the devices.
    - it allows NGSI clients to retrieve information through the Publish Subscribe Broker;
    - it stores all measurements from the houses into a NoSQL store for later retrieval and analysis;
    - it stores external data from weather and energy services into a NoSQL store for later usage in the *Scheduler* and *Controleum*;
    - it performs monitoring on all equipment in the houses, so causes of errors can easily be identified and eliminated.
- *SQL Server* has a model of the physical configuration of equipment and the software deployment;
- *Scheduler:* uses the measurements from the houses, simulation of heat loss for the individual houses and weather and electricity production/usage prognosis from various services in order to optimise the way energy is used in the smart grid as a whole. Control instructions for the houses are provided by *Controleum* and executed in this component.
- *Distributed Data Layer:* provides the communication bus facilitating the exchange of measurement data, queries and control messages between the components in the system. It features a distributed platform providing location-transparent communication between components.
- *Controleum* is a framework for multi-objective control problems where each objective represents a concern in the control domain, like maintaining the air quality within a comfort-band, or reducing electricity consumption by extending the comfort-band in case of a demand-response event. It is the responsibility of Controleum to find a Pareto optimal solution and to identify conflicts between objectives.
- *Azure Table Storage* is used for storing measurement.

Figure 3 shows the following components which have been integrated into the Madrid trial site:

- the four systems at the Acciona building which provide data from the building's equipment and sensors to FIWARE GEs;
- *Web API* module exposes, through appropriate security control, the the API that all external services will use;
- *Temporal Consistency* DSE pre-processes data stored in the Big Data GE by from any of the Madrid trial data sources: the Weather Forecasting module, the Building Control Centre, the Microgrid data concentrator, and/or the Smart Metering gateway. It detects inconsistencies and removes non-valid values. It uses HiveQL Client (Backend) to interface to Big Data GE.
- *Scene Manager* DSE allow configuration of a set of multiple parameters (scene), based on which different alerts can be triggered and offered to subscribed users. It works together with the Public/Subscribe Context Broker – Context Awareness Platform GE in order to perform the event configuration, receive alert notifications and manage the subscriptions to those events.

#### 2.2.1.1 WP2 Horsens

Note: the letters in brackets e.g. "Security (A)" refer to the GE Groups illustrated in Figure 1 above.

Security (A)
The trial site has successfully integrated *Identity Management (GCP)* to authenticate trial site users (external apps and owners of houses involved in the trial).

Data/Context Management (C)
*Orion Context Broker* GE is integrated.

IoT Gateway (E)
Locating a number of GEs in the Technicolor hardware box in the houses participating in the trial was studied. WP2 considered hosting *Protocol Adapter (ZPA)*, *Gateway Data Handling (EspR4FastData)* and *Gateway Device Management (Fraunhofer)* on the box. Due to compatibility problems with using NGSI between the *ZPA* and *EspR4FastData* GEs and towards the IoT Backend, *EspR4FastData* was not integrated.

IoT Backend (D)
A backend comprising the *Backend IoT Broker (NEC)* and *Backend Configuration Manager (Orion)* is integrated.

#### 2.2.1.2 WP2 Madrid

Note: the letters in brackets e.g. “Security (A)” refer to the GE Groups illustrated in Figure 1 above.

Security (A)
It is planned to use *Identity Management (Keyrock)*.

Data/Context Management (C)
Integration of the *Big Data Analysis (Cosmos)* and *Publish/Subscribe Context Broker (Context Awareness Platform)* GEs is completed. The Cygnus module is used for converting XML data streams input to the *Publish/Subscribe Context Broker (Orion)*, which has been integrated.

## 2.3 WP3 Integration Architecture

WP3’s trial site comprise a Virtual Power Plant (VPP) comprising over 10 Distributed Energy Resource sites in Belgium and Germany and a Smart Factory in Aachen. Figure 4 shows how the VPP, the Smart Factory, a simulation of the VPP and the FPL (described in Ch. 2.1 on WP1 above) are connected via a FIWARE cloud-based infrastructure. Also, Figure 4 shows the Future Internet Smart Factory Energy Planning System (FISFEPS), which finds the best match of the power which is generated by the VPP and the production plans which are provided by the Smart Factory.

The WP3 trial site comprises the following components:

- *VPP Power Plant* sites (windmills, PV plants and biogas plants): here, proprietary *Gateways* collect energy data from the DERs’ meters and send it in encrypted form to a central proprietary QSC *Gateway Server* which decrypts and stores the data locally and forwards it to the *Complex Event Processing* GE on the FI Testbed.
- The *Generation Schedule Manager* DSE provides information about the VPP’s energy generation. The *Production Schedule Manager* DSE processes the factory’s production steps (including the associated power requirement) into a production plan. The *Complex Event Processing* GE takes the output of these two DSEs to plan how to balance the energy production and consumption.
- The *Modbus Connector* component supports the connection of the Factory shopfloor infrastructure to the *Gateway Data Handling* GE. The *ODBC Event Sink* DSE provides local storage of data, which is typically mandated by manufacturers. All these components are instantiated locally at the factory.
- In the Factory, the *Application Mashup* GE allows integration of the factory-related events into existing factory production management systems.

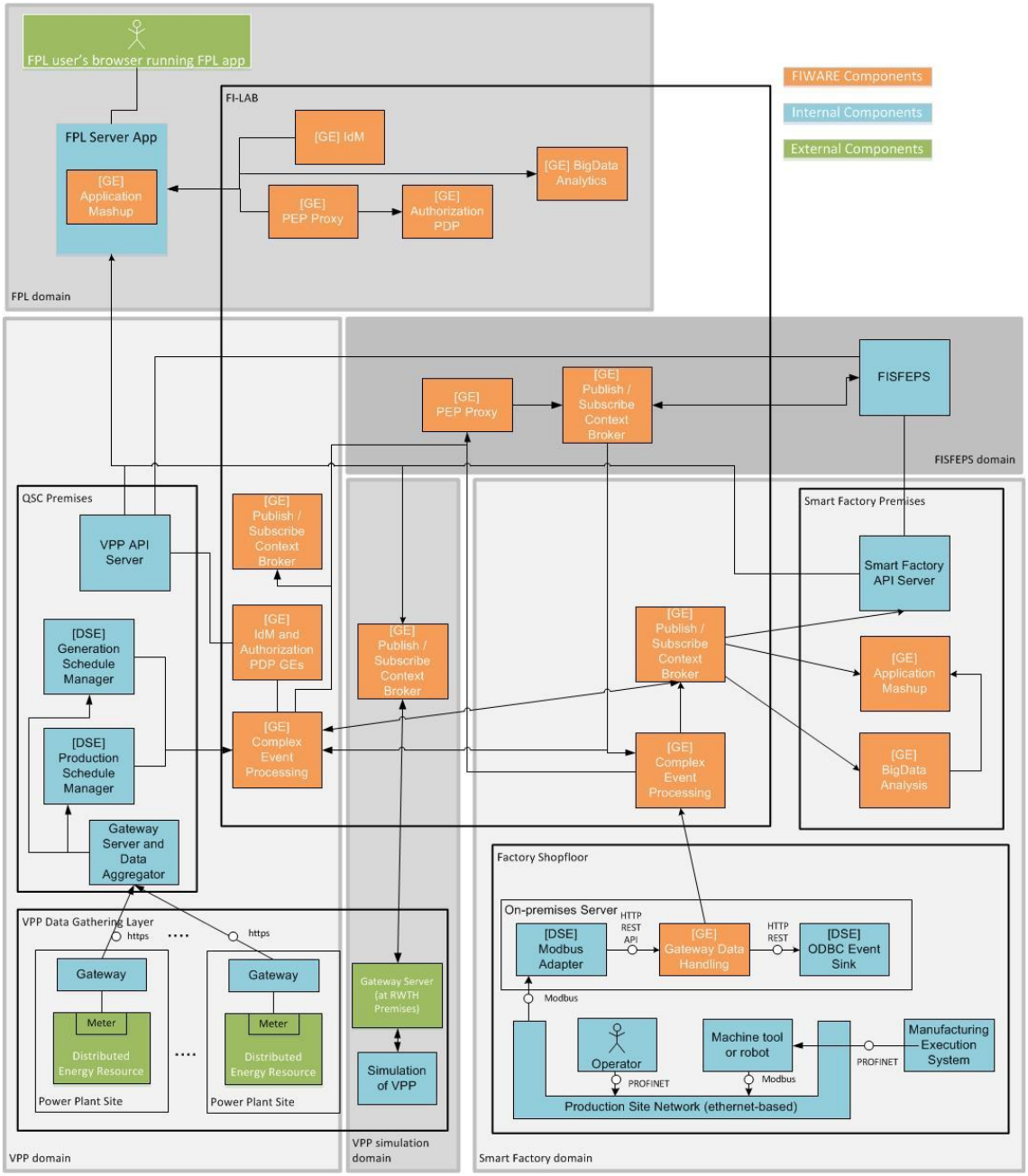


**Figure 4: - WP3 Integration Architecture**

Note: the letters in brackets e.g. "Security (A)" refer to the GE Groups illustrated in Figure 1 above.

Security (A)
VPP uses *Authorization PDP* and *Identity Management (Keyrock).*

Data/Context Management (C)
VPP has integrated *Complex Event Processing* GE to collect events from the VPP and Smart Factory and distribute processed events. The Smart Factory has integrated *Complex Event Processing* GE and *Publish/Subscribe Context Broker (Orion)* for event collection and distribution.

IoT Gateway (E)
Smart Factory has integrated *Gateway Data Handling (EspR4FastData)* GE locally on a factory server to act as a gateway between the factory and the cloud.

## 2.4 WP4 Integration Architecture

Figure 5 depicts the architecture of the WP4 Terni trial site. It shows the following components which have been integrated into an energy marketplace whose data are collected at the Terni trial site:

- *AMM2Metering*, which retrieves "raw" consumption and production data from the smart meters installed at the trial site and passes them over IP to *Metering2Orion*;
- *Metering2Orion* DSE, which translates metering data coming from *AMM2Metering* into an NGSI10-compliant format (ORION context events) and finally publishes them on the ORION Context Broker GE;
- *WeaFor2Orion* DSE, which collects data from a weather forecasting service every five minutes and sends them to ORION Context Broker.
- *Social2Orion* DSE, a REST-based client that exposes an @POST method via which an external provider can send data on social events (such as concerts, football matches, etc.) that can affect consumption/production in the trial site area.
- *NGSI2Cosmos* is a special data injector connecting ORION to COSMOS. It subscribes to the data to be persisted) and when their values change, it automatically appends the new value in a COSMOS file (located within its HDFS file system);
- *Cosmos2Orion* is a Timer service which retrieves aggregated information on total consumption and production for the trial site area and sends it to ORION Context Broker GE;
- *HiveQueryCosmos*, which analyses and retrieves data from COSMOS GE via HIVE, It establishes the connection to the HIVE Data Warehouse, executes the Hive Query in HQL language, retrieves aggregated data and sends them to Rest2Cosmos;
- *Rest2Cosmos* is a REST-based client that exposes methods (GET) to retrieve the aggregated data from COSMOS GE via the HiveQueryCosmos module.
- *AMR2AMI*, is an "alternative" metering capture system which has been implemented at the trial site: the Smart Meters, which are of a different type to those communicating with *AMM2Metering*, communicate using the DLMS/COSEM protocol over Ethernet to a PLC modem. A PLC concentrator at the substation terminates the PLC and communicates over Ethernet to the *SENSOR2AMI* DSE, which comprises
    - IAM-Reader, which collects real time metering data, converting it to the DLMS/COSEM protocol if needed;
    - IAM-Server Relay, a middleware server which receives DLMS/COSEM metering objects from IAM-Readers and posts them to IAM2IDAS;
    - IAM2IDAS, which converts the DLMS objects to the format required the *(Backend) Device Management (IDAS)* GE;
- *ContractInformation2Orion* DSE is a REST-based client that exposes methods (POST) whereby an external provider can send data on the cost of energy, the cost of energy produced by DERs and the cost of system transmission power plants;
- *Issue Detector Processor* DSE (not shown in Figure 5), which is composed of the following sub-modules:
    - *Event2Issue* listens to updates in the CEP singleton entity, which is sent by PROTON to ORION as NGSI10 notifyContext after the evaluation of pre-defined patterns of behaviour, processes the information and generates (or updates) the corresponding Issue in the Orion Context Broker (using NGSI10 updateContext request).
    - *Cosmos2SCILAB* DSE is a Timer service that retrieves weather forecast and historical consumption/production data from COSMOS GE (via *Rest2Cosmos*) and then stores it in a configurable directory accessible to the SCILAB simulator software;

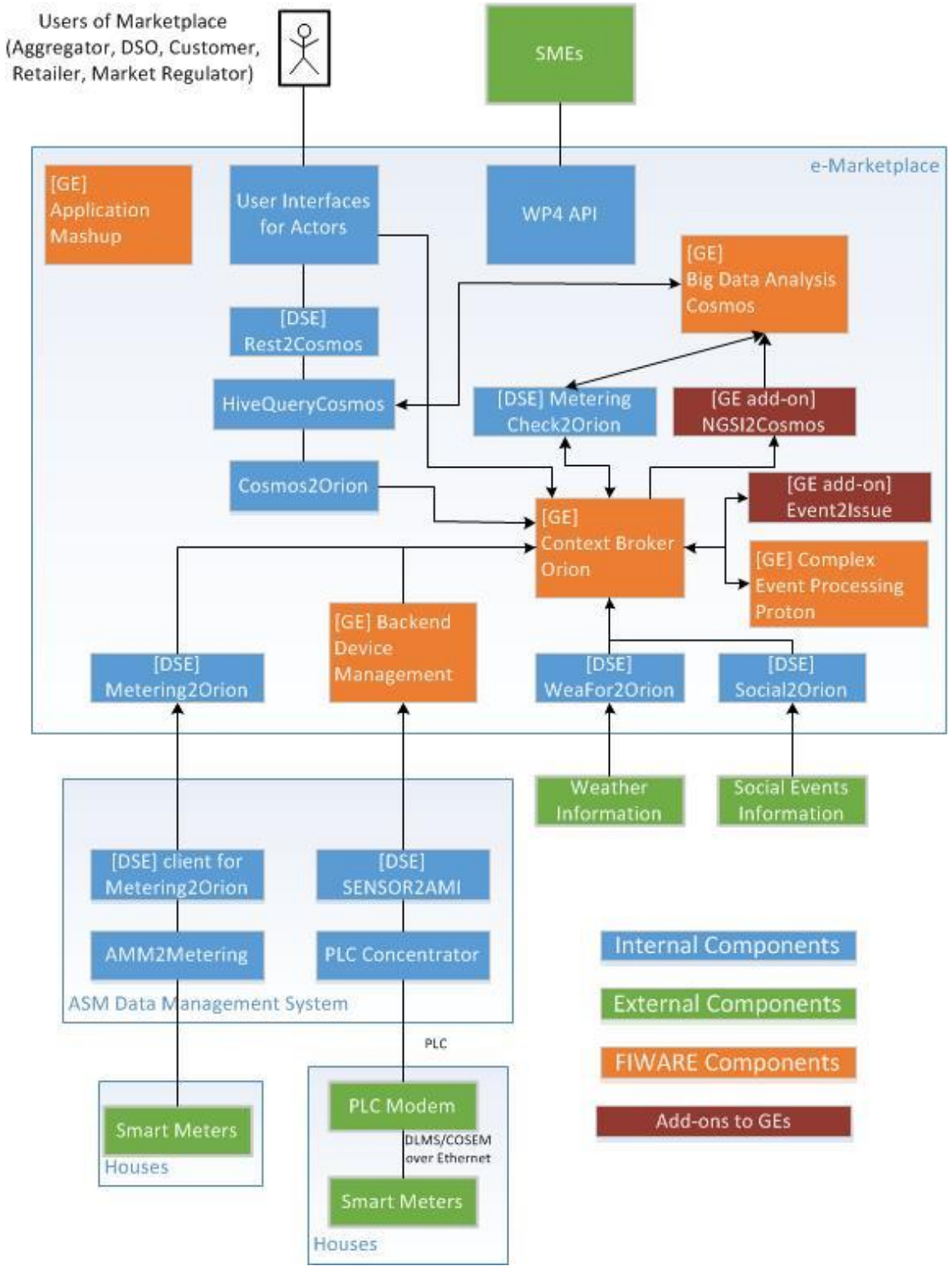


**Figure 5–WP4 Integration Architecture**

- *SCILAB2Orion* DSE(not shown in Figure 5) is a Timer service that retrieves “power losses”, “voltage drops” and consumption/prediction data from SCILAB and sends them to ORION;
- *INP SCILAB* DSE (not shown in Figure 5) accepts weather forecast and historical consumption/production data retrieved by *Cosmos2SCILAB* via *Rest2Cosmos* from *Big Data Analysis (Cosmos*) GE. It performs a simulation and returns to *SCILAB2Orion* information on power losses and voltage drops in the trial site grid) and short time (next twenty-four hours) predictions on consumption/production. *INP SCILAB* is developed on SCILAB, an open

licensed software that is compatible with the Linux version installed on the FI-Lab VM where it has been deployed.

- The-marketplace offers an external interface over an API, shown in Figure 5 as *WP4 API*.

Note that Figure 5 does not show WP4's usage of Object Storage or other Cloud GEs used to deploy thee-Marketplace in FI-Lab.

Note: the letters in brackets e.g. "Security (A)" refer to the GE Groups illustrated in Figure 1 above.

Cloud
The FI-Lab implementation of the IaaS Data Center Resource Management, Self Service Interfaces, Object Storage and Monitoring GEs is being used. These GEs have all worked well.

The public FI-Lab instance of *Object Storage* GE is included in the design and integrated. It is being used to store and share files among Wirecloud users and works well.

Apps
*Application Mashup (Wirecloud)* works as expected and is fast and stable. Support has been excellent. Its integration continues as more "panels" are being included in the UI for the different stakeholders included in the process.

*WStore, Marketplace and Repository* GEs are being used for billing and accounting for various software resources, and together with *Wirecloud*, to upload and distribute resources.

Security (A)
*Identity Management (Keyrock)* is included in the design and integrated. It is used to authorise users and give them a single sign-on to FI-Lab and Wirecloud.

Data/Context Management (C)
*Big Data (COSMOS)*, *Context Broker (ORION)* and *Complex Event Processing (PROTON)*are integrated.

IoT Backend (D)
The Smart Meters are connected to the Terni trial infrastructure in two different ways: twelve meters are connected via *AMM2Metering* and *Metering2Orion* to the GE; additionally, another metering capturing system (AMM2AMI) collects data from a different type of smart meters and sends the metering data via the *Backend Device Management (IDAS)* GE to the *Orion Context Broker GE*.

## 2.5 WP5 Integration Architecture

The Stream 1 trial comprises the following components:

- the *Electrical Vehicle Supply Equipment (EVSE)* to charge electrical vehicles parked at the houses;
- *Cloud Edge* GE at the houses supporting *COS – EVSE communication;*
- the *Charging Optimisation System (COS)* controls EVSE charging;
- *SERVO,* an external DSO system which authorises *EVSE* charging based on its knowledge of the effect that a given EVSE's charging has on the LV and MV grid conditions; *SERVO* exposes an OpenADR VTN interface to the COS; *SERVO* is not currently fully operational, so COS is currently working on the assumption that *SERVO* always authorises charging requests;
- The *Grid Emergency Initiator* allows an grid emergency state to be defined and communicated encrypted to *COS;*
- *Optimisation Service:* algorithm which generates an EV charging schedule using EVSE state information retrieved from the COS and sends it to the COS for implementation during the next optimisation cycle (15 minutes);
- *WP5 Stream 1 API* provides an API for both internal WP usage and for external usage

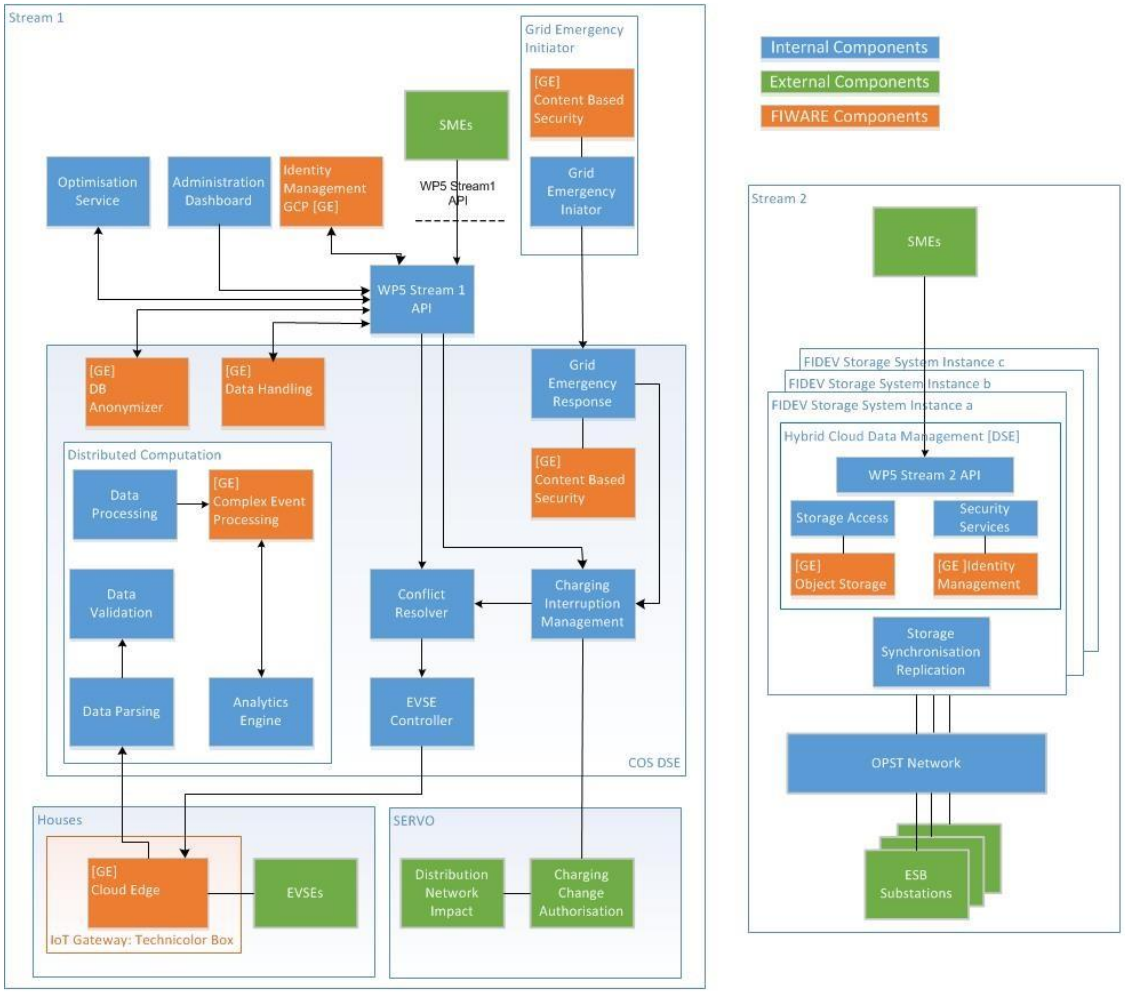


**Figure 6–WP5 Intermediate Integration Architecture**

The Stream 2 trial comprises the following components:

- an *Optical Packet Switch and Transport Network* connecting several MV substations via optical switches and optical fibre
- *FIDEV Storage System* is a distributed, cloud-based data storage system. Currently it is planned to use EVSE data which will be fed from *COS* to the OPST network, rather than DSO data from the substations, as originally intended.
- *Hybrid Cloud Data Management* is a DSE containing the parts of *FIDEV Storage System* which provide access to the local and distributed storage. The API for controlling the DSE is offered as part of the FINESCE API.

#### 2.5.1.1 WP5 Stream 1

Note: the letters in brackets e.g. “Security (A)” refer to the GE Groups illustrated in Figure 1 above.

Security (A)

*Identity Management (GCP)* and *Data Handling* are included in the design and integrated. *IdM GCP* is used to authenticate API users and *Data Handling* to enforce privacy of EVSE data. *DB Anonymizer* is included in the design.

Security (B)

*Content-based Security* is included in the design for encryption of data between COS and external TSO systems.

Data/Context Management (C)
*Complex Event Processing (IBM)* is included in the design to support provision of historical EVSE data.

#### 2.5.1.2 WP5 Stream 2

Note: the letters in brackets e.g. “Security (A)” refer to the GE Groups illustrated in Figure 1 above.

*Object Storage* GE will be used for storage of data in FIWARE cloud

Security (A)
Identity Management (Keyrock) will be used for user access and management.

## 2.6 Where the GEs Are Instantiated

FINESCE GEs are instantiated either in the FI-PPP Testbed (FIWARE-internal but available to Use Case projects with FIWARE support), FI-Lab (a shared resource), or as an own local instantiation. The way each WP has instantiated its GEis is shown in Table 1.

| **WP** | **Instantiation** |
|---|---|
| WP1 | FI-Lab |
| WP2 Horsens | FI-Lab, except for<br>• GEs on hardware located at houses in trial.<br>• Identity Management GCP, where the multi-tenant instantiation hosted by the GE owner which must be used |
| WP2 Madrid | • FI Testbed for Publish/Subscribe Broker, Data Handling, Orion Context Broker and IdentityManagement<br>• Telefonica I+D cluster for BigData Analysis |
| WP3 Factory | • FI-Testbed for Object Storage, Big Data Analysis<br>• FI-Lab for Gateway Data Handling, CEP, Publish/Subscribe Broker Orion<br>• Gateway Data Handling local. |
| WP3 VPP | FI-Lab |
| WP4 | FI-PPP Testbed for COSMOS and IDAS (“global” instances, available for 2nd Phase projects and developers). Otherwise, FI-Lab (“private” instances set-up and managed by WP4). |
| WP5 Stream 1 | Local, except for Identity Management GCP (see WP2 Horsens above). |
| WP5 Stream 2 | Local |

**Table 1: Instantiation of GE Implementations by WPs**

# 3. Selection and Evaluation of Generic Enablers

This chapter describes how GEs have been selected and evaluated in FINESCE.

A word on terminology: the term “selection” is used here to refer to the complete process of choosing which GE shall be used; selection is a continuous iterative per-trial-site process which continues until the GE has been successfully integrated in the trial site or until it has been decided not to use the GE. The term “evaluation” refers to the formal unified GE evaluation, which has been done collectively by all FINESCE WPs.

The basic organisation of FINESCE into independent trial sites carried over into the GE selection process, with each WP being responsible for selecting its own used GEs. A project-internal Wiki has been used to share and make visible the evaluation results. The selection of GEs has, therefore, been a continuing, iterative process because the GEs themselves have continued to be developed and thus the available GE implementations, their level of maturity, the quality of the support offered by their developers and the level of user experience with them have evolved also.

WPs have used the following selection criteria for selecting GEs:

- the GE’s fit to a role in the trial site’s functional architecture and within the FINESCE partners’ future plans. This involves firstly a study of the GEs on the level of their technical chapters, then on the level of the descriptions provided for the individual GEs (including its terms and conditions), then on the level of how the GE can fit to the trial site architecture. If the GE is included in the trial site architecture then it will subsequently undergo a process of integration into the trial site, during which their functionality continues to be evaluated and more deeply understood as they are tested and debugged. GEs from some FIWARE chapters (such as Data/Context Management, Security, Internet of Things) have been of most interest to the FINESCE trial sites in the Smart Energy domain, as described in Ch. 2 above.
- the GE’s terms and conditions and availability from FIWARE (in either the FIWARE Testbed, FI-Lab or as a downloadable product, as per the trial site’s specific needs);
- whether the GE is included in the FIWARE Catalogue;
- whether the GE’s documentation is of sufficient quality to allow the GE to be studied and, later, to be integrated into the trial site;
- whether there is sufficiently good support of the GE by its developers.

A word on the inclusion of GEs in the FIWARE Catalogue: as can be seen in ANNEX 2, FINESCE has worked with many GEs which are not in the current Catalogue. This is partly because the GEs have been under development during FINESCE, so that the development of some of them has stopped. Also, the Catalogue has evolved in the direction of containing only open source GEs: this has led to some GEs which had already been extensively worked with by FINESCE, and in some cases integrated into the trial sites, being removed from the Catalogue. The formal GE evaluation presented in Ch. 4 concentrates, however, only on those GEs included in the FIWARE Catalogue.

The formal evaluation of the GEs is made by scoring the GE’s performance on a set of criteria developed from the ISO/IEC 25010:2011 specification (“Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE). The criteria headings are, as shown in Table 8 in ANNEX 1: Functional suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, Maintainability and Portability. Under each of these headings, a set of sub-criteria has been developed under which each GE receives a score (1-5). Each criterion is allocated a Weighting factors (WF) The weighted scores (i.e. score multiplied by weighting factor) are summed to give a numerical evaluation result. This is also expressed as a percentage of the maximum possible score. The formal evaluation is a collective pan-FINESCE exercise which gives a single unified judgement on the GEs.

# 4. Generic Enablers Evaluation Results

This chapter gives an overview of the GE evaluation results, including a number of comparisons of GEs with commercial competitors.

The number of GE instantiations (GEis) that are integrated into FINESCE trial infrastructures is shown in Table 2, on a per FIWARE chapter basis. It can be seen that the GEs of the Data/Context Management, IoT and Security chapters have been those most used: this reflects the FINESCE trials' emphasis on gathering and distributing Smart Energy data securely.

Over a period of almost two years, FINESCE has worked with GEs continually as they developed. In some cases, GEs under study or integration were dropped from the FIWARE Catalogue, in which case FINESCE has, naturally, also stopped its work on them. There are, however, some exceptional cases where FINESCE had already integrated GEs which were subsequently dropped, as shown in Table 2 where the number of GEis under the "GEs Integrated" column includes both GEs currently in the Catalogue and GEs which had already been integrated in FINESCE trials before the GEis were removed from the FIWARE Catalogue. These non-Catalogue GEis are the Context Awareness Platform instantiation of Publish/Subscribe Broker (in WP2 Madrid), the ZPA instantiation of Gateway Protocol Adapter (in WP2 Horsens), and several Security GEs: IdM GCP (in WP2 Horsens and WP5 Stream 1) and Data Handling, DB Anonymizer, Content-based Security (in WP5 Stream 1).

| FIWARE GE Chapter | GEis Integrated | Non-Catalogue GEis Integrated |
|---|---|---|
| Cloud | 4 | 0 |
| Data/Context Management | 17 | 1 |
| Apps | 6 | 0 |
| IoT | 7 | 1 |
| Security | 13 | 5 |
| I2ND | 0 | 0 |
| | 47 | 7 |

**Table 2:- GEis Integration Status per FIWARE Chapter**

Table 3 gives a per-WP view of the the current status of GEi usage in FINESCE. It shows that the GEi integration activity is well advanced but that a number of GEis are still under investigation. More statistical details of the GE evaluation results are included in ANNEX 2.

| GEi Status for WP ↓ | WP1 | WP2 | WP3 | WP4 | WP5 |
|---|---|---|---|---|---|
| Total under consideration "E" | 0 | 3 | 4 | 2 | 1 |
| Total in design "U" | 0 | 0 | 0 | 0 | 3 |
| Total integrated in trial "D" | 6 | 9 | 14 | 13 | 5 |

**Table 3 – GEis Integration Status per WP**

In the following sub-chapters, GE evaluation results are presented for the GEis in the FIWARE Catalogue which FINESCE has integrated. These evaluations are supported by formal GE evaluations, performed using the criteria listed in ANNEX 1, results of which are presented in ANNEX 3, where the GEs receive detailed categorised scores on how well they fulfil FINESCE's requirements. Both the GE evaluation results below and the formal GE evaluations represent the unified opinion of FINESCE.

The overall evaluation conclusions are that the FIWARE platform integrates a good number of mature enough Generic Enablers with adequate operational performance to be used in real operational Smart Energy scenarios. The offering comprises not just a set of GEs, but also a set of supporting tools and a development environment which together speed up the development process.

This has been generally complemented with a satisfactory technical support from the GEs' development teams, and a good quality of the documentation, with some exceptions that are detailed in the following subsections below.

For some (but not for all) GEs, notifications regarding updates or maintenance are issued: such notifications should be available for all GEs.

The discontinuation of some GEs (e.g. ZPA and other changes implemented in the IoT Chapter, Template Handler) has meant having to adapt integration plans to the changed circumstances. On the other hand, FINESCE has continued to study emerging GEs to see whether they can be used; this study is still ongoing, as evidenced by the GEs "under consideration" or "in design" in Table 3. It is considered that the stabilisation of the FIWARE Catalogue is crucial to ensure the wide adoption of this platform by third party developers.

Also, there is no communication mechanism in place whereby notifies of changes or updates to the FIWARE Catalogue: the need for such a mechanism to spread information and build user trust and confidence seems obvious, but it is not in place.

## 4.1 "Cloud GEs": IaaS Data Center Resource Management and Self-service Interfaces - Cloud Portal (UPM)

The services offered by the Cloud GEs matches the expectations. The level of support is good although there have been times when support took a lot of time to reply to questions. Documentation is satisfactory.

The main requirements were:

- having the possibility to create and manage VMs ("equipped" with a pre-defined software stack) in a cloud environment;
- using local instance of GEs with no need to download packages and perform installation/configuration activities (this was accomplished by choosing GE images to be "deployed" in the FINESCE trial site's area of FIWARE Lab/FI-PPP Testbed);
- having the chance to manage security for a VM (enabling ports for TCP/UDP, creation or importation of key pair).

The functionalities provided by the "Cloud GEs" totally cover the requirements.

There is one main issue to report and it is related to the stability of the cloud: too many times the cloud VMs have been restarted without any type of communication, thus resulting in time windows when the data collected at the trial site cannot be forwarded to the cloud application.

Figure 7 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.1 below. The low score under Reliability is explained above. Under Security, functionality to prevent application users accessing cloud functionality and a user history panel are needed.

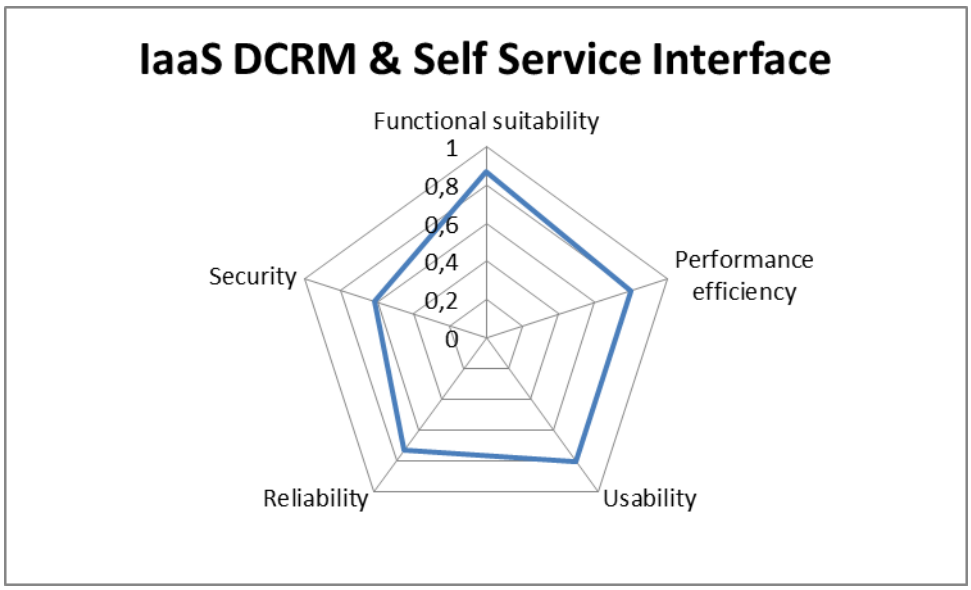


**Figure 7: Cloud GEs Evaluation Result**

## 4.2 Monitoring - TID Implementation

The services offered by the Monitoring GEs are related to the operation side of the infrastructure built up for the marketplace. The level of support was not satisfactory as the details about the installation have been clarified with one mail after another. Documentation is a bit confusing (it refers to “probes” without explaining what a “probe” consists of) and not very clear (the reference architecture misses both the NAGIOS server and the NEB component).

The main requirements were:

- a monitoring platform for all the VMs of a FI-Lab cloud region;
- a monitoring platform for both DSEs and custom software modules deployed on a FI-Lab cloud VM;
- Monitoring data to be forwarded to ORION (as NGSI-compliant entities);
- Monitoring platform authentication.

Most of the requirements are covered by the functionalities offered by NAGIOS which is not a FIWARE GE; actually it is a component that must be installed as a pre-requisite for the installation of the GE modules (NEB + NGSI Adapter.

Figure 8 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.2 below.

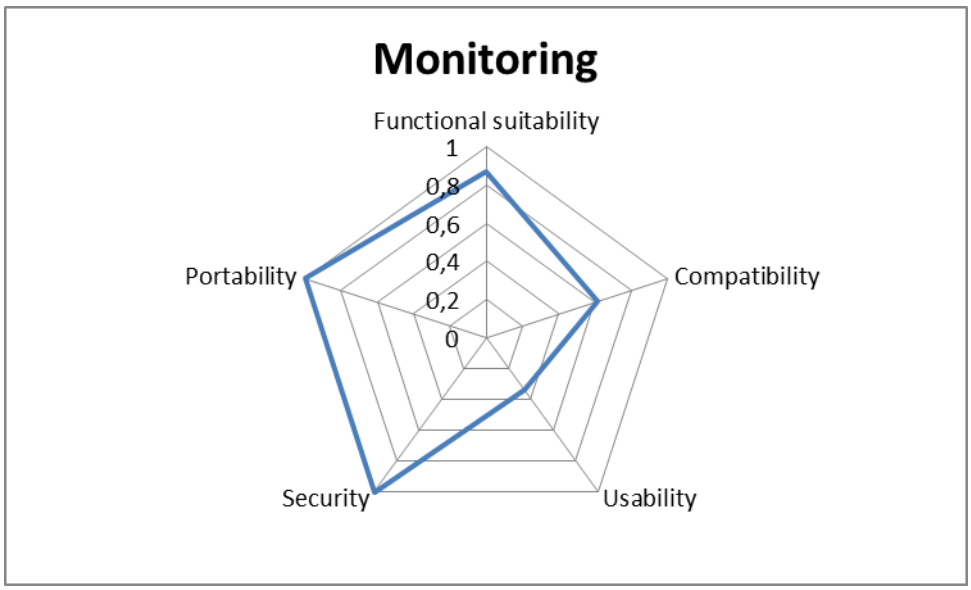


**Figure 8: Monitoring GE Evaluation Result**

## 4.3 Object Storage - FIWARE Implementation

The Object Storage global instance generally worked as expected without unexpected exceptions/problems, only exhibiting some performance problems, probably related to the heavy load of the FI Lab's Spain node facilities. However, during a scheduled FI Lab maintenance, the containers already uploaded disappeared and the data were not accessible in any way. Everything was settled after another container was created; then, all the previous containers also reappeared, with no data loss. No other significant deficiencies of the GE were noticed.

Regarding the GE documentation, it is adequate and covers all the aspects needed to operate the GE and integrate it with a number of the FIWARE components.

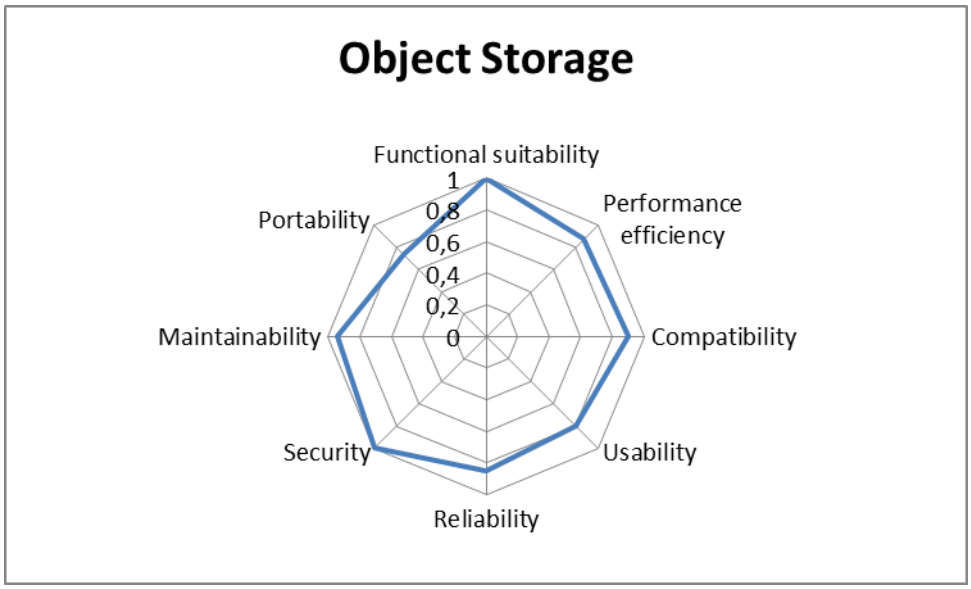


**Figure 9: Object Storage GE Evaluation Result**

In terms of functionality, the main requirements may be summarized as follows:

- Store and retrieve binary objects,
- Allow for fine-grained accessibility options, possibly allowing file sharing with users belonging in common tenants,
- Allow file access only after user authentication and authorization
- File exchange should be secure, fast and trustworthy,
- Offer zero data loss probabilities

The GE public instance satisfied all the aforementioned requirements.

Figure 9 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.3 below.

## 4.4 Big Data Analysis – Cosmos

The Big Data Analysis GE works as expected. The GE is stable and the level of support provided by the GE owner is satisfactory. Documentation available in the FIWARE catalogue is helpful and complete.

The main requirements were:

- to support custom map / reduce jobs (with custom code / libraries added);
- to support Hive;
- to allow data retrieval via SQL-like queries (by supporting Shark/Spark);
- to provide the users with enough resources to perform GE functions (e.g. data retrieval) without overhead or loss of data;
- to be able to co-exist as a part of a larger integrated architecture (within a cloud), without having negative impact on any other part;
- to provide a consistent level of bandwidth, processing speed, etc. at all times;
- to be available and operational for use at all times;
- to remain available and operational with consistent level of bandwidth, processing speed, etc., making hardware or software faults unnoticed by users;
- Should a failure occur, the GE shall provide a way to recover data and state;
- to implement a strict and secure authorization policy, ensuring that data is only available to those who need access to the specific data;
- to implement a strict and secure authorization policy, ensuring that unauthorized users lack access to read/write;
- to provide a secure authentication process (e.g. to HDFS file system).

The reliability of the GE has not always been satisfactory due to frequent stoppage for maintenance/upgrading tasks . In the last months issues on the Shark/Spark component (of the Hadoop ecosystem) rose very often ("*Execution Error, return code -101 from shark.execution.SparkTask*"). It gets overloaded and then crashes, thus making impossible to launch any HIVE SQL-LIKE query and retrieve trial site data.

There is a problem creating an account because the Cosmos portal's form does not handle the extended character set (i.e., characters such as *, -, %, &, /, etc.) used to harden the password. The solution was to weaken our password by using only the alphanumeric characters. The second problem that we found was that all the communication between remote clients and the Cosmos services uses plain text HTTP connections. Considering that the Smart Grid applications involve highly sensitive data in terms of privacy, this is a serious security problem.

The performance efficiency evaluated in terms of the capacity of processing large datasets is also satisfactory, although slightly lower than commercial alternatives with which it has been compared. However, a point of improvement could be the usability aspects, as more intuitive interfaces would be needed to ease the configuration tasks, which should be done without any support from the GE development team.

A reverse subscription for returning data from analysis in Cosmos to Orion would certainly be a welcome addition that would greatly increase the usability and ease of use of the GE.

Figure 10 gives a per-category overview of the results of the formal GE evaluation, including comparison with two commercial alternatives. Details are given in Annex 3.4 below.

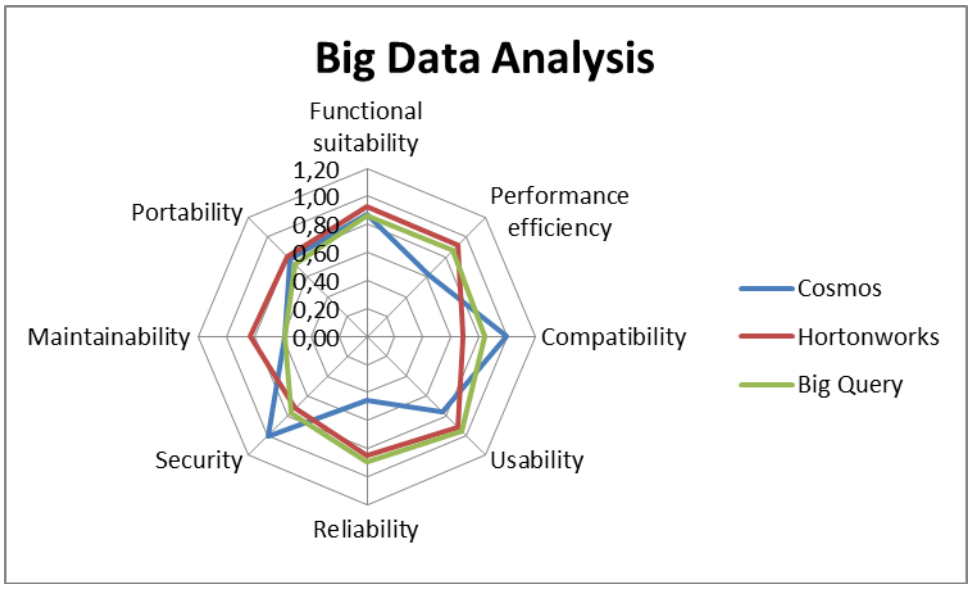


**Figure 10: Big Data Analysis GE Evaluation Result**

## 4.5 Complex Event Processing (CEP) - IBM Proactive Technology Online

The GE Complex Event Processing performed very well in the trials. It fulfils all advertised functionality to a very satisfying degree. The functionality is appropriate for the proposed use cases. All required event patterns for the use case could be created with the GE with ease. No instances of faulty results could be observed. The GE behaved as expected at all times.

Documentation and advertisement of functions of the GE are clear and understandable, very good and concise webcasts facilitate an easy introduction to the GE. Overall, the use cases for the GE are not as clear, though this is influenced by the nature of CEP engines and not specific for the GE. Installation guide and learning material are appropriate, the GUI for configuration is helpful, though it could use further documentation and tooltips. The documentation lacked low level detail and explanations of how to interact with the various subsystems. The GE offers a very flexible configuration interface based on an established industry solution on how to design and configure Complex Event Processing (CEP) engines. Therefore, external tutorials on the definition language can be used as well. Support by the GE owners is fast, reliable and generally very helpful.

The time behaviour of the GE is very good, as responses are fed forward in a manner respecting all the use cases time requirements and constraints. However, requirements are not very high for the specific use cases. No capacity constraints of the GE were met in the use case implementation. Integration with the Publish/ Subscribe Context Broker GE was very good, the open and flexible interfaces allowed for easy integration with other software. Configuration and interaction with the GE is done via RESTful web services using XML-compliant messages, with a high degree of standard compatibility.

Hardware faults from the event source can actively be monitored and dealt with. Hardware faults of the underlying communication channels can hence be detected as well. The GE features an easy way to be configured, further its configuration can be automated via an external client and storing configuration files. However, configuration is not automatically recovered and the GE needs to be usually reset after a fault.

The main requirements were:

- to handle events with a unique ID, a timestamp and additional information about the class and type of the event;
- input data can be processed in different formats using a flexible structure by defining single fields of a REST and XML format and mapping them to event attributes needed for the rules;
- users can define complex events by defining rules for the combination of (input) events through a logical e.g. sequential correlation;
- users can define complex events by defining more complex rules through the combination of other rules;
- users can define event output streams by defining receivers in terms of other systems to which data output data should be forwarded;
- several output receivers (consumers) can be defined for one rule for a complex event;
- several rules (100+) can be stored in the GE and be monitored in parallel;
- the availability of a clear and understandable user interface for definition of event rules.

The functionalities provided by the Complex Event Processing GE totally cover the requirements.
Regarding the last requirement in the list, the UI for definition of event rules (known as Authoring Tool) is not very user-friendly as a couple of issues have been found out:

- fields do not keep the actual value when clicking on it to amend it;
- duplication of elements in the left-hand menu does not sometimes work;
- in the EPAS definition, some panels are hidden by default when these should be visible as they include fields that must be mandatory filled in.

Figure 11 gives a per-category overview of the results of the formal GE evaluation, including comparison with two commercial alternatives. Details are given in Annex 3.5 below.

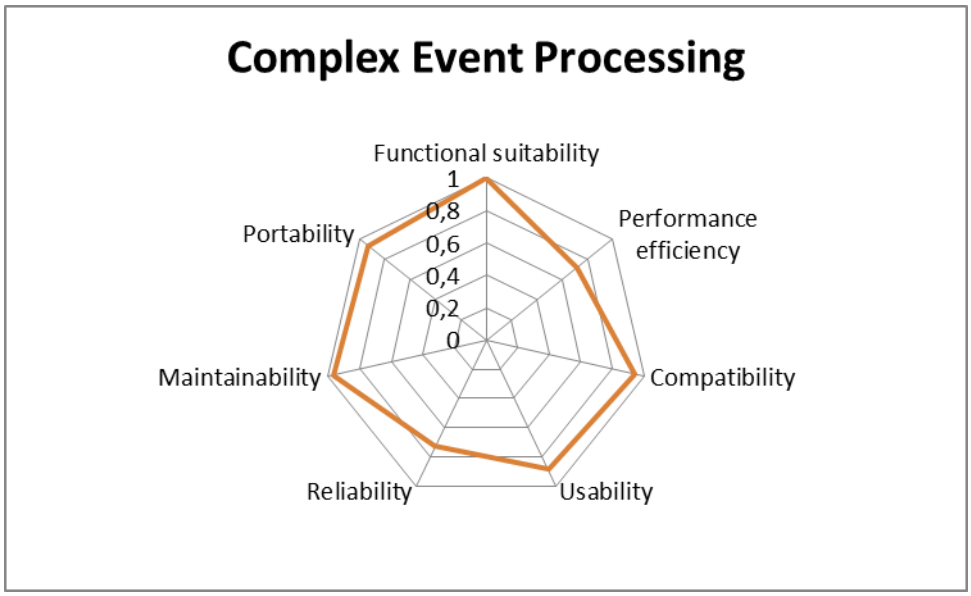


**Figure 11: Complex Event Processing GE Evaluation Result**

## 4.6 Publish/Subscribe Context Broker - Orion Context Broker

The Orion Context Broker is found as a suitable solution to transport data between different parties. It adequately supported the functional requirements and plays the role it has been designed for. It is one of the best implementations of NGSI with correct binding of both XML and JSON.

The level of support provided by the GE owner has a really high standards. The documentation available in the FIWARE Catalogue is helpful and complete. Updates on Context Broker GE releases are immediately communicated by means of a bulletin and this is considered quite helpful to know which new features offered by the GE have been implemented.

As regards stability: crashes were experienced in some situations in which GE should remain operational despite incorrect usage, for example in case of calling URLs containing space characters. When it crashes, it would be convenient if it could start back up on its own, alternatively that it could be started without direct access to the machine it's running on.

A drawback experienced with Orion Context Broker is limited performance efficiency with respect to capacity: more than 50 updates per second (20 entities with 5 attributes) could not be achieved in ideal conditions (physical machine, local network).

There is room for improvement when it comes to security. More thorough logging of users and actions as well as the option of setting restrictions for users would improve the integrity of data.

The main requirements were:

- to support all synchronous NGSI10 operations (query, update);
- to support all asynchronous NGSI10 operations (subscribe, updateContextSubscription, unsubscribe);
- to support the "duration" option in the subscribe requests;
- to support "attributeList" option in the subscribe requests;
- to support "notifyConditions" options of type "ONCHANGE" in the subscribe requests;
- to be able to manage alerts according to conditions that are defined based on attribute values;
- to support changing of active subscriptions;
- to support native integrations with Complex Event Processing GE and Big Data Analytics GE (under the form of the ability to forward entity attributes matching subscription conditions to REST methods exposed by other GEs).

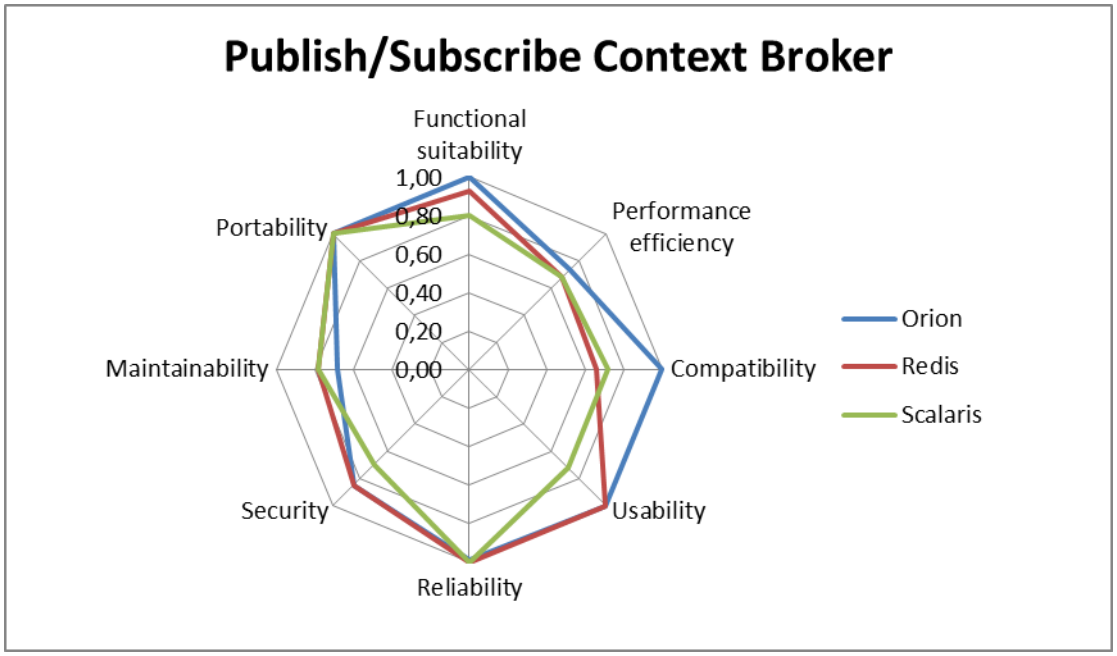


**Figure 12: Publish/Subscribe Context Broker GE Evaluation Result**

Figure 12 gives a per-category overview of the results of the formal GE evaluation, including comparison with two commercial alternatives. Details are given in Annex 3.6 below.

## 4.7 Application Mashup – Wirecloud

WireCloud performance was stellar and it gets mostly the highest points in all important aspects The learning of the tool's usage is reasonably quick, thanks to a combination of a clear interface

and reasonably good documentation. The documentation is updated frequently and is constantly up-to-date.

Moreover, the GE's codebase is updated on a regular basis. Furthermore, it can be very easily integrated with other GEs (including Marketplace, WStore, Object Storage and IDM). Responses from the developer are very timely, accurate and informative.

In terms of security, the GEri sets the ownership of the wiring and a protection against an unauthorized modifications or deletion of someone else's wiring. The security of the mashups, however, is completely in the widgets themselves and the services they, in turn, are accessing.

The GEri loses a few score points in the functional suitability criteria, because it currently has a weak collaboration functionality in the editor, and the theming and branding of wirings is not obvious. The GEri needs to obtain some more stability and maturity. It is also not yet friendly to automated deployment and testing techniques, as it is missing tools for handling uploading and replacing the widget implementations. The API to do it is there, but it leaves the developers to create their own widget and wiring deployment tools.
Wirecloud received its weakest score for the non-repudiation criteria, because in a hosted environment there is no way of obtaining the access logs. Therefore, for the use-cases where such logging is important, a private installation of the Wirecloud is recommended.

The basic requirements for this GE are the following:

- Host widgets and operators and persist their state preferences.
- Allow for redirecting the output of a widget/operator to another widget/operator
- Preserving the state of the workspaces upon server changes
- Allow for authenticated, controlled access to the workspaces through IDM integration
- Integrate with Marketplace/Store GEs in order to use resources offered by other FILAB users
- Integrate with Object Storage GE to store binary data
- Allow for easy upgrading without losing end-user data

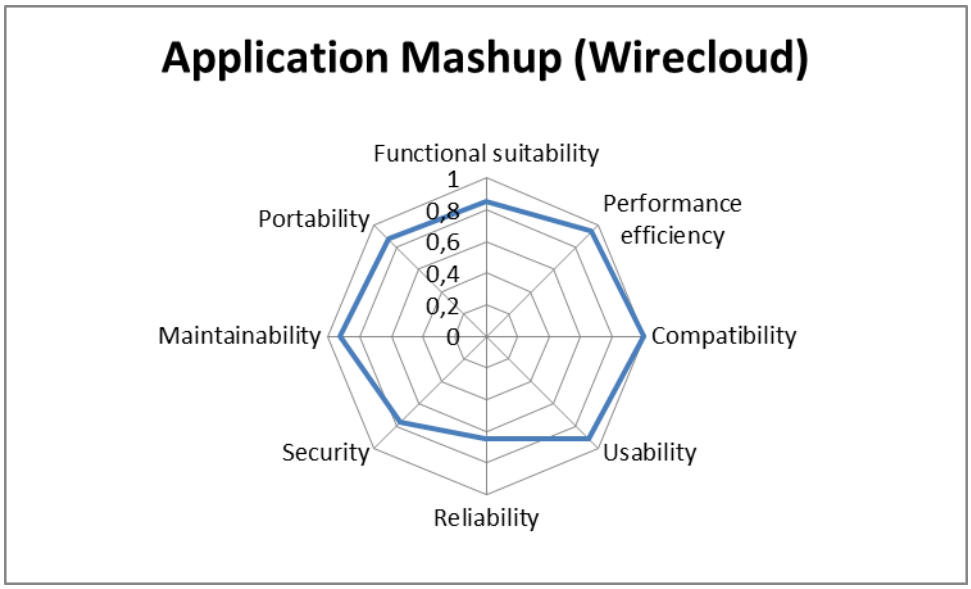


**Figure 13: Application Mashup (Wirecloud)GE Evaluation Result**

The current implementation of the GE is considered more than satisfactory, covering all the above requirements.

Figure 13 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.7 below.

## 4.8 Marketplace - UPM RI

The Marketplace GE is expected to be used as a hub allowing a user to register new and discover existing Store GE instances and resource offerings. The official documentation clearly states that it should expose also capabilities related to offerings, pricing schemes, reviews and ratings and, finally, recommendations. However, part of this functionality (including the capabilities relating to pricing etc.) has been moved to the Store GE specifications.

The documentation of the GE is considered inadequate, at least considering the extent of services it is supposed to provide; only a few of the services exposed by the GE were documented and the default installation process did not result in a fully working GE instance operation, although after a little tweaking it finally worked. These issues might be a result of the signs of abandonment that the GE has showed during the last 15 months, during which the code base has not been updated and the relevant issues recorded in the GE's github issue tracker were not commented by the GE owners. Recently, the GE owner was changed. The new owner was very quick to respond to emails but indicated the same problem; the GE was practically abandoned and development processes have been just restarted. It was also stated that the new versions of the GE would break compatibility with WStore and WireCloud; this would, however, greatly reduce the merit of adopting this GE.

Functionality-wise, this GE should offer the following:

- Allow for easy IDM integration to support AAA procedures
- Support for easy creation/management of new/existing offers
- Support for easy discovery of new and interesting offers
- Allow for easy WStore integration
- Support registering new offerings and demands,
- Support reviews and ratings,
- Offer recommendations to the users

A crucial deficiency of the current implementation of the Marketplace GE is the lack of IdM support; AAA options are only available as Spring security modules and are in no way connected to IdM. The rest of the requirements work as expected.

Figure 14 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.8 below.

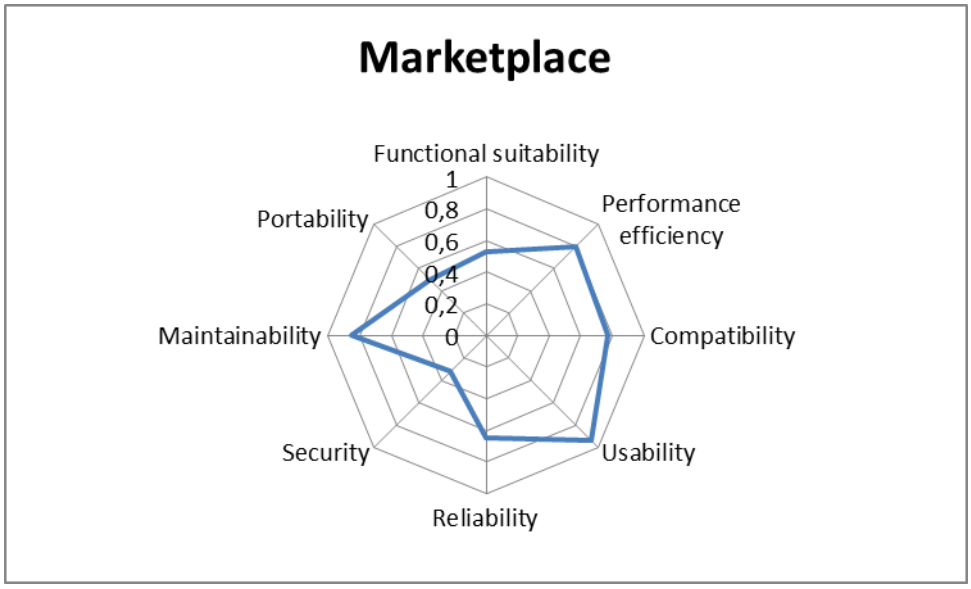


**Figure 14: Marketplace GE Evaluation Result**

## 4.9 Repository - UPM RI

The Repository GE is expected to act as a place to store USDL descriptions and media files for the GEs of the business framework (basically Store, Marketplace and Wirecloud). We were not able to successfully configure and use a private instance of the Repository GE, even though the documentation was easy to follow (the core application crashed with unhandled exceptions), but the global instance of it works flawlessly (it is already integrated with WStore public instance). The current GE owner answer the emails that were sent in order to let us know how to deal with these exceptions, but did not give any clear answer solving the problem. It should however be noted that the GE owner was only recently changed (same situation as with the Marketplace GE).

The requirements of this GE include:

- Allow for easy IDM integration to support AAA procedures,
- Allow for easy integration with WStore
- Support complex USDL service descriptions

Our experience with the global instance indicated that the latter two requirements are fulfilled. However, we are not sure about the first one, since the software architecture follows the same approach as the Marketplace one, where IDM support was absent**.**

Figure 15 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.9 below.

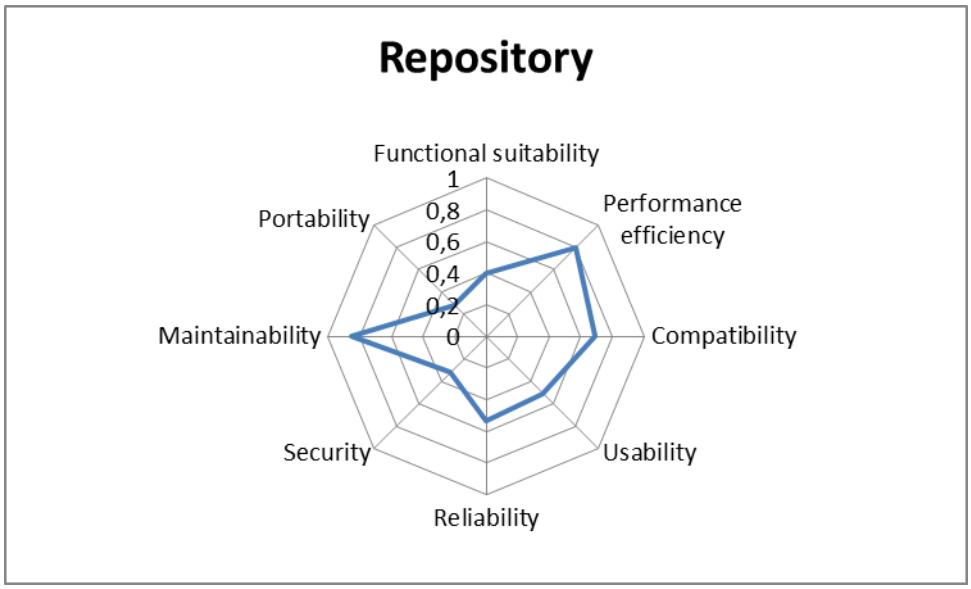


**Figure 15: Repository GE Evaluation Result**

## 4.10 Store – WStore

The role of this GE is to provide a place where FI-LAB users can buy and sell software resources within the FIWARE ecosystem. Although the official documentation clearly states that this GE is not meant to be instantiated by third parties and the global instances should be used, the GE owners have provided very detailed documentation on how to install and administer private GE instances. The installation procedure was performed in a step-wise manner and was very easy to follow, as were the configuration options documented. The code base is very frequently updated and the support from the developers is timely and to the point; the GE owner was contacted once and the response was not only available in a few minutes but was also very clarifying and thorough.

The basic requirements of the GE are the following:

- Support for charging/billing mechanisms
- Support for popular electronic wallet systems such as PayPal, Google Wallet etc.
- Easily integrate with IDM to take advantage of the AAA capabilities of the latter
- Integrate with WireCloud in order to facilitate code/module reuse among users of FIWARE ecosystem

The current implementation of the GE satisfies the aforementioned requirements.

Figure 16 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.10 below.

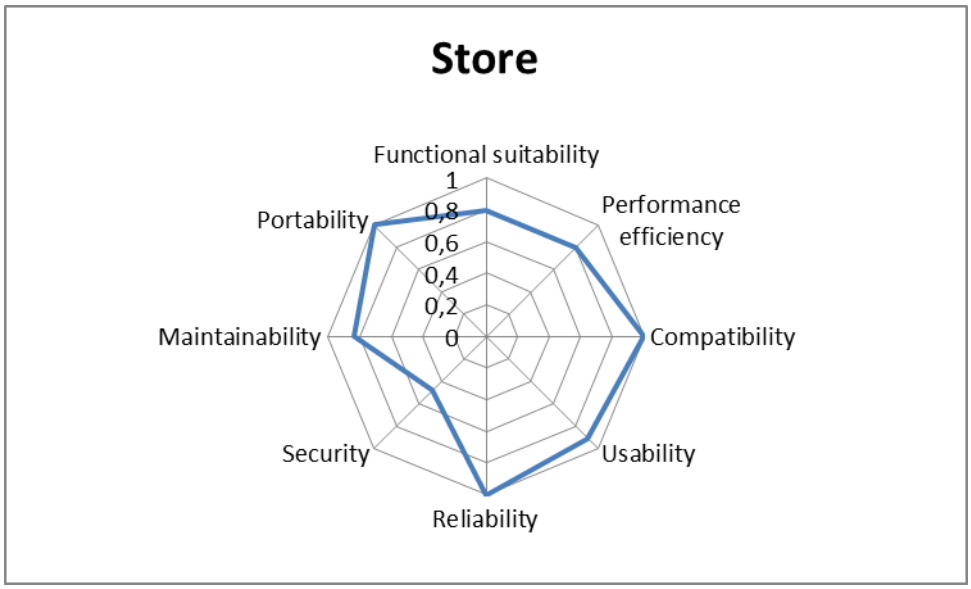


**Figure 16: Store GE Evaluation Result**

## 4.11 Backend Device Management – IDAS

The Backend Device Management GE works as expected. It receives the SensorML formatted data carrying the DLMS/COSEM objects (those acquired from the Landis+Gyr meters deployed at Terni trial site) and then forwards NGSI-compliant datasets to the Context Broker GE.

In the currently available implementation of the Backend Device management GE, the compatibility with the SensorML is limited to the Specifications “1.0.1”, while the standard has recently been evolved up to the “2.0” specifications. The Backend Device Management GE owner was asked to clarify the next steps of development, but there are no plans to deploy a version that is compatible with the SensorML 2.0.

Because of the implementation of the SensorML 1.0 only, the Backend Device Management GE translated the meter observation in too many calls dispatched to the Context Broker GE. In the experiment, the Backend Device Management GE received ten attributes to be updated and it then posted ten updates to the corresponding entity into the Context Broker GE. This has required a change in the IAM2IDAS software.

From a functionality point of view, this GE was required to:

- Receive data from sensors in “pull” modality
- Propagate the context updates to the Context Broker GE in the “push” modality

The overall experience deriving from the use of the Backend Device Management is positive and the requirements are covered. The debugging tools are limited only to a set of CURLs. During the verification and testing, there were no GUI tools that could be used.

Figure 17 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.12 below.

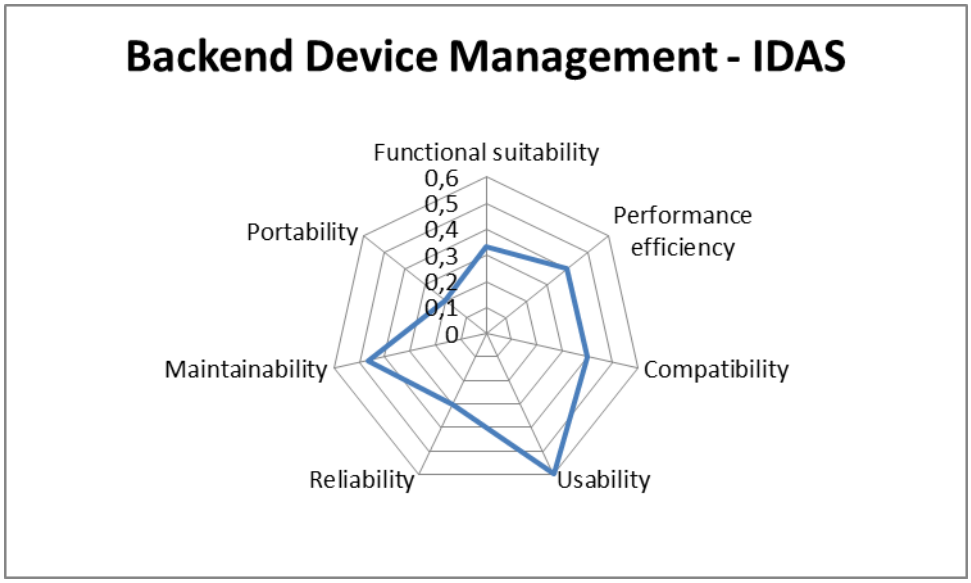


**Figure 17: Backend Device Management GE Evaluation Result**

## 4.12 Backend Configuration Manager - Orion Context Broker

The experience with Backend Configuration Management has been good. When we needed it, the support from the developer has been good. There have been frequent updates and there have been advance notice before each. The source code is Open Source and available on github. It is one of the best implementation of NGSI with correct binding of both XML and JSON. The documentation has been good for our usage as well as performance. The installation has been easy running it in FI-Lab (Spain region), the only issue has been stability but that might be due to the FI-LAB hardware restrictions (Spain region).

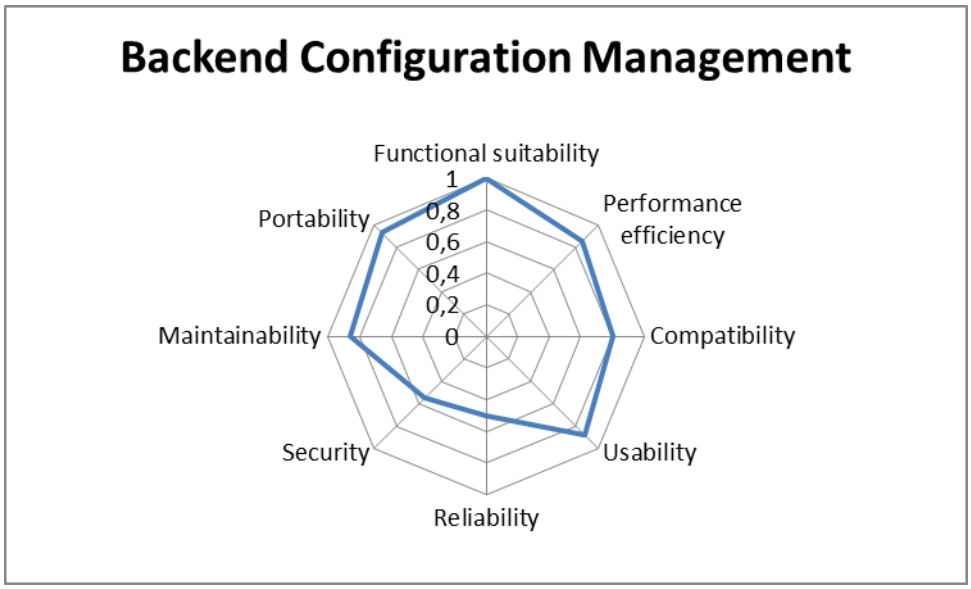


**Figure 18: Backend Configuration Management GE Evaluation Result**

Figure 18 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.14 below.

## 4.13 Gateway Data Handling GE - EspR4FastData

It has fulfilled all advertised functionality well. Its time behaviour of the GE met requirements. Used storage is low and utilization of CPU time good, even when applying high stress on the GE. No capacity constraints of the GE were met in the use case implementation.

The documentation have been good with scenarios with common use cases and the developer has provided SoapUI tests. However, the IoT chapter documentation is not consistent on how to achieve an integration as GEs are discontinued and overall structure has been changed. The contact person of the GE are very competent and helpful in this matter. For integration of the GE a very good installation guide, configuration tutorial and excessive documentation is available.

In one trial, it was not possible to get the GE running on the embedded device (a TechniColor box) together with ZPA.

The GE encounters no reliability or availability problems. It is easy to configure and the configuration can be automated via an external client and storing configuration files. However, configuration is not automatically recovered and the GE needs to be usually reset after a fault.

Confidentiality is guaranteed by defining dedicated Event Sink, which are the only entities to retrieve results. Integrity of the GE can be achieved by securing the hosting Tomcat with a SSL certificate. The GE builds upon the logging module log4j and hence can create sufficient logs if necessary. This can also be used to backtrace eventual faulty EventSinks. Authenticity of the GE can be achieved by securing the hosting Tomcat with a SSL certificate.

## 4.14 Backend IoT Broker - NEC

The experience with Backend IoT Broker (NEC) has been ok. The fact that it implements NGSI10 makes for a simplified integration with the Publish/Subscribe Context Broker GE The installation is easy, running it in FI-Lab, and it been tested with the other IoT GEs and the Publish/Subscribe Context Broker GE. The biggest problem is that the documentation has been limited: more specification of functionalities and user guides on these would be an improvement. It has not been part of a long-term test yet, so we have no thorough experience with stability or performance.

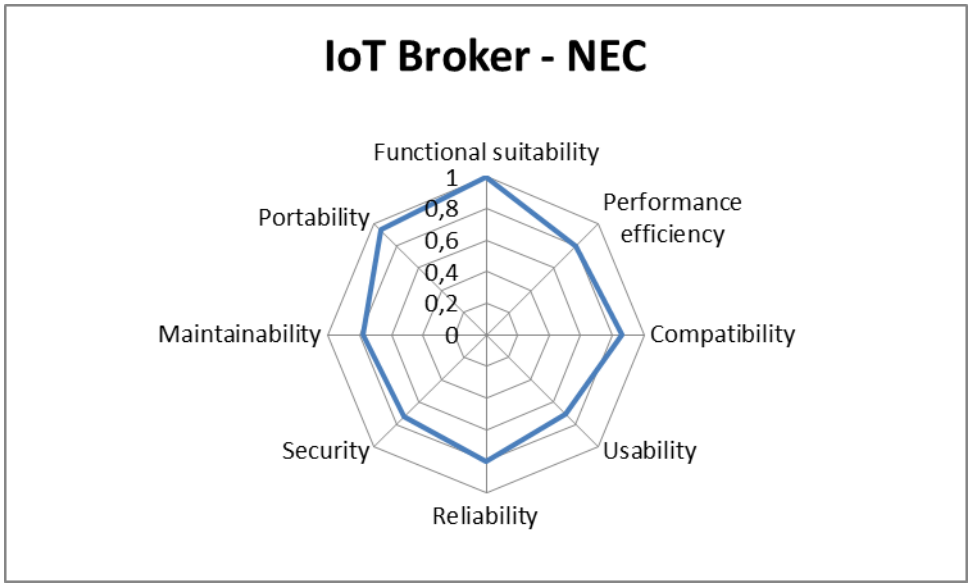


**Figure 19: IoT Broker GE Evaluation Result**

The security could be improved by additional and more extensive logging of users and actions. From our knowledge there does not appear to be a way to add additional security in the form of Oath or similar, this would be required for handling more sensitive data with high security demands.

Figure 19 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.13 below.

## 4.15 Authorization PDP – AuthZForce

The basic operations work well. We can extract the currently applied rule set, apply a new one and test the rules against different user credentials with correct results. It supports a hierarchical system of providing access control policies (usable, e.g., for expressing a user in a department and in an organization). The management interface is rudimentary, however, letting only the whole policy set to be updated at one time. The service is thus only suitable for unattended use such as through automated set-up.

The XACML standard specifies policy formatting for exactly such functionality. A recent update to the GEri has extended the support to the version 3.0 of the XACML, therefore the future usage will be more flexible with functionality enabling simpler writing of policies. Most of the security policies should also need only infrequent modifications, therefore the drawbacks of inefficient management are not so significant.

The PDP could additionally benefit from adding JSON support, which is missing but would provide communication with less overhead.

The ability to extend the current rule set with additional smaller rules is missing. The interface seems to support only adding a single policy set: when we upload a new one, the older is always overwritten even if the names and IDs of the sets differ.

The source code and binaries of the GE have been offered for download only recently, therefore we have not tested the installation process and all our work has been done on a public instance with our own tenant specified and protected with user certificates.

Figure 20 gives a per-category overview of the results of the formal GE evaluation. Details are given in Annex 3.15 below.

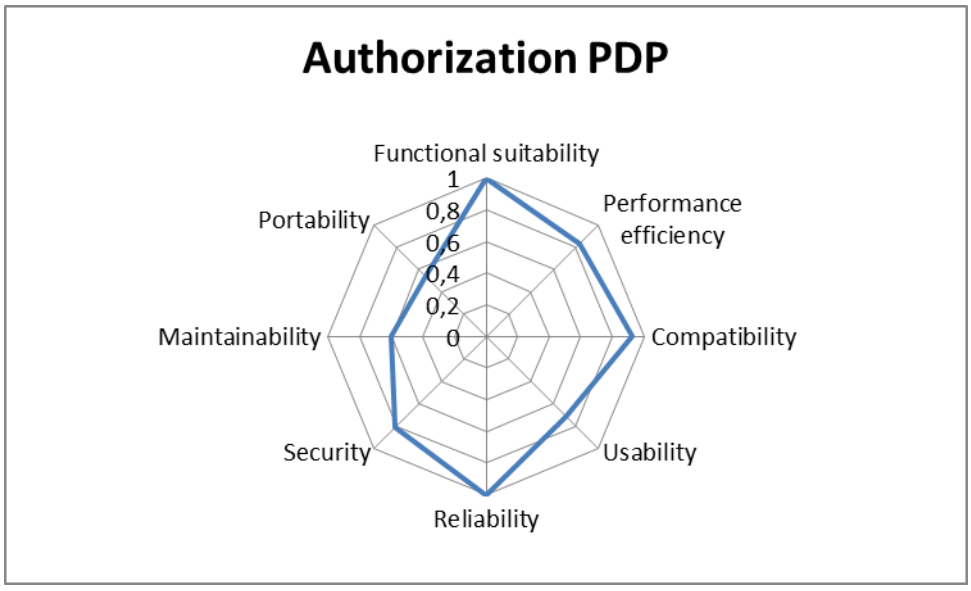


**Figure 20: Authorization PDP GE Evaluation Result**

## 4.16 Identity Management – KeyRock

The Identity Management GE works as expected. Designed to provide an OAuth2.0 AAA mechanism for all FIWARE-compatible resources, it is fast and integrates well with a large set of GEs available by the FIWARE platform. The service itself is very easy to use.

From a functionality point of view, this GE should be able to:

- Support OAuth2 AAA capabilities in order to be easily usable from third party applications
- Integrate easily with the rest of the Security Chapter GEs to form a more powerful security and accounting ecosystem of services
- Integrate easily with the maximum possible number of GEs available
- Offer SSO capabilities to avoid constant logins from the customers side

All these requirements are met by the present IdM implementation.

The API and the user interface are responsive and produce expected results, with the exception of role retrieval in organizations, which seems to be missing when requesting user information with his access token, although the global roles of the user are received in the response.

The biggest issue is the documentation, which is incomplete and inconsistent across the various sources (guides, GitHub, open specification), especially the API which lacks a structured overview with better examples. The web interface also seems to offer some other functionality (e.g. XACML role specification) that is not mentioned in documentation and therefore makes the GE look unfinished.

A desired additional feature is to support custom user attributes to be able limit access to a certain set of resources.

Figure 21 gives a per-category overview of the results of the formal GE evaluation, including comparison with the IdM GCP GEi. Details are given in Annex 3.16 below.

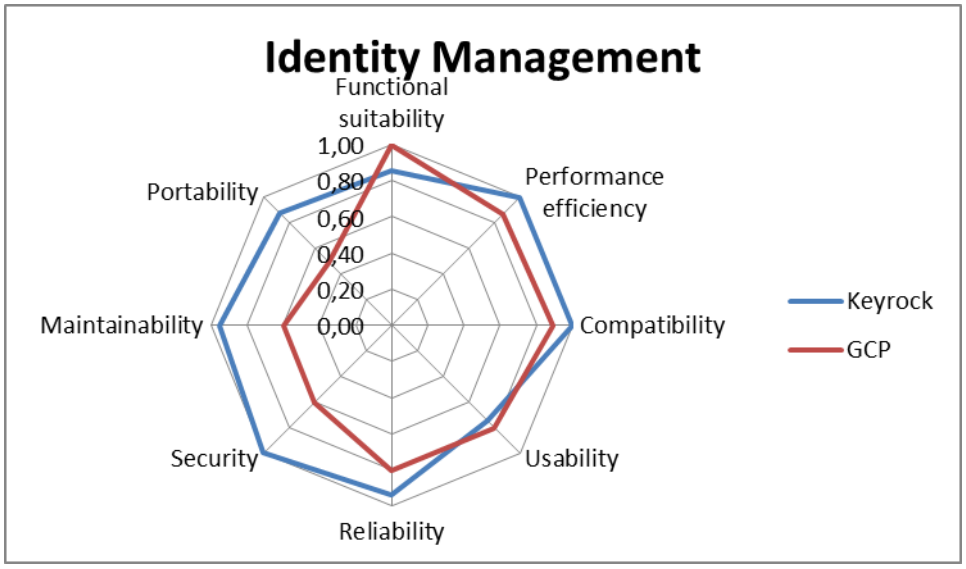


**Figure 21: Identity Management GE Evaluation Result**

## 4.17 PEP Proxy – Wilma

The GE PEP Proxy – Wilma provides a good basis for a proxy service to ensure that only authorised requests are sent to an application, based on the policy responses from the PDP when it checks the given user credentials against its stored security policies. However, the

current implementation is apparently still in its early stages, as it does not yet integrate the communication with the PDP. It basically only checks received access tokens with the IdM, which sends back user credentials if the token is valid. If it is, the PEP uses the received user attributes to add attribute headers to the received request and forwards the request to the protected service and then sends the reply back to the source of the request.

Even though communication with the PDP is not yet built in, we have modified the PEP source code for our purposes to also include this functionality. We have successfully integrated and tested this set up as a proxy to our application.

Given that the GE has only become available very recently, we have not yet had enough time to formally evaluate it like we have done for all the other GEs.

## 4.18 Comparison of GEs With Other Commercial Alternatives

This chapter presents a brief comparison between some FIWARE GEs and products available on the market offering the same functionality.

For each GE, we have divided this activity into two tasks:

- Selecting the “alternatives”; e.g. alternative products/services available on the market (either Open Source or COTS);
- Defining a series of extra-features that a user may consider "an advantage to gain" when comparing the FIWARE GEs to the “alternatives”.

### 4.18.1 Alternatives on the Market to FIWARE GEs

The “alternatives” have been identified among those offering the same functionalities/services as the ones provided by the FIWARE GEs.

The following table shows the results of this analysis:

| FIWARE GEs | “Alternatives” products/services |
|---|---|
| Cloud GEs | Cloud services from TELCO and IT companies (e.g. Amazon AWS, Google Cloud, Microsoft Azure) |
| COSMOS Big Data Analysis GE | Cloudera’s Hadoop, HortonWorks’s Hadoop, MapR’s Hadoop, EMC-spinoff PIVOTAL, IBM InfoSphere BigInsights |
| WIRECLOUD Application Mashup GE | Mashup[2] platforms such as:<br>iMashup, iGoogle, Apache Shindig, Apache Rave, Apache Wookie & Cordova |
| ORION Context Broker GE | Message Brokers - Distributed publish-subscribe Messaging System[3] such as:<br>Redis, RabbitMQ, Apache Kafka, Apache ActiveMQ, and Kestrel |
| PROTON Complex Event Processing GE | Event Processing Software[4] such as:<br>Oracle Event Processing, Tibco Streambase, Esper, Drools and IBM Infosphere |
| OBJECT STORAGE GE | Cloud storage products/services based on CDMI such as those listed in [5] |

[2]Mashup - http://en.wikipedia.org/wiki/Mashup_(web_application_hybrid)

[3]Apache Kafka - http://www.infoq.com/articles/apache-kafka
Exploring Message Brokers: RabbitMQ, Kafka, ActiveMQ, and Kestrel - http://java.dzone.com/articles/exploring-message-brokers
RabbitMQ vs Kafka - http://www.quora.com/RabbitMQ/RabbitMQ-vs-Kafka-which-one-for-durable-messaging-with-good-query-features

[4]An Overview of Event Processing Software - http://www.complexevents.com/2014/08/25/an-overview-of-event-processing-software/

[5]CDMI Server Implementations - http://www.snia.org/technology-communities/cloud-storage-initiative/snia-cloud-technology-community/list-cdmi-server-imp

| | |
|---|---|
| KEYROCK Identity Management GE | Different implementation of the OAuth2 standard[6] |
| IDAS (Backend) Device Management GE | IoT Device Management products such as: Oracle's Internet of Things platform, Axeda Ready M2M, Device Cloud by Etherion and Wind River® Intelligent Device Platform XT |

**Table 4 - FIWARE GEs vs. Alternative Products/Services**

### 4.18.2 Advantages of using FIWARE GEs compared to selected "Alternatives"

For filling in the following table we have used an approach which is based on defining a series of advantages that a user may consider appealing when choosing to go for a FIWARE GE instead of an alternative product/service available on the market (either Open Source or COTS).

| ADVANTAGES / GENERIC ENABLERS | Cloud GEs | COSMOS Big Data Analysis GE | WIRECLOUD Application Mashup GE | ORION Context Broker GE | PROTON Complex Event Processing GE | OBJECT STORAGE GE | KEYROCK Identity Management GE | IDAS (Backend) Device Management GE |
|---|---|---|---|---|---|---|---|---|
| free support (contact person available via email) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| no hardware to be purchased | ■ | ■ | | | | | | |
| free usage (no costs per hour / no licensing costs) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| cloud based (available as SaaS) + no hardware to be purchased + no installation activities to be carried forward (GE Global instance) | | ■ | | ■ | | ■ | | ■ |
| openness: no vendor lock in | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| no need of extreme hardware configuration | | ■ | | | | ■ | | ■ |
| comes with native integration with other GEs, thus being part of an entire ecosystem | | ■ | ■ | ■ | ■ | | ■ | ■ |
| cloud based: installable from image available on a catalogue (coming with a default configuration) on a cloud-based VM (GE private instance) | | | ■ | ■ | ■ | | | |
| natively integrated in the FIWARE cloud infrastructure | | | | | | ■ | ■ | |

**Table 5 - "Advantages" of using FIWARE GEs**

From the above table, a couple of considerations can be made:

- the key factor of choosing a GE would definitely be the availability of a contact person (the "GE owner") who can eventually help a user in sorting out issues during both set-up and operation;
- set-up an entire infrastructure would not imply costs of hardware, hosting and licensing in the context of FI-PPP programme;
- most of the GEs are natively integrated each with the other thus representing a Future Internet "ecosystem" through which data can be acquired, stored, processed/analysed and, finally, exposed;
- GEs are based on open standards and so can easily work in conjunction with other products both open source and COTS.

[6] OAuth open standard to authorization - http://en.wikipedia.org/wiki/OAuth

# 5. FINESCE Domain-Specific Enablers (DSEs)

This chapter outlines how the FINESCE DSEs have been selected and gives an overview of them. Further detailed information is available on http://www.finesce.eu/FINESCE_DSEs.html.

A DSE is an enabler, like a GE, but covers some re-usable functionality inside a domain, in FINESCE's case the Smart Energy domain[7]. That is, FINESCE DSEs are software components that are considered potentially useful to other developers in the Smart Energy domain. FINESCE DSEs consist of a reference implementation inside one of the trial sites and downloadable specifications and code. The structure of the DSE documentation follows that in the FIWARE Catalogue.

The FINESCE DSEs are miscellaneous Smart Energy components which have been developed in the context of the individual trials. They do not form a complete offering but are rather individual, stand-alone components which may be of use to developers in integrating GEs and developing Smart Energy applications. They constitute a small first step towards making a fuller, more complete set of such open source components.

FINESCE DSEs are made available under an Apache 2.0 license, with the exception of the Protocol Adapter AMM which has been released under the GPLv2 license because it depends on the Gurux GPLv2 library.

The DSEs which FINESCE is making available as DSEs are listed in Table 6. Currently a total of fifteen DSEs are planned.

| DSE Name | DSE Description |
|---|---|
| CSharp Component Composition Framework | Mediates various external device-related APIs to a trial-site internal format |
| Temporal Consistency | Pre-processing of large data sets for removing invalid values |
| Scene Manager | Define customised scenarios based on multiple parameters and get warning if a scenario happens |
| ODBC Event Sink (EvSi) | Local storage of shop floor events |
| Generation Schedule Manager | Makes schedule from forecast data and actual generation data |
| Production Schedule Manager | Makes schedule of possible variations of factory production schedules. |
| Contract Tailor Processor | Calculates a new contract for a specific customer based on an incentive plan (issued by a Retailer and approved by a Market Regulator Authority). |
| Social Events Interface (Social2Orion) | REST-based client send Social events data loaded from an external provider to an instance of ORION Context Broker GE |
| Weather Condition Interface (WeaFor2Orion) | Timer service that collects data from a weather forecasting service and sends them to to an instance of ORION Context Broker GE |
| Contract Information (ContractInformation2Orion) | REST service which allows clients (e.g. Retailers) to register data about cost of energy produced from the DERs, costs of transmission system and power plants, energy costs in an instance of ORION Context Broker GE. |
| Metering (Metering2Orion) | REST service which allow clients (e.g. DSOs) to register data about metering and load profile in a specific area into an instance of ORION Context Broker GE + a Java client which accepts data about metering and load profile coming from the smart meters (via either an IoT gateway or an existing legacy system) and then "passes" the data to the above mentioned REST service |
| Protocol Adapter AMM (Sensor2AMI) | Gathers Smart Meters information through DLMS/COSEM protocol and feeds it into an instance of IDAS (Backend) Device Management GE (which then sends it on to an instance of ORION Context Broker GE) |

[7] See The FIWARE Vision (http://forge.FIWARE.eu/plugins/mediawiki/wiki/fiware/index.php/Overall_FIWARE_Vision)

| DSE Name | DSE Description |
|---|---|
| Issue Detector Processor | Detects issues related to weather forecast, social events, consumption/production aggregated data, power losses and voltage drops |
| Hybrid Cloud Data Management: Storage Access | Storage Access: provides transparent access to the distributed local storage or cloud storage system Provides transparent access to the Hybrid Cloud (distributed local storage or cloud storage system) infrastructure.<br>Security Service: Provides data encryption functionalities, integrating Object Storage GE and Identity Management Keyrock GE |
| FINESCE API Mediator | Provides a single point-of-entry to the FINESCE trial infrastructures, exposing the FINESCE API specifications offered by each FINESCE trial. |

**Table 6: FINESCE DSEs**

FINESCE is also making available the specifications of some additional components which are also considered potentially useful for Smart Energy developers. The first is a documented GE integration process and the others are specifications of components which have been integrated in FINESCE trial sites. Further detailed information is available on http://www.finesce.eu/FINESCE_DSEs.html

| Component Name | Component Description |
|---|---|
| Integration Kit | Documented process including some examples for the established integrations within WP1 |
| Modbus Connector (ModConn) | Protocol Adapter from local shopfloor to Gateway Data Handling GE |
| Production Planning and Control System Integrator (PPSI) | Connecting factory planning systems to the cloud |
| Charging Optimisation | Optimisation of Electric Vehicle Charging |

**Table 7: Other FINESCE Components**

# 6. Conclusion

FINESCE has implemented different Smart Energy use cases which, taken together, broadly cover much of the Smart Energy domain, including electricity grids, city quarters, buildings, electric vehicles, factories and energy marketplaces. The purpose of FINESCE is to apply ICT, and particularly FIWARE technologies, to these use cases. At the time of writing, FINESCE is in its twenty-fourth month, the trial infrastructures have been largely completed (including the integration of GEs and DSEs). FINESCE's offering to FI-PPP Phase 3 participants consists of the FINESCE API, which exposes a set of services whereby users can access the live trial sites and the DSEs, which are available as open-source enablers.

In order to allow the way FINESCE is using GEs and DSEs to be understood, this report has given technical overviews of the individual trial sites' functional architectures and described how GEs and DSEs are being used there. This creates the background context within which the results of the GE evaluation and integration activity have been presented.

FINESCE has put substantial effort into GE selection and evaluation. Each individual trial site has its own particular use of GEs. However, the GEs used in FINESCE reflect that FINESCE trials are broadly concerned with securely gathering and processing data from equipment and sensors in buildings, grids and cars. The GEs that have been of most interest to FINESCE have come from the Data/Context Management, IoT and Security chapters. GEs from these chapters are being given an intensive field trial in FINESCE, and FINESCE has given continuous feedback on issues and improvement suggestions to the GE developers.

A formal evaluation method has been applied to the FIWARE Catalogue GEs which have been integrated. Requirements on the GEs have been defined by FINESCE and the GEs have been evaluated based on their fulfilment of these. Detailed comments on the performance of each GE in the individual categories have been made. The general conclusion of the evaluation is that the GEs have, in general, met FINESCE's requirements very well and have proven to be useful, largely dependable parts on the trial infrastructures.

The GEs have undergone continuous development during the period in which FINESCE has been trialling them, so that many GEs which FINESCE has worked with are no longer part of the Catalogue. This process of maturation of the GEs, although normal for a new technology, has meant that some GEs that FINESCE has put considerable effort into integrating have subsequently been dropped from FIWARE's offering. Such GEs have, in some cases, been retained in the trial sites and, in others, replaced by compatible new GEs. FINESCE considers that, in order to be attractive to third-party developers, FIWARE should strive to stabilise the Catalogue and adopt a transparent communications policy concerning upcoming changes to it.

In developing the trial sites, FINESCE has developed a number of Smart Energy components, which are published as open-source DSEs and can be freely made use of by developers. These are components from the trial sites which have been developed to help integrate the GEs towards trial site equipment or to perform particular Smart Energy domain-specific functions not already covered by GEs. The FINESCE DSEs are published as open-source code, free to be used by developers, who should contact the FINESCE owner for further information and support.

# 7. List of Abbreviations

| | |
|---|---|
| API | Application Programming Interface |
| BMS | Building Management System |
| COTS | Commercial off-the-shelf |
| DER | Distributed Energy Resources |
| DSE | Domain Specific Enabler |
| ERP | Enterprise Resource Planning |
| EVSE | Electrical Vehicle Supply Equipment |
| FI | Future Internet |
| GE | Generic Enabler |
| GEi | Generic Enabler Instantiation |
| HMS | Home Energy Management System |
| I2ND | Interfaces to the Network and Devices |
| IaaS | Infrastructure as a Service |
| ICT | Information and Communication Technology |
| IoT | Internet of Things |
| KPI | Key Performance Indicator |
| NGSI | Next Generation Services Interface |
| ODBC | Open Database Connectivity |
| OPST | Optical Packet Switch and Transport |
| PLC | Power Line Communications |
| PV | Photovoltaic |
| SME | Small and Medium-Sized Enterprises |
| VPP | Virtual Power Plant |
| VTN | Virtual Tenant Network |
| WP | Work Package |

# ANNEX 1 Formal GE Evaluation Criteria

The criteria used for the formal GE Evaluation, based on the ISO/IEC 25010:2011 specification are given in Table 8 below.

| Label | Category/Criteria | Category/Criteria Explanation |
|---|---|---|
| **1** | **Functional suitability** | degree to which enabler provides functions that meet stated and implied needs when used under specified conditions. |
| 1.1 | Functional completeness | degree to which the set of functions covers all the specified tasks and user objectives. |
| 1.2 | Functional correctness | degree to which enabler provides the correct results with the needed degree of precision. |
| 1.3 | Terms and Conditions | degree to which Terms and Conditions of usage of enabler fulfil Phase 2 and Phase 3 needs. E.g. is product available under Open Source conditions? |
| **2** | **Performance efficiency** | performance relative to the amount of resources used under stated conditions. Resources can include other software products, the software and hardware configuration of the system. |
| 2.1 | Time behaviour | degree to which the response and processing times and throughput rates of enabler, when performing its functions, meet requirements |
| 2.2 | Resource utilisation | degree to which the amounts and types of resources used by enabler, when performing its functions, meet requirements. |
| 2.3 | Capacity | degree to which the maximum limits of enabler meet requirements. Parameters can include the number of items that can be stored, the number of concurrent users, the communication bandwidth, throughput of transactions, and size of database, scalability. |
| **3** | **Compatibility** | degree to which enabler can exchange information with other enablers, systems or components, and/or perform its required functions, while sharing the same hardware or software environment. |
| 3.1 | Co-existence | degree to which enabler can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product. |
| 3.2 | Interoperability | degree to which enabler can exchange information with other enablers, systems, or components and use the information that has been exchanged |
| 3.3 | Standards compliance | degree of alignment with existing de-facto standards like REST, XML, JSON etc. |
| **4** | **Usability** | degree to which a enabler can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. |
| 4.1 | Appropriateness recognisability | degree to which users can recognise whether enabler is appropriate for their needs from initial impressions of the enabler and/or any demonstrations, tutorials, documentation. |
| 4.2 | Learnability | degree to which users can learn to use enabler with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use. Includes the availability of, and quality of, product documentation and training material. |
| 4.3 | Quality of Documentation | quality of the documentation. |
| 4.4 | Operability | degree to which enabler has attributes that make it easy to operate and control. |
| 4.5 | Support for Implementation | degree and quality of support provided to users implementing with the enabler. |
| **5** | **Reliability** | degree to which enabler performs specified functions under specified conditions for a specified period of time. |
| 5.1 | Maturity | degree to which enabler meets needs for reliability under normal operation. |
| 5.2 | Availability | degree to which enabler is operational and accessible when required for use. |

| Label | Category/Criteria | Category/Criteria Explanation |
|---|---|---|
| 5.3 | Fault tolerance | degree to which enabler operates as intended despite the presence of hardware or software faults |
| 5.4 | Recoverability | degree to which, in the event of an interruption or a failure, enabler can recover the data directly affected and re-establish the desired state of the system. |
| **6** | **Security** | degree to which enabler protects information and data so that persons or other products or systems have the degree of data access appropriate to their types and levels of authorisation. |
| 6.1 | Confidentiality | degree to which enabler ensures that data are accessible only to those authorised to have access. |
| 6.2 | Integrity | degree to which enabler prevents unauthorised access to, or modification of, computer programs or data |
| 6.3 | Non-repudiation | degree to which actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later. |
| 6.4 | Accountability | degree to which the actions of an entity can be traced uniquely to the entity. |
| 6.5 | Authenticity | degree to which the identity of a subject or resource can be proved to be the one claimed. |
| **7** | **Maintainability** | degree of effectiveness and efficiency with which enabler can be modified by the intended maintainers. Modifications can include corrections, improvements or adaptation of the software to changes in environment, and in requirements and functional specific |
| 7.1 | Modularity | degree to which enabler is composed of discrete components such that a change to one component has minimal impact on other components. |
| 7.2 | Reusability | degree to which enabler can be used in more than one system, or in building other systems or enablers. |
| 7.3 | Testability | degree of effectiveness and efficiency with which test criteria can be established for enabler and tests can be performed to determine whether those criteria have been met. |
| **8** | **Portability** | degree of effectiveness and efficiency with which enabler can be transferred from one hardware, software or other operational or usage environment to another. |
| 8.1 | Adaptability | degree to which enabler can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments. Adaptability includes the scalability of internal capacity. |
| 8.2 | Installability | degree of effectiveness and efficiency with which enabler can be successfully installed and/or uninstalled in a specified environment. E.g. can the product be downloaded and installed locally? |
| 8.3 | Replaceability | degree to which enabler can replace another version of the enabler for the same purpose in the same environment. Replaceability of a new version of a software product is important to the user when upgrading. |

**Table 8: Formal GE Evaluation Criteria**

# ANNEX 2 Statistics of GE Evaluation Results

This chapter gives an overview of the WP's GE evaluation results and plans for using GEs. The total number of GE instantiations (GEis) that have been evaluated is 188. This includes many GEis which are not in the current Catalogue anymore, or never were included in it. Those GEis which were experimented with by at least one WP are shown in Table 9 below.

In the first column the name of the GEi is given.

The second column gives the GEi name and the GEi owner: for several GEs, there is more than one implementation (GEi). In some cases, the GEi assessment was made before the GEi was entered in the FIWARE Catalogue and, subsequently, no GEi was entered in the Catalogue: these GEis are marked with "None" in the second column.

The other columns give the current evaluation result for each WP (and for the individual trial sites WPs 2, 3, 5). The meaning of the entries is as follows:

- a blank means that the WP did not evaluate the GEi;
- "N" means that the GEi was evaluated but it was neither experimented with nor taken into consideration in the trial design;
- the codes "E", "U" and "D" are the same as those used in the FI-PPP GE Cockpit and mean that the GE is under evaluation or has already been included in the trial infrastructure:
    - WP has already integrated the GEi into its trial infrastructure ("D")
    - WP has already taken the GEi into consideration in its trial infrastructure design ("U")
    - WP plans to experiment with it and consider it based on results ("E")

The progression between these codes is from "E" to "U" and finally to "D". If a GEi does not progress from "E" or "U" to "D", but is discarded, then this is indicated by "EX" or "UX", respectively.

In Table 9, the number of GEis per-trial in each of the states "E", "U" and "D" is shown, giving an overview of the GEs that are under evaluation, included in the trial design or already integrated into the trial infrastructures. All trial sites (except WP5 Stream 2) have already integrated GEis.

Table 9 shows that forty seven different instantiations of different GE implementations have already been integrated into trial sites, that an additional three such different instantiations are included in the trial designs but not yet integrated and that an additional seven such instantiations are still being considered for inclusion in the trial design.

Many of the GEis have been evaluated separately by more than one WP. Just considering the GEis in statuses "E", "U" or "D"; there is a total of ninety two instances of thirty four different GEis in these statuses, i.e. thirty four different GEis have reached at least status "U" and, counting that some of them are being used by several trial sites, there are ninety two such instances.

| FIWARE GEs | GEi Name | WP1 | WP2 Horsens | WP2 Madrid | WP3 Factory | WP3 VPP | WP3 Other | WP4 | WP5 Str.1 | WP5 Str .2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cloud Chapter | | | | | | | | | | |
| IaaS Data Center Resource Mgmt. | - | N | | | | | | D | N | EX |
| Self Service Interfaces | Cloud Portal | N | | | | | | D | N | |
| Object Storage | - | N | | | EX | EX | | D | N | U |
| Monitoring | - TID | | | | | | | D | N | N |
| Data/Context Management Chapter | | | | | | | | | | |
| Publish/Subscribe Broker | Orion Context Broker | D | D | D | D | D | 2D | D | N | |
| Complex Event Processing (CEP) | IBM (PROTON) | EX | | | D | D | | D | U | N |
| BigData Analysis | COSMOS | D | E | D | D | | E | D | N | |
| Publish/Subscribe Broker | Context Awareness Platform | N | | D | N | | | | N | N |
| Apps Chapter | | | | | | | | | | |
| Application Mashup | WireCloud | N | | | D | | D | D | N | |
| Store | WStore | | | | | | | D | | |
| Marketplace | UPM | | | | | | | D | | |
| Repository | UPM | | | | | | | D | | |
| IoT Chapter | | | | | | | | | | |
| (Backend) Device Management | IDAS DCA - TID | EX | E | | | | | D | N | |
| (Backend) IoT Broker | IoT Broker – NEC | D | D | | | | | EX | N | |
| (Backend) Configuration Management | Orion Context Broker | EX | D | | | | | UX | | |
| (Backend) Configuration Management | IoT Discovery - UNIS | N | | | | | | UX | N | |
| (Gateway) Data Handling | EspR4FastData | N | D | | D | | | UX | N | |
| (Gateway) Device Management | OPENMTC | N | EX | | | | | EX | | |
| (Gateway) Protocol Adapter | ZPA | N | D | | N | | | UX | N | |
| (Backend) Template Handler | Template Handler | | | | | | | EX | | |
| (Gateway) Device Management | Ericsson IoT Gateway | N | | | EX | | | EX | N | |
| (Gateway) Data Handling | SOL-CEP | N | | | | | | UX | | |
| Security Chapter | | | | | | | | | | |
| Identity Management | KeyRock | D | | E | | E | D | D | | U |
| AccessControl | Thales | | EX | | | EX | UX | EX | N | N |
| Authorization PDP | / AuthZForce | D | | | | E | D | | | |
| PEP Proxy | / Wilma | D | | | | | 2D | | | |
| Privacy | - / | N | | | | | | EX | EX | N |
| Identity Management | GCP | N | D | UX | | | | | D | N |
| Identity Management | One-IDM | EX | | | | | | | N | N |
| Data Handling | PPL | N | | EX | | | | UX | D | N |
| DB Anonimyzer | DBA | N | EX | | | | | UX | D | |
| Content-based Security | CBS | N | | | | | | EX | D | U |
| I2ND Chapter | | | | | | | | | | |
| Cloud Proxy a.k.a. Cloud Edge | CloudProxy | N | EX | | N | | | EX | UX | EX |
| (I2ND) Network Information and Control (NetIC) | Altoclient | | | | | | | | N | EX |
| Total Evaluated | 68 different GEis evaluated | 32 | 13 | 7 | 13 | 6 | 10 | 28 | 58 | 21 |
| Considered but discarded “EX” | 25 | 4 | 4 | 1 | 2 | 2 | 0 | 8 | 1 | 3 |
| Under consideration "E" | 14 | 0 | 2 | 1 | 2 | 2 | 2 | 0 | 0 | 0 |
| Was in design but then discarded, "UX" | 10 | 0 | 0 | 1 | 0 | 0 | 1 | 7 | 1 | 0 |
| In design "U" | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Integrated "D" | 47 | 6 | 6 | 3 | 5 | 2 | 7 | 13 | 5 | 0 |
| Total in status “E”, ”EX”, “U”, “UX” or “D | 92 instances of GEis / 34 individual GEis | 10 | 12 | 6 | 7 | 6 | 10 | 28 | 7 | 6 |

**Table 9: Overview of GE Evaluation**

| FIWARE GE Chapter | Number of "E" or “EX” | Number of "U" or “UX” | Number of "D" |
|---|---|---|---|
| Cloud | 3 | 1 | 4 |
| Data/Context Management | 3 | 0 | 17 |
| Apps | 1 | 0 | 6 |
| IoT | 9 | 5 | 7 |
| Security | 12 | 6 | 13 |
| I2ND | 4 | 1 | 0 |
| | 32 | 13 | 47 |

**Table 10:- GEis Integration Status per FIWARE Chapter**

Table 10 shows the FIWARE chapters which have been of most interest to the FINESCE WPs. Most of the integrated GEis come from the Data/Context Management, IoT and Security chapters. A lot of GEis from the IoT and Security chapters have been considered for inclusion in the trial designs but have not progressed beyond status “E”, indicating that these GEis were not considered useful. The Security and IoT chapters also contain the most GEis that have been included in the trial design but not yet integrated (“U”), which is a further indication of the importance of these chapters for FINESCE.

# ANNEX 3 Detailed Results of Formal GE Evaluations

The GEs have been evaluated according to the criteria listed in Table 8 of ANNEX 1 above.

Each criterion is given a weighting factor ("WF") between 1 (lowest) and 5 (highest) according to its perceived importance: The GE is evaluated by entering a score S (5 = Outstanding, 4 = Good, 3 = Satisfactory, 2 = Poor, 1 = Unsatisfactory) per criterion, which is multiplied by WF to give the weighted score per criterion. Then all the per-criterion scores are added up to give an overall score in % of the possible maximum score. Criteria which are not applicable for a given GE are left out of the evaluation.

FINESCE's requirements on the GE are stated per criterion of Table 8 of ANNEX 1 above. Comments are given on how well the requirements were met.

## 3.1 "Cloud GEs" (IaaS Data Center Resource Management and Self-service Interfaces - Cloud Portal (UPM)

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Manage access to VMs (organizations, users)<br>R1.1.2 create a VM<br>R1.1.3 manage VM configuration (Operating System (IMAGES), RAM + disk space (FLAVORS))<br>R1.1.4 manage IP for a VM (associate, disassociate, release)<br>R1.1.5 manage security for a VM (enabling ports for TCP/UDP, create or import keypair)<br>R1.1.6 connect to VM display<br>R1.1.7 view VM logs<br>R1.1.8 monitoring a VM<br>R1.1.9 manage an existing VM (Pause, unpause, suspend, resume, reboot, terminate)<br>R1.1.10 manage snapshots (create a snapshot for a VM, edit/launch/delete a snapshot image) | 5 | 5 | 25 | R1.1.1 covered<br>R1.1.2 covered<br>R1.1.3 covered<br>R1.1.4 covered<br>R1.1.5 covered<br>R1.1.6 covered<br>R1.1.7 covered<br>R1.1.8 covered<br>R1.1.9 covered<br>R1.1.10 covered |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3<br>R1.2.4 accomplishing R1.1.4<br>R1.2.5 accomplishing R1.1.5<br>R1.2.6 accomplishing R1.1.6<br>R1.2.7 accomplishing R1.1.7<br>R1.2.8 accomplishing R1.1.8<br>R1.2.9 accomplishing R1.1.9<br>R1.2.10 accomplishing R1.1.10 | 5 | 3 | 15 | R1.1.1 working<br>R1.1.2 working<br>R1.1.3 working<br>R1.1.4 working<br>R1.1.5 working<br>R1.1.6 not working on any VM<br>R1.1.7 not working on any VM<br>R1.1.8 not working<br>R1.1.9 working<br>R1.1.10 sometimes not working |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2. Product does not need to be | 5 | 5 | 25 | GE is open source and does not need to be installed at user's premise |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | installed at user's premise | | | | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Response times when accessing a VM (for either administration or operation) are reasonable<br>R2.1.2 Processing times when launching services deployed on VMs are reasonable | 5 | 4 | 20 | Both response times when accessing a VM and processing times when launching services (deployed on VMs) have sometimes been not reasonable. |
| 2.2 | | | | | |
| 2.3 | R2.3.1 VM disk partition quota can be enlarged<br>R2.3.2 Applications deployed on VMs keeps stability when number of concurrent users grows<br>R2.3.3 No limits at the number of VMs that can be created | 5 | 4 | 20 | Disk quota has been sometimes exceeded in ORION VMs due to large amount of logs and could not be enlarged; applications are stable even when services deployed are invoked by different clients; no limit on number of VMs that can be created in the FINESCE WP4 cloud region |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 3 | 5 | 15 | R4.1.1 covered |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 3 | 4 | 12 | R4.1.1 covered (not all the functionalities are well explained in the Users and Programming Guide (e.g. managing security) |
| 4.3 | R4.3.1 Documentation is satisfactory | 5 | 4 | 20 | R4.3.1 covered (although some parts of it should be enhanced) |
| 4.4 | R4.4.1 Availability of a tool which alerts when VMs are shutdown or not working | 3 | 3 | 9 | R4.4.1 The tool exists (R1.1.8) but it does not seem to be working |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 4 | 20 | R4.5.1 covered (although there have been times when support took a lot of time to reply to questions) |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 Enabler(s) is reliable under normal operation conditions | 5 | 3 | 15 | A lot of unexpected shutdowns happened in the last six months without having been informed (what about a bulletin?) |
| 5.2 | R5.2.1 Enabler(s) is operational and accessible 24X7 | 5 | 3 | 15 | A lot of unexpected shutdowns happened in the last six months without having been informed (what about a bulletin?) |
| 5.4 | R5.4.1 VMs are recovered after failures | 5 | 5 | 25 | After shutdowns, VMs are completely restored |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Access to VMs and related services are granted under authentication<br>R6.1.2 Roles and privileges of users are governed with an authorization process | 5 | 5 | 25 | R6.1.1 covered<br>R6.1.2 covered |
| 6.2 | R6.2.1 Unauthorized users cannot use services offered by the enabler(s)<br>R6.2.2 Application users should not access cloud functionalities (assigned to administration users) | 5 | 3 | 15 | R6.2.1 Unauthorized users cannot use services offered by the enabler(s)<br>R6.2.2 not covered |
| 6.3 | R6.3.1 History of actions performed by users should be available in the form of a "user tracking" panel | 3 | 0 | 0 | Panel not available |
| | **Total Score** | | | **276** | out of |
| | | | | **360** | = 76,67% |

## 3.2 Monitoring GE - TID Implementation

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | 5 | 10 | 65 | |
| 1.1 | R1.1.1 Implement a monitoring platform for all the | 5 | 5 | 25 | R1.1.1 covered (although provided by |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | VMs of a FI-Lab cloud region<br>R1.1.2 Implement a monitoring platform for both DSEs and custom software modules deployed on a FI-Lab cloud VM<br>R1.1.3 Monitoring data need to be forwarded to ORION (as NGSI-compliant entities)<br>R1.1.4 Monitoring platform authentication is needed | | | | NAGIOS, which is a component to be installed as a pre-requisite<br>R1.1.2 covered (although provided by NAGIOS, which is a component to be installed as a pre-requisite<br>R1.1.3 covered<br>R1.1.4 covered (although provided by NAGIOS, which is a component to be installed as a pre-requisite) |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3<br>R1.2.4 accomplishing R1.1.4 | 5 | 3 | 15 | R1.1.1 working (but too tricky to be set up)<br>R1.1.2 working (but too tricky to be set up)<br>R1.1.3 working<br>R1.1.4 working |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2. Product does not need to be installed at user's premise | 5 | 5 | 25 | GE is open source and does not need to be installed at user's premise |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region) | 3 | 3 | 9 | R3.1.1 partially covered (it works only with NAGIOS 3.4.1, although NAGIOS latest version is 4.0.8)<br>R31.2 covered |
| 3.2 | R3.2.1 Integration with ORION GE | 5 | 5 | 25 | R3.2.1 covered |
| 3.3 | R3.3.1 Monitoring operation activities to be performed by using REST methods | 3 | 0 | 0 | R3.3.1 not covered |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 3 | 0 | 0 | R4.1.1 not covered (the documentation skips the installation of required components such as NAGIOS or Zabbix which is very tedious and error prone) |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 3 | 0 | 0 | R4.2.1 not covered (the documentation skips the installation of required components such as NAGIOS or Zabbix which is very tedious and error prone) |
| 4.3 | R4.3.1 Documentation is satisfactory | 5 | 0 | 0 | R4.3.1 it should be massively enhanced (installing pre-requisites components is skipped whilst it should not as it is not trivial; the documentation never mentions to install NAGIOS 3.4.1 instead of the latest 4.0.8) |
| 4.4 | R4.4.1 Availability of Event Broker module logs<br>R4.1.2 Availability of NGSI Adapter logs | 3 | 2,5 | 7,5 | R4.4.1 not covered<br>R4.4.2 covered |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 5 | 25 | R4.5.1 covered |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Access to underlying monitoring platform (such as NAGIOS) are granted under authentication<br>R6.1.2 Roles and privileges of users are governed with an authorization process | 5 | 5 | 25 | R6.1.1 covered<br>R6.1.2 covered |
| 6.2 | R6.2.1 Unauthorized users cannot use services offered by the underlying monitoring platform | 5 | 5 | 25 | R6.2.1 Unauthorized users cannot use services offered by the enabler(s) |
| **8** | **Portability** | | | | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 5 | 25 | R8.2.1 covered |
| | **Total Score** | | | **207** | |
| | | | | out of | |
| | | | | **300** | |
| | | | | 68,8% | |

## 3.3 Object Storage GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | 5 | | 75 | |
| 1.1 | | 5 | 5 | 25 | |
| 1.2 | | 5 | 5 | 25 | |
| 1.3 | | 5 | 5 | 25 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | | 5 | 4 | 20 | |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | | 5 | 5 | 25 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3 | 3 | 9 | The installation of Object Storage GE necessitates the installation of the whole Openstack ecosystem, which could be a huge waste of resources, especially when only a plain Cloud Storage service is required and not a complete Cloud Management Platform. |
| 3.2 | | 4 | 5 | 20 | |
| 3.3 | | 5 | 5 | 25 | |
| **4** | **Usability** | | | | |
| 4.1 | | 4 | 5 | 20 | |
| 4.2 | | 4 | 4 | 16 | |
| 4.3 | | 4 | 4 | 16 | The installation guide points to the Openstack installation guides which are too generic (granted that they refer to a generic cloud management platform). |
| 4.4 | | 4 | 4 | 16 | |
| 4.5 | | 4 | 3 | 12 | There was no need to interact with the FIWARE representatives, but the documentation is Openstack Swift oriented so when we faced a problem we referred to Swift guides. However, this should not be the case; FIWARE GEs documentation guides and tutorials should be standalone, not referring to third parties. |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 4 | 20 | |
| 5.2 | | 5 | 4 | 20 | |
| 5.3 | | 5 | 4 | 20 | |
| 5.4 | | 5 | 5 | 25 | |
| **6** | **Security** | | | | |
| 6.1 | | 5 | 5 | 25 | |
| 6.2 | | 5 | 5 | 25 | |
| 6.3 | | 5 | 5 | 25 | |
| 6.4 | | 5 | 5 | 25 | |
| 6.5 | | 5 | 5 | 25 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 4 | 4 | 16 | |
| 7.2 | | 5 | 5 | 25 | |
| 7.3 | | 5 | 5 | 25 | |
| **8** | **Portability** | | | | |
| 8.1 | | 5 | 4 | 20 | |
| 8.2 | | 4 | 3 | 12 | The installation of the GE is particularly complicated, granted that a successful installation & configuration of Openstack is required. The installation guidelines also redirect to Openstack manuals. A standalone installation would be, for sure, preferred for those who do not know how or do not want to install Openstack to just get a Storage service |
| 8.3 | | 4 | 4 | 16 | |
| | | | | | |
| | **Total Score** | | | **590** | |
| | | | | out of | |
| | | | | **660** | |
| | | | | 89,4% | |

## 3.4 Big Data Analysis GE - Cosmos

The first table below gives the evaluation results for the Cosmos GE. The second table gives the scores for two commercial alternatives: Hortonworks and Big Query.

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | * R1.1.1 The GE shall support Storm, Sparq or equivalent (for near/real-time processing)<br>* R1.1.2 The GE shall support custom made implementations on top of YARN<br>* R1.1.3 The GE shall support custom map / reduce jobs (with custom code / libraries added)<br>* R1.1.4 The GE shall support R<br>* R1.1.5 The GE shall support Scalding<br>* R1.1.6 The GE shall support Hive (with "Stinger")<br>* R1.1.7 The GE shall support Hbase<br>* R1.1.8 The GE shall support Zookeeper custom integration<br>* R1.1.9 The GE shall support UDF:s in Hive<br>* R1.1.10 The GE shall support Pig<br>* R1.1.11 The GE shall support Drill or equivalent for incorporating other data sources in query<br>* R1.1.12 The GE shall support Custom Serialization Formats<br>* R1.1.13 The GE shall support Oozie Workflows<br>* R1.1.14 The GE shall support Replication Configuration<br>* R1.1.15 The GE shall support Resource Manager Configuration<br>* R1.1.16 The GE shall support Job monitoring<br>* R1.1.17 The GE shall support data injection and delivery through web services<br>* R1.1.18 The GE shall support performing periodical sets of analysis on injected data<br>* R1.1.19 The GE shall support the export of data analysis results to external databases | 5,00 | 5 | 25,0 | |
| 1.2 | * R1.2.1 For realtime scenarios it shall support updates under 1 second | 4,33 | 3 | 13,0 | |
| 1.3 | * R1.3.1 The GE shall be available as Open Source.<br>* R1.3.2 The GE shall have a commercial support option | 4,67 | 5 | 23,3 | BigQuery is not available under Open Source License |
| **2** | **Performance efficiency** | | | | |
| 2.1 | * R2.1.1 The GE shall at all times respond within 1s. | 4,33 | 3 | 13,0 | The score achieved by Cosmos GE in terms of performance efficiency, and more specifically with regard to time behaviour, can be considered adequate, although not outstanding. In fact, when performing comparisons with BigQuery alternative, this proved to be slightly faster. |
| 2.2 | * R2.2.1 The GE shall provide enough resources for the users to perform the GE's functions without overhead or loss of data<br>* R2.2.2 The resource utilization shall be configurable per job basis | 5,00 | 4 | 20,0 | |
| 2.3 | *R2.3.1 The GE shall provide enough storage and bandwidth to support usage in a business environment.<br>* R2.3.2 The GE shall have a graphical interface / rest API to grow and shrink the capacity in runtime | 3,67 | 2 | 7,3 | In terms of capacity Cosmos GE also lagged behind BigQuery, as it showed higher latencies |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | * R2.3.3 The GE shall provide a low latency TLS based connection for fast interaction<br>* R2.3.4 The GE shall provide online incremental backup and restore for at least 1 TB of data | | | | |
| **3** | **Compatibility** | | | | |
| 3.1 | * R3.1.1 The GE shall be able to co-exist as a part of a larger integrated architecture, without having negative impact on any other part. | 3,67 | 5 | 18,3 | |
| 3.2 | * R3.2.1 The GE shall easily and with a minimum of manual configuration be interoperable with any other GE the users want to integrate with.<br>* R3.2.2 The GE shall support a standard REST API | 4,00 | 5 | 20,0 | |
| 3.3 | * R3.3.2 The GE shall follow pre-existing standards rather than creating its own | 2,33 | 5 | 11,7 | |
| **4** | **Usability** | | | | |
| 4.1 | * R4.1.1 The GE shall have enough documentation for users to easily see if the GE suits their needs. The documentation must be up-to-date and complete. | 5,00 | 5 | 25,0 | |
| 4.2 | * R4.2.1 The GE shall have enough documentation of how it can be used most efficiently and safely. The documentation must be up-to-date and complete. | 5,00 | 5 | 25,0 | |
| 4.3 | * R4.3.1 The GE documentation must cover all functionalities provided including required configurations and usage. The documentation must be up-to-date and complete. | 5,00 | 4 | 20,0 | |
| 4.4 | * R4.4.1 The GE shall provide an intuitive interface for reducing the configuration overhead of the entities created in it. | 5,00 | 2 | 10,0 | There is room for improvement in Cosmos in order to improve its usability, as it lacks an adequate interface for reducing the configuration overhead. This means that many configurations have to be done manually and directly into the machine instances created in the cluster |
| 4.5 | * R4.5.1 The support contact must be easy to find and accomplish, and provide help within 1h. | 5,00 | 3 | 15,0 | |
| **5** | **Reliability** | | | | |
| 5.1 | * R5.1.1 The GE shall provide a consistent level of bandwidth, processing speed, etc. at all times. | 5,00 | 3 | 15,0 | |
| 5.2 | *R5.2.1 The GE shall be available and operational for use at all times. | 5,00 | 2 | 10,0 | BigQuery Service commits to an uptime percentage higher than 99.9%, which is higher than the uptimes observed with the Cosmos instance |
| 5.3 | * R5.3.1 The GE shall remain available and operational with consistent level of bandwidth, processing speed, etc., making hardware or software faults unnoticed by users. | 5,00 | 2 | 10,0 | Hardware faults have been frequently noticed during Big Data - Cosmos evaluation period |
| 5.4 | * R5.4.1 Should a failure occur, the GE shall provide a way to recover data and state. | 4,33 | 2 | 8,7 | After failures it has been frequently impossible to recover the normal work state, needing the support from the Cosmos development team. |
| **6** | **Security** | | | | |
| 6.1 | * R6.1.1 The GE shall implement a strict and secure authorization policy, ensuring that data is only available to those who need access to the specific data. This should be realized with e.g. encryption | 5,00 | 5 | 25,0 | |
| 6.2 | * R6.2.1 The GE shall implement a strict and secure authorization policy, ensuring that unauthorized users lack access to read/write.<br>'* R6.2.2 The GE shall support standard authentication methods for client applications (e.g. OAuth2). | 5,00 | 5 | 25,0 | |
| 6.3 | * R6.3.1 The GE shall perform logging of users | 3,33 | 5 | 16,7 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | and actions taken. | | | | |
| 6.4 | * R6.4.1 The GE shall perform logging of users and actions taken. | 3,33 | 5 | 16,7 | |
| 6.5 | * R6.5.1 The GE shall provide a secure authentication process. | 5,00 | 5 | 25,0 | |
| **7** | **Maintainability** | | | | |
| 7.1 | * R.7.1.1 The GE shall have a modular internal structure, in order to minimize the impact of changes on the data injection/extraction operations from external applications. | 3,00 | 3 | 9,0 | |
| 7.2 | * R.7.2.1 The GE shall provide the possibility to integrate in several different system architectures. | 2,67 | 4 | 10,7 | |
| **8** | **Portability** | | | | |
| 8.1 | * R8.1.1 The GE shall be able to run efficiently in several different system architectures, regardless of hardware or software differences. | 2,67 | 5 | 13,3 | |
| 8.2 | * R8.2.1 The GE shall be easily downloadable and installable locally. | 4,33 | 2 | 8,7 | The installation process has been complex due to the necessity of repeating a several configuration steps for each of the machine instances running in the cluster |
| 8.3 | * R8.3.1. The GE shall be easy to upgrade to a newer version and require a minimum of manual configuration of the user. | 5,00 | 5 | 25,0 | |
| | | | | | |
| | **Total Score** | | | **465** | |
| | | | | out of | |
| | | | | **603** | |
| | | | | 77,1% | |

The following table gives the scores for two commercial Big Data Analysis alternatives: Hortonworks and Big Query. The “Specific FINESCE Requirements” texts and the “Comments” column from the above table apply here also, but are left out for space reasons.

| | | | Hortonworks | | Big Query | |
|---|---|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** | **S** | **WF*S** |
| **1** | **Functional suitability** | | | | | |
| 1.1 | | 5,00 | 4 | 20,0 | 5 | 25,0 |
| 1.2 | | 4,33 | 5 | 21,7 | 5 | 21,7 |
| 1.3 | | 4,67 | 5 | 23,3 | 3 | 14,0 |
| **2** | **Performance efficiency** | | | | | |
| 2.1 | | 4,33 | 5 | 21,7 | 5 | 21,7 |
| 2.2 | | 5,00 | 4 | 20,0 | 4 | 20,0 |
| 2.3 | | 3,67 | 5 | 18,3 | 4 | 14,7 |
| **3** | **Compatibility** | | | | | |
| 3.1 | | 3,67 | 4 | 14,7 | 5 | 18,3 |
| 3.2 | | 4,00 | 2 | 8,0 | 3 | 12,0 |
| 3.3 | | 2,33 | 5 | 11,7 | 5 | 11,7 |
| **4** | **Usability** | | | | | |
| 4.1 | | 5,00 | 5 | 25,0 | 5 | 25,0 |
| 4.2 | | 5,00 | 5 | 25,0 | 5 | 25,0 |
| 4.3 | | 5,00 | 5 | 25,0 | 5 | 25,0 |
| 4.4 | | 5,00 | 4 | 20,0 | 5 | 25,0 |
| 4.5 | | 5,00 | 4 | 20,0 | 4 | 20,0 |
| **5** | **Reliability** | | | | | |
| 5.1 | | 5,00 | 4 | 20,0 | 5 | 25,0 |
| 5.2 | | 5,00 | 4 | 20,0 | 4 | 20,0 |
| 5.3 | | 5,00 | 4 | 20,0 | 4 | 20,0 |
| 5.4 | | 4,33 | 5 | 21,7 | 5 | 21,7 |
| **6** | **Security** | | | | | |

| | | | Hortonworks | | Big Query | |
|---|---|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** | **S** | **WF*S** |
| 6.1 | | 5,00 | 3 | 15,0 | 4 | 20,0 |
| 6.2 | | 5,00 | 4 | 20,0 | 5 | 25,0 |
| 6.3 | | 3,33 | 3 | 10,0 | 4 | 13,3 |
| 6.4 | | 3,33 | 4 | 13,3 | 3 | 10,0 |
| 6.5 | | 5,00 | 4 | 20,0 | 3 | 15,0 |
| **7** | **Maintainability** | | | | | |
| 7.1 | | 3,00 | 4 | 12,0 | 3 | 9,0 |
| 7.2 | | 2,67 | 4 | 10,7 | 4 | 10,7 |
| 7.3 | | 1,00 | 5 | 5,0 | | 0,0 |
| **8** | **Portability** | | | | | |
| 8.1 | | 2,67 | 4 | 10,7 | 4 | 10,7 |
| 8.2 | | 4,33 | 4 | 17,3 | 3 | 13,0 |
| 8.3 | | 5,00 | 4 | 20,0 | 4 | 20,0 |
| | | | | | | |
| | **Total Score** | | | **510** | | **512** |
| | | | | out of | | out of |
| | | | | **608** | | **603** |
| | | | | 83,8% | | 84,9% |

## 3.5 Complex Event Processing GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE can handle events with a unique ID, a timestamp and additional information about the class and type of the event<br>R1.1.2 Users can create event input streams by providing an interface to other systems<br>R1.1.3 Input events can be processed in different formats using a flexible structure by defining single fields of a REST and XML format and mapping them to event attributes needed for the rules<br>R1.1.4 Users can define event output streams by defining receivers in terms of other systems<br>R1.1.5 Several output receivers can be defined for one rule for a complex event<br>R1.1.6 Output events can be defined in REST and XML<br>R1.1.7 Output events can be stored in a database<br>R1.1.8 Users can define complex events by defining rules for the combination of (input) events through a temporal correlation<br>R1.1.9 Users can define complex events by defining rules for the combination of (input) events through a logical e.g. sequential correlation<br>R1.1.10 Users can define complex events by defining more complex rules through the combination of other rules<br>R1.1.11 Rules for complex event definition can be reused | 5,00 | 5 | 25,0 | |
| 1.2 | R1.2.1 Rules are processed correctly | 5,00 | 5 | 25,0 | |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2 Product is available for download<br>R1.3.3.Download is easily accessible<br>R1.3.4 An instance is available to use | 4,75 | 5 | 23,8 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Requests on test implementation are completed in expected time | 5,00 | 3 | 15,0 | It is occasionally very slow (almost inaccessible after sending some events to the instance) - which to be sure are not the network problems since two |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | instances are used for testing. |
| 2.2 | | 4,00 | 5 | 20,0 | |
| 2.3 | R2.3.1 Large amounts of event inputs can be captured and processed with rules (5000+ events per second)<br>R2.3.2 Several rules (100+) can be stored in the GE and be monitored in parallel | 5,00 | 3 | 15,0 | tested sending 8 events every minutes, after some time it became very very slow |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3,33 | 4 | 13,3 | |
| 3.2 | R3.2.1 Remote applications can perform requests<br>R3.2.2 Remote applications receive decisions | 4,25 | 5 | 21,3 | tested: can send events to Pub/sub context broker |
| 3.3 | R3.3.1 Support for JSON<br>R3.3.2 Includes RESTful API | 4,25 | 5 | 21,3 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 Quickly recognizable functionality<br>R4.1.2 Available demonstrations for testing<br>R4.1.3 Available documentation on functionality<br>R4.1.4 Available tutorials | 5,00 | 5 | 25,0 | |
| 4.2 | R4.2.1 Clear and understandable user interface for definition of event rules | 4,75 | 4 | 19,0 | If a cep definition is changed, it is difficult to make the change effective. Sometimes by rebooting of the instance. |
| 4.3 | R4.3.1 Usage learnable from the supplied documentation<br>R4.3.2 Text is written well enough to understand<br>R4.3.3 Short time from start to usage | 4,50 | 4 | 18,0 | |
| 4.4 | R4.4.1 Input event definition can be done easily<br>R4.4.2 Output event definition can be done easily<br>R4.4.3 Ease of tutorial execution | 3,75 | 4 | 15,0 | |
| 4.5 | R4.5.1 Support is responsive<br>R4.5.2 Support is comprehensive | 4,75 | 5 | 23,8 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 Requests always receive responses | 4,75 | 4 | 19,0 | |
| 5.2 | R5.2.1 Instance is always available on regular usage<br>R5.2.2 Instance is normally available even after a long time | 5,00 | 3 | 15,0 | don't know whether an instance is available, but sometime it is not accessible. |
| 5.3 | R5.3.1 Mal-formed input events throw an exception<br>R5.3.2 Exceptions are given as feedback to input event providers<br>R5.3.3 Exceptions are accessible in an error log | 4,50 | 3 | 13,5 | the feedback is too general to be helpful |
| 5.4 | R5.4.1 Short times of unavailability do not affect state of data | 3,25 | 5 | 16,3 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 4,50 | 5 | 22,5 | |
| 7.2 | | 4,50 | 5 | 22,5 | |
| 7.3 | R7.3.1 A set of tests can be specified to test common usage patterns<br>R7.3.2 A set of tests is defined in the documentation<br>R7.3.3 A set of tests is available to download | 2,00 | 4 | 8,0 | The provided examples are difficult to manage to get results. There could be more complex examples. |
| **8** | **Portability** | | | | |
| 8.1 | | 3,00 | 5 | 15,0 | cloud hosted solution offers good installability and integration into existing architecture |
| 8.2 | | 4,00 | 5 | 20,0 | |
| 8.3 | R8.3.1 API does not change or is backward compatible<br>R8.3.2 API has all functionality expected in the future | 3,75 | 4 | 15,0 | |
| | **Total Score** | | | **447** | |
| | | | | out of | |
| | | | | **513** | |
| | | | | 87,2% | |

## 3.6 Publish / Subscribe Context Broker GE

The first table below gives the evaluation results for the Orion GE. The second table gives the scores for two commercial alternatives: Redis and Scalaris.

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE shall support all synchronous NGSI10 operations (query, update)<br>R1.1.2 The GE shall support all asynchronous NGSI10 operations (subscribe, updateContextSubscription, unsubscribe)<br>R1.1.3 The GE shall support the "duration" option in the subscribe requests.<br>R1.1.4 The GE shall support the "throttling" option in the subscribe requests.<br>R1.1.5 The GE shall support "attributeList" option in the subscribe requests.<br>R1.1.6 The GE shall support "notifyConditions" options of type "ONTIMEINTERVAL" and "ONCHANGE" in the subscribe requests.<br>R1.1.7 The GE shall shall be able to communicate through ASMX and WCF web services<br>R1.1.8 The GE shall be able to handle different types of data variables (int, float, string…)<br>R1.1.9 The GE shall be able to compare all types of attributes<br>R1.1.10 The GE shall be able to compare attributes from different entities<br>R1.1.11 The GE shall be able to manage alerts according to conditions that are defined based on attribute values<br>R1.1.12 The GE shall support variable data sending frequencies for the different attributes through the update of subsets of attributes.<br>R1.1.13 The GE shall support filtered retrieval of entities, values<br>R1.1.14 The GE shall store time stamps of updates<br>R1.1.15 The GE shall support expiration of data values<br>R1.1.16 The GE shall support both push and pull of data.<br>R1.1.17 The GE shall support JSON<br>R1.1.18 The GE shall support REST<br>R1.1.19 The GE shall support optional secure access of the REST API<br>R1.1.20 The GE shall support changing of active subscriptions<br>R1.1.21 The GE shall support asynchronous / synchronous operation<br>R1.1.22 The GE shall support Reliability – e.g. Retransmission & Queueing<br>R1.1.23 The GE shall support Native Integrations with Other GEs (Score per GE integration / Quality – functional completeness) | 5 | 5,0 | 25,0 | R1.1.1, R1.1.2: Redis and Scalaris do not support NGSI, but offer equivalent alternatives.<br>R1.1.3: Scalaris does not support timeouts of subscriptions. Redis cancels subscriptions on disconnect.<br>R1.1.4: Redis and Scalaris do not support throttled subscriptions.<br>R1.1.5: Scalaris only allows direct subscriptions to keys.<br>R1.1.6: Redis and Scalaris do not support intervalled subscriptions.<br>R1.1.11: WP3 does not require this functionality, even if it is missing.<br>R1.1.13: Redis supports this through filtered retrieval of key lists, while Scalaris does not support such retrieval.<br>R1.1.14: While it is not natively supported by Orion, it is possible to attach metadata to attributes. A similar solution can be achieved with Redis and Scalaris.<br>R1.1.15: Scalaris does not support expiration of entries.<br>R1.1.17, R1.1.18: Redis does not offer a web interface, but can be expanded with a web service, e.g. Webdis (http://webd.is/)<br>R1.1.19: None of the evaluated implementations support secure access, although Redis supports basic password authentication for clients and Orion supports HTTPS since v0.12.0. |
| 1.2 | R1.2.1 The GE shall ensure that queries are replied correctly.<br>R1.2.2 The GE shall ensure that updates are delivered correctly.<br>R1.2.3 The GE shall ensure that new entities are registered correctly. | 5 | 5,0 | 25,0 | R1.2.7. This requirement does not apply to Scalaris, as it does not offer value expirations.<br>R1.2.6 and R1.2.7: Since timestamps and expiration date are provided as metadata per attribute and not actually handled by Orion, R1.2.6 and R1.2.7 are somehow fullfilled, even |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | R1.2.4 The GE shall always notify subscribers about changes.<br>R1.2.5 The GE shall correctly filter retrieved lists.<br>R1.2.6 The GE shall store time stamps of updates.<br>R1.2.7 The values stored by the GE shall expire after a determined time.<br>R1.2.8 Subscription notifications shall be correctly triggered.<br>R1.2.9 The GE shall support updates every second.<br>R1.2.10 For realtime scenarios it shall support updates under 50 milliseconds | | | | if not directly by Orion. |
| 1.3 | R1.3.1 The GE shall be open source.<br>R1.3.2 The GE shall be available for download.<br>R1.3.3 The GE shall have an easily accessible download.<br>R1.3.4 An instance of the GE shall be available to use.<br>R1.3.5 The GE shall have a commercial support option | 4 | 5,0 | 21,3 | R1.3.4. Scalaris does not have a public instance, although this is less important than other requirements under this category. Redis has a tutorial instance available. |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall not introduce a delay larger than 100ms (not counting network latency) when an entity changes and the subscription is of type "ONTIMEINTERVAL".<br>R2.1.2 The GE shall not introduce a delay larger than 500ms (not counting network latency) when an entity changes and the subscription is of type "ONTIMEINTERVAL". | 4 | 3,0 | 13,0 | R2.1.1: We could not achieve this with Orion in our tests. |
| 2.2 | R2.2.1 The GE shall work properly on expected hardware<br>R2.2.2 The GE shall provide enough resources for the users to perform the GE's functions without overhead or loss of data<br>R2.2.3 The resource utilization shall be configurable per job basis | 4 | 4,0 | 17,0 | R2.2.1: There is no handling of data types other than strings in Orion. The client needs to properly (de)serialize the data for correct exchange of the attribute values. The 'type' property of attribute is arbitrary, therefore it is up to the clients to interpret the values in a proper format. Redis also supports only strings, but adds support for sets, lists, hashes and incrementation of integer strings. |
| 2.3 | R2.3.1 The GE shall be able to handle a throughput of 100+ updates to entities per second<br>R2.3.2 The GE shall be able to handle a throughput of 1000+ updates to entities per second<br>R2.3.3 The GE shall be able to handle 10000+ entities with each 50+ attributes.<br>R2.3.4 Regular updates shall be possible regardless of the number of entities<br>R2.3.5 Several concurrent users shall be possible<br>R2.3.6 The GE shall provide enough storage and bandwidth to support usage in a business environment.<br>R2.3.7 The GE shall have a graphical interface / rest API to grow and shrink the capacity in runtime<br>R2.3.8 The GE shall support local cluster as well as a DC to DC replication within cluster including “locality awareness”<br>R2.3.9 The GE shall provide a low latency TLS based connection for fast interaction<br>R2.3.10 The GE shall provide online incremental backup and restore for at least 1 TB of data | 5 | 4,0 | 20,0 | R2.3.2: With Orion, we could not achieve more than 300 updates per second in ideal conditions of our set-up. Scalaris offers comparable performance judging by online benchmark, but offers almost linear scalability with multiple servers.<br>R2.3.7, R2.3.8: None of the implementations offers a GUI, but Scalaris does offer an API to scale in runtime and Redis also provides a similar procedure.<br>R2.3.10: Backups are only possible through database replication for all three implementations.<br>R2.3: On our test system (RWTH ACS) we could not achieve more than 50 updates per second (20 entities with 5 attributes) in ideal conditions (physical machine, local network). |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 The GE shall operate in a virtual machine as expected<br>R3.1.2 The GE shall operate as a service that can coexist with others on same system | 4 | 5,0 | 21,3 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | R3.1.3 The GE shall be able to co-exist as a part of a larger integrated architecture, without causing negative effects on any other part. | | | | |
| 3.2 | R3.2.1 The GE shall be able to communicate through NGSI10 with the IoT Broker GE.<br>R3.2.2 The GE shall be able to communicate with Java client applications<br>R3.2.3 The GE shall be able to communicate with ASMX and WCF Web Services<br>R3.2.4 The GE shall be able to store its database on another system<br>R3.2.5 The GE shall support remote registrations, updates and subscriptions<br>R3.2.6 The GE shall easily and with a minimum of manual configuration be interoperable with any other GE the users want to integrate with. | 4 | 5,0 | 17,5 | R3.2.1, R3.2.6: Redis and Scalaris do not support NGSI, therefore they do not offer a direct connection with some FIWARE GEs. In addition, Redis does not by itself offer a web interface. |
| 3.3 | R3.3.1 The GE shall support the NGSI-9 standard<br>R3.3.2 The GE shall support the NGSI-10 standard<br>R3.3.3 The GE shall support JSON<br>R3.3.4 The GE shall support XML<br>R3.3.5 The GE shall include a RESTful API | 5 | 5,0 | 23,8 | R3.3.1, R3.3.2: Redis and Scalaris do not support NGSI or XML or a RESTful API, although Redis can be interfaced with a lot of third-party services, while Scalaris offers a JSON API. |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1. Quickly recognizable functionality<br>R4.1.2. Available demonstrations for testing<br>R4.1.3. Available documentation on functionality<br>R4.1.4. Available tutorials | 5 | 5,0 | 22,5 | R4.1.2, R4.1.4: Scalaris does not offer tutorials or demonstrations in its otherwise comprehensive documentation. |
| 4.2 | R4.2.1. API is well designed to be quickly used by programmers<br>R4.2.2. Tutorials are easy to understand | 5 | 5,0 | 22,5 | Scalaris does not offer tutorials in its documentation. |
| 4.3 | R4.3.1 The GE must provide comprehensive documentation for all implemented NGSI operations.<br>R4.3.2 The GE must provide comprehensive documentation for all startup options.<br>R4.3.3 The GE shall allow being operated exclusively with the help of the documentation guide, with no need for support from the GE owner/development team<br>R4.3.4 The documentation of the GE shall be structured well<br>R4.3.5 The GE shall have a short time from start to usage | 5 | 5,0 | 23,8 | Without a tutorial, Scalaris is not as easy to start with as the other two implementations. |
| 4.4 | R4.4.1 The GE shall not require extra background processes to continue normal execution (e.g. keeping subscriptions alive).<br>R4.4.2 The API of the GE shall be simple to use<br>R4.4.3 The tutorial for the GE shall be easy to execute | 5 | 5,0 | 25,0 | R4.4.1: The subscriptions expire by design, but the duration of them is configurable upon subscription request. At WP3 (FPL) we did not have a problem with this functionality, even if we had to implement our own keep-alive service. |
| 4.5 | R4.5.1 The GE's support shall be responsive<br>R4.5.2 The GE's support shall be comprehensive<br>R4.5.3 A support issue database shall be available with common issues and solutions | 4 | 5,0 | 20,0 | Scalaris does not have a very active community. |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall always provide expected responses as specified in NGSI10<br>R5.1.2 The GE shall always provide expected responses as specified in NGSI9<br>R5.1.3 The GE shall provide meaningful error messages when overloaded or otherwise unable to complete requests<br>R5.1.4 The GE data will be persistent and remain correctly stored even after prolonged usage<br>R5.1.5 Subscribers to events shall always receive | 5 | 5,0 | 25,0 | R5.1.1, R5.1.2: Even though Redis and Scalaris do not support NGSI, they offer adequate performance for the available standards. |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | updates on changes | | | | |
| 5.2 | R5.2.1 The GE must be able to run without interruptions for an extended period of time (>1 month)<br>R5.2.2 The GE shall remain reliably accessible under heavier load<br>R5.2.3 The GE shall be available and operational for use at all times. | 5 | 5,0 | 25,0 | |
| 5.3 | R5.3.1 The GE must not delete or corrupt any data as a result of faults or errors.<br>R5.3.2 The GE must remain operational despite incorrect usage of the API<br>R5.3.2 The GE must remain operational despite attempts to store corrupted data | 5 | 4,8 | 21,6 | R5.3: There were some crashes in some cases e.g. Calling URLs containing space characters. |
| 5.4 | R5.4.1 The GE shall be able to continue after a restart due to a fault or watchdog reset<br>R5.4.2 The GE shall be able to recover data in the event of an interruption and all subscriptions shall be kept alive | 5 | 5,0 | 25,0 | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 The GE shall support authorization of requests.<br>R6.1.2 The GE shall support authentication through the KeyRock Identity Management GE | 4 | 4,0 | 17,3 | The Orion GE does not have any built-in capability of authentication and authorization. The security relies on a specialised service used in front of the GE itself. The Orion developers provide a PEP Proxy for this purpose. The two alternative implementations also mostly rely on external protection, although Redis has a built-in password protection option. |
| 6.2 | R6.2.1 The GE shall implement a strict and secure authorization policy, ensuring that unauthorized users lack access to read/write. | 5 | 4,0 | 18,0 | The Orion GE does not have any built-in capability of authentication and authorization. The security relies on a specialised service used in front of the GE itself. The Orion developers provide a PEP Proxy for this purpose. The two alternative implementations also mostly rely on external protection, although Redis has a built-in password protection option. |
| 6.3 | R6.3.1 The GE shall perform logging of users and actions taken. | 2 | 5,0 | 10,0 | We have not extensively examined the logging, but all three implementation offer logging at various levels. |
| 6.4 | R6.4.1 The GE shall perform logging of users and actions taken. | 3 | 5,0 | 12,5 | We have not extensively examined the logging, but all three implementation offer logging at various levels. |
| 6.5 | R6.5.1 The GE shall provide a secure authentication process. | 5 | 4,0 | 20,0 | The Orion GE does not have any built-in capability of authentication and authorization. The security relies on a specialised service used in front of the GE itself. The Orion developers provide a PEP Proxy for this purpose. The two alternative implementations also mostly rely on external protection, although Redis has a built-in password protection option. |
| **7** | **Maintainability** | | | | |
| 7.2 | R7.2.1 The GE shall provide the possibility to integrate in several different system architectures. | 4 | 3,0 | 12,0 | A CentOS or RedHat operating system is required for Orion. While Redis and Scalaris are also limited to Unix based systems by default, a Windows port for Redis is maintained by Microsoft and an unofficial Windows installation is available for Scalaris also. |
| 7.3 | R7.3.2 The GE should provide end to end test for ensuring correct setup and deployment. | 3 | 5,0 | 16,3 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **8** | **Portability** | | | | |
| 8.1 | R8.1.1 The GE shall support a way to expand the storage capacity of its database without losing data.<br>R8.2.1 The GE shall be able to run efficiently in several different system architectures, regardless of hardware or software differences. | 4 | 5,0 | 20,0 | |
| 8.2 | R8.2.1 The GE shall be installable locally as a component in a system.<br>R8.2.2 The operation of the GE shall not require remotely installed components. | 5 | 5,0 | 25,0 | |
| 8.3 | R8.3.1 The GE shall be backwards compatible such that previous versions of the IoT Broker GE can communicate with it.<br>R8.3.2 The API of the GE shall remain operational in its original form even if adding new features.<br>R8.3.3 The GE shall be easy to upgrade to a newer version and require a minimum of manual configuration of the user. | 5 | 5,0 | 23,8 | |
| | | | | | |
| | **Total Score** | | | **568,9** | |
| | | | | out of | |
| | | | | **609,6** | |
| | | | | 93,33% | |

The following table gives the scores for two commercial Big Data Analysis alternatives: Redis and Scalaris. The "Specific FINESCE Requirements" texts and the "Comments" column from the above table apply here also, but are left out for space reasons.

| | | | Redis | | Scalaris | |
|---|---|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** | **S** | **WF*S** |
| **1** | **Functional suitability** | | | | | |
| 1.1 | | 5,00 | 4 | 20,0 | 3 | 15,0 |
| 1.2 | | 4,33 | 5 | 25,0 | 5 | 25,0 |
| 1.3 | | 4,67 | 5 | 21,3 | 4 | 17,0 |
| **2** | **Performance efficiency** | | | | | |
| 2.1 | | 4,33 | | 0,0 | | 0,0 |
| 2.2 | | 5,00 | 5 | 21,3 | 5 | 21,3 |
| 2.3 | | 3,67 | 5 | 25,0 | 5 | 25,0 |
| **3** | **Compatibility** | | | | | |
| 3.1 | | 3,67 | 5 | 21,3 | 5 | 21,3 |
| 3.2 | | 4,00 | 3 | 10,5 | 4 | 14,0 |
| 3.3 | | 2,33 | 2 | 9,5 | 2 | 9,5 |
| **4** | **Usability** | | | | | |
| 4.1 | | 5,00 | 5 | 22,5 | 3 | 13,5 |
| 4.2 | | 5,00 | 5 | 22,5 | 3 | 13,5 |
| 4.3 | | 5,00 | 5 | 23,8 | 4 | 19,0 |
| 4.4 | | 5,00 | 5 | 25,0 | 4 | 20,0 |
| 4.5 | | 5,00 | 5 | 20,0 | 4 | 16,0 |
| **5** | **Reliability** | | | | | |
| 5.1 | | 5,00 | 5 | 25,0 | 5 | 25,0 |
| 5.2 | | 5,00 | 5 | 25,0 | 5 | 25,0 |
| 5.3 | | 5,00 | 5 | 22,5 | 5 | 22,5 |
| 5.4 | | 4,33 | 5 | 25,0 | 5 | 25,0 |
| **6** | **Security** | | | | | |
| 6.1 | | 5,00 | 4 | 17,3 | 3 | 13,0 |
| 6.2 | | 5,00 | 4 | 18,0 | 3 | 13,5 |
| 6.3 | | 3,33 | 5 | 10,0 | 5 | 10,0 |
| 6.4 | | 3,33 | 5 | 12,5 | 5 | 12,5 |
| 6.5 | | 5,00 | 4 | 20,0 | 3 | 15,0 |

| | | | Redis | | Scalaris | |
|---|---|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** | **S** | **WF*S** |
| **7** | **Maintainability** | | | | | |
| 7.1 | | 3,00 | | 0,0 | | 0,0 |
| 7.2 | | 2,67 | 4 | 16,0 | 4 | 16,0 |
| 7.3 | | 1,00 | 5 | 16,3 | 5 | 16,3 |
| **8** | **Portability** | | | | | |
| 8.1 | | 2,67 | 5 | 20,0 | 5 | 20,0 |
| 8.2 | | 4,33 | 5 | 25,0 | 5 | 25,0 |
| 8.3 | | 5,00 | 5 | 23,8 | 5 | 23,8 |
| | | | | | | |
| | **Total Score** | | | **544** | | **493** |
| | | | | out of | | out of |
| | | | | **588** | | **588** |
| | | | | 92,5% | | 83,8% |

## 3.7 Application Mashup GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | 5 | 10 | 65 | |
| 1.1 | R1.1.1. Functionality 1: Insertion of widgets into mashup page<br>R1.1.2. Functionality 2: Programmability of custom widgets<br>R1.1.3. Functionality 3: Configurability of data flow between widgets<br>R1.1.4. Functionality 4: Automatic data transfer between widget outputs and inputs<br>R1.1.5. Functionality 5: Widget library<br>R1.1.6. Functionality 6: Independence of widget design<br>R1.1.7. Functionality 7: Configurability of widget layout<br>R1.1.8. Functionality 8: Mashups embeddable in other websites<br>R1.1.9. Functionality 9: Configurability of general website theme<br>R1.1.10. Functionality 10: Configurability of widget outlines<br>R1.1.11. Functionality 11: Connection to remote data sources<br>R1.1.12. Functionality 12: Authorization support<br>R1.1.13. Functionality 13: Public sharing of mashups<br>R1.1.14. Functionality 14: Private sharing of mashups<br>R1.1.15. Functionality 15: Export/import of mashups<br>R1.1.16. Functionality 16: Export/import of widget packs<br>R1.1.17. Functionality 17: Widget error reporting<br>R1.1.18. Functionality 18: Widget debugging | 5 | 4 | 20 | R1.1.14. Mashups cannot be shared privately between specific members.<br>R1.1.18. Some error messages are not visible in the console, with no additional information when widget execution stops. |
| 1.2 | R1.2.1. F1: Mashups allow insertion of widgets<br>R1.2.2. F2: Custom widgets can be programmed<br>R1.2.3. F3: Data flow between widgets is configurable<br>R1.2.4. F4: Data transfer between widget outputs and inputs is automatic<br>R1.2.5. F5: A library of widgets is available<br>R1.2.6. F6: Widgets can be designed independently of each other<br>R1.2.7. F7: Widget layout is configurable<br>R1.2.8. F8: Mashups can be embedded in other websites | 5 | 4 | 20 | R1.2.9. There is no documentation on how themes can be prepared.<br>R1.2.10. Widget outlines are not configurable, similar to the theme.<br>R1.2.14. Mashups cannot be shared privately between specific members.<br>R1.2.16. While some widget packs are available in the store, we have not found a way to prepare packs ourselves.<br>R1.2.18. Some error messages are not visible in the console, with no additional |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | R1.2.9. F9: General website theme can be configured<br>R1.2.10. F10: Widget outlines can be configured<br>R1.2.11. F11: Widgets can connect to remote data sources<br>R1.2.12. F12: Mashups can require authorization<br>R1.2.13. F13: Mashups can be shared publicly<br>R1.2.14. F14: Mashups can be shared privately<br>R1.2.15. F15: Mashups can be exported and imported<br>R1.2.16. F16: Widget packs can be exported and imported<br>R1.2.17. F17: Errors in widgets are reported to the user<br>R1.2.18. F18: Widgets offer debugging info | | | | information when widget execution stops. |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2. Product is available for download<br>R1.3.3. Download is easily accessible<br>R1.3.4. An instance is available to use | 3,5 | 5 | 17,5 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1. Mashup design interface is usually responsive<br>R2.1.2. Mashup design interface is always responsive<br>R2.1.3. Interface of completed mashups is usually responsive<br>R2.1.4. Interface of completed mashups is always responsive<br>R2.1.5. Uploads of widgets are completed in expected time<br>R2.1.6. Transfers of data between widgets is completed in expected time | 4 | 4 | 16 | R2.1.2. When installing new widgets, the interface sometimes freezes and needs to be reloaded. |
| 2.2 | R2.2.1. The GE works properly on expected hardware | 5 | 5 | 25 | |
| 2.3 | R2.3.1. Tested widgets are stored in library without exceeding capacity<br>R2.3.2. Mashup with a large number of widgets operates properly<br>R2.3.3. Complex wiring of widget inputs and outputs properly handles all data transfers | 5 | 5 | 25 | |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1. GE operates in a virtual machine as expected<br>R3.1.2. GE operates as a service that can coexist with others on same system | 3 | 5 | 15 | |
| 3.2 | R3.2.1. External sources can supply data<br>R3.2.2. Data can be pushed to external sources<br>R3.2.3. Remote applications can trigger widget functions<br>R3.2.4. Works with an identity management GE<br>R3.2.5. Works with a context broker GE | 4 | 5 | 20 | |
| 3.3 | R3.3.1. Support for JSON<br>R3.3.2. Support for XML<br>R3.3.3. Support for general website technologies in widgets<br>R3.3.4. Includes RESTful API<br>R3.3.5. Support for OAuth | 4 | 5 | 20 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1. Quickly recognizable functionality<br>R4.1.2. Available demonstrations for testing<br>R4.1.3. Available documentation on functionality<br>R4.1.4. Available tutorials | 4 | 5 | 20 | |
| 4.2 | R4.2.1. Interface is intuitive enough to use without an extensive read of documentation<br>R4.2.2. API is well designed to be quickly used by programmers | 4,5 | 5 | 22,5 | |
| 4.3 | R4.3.1. Usage learnable from the supplied documentation | 4 | 4 | 16 | R4.3.4. With some documentation on FIWARE and some on CONWET sites, with a |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | R4.3.2. Text is written well enough to understand<br>R4.3.3. Documentation is comprehensive<br>R4.3.4. Documentation is well structured<br>R4.3.5. Short time from start to usage | | | | different layout, the documentation should be consolidated better, considering its size. |
| 4.4 | R4.4.1. Mashups are simple to manipulate<br>R4.4.2. Simple insertion of new widgets into mashups<br>R4.4.3. Simple upload of new widgets<br>R4.4.4. Simple updating of widgets<br>R4.4.5. Simple wiring<br>R4.4.6. API is simple to use<br>R4.4.7. Ease of tutorial execution | 4 | 4 | 16 | R4.4.4. Widgets replacement with newer versions requires too many steps - deletion, reuploading, reinclusion into mashup, rewiring. Together with the lack of widget debugging tools, it makes development difficult. |
| 4.5 | R4.5.1. Support is responsive<br>R4.5.2. Support is comprehensive<br>R4.5.3. Support issue database is available | 3,5 | 5 | 17,5 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1. Modifications of widget layouts are usually persistent<br>R5.1.2. Modifications of widget layouts are always persistent<br>R5.1.3. Modifications of widget wiring is usually persistent<br>R5.1.4. Modifications of widget wiring is always persistent<br>R5.1.5. Operations on the interface are usually successful<br>R5.1.6. Operations on the interface are always successful | 4 | 3 | 12 | Not all browsers are supported. Additionally, when an unsupported browser is used, wiring can break, leading to unexpected errors.<br>R5.1.4. Wiring is saved only when changing tabs (if browser is closed, changes are lost).<br>R5.1.6. Reloading is sometimes needed as the interface stops responding, most frequently when installing new widgets. |
| 5.2 | R5.2.1. Instance is always available on regular usage<br>R5.2.2. Instance is normally available even after a long time | 4,5 | 5 | 22,5 | |
| 5.4 | R5.4.1. Short times of unavailability do not affect state of data<br>R5.4.2. Layouts are restored correctly on refresh | 5 | 5 | 25 | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1. Only authorized users can access private mashups | 5 | 5 | 23 | |
| 6.2 | R6.2.1. Only authorized users can modify the data in mashups | 5 | 5 | 23 | |
| 6.3 | R6.3.1. Logging is available<br>R6.3.2. Logging is fully documented | 4 | 3 | 12 | R6.3.1. For private instances, logging is based on Django defaults. However, when using the global instance, logging is completely unavailable. |
| 6.5 | R6.5.1. Support for authorization<br>R6.5.2. Support for single sign-on | 4 | 5 | 20 | |
| **7** | **Maintainability** | | | | |
| 7.1 | R7.1.1. Support for independent or connected widgets<br>R7.1.2. Interface theme separate from widget programming<br>R7.1.3. Wiring in a separate module<br>R7.1.4. Library of widgets in a separate module | 4 | 5 | 20 | |
| 7.2 | R7.2.1. GE is generally usable without special requirements | 3 | 5 | 15 | |
| 7.3 | R7.3.1. A set of tests can be specified to test common usage patterns<br>R7.3.2. A set of tests is defined in the documentation<br>R7.3.3. A set of tests is available to download<br>R7.3.4. Testing custom widgets should support a console or an error log | 4 | 4 | 16 | R7.3.3. A scenario is available in the latest documentation, even though the download link for the examples do not seem to be working and they test only the main functionality of the platform.<br>R7.3.4. Logs stored on the server are not documented to help resolving problems and debugging widgets. |
| **8** | **Portability** | | | | |
| 8.1 | R8.1.1. GE is generally usable without special | 5 | 5 | 25 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | requirements | | | | |
| 8.2 | R8.2.1. Local install possible<br>R8.2.2. Installation process clearly documented | 4 | 5 | 20 | |
| 8.3 | R8.3.1. Built-in update mechanism<br>R8.3.2. Widgets are transferrable between versions | 4 | 3 | 12 | R8.3.1. There is no auto-update mechanism. Also, the default Django update procedure can lead (under certain circumstances) to unexpected errors. |
| | **Total Score** | | | **515** | |
| | | | | out of | |
| | | | | **565** | |
| | | | | 91,2% | |

## 3.8 Marketplace GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Integrate with IDM<br>R1.1.2 Integrate with Application Mashup GE<br>R1.1.3 Integrate with WStore GE | 5 | 2 | 10 | R1.1.1 Does not integrate with IDM<br>R1.1.2 OK<br>R1.1.3 OK<br>IDM is not integrated which hinders the interoperability with other GEs. Currently, all interoperability operations are hardcoded. Indicatively, Application Mashup GE integrates with Marketplace using the default, well-known, publicly available credentials (demo1234). |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3 | 5 | 2 | 10 | R1.2.1 Not OK (See above)<br>R1.2.2 OK<br>R1.2.3 OK |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2 The license of the GE is Apache 2.0 | 5 | 4 | 20 | R1.3.1 OK<br>R1.3.2 License is BSD<br>The license is BSD (not Apache). Although they share a great deal of common characteristics, Apache is more liberal when it comes to patenting software |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Responses to large datasets should take < 0.5 seconds | 5 | 4 | 20 | R2.1.1 OK |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | | 3 | 4 | 12 | |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region)<br>R3.1.3 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of another GE deployed in the same VM instance | 4 | 5 | 20 | R3.1.1 OK<br>R3.1.2 OK<br>R3.1.3 OK |
| 3.2 | See R1.1.1, R1.1.2, R1.1.3 | 5 | 2 | 10 | See first comment |
| 3.3 | | 4 | 5 | 20 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 4 | 5 | 20 | R4.1.1 OK |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be | 5 | 4 | 20 | R4.2.1 OK |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | started from available documentation | | | | |
| 4.3 | | 5 | 2 | 10 | Only a few APIs are documented and the installation instructions are only minimal. Testing procedures are vague and considered inadequate |
| 4.4 | | 3 | 2 | 6 | Only a few aspects of the GE can be configured without heavy code editing |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 2 | 10 | R4.5.1 OK<br>The GE owners responded to the emails I sent, but were not very familiar with the GE itself due to a recent GE owner change |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 3 | 15 | The DB of the GE should be tweaked in order to be fully operating |
| 5.2 | R5.2.1 GE should be available without any time exception | 5 | 5 | 25 | |
| 5.3 | R5.3.1 GE should be aware of wrong input on creating an offering or on updating offerings from Marketplace | 5 | 5 | 25 | |
| 5.4 | R5.4.1 The internal DB should maintain its state upon failure | 5 | | | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Full IDM integration is needed | 5 | 1 | 5 | R6.1.1 Not OK (see R1.1.1)<br>IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. Spring security is enabled by default, but auth credentials are well known. |
| 6.2 | See R6.1.1 | 5 | 1 | 5 | R6.1.1 Not OK (see R1.1.1)<br>IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. Spring security is enabled by default, but auth credentials are well known. |
| 6.3 | | 3 | 4 | 12 | |
| 6.4 | | 3 | 4 | 12 | |
| 6.5 | | 5 | | | Did not test |
| **7** | **Maintainability** | | | | |
| 7.1 | | 2 | 3 | 6 | It is monolithic |
| 7.2 | | 5 | 5 | 25 | |
| 7.3 | | 5 | 4 | 20 | |
| **8** | **Portability** | | | | |
| 8.1 | | 3 | 4 | 12 | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 2 | 10 | R8.2.1 OK<br>Requires tweaking to make it work in collaboration with other enablers |
| 8.3 | R8.3.1 A GEi can be updated with minor/no user configuration | 4 | 2 | 8 | R8.3.1 OK<br>The GE owners stated that another version of the Marketplace GE will soon be available, though it will break compatibility with Store and possibly Application Mashup GEs |
| | **Total Score** | | | **380** | |
| | | | | out of | |
| | | | | **580** | =65.5% |

## 3.9 Repository GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Integrate with IDM | 5 | 1 | 5 | IDM is not integrated which hinders the interoperability with other GEs. Currently, all |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | R1.1.2 Integrate with WStore GE | | | | interoperability operations are hardcoded. Also, WStore integration fails (unhandled exceptions occur) on private instances. Global instance works ok |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2 | 5 | 1 | 5 | See first comment |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2 The license of the GE is Apache 2.0 | 5 | 4 | 20 | The license is BSD (not Apache). Although they share a great deal of common characteristics, Apache is more liberal when it comes to patenting software |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Responses to large datasets should take < 0.5 seconds | 5 | 4 | 20 | |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | | 3 | 4 | 12 | |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region)<br>R3.1.3 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of another GE deployed in the same VM instance | 4 | 5 | 20 | |
| 3.2 | See R1.1.1, R1.1.2<br>See first comment | 5 | 1 | 5 | See first comment |
| 3.3 | | 4 | 5 | 20 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 4 | 5 | 20 | |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 5 | 2 | 10 | The documentation is inadequate. Even the scope of the GE is hard to perceive at once. |
| 4.3 | | 5 | 2 | 10 | Only a few APIs are documented and the installation instructions are only minimal. Testing procedures are vague and considered inadequate. Also, see comment above |
| 4.4 | | 3 | 2 | 6 | Only a few aspects of the GE can be configured without heavy code editing |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 2 | 10 | The GE owners responded to the emails I sent, but were not very familiar with the GE itself due to a recent GE owner change |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 2 | 10 | Global instance seems to be working fine, private ones are totally immature and would not integrate with WStore out of the box |
| 5.2 | R5.2.1 GE should be available without any time exception | 5 | 5 | 25 | |
| 5.3 | R5.3.1 GE should be aware of wrong input on creating an offering or on updating offerings from Marketplace | 5 | 1 | 5 | GE stopped while integrating with WStore and could not handle the exception thrown |
| 5.4 | R5.4.1 The internal DB should maintain its state upon failure | 5 | | | Did not notice any failure to be able to judge |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Full IDM integration is needed<br>IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. | 5 | 1 | 5 | IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 6.2 | See R6.1.1 | 5 | 1 | 5 | IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. |
| 6.3 | | 3 | 4 | 12 | |
| 6.4 | | 3 | 4 | 12 | |
| 6.5 | | 5 | | | Did not test |
| **7** | **Maintainability** | | | | |
| 7.1 | | 2 | 3 | 6 | It is monolithic |
| 7.2 | | 5 | 5 | 25 | (In theory and based on the public instance) |
| 7.3 | | 5 | 4 | 20 | |
| **8** | **Portability** | | | | |
| 8.1 | | 3 | 4 | 12 | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 1 | 5 | Its main purpose (combined with Store) fails on default installations. Also, the images available in FILAB contain very old software |
| 8.3 | R8.3.1 A GEi can be updated with minor/no user configuration | 4 | | | Did not test |
| | **Total Score** | | | **317** | |
| | | | | out of | |
| | | | | **560** | |
| | | | | 56,6% | |

## 3.10 Store GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Integrate with IDM<br>R1.1.2 Integrate with Application Mashup GE<br>R1.1.3 Integrate with Repository GE<br>R1.1.4 Integrate with Marketplace GE | 5 | 5 | 25 | R1.1.1 OK<br>R1.1.2 OK<br>R1.1.3 OK<br>R1.1.4 OK |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3<br>R1.2.4 accomplishing R1.1.4 | 5 | 5 | 25 | R1.2.1 OK<br>R1.2.2 OK<br>R1.2.3 OK<br>R1.2.4 OK |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2 The license of the GE is Apache 2.0 | 5 | 2 | 10 | R1.3.1 OK<br>R1.3.2 License is European Union Public License (EUPL) 1.1<br>The license is not Apache which can prove to be restricting |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Getting all available offers should take < 0.5 seconds | 5 | 4 | 20 | R2.1.1 OK |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | | 3 | 4 | 12 | |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region)<br>R3.1.3 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of another GE deployed in the same VM instance | 4 | 5 | 20 | R3.1.1 OK<br>R3.1.2 OK<br>R3.1.3 OK |
| 3.2 | See R1.1.1, R1.1.2, R1.1.3, R1.1.4 | 5 | 5 | 25 | |
| 3.3 | | 4 | 5 | 20 | |
| **4** | **Usability** | | | | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 4 | 5 | 20 | R4.1.1 OK |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 5 | 4 | 20 | R4.2.1 OK |
| 4.3 | | 5 | 4 | 20 | |
| 4.4 | R4.4.1 For private instances, allow Django Admin panel | 3 | 5 | 15 | R4.4.1 OK |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 5 | 25 | R4.5.1 OK |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 5 | 25 | |
| 5.2 | R5.2.1 GE should be available without any time exception | 5 | 5 | 25 | R5.2.1 OK |
| 5.3 | R5.3.1 GE should be aware of wrong input on creating an offering or on updating offerings from Marketplace | 5 | 5 | 25 | R5.3.1 OK |
| 5.4 | R5.4.1 The internal DB should maintain its state upon failure | 5 | | | Did not notice any failure to be able to judge |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Full IDM integration is needed | 5 | 5 | 25 | R6.1.1 OK |
| 6.2 | See R6.1.1 | 5 | 5 | 25 | |
| **7** | **Maintainability** | | | | |
| 7.2 | | 5 | 5 | 25 | |
| 7.3 | | 5 | 5 | 25 | |
| **8** | **Portability** | | | | |
| 8.1 | | 3 | 5 | 15 | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 5 | 25 | R8.2.1 OK |
| 8.3 | R8.3.1 A GEi can be updated with minor/no user configuration | 4 | 5 | 20 | R8.3.1 OK |
| | **Total Score** | | | **504** | |
| | | | | out of | |
| | | | | **540** | |
| | | | | 93,3% | |

## 3.11 Marketplace GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Integrate with IDM<br>R1.1.2 Integrate with Application Mashup GE<br>R1.1.3 Integrate with WStore GE | 5 | 2 | 10 | R1.1.1 Does not integrate with IDM<br>R1.1.2 OK<br>R1.1.3 OK<br>IDM is not integrated which hinders the interoperability with other GEs. Currently, all interoperability operations are hardcoded. Indicatively, Application Mashup GE integrates with Marketplace using the default, well-known, publicly available credentials (demo1234). |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3 | 5 | 2 | 10 | R1.2.1 Not OK (See above)<br>R1.2.2 OK<br>R1.2.3 OK |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2 The license of the GE is Apache 2.0 | 5 | 4 | 20 | R1.3.1 OK<br>R1.3.2 License is BSD<br>The license is BSD (not Apache). Although they share a great deal of common characteristics, Apache is more liberal when it comes to patenting software |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 Responses to large datasets should take < 0.5 seconds | 5 | 4 | 20 | R2.1.1 OK |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | | 3 | 4 | 12 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region)<br>R3.1.3 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of another GE deployed in the same VM instance | 4 | 5 | 20 | R3.1.1 OK<br>R3.1.2 OK<br>R3.1.3 OK |
| 3.2 | See R1.1.1, R1.1.2, R1.1.3 | 5 | 2 | 10 | See first comment |
| 3.3 | | 4 | 5 | 20 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available documentation | 4 | 5 | 20 | R4.1.1 OK |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 5 | 4 | 20 | R4.2.1 OK |
| 4.3 | | 5 | 2 | 10 | Only a few APIs are documented and the installation instructions are only minimal. Testing procedures are vague and considered inadequate |
| 4.4 | | 3 | 2 | 6 | Only a few aspects of the GE can be configured without heavy code editing |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 2 | 10 | R4.5.1 OK<br>The GE owners responded to the emails I sent, but were not very familiar with the GE itself due to a recent GE owner change |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 3 | 15 | The DB of the GE should be tweaked in order to be fully operating |
| 5.2 | R5.2.1 GE should be available without any time exception | 5 | 5 | 25 | |
| 5.3 | R5.3.1 GE should be aware of wrong input on creating an offering or on updating offerings from Marketplace | 5 | 5 | 25 | |
| 5.4 | R5.4.1 The internal DB should maintain its state upon failure | 5 | | | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Full IDM integration is needed | 5 | 1 | 5 | R6.1.1 Not OK (see R1.1.1) IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. Spring security is enabled by default, but auth credentials are well known. |
| 6.2 | See R6.1.1 | 5 | 1 | 5 | R6.1.1 Not OK (see R1.1.1) IDM is not integrated and default users are too easy to find. A guide to let the user choose users should be employed. Spring security is enabled by default, but auth credentials are well known. |
| 6.3 | | 3 | 4 | 12 | |
| 6.4 | | 3 | 4 | 12 | |
| 6.5 | | 5 | | | Did not test |
| **7** | **Maintainability** | | | | |
| 7.1 | | 2 | 3 | 6 | It is monolithic |
| 7.2 | | 5 | 5 | 25 | |
| 7.3 | | 5 | 4 | 20 | |
| **8** | **Portability** | | | | |
| 8.1 | | 3 | 4 | 12 | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 2 | 10 | R8.2.1 OK<br>Requires tweaking to make it work in |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | collaboration with other enablers |
| 8.3 | R8.3.1 A GEi can be updated with minor/no user configuration | 4 | 2 | 8 | R8.3.1 OK<br>The GE owners stated that another version of the Marketplace GE will soon be available, though it will break compatibility with Store and possibly Application Mashup GEs |
| | | | | | |
| | **Total Score** | | | **380** | |
| | | | | out of | |
| | | | | **580** | |
| | | | | 65,5% | |

## 3.12 Backend Device Management (IDAS) GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | | 5 | 1 | 5 | IAM2IDAS needs to send multiple attributes (active power, reactive power, etc.) per each meter reading, but the IDAS (SensorML1.0) does not allow this behaviour: it's possible just to send 1 value per IDAS message (HTTP call). |
| 1.2 | | 5 | 3 | 15 | the IDAS call correctly sends data to ORION |
| 1.3 | | 5 | 1 | 5 | IDAS remain SensorML 1.0. It is not planned to be evolved to SensorML 2.0 |
| **2** | **Performance efficiency** | | | | |
| 2.1 | | 5 | 1 | 5 | IDAS proliferates 10 (14) instances per each call. It takes too much time. Real time scalability is not achievable |
| 2.2 | | 5 | 5 | 25 | ok |
| 2.3 | | 5 | | | The number of meters could be very high (up to millions). This feature was not tested. In FINESCE 10 meters only are experimented. |
| **3** | **Compatibility** | | | | |
| 3.1 | | 5 | 3 | 15 | Can coexist, but cannot interoperate timely with ORION running in real time at the same time. The lack of synchronization appears. To transfer a dataset through IDAS, a number of separate calls (attribute per attribute) is needed. To transfer the same dataset via ORION one call is sufficient. |
| 3.2 | | 5 | 1 | 5 | Can coexist, but cannot interoperate timely with ORION running in real time at the same time. The lack of synchronization appears. To transfer a dataset through IDAS, a number of separate calls (attribute per attribute) is needed. To transfer the same dataset via ORION one call is sufficient. |
| 3.3 | | 5 | 2 | 10 | fully compliant with REST/XML/JSON, but not compliant with SensorML 2.0 |
| **4** | **Usability** | | | | |
| 4.1 | | 5 | 3 | 15 | Complete implementation of SensorML and Sensor Web Enablement Architecture is required. |
| 4.2 | | 5 | 3 | 15 | The availability of the step-by-step tutorial is required, but unavailable (FIGWAY example only) |
| 4.3 | | 5 | 1 | 5 | The integration procedure should be formalised step-by-step (but it is not). The remote debug tools are necessary (but very limited). |
| 4.4 | | 5 | 4 | 20 | User Manual |
| 4.5 | | 5 | 4 | 20 | |
| **5** | **Reliability** | | | | |
| 5.1 | | 5 | 1 | 5 | SensorML 2.0 |
| 5.2 | | 5 | 5 | 25 | ready-made bundle or instantiation on request |
| 5.3 | | 5 | 0 | | IDAS should trace the delivery of DLMS/COSEM attributes in stateful manner, but SensorML 1.0 does not allow this |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 5.4 | | 5 | 0 | | The recovery of DLMS/COSEM objects should be stateful, but IDAS operates context updates in stateless manner. |
| **6** | **Security** | | | | |
| 6.1 | | 5 | | 0 | Requested, but the data travel in "clear" |
| 6.2 | | 5 | | 0 | Not necessary if DLMS/COSEM object is handled entirely, but it does not |
| 6.3 | | 5 | | 0 | Not necessary if DLMS/COSEM object is handled entirely, but it does not |
| 6.4 | | 5 | | 0 | Stateful required, but stateless implemented |
| 6.5 | | 5 | | 0 | Not requested |
| **7** | **Maintainability** | | | | |
| 7.1 | | 5 | 5 | 25 | |
| 7.2 | | 5 | 0 | | currently, IDAS is not compliant with the SensorML 2.0 |
| 7.3 | | 5 | 2 | 10 | limited remote debug tools offered |
| **8** | **Portability** | | | | |
| 8.1 | | 5 | 2 | 10 | Limited scalability because handling attributes as separate instances |
| 8.2 | | 5 | 1 | 5 | We attempted the download of the package and tried to make new clean installation on our hardware. We were unable to make a new clean install based on the documentation. |
| 8.3 | | 5 | 0 | 0 | not tested |
| | **Total Score** | | | **240** | |
| | | | | out of | |
| | | | | **700** | |
| | | | | 34.2% | |

## 3.13 Backend IoT Broker GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE shall be able to pass data through from the Gateway Data Handling GE to the Publish Subscriber GE through NGSI.<br>R1.1.2 The GE shall be able to not modify data. | 5 | 5 | 25 | |
| 1.2 | | 5 | 5 | 25 | |
| 1.3 | R1.3.1 The GE shall be available as binary or source code | 4 | 5 | 20 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall not introduce a significant delay (<5ms) | 4,5 | 4 | 18 | |
| 2.2 | | 3 | 4 | 12 | |
| 2.3 | R2.3.1 The GE shall allow scale-out (multiple instances, avoid bottleneck) | 5 | 4 | 20 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 5 | 4 | 20 | |
| 3.2 | R3.2.1 The GE shall be able to communicate through NGSI with the Publish Subscribe Broker GE, Configuration Manager GE and the Gateway Data Handling GE without compatibility issues. | 5 | 4 | 20 | |
| 3.3 | R3.3.1 The GE shall support the NGSI XML binding. | 4,5 | 5 | 22,5 | |
| **4** | **Usability** | | | | |
| 4.1 | | 4 | 5 | 20 | |
| 4.2 | | 4 | 3 | 12 | |
| 4.3 | R4.3.1 The GE should provide tutorials for the most common scenarios involving other GE's. | 5 | 3 | 15 | |
| 4.4 | | 5 | 3 | 15 | |
| 4.5 | R4.5.1. The GE's support shall be responsive and comprehensive | 5 | 4 | 20 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall always provide expected responses as specified in NGSI | 5 | 4 | 20 | |
| 5.2 | | 5 | 4 | 20 | |
| 5.3 | R5.3.1 The GE must not delete or corrupt any data as a result of faults or errors. | 5 | 4 | 20 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 5.4 | R5.4.1 The GE shall be able to continue after a restart due to a fault or watchdog reset | 5 | 4 | 20 | |
| **6** | **Security** | | | | |
| 6.1 | | 3 | 4 | 12 | |
| 6.2 | | 5 | 4 | 20 | |
| 6.3 | | 3 | 3 | 9 | |
| 6.4 | | 3 | 3 | 9 | |
| 6.5 | | 3 | 4 | 12 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 3 | 4 | 12 | |
| 7.2 | | 3 | 5 | 15 | |
| 7.3 | R7.3.2 The GE should provide end to end test for ensuring correct setup and deployment. | 4 | 3 | 12 | |
| **8** | **Portability** | | | | |
| 8.1 | | 4 | 5 | 20 | We have given a score of 5 since we haven't had any problems but it has not been thoroughly tested |
| 8.2 | R8.2.1 The GE shall be installable locally as a component in a system. | 3,5 | 4 | 14 | |
| 8.3 | R8.3.1 The GE shall be backwards compatible such that previous versions can communicate with the other IoT Chapter GEs | 4,5 | 5 | 22,5 | We have given a score of 5 since we haven't had any problems but it has not been thoroughly tested |
| | **Total Score** | | | **502** | |
| | | | | out of | |
| | | | | **615** | |
| | | | | 81,63% | |

## 3.14 Backend Configuration Management GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE shall support all synchronous NGSI9 operations (registerContext, discoverContextAvailability)<br>R1.1.2 The GE shall support all asynchronous NGSI9 operations (subscribeContextAvailability, updateContextAvailability, unsubscribeContextAvailability) | 5 | 5 | 25 | |
| 1.2 | R1.2.1 The GE shall ensure that updates are delivered correctly<br>R1.2.2 The GE shall ensure that new entities are registered correctly | 5 | 5 | 25 | |
| 1.3 | R1.3.1 The GE shall be open source. | 5 | 5 | 25 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | | 5 | 5 | 25 | |
| 2.2 | | 4 | 5 | 20 | |
| 2.3 | R2.3.1 The GE shall be able to handle 10000+ entities with each 50+ attributes. | 5 | 3 | 15 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 5 | 3 | 15 | |
| 3.2 | R3.2.1 The GE shall be able to communicate through NGSI9 with the IoT Broker GE and the Gateway Data Handling GE | 5 | 4 | 20 | |
| 3.3 | R3.3.1 The GE shall support the NGSI XML binding. | 5 | 5 | 25 | |
| **4** | **Usability** | | | | |
| 4.1 | | 4 | 5 | 20 | |
| 4.2 | | 3 | 4 | 12 | |
| 4.3 | R4.3.1 The GE must provide comprehensive documentation for all implemented NGSI operations.<br>R4.3.2 The GE must provide comprehensive documentation for all | 5 | 4 | 20 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | startup options. | | | | |
| 4.4 | | 4 | 4 | 16 | |
| 4.5 | R4.5.1. The GE's support shall be responsive and comprehensive | 5 | 5 | 25 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall always provide expected responses as specified in NGSI9 | 5 | 3 | 15 | |
| 5.2 | | 5 | 2 | 10 | |
| 5.3 | R5.3.1 The GE must not delete or corrupt any data as a result of faults or errors.<br>R5.3.2 The GE must be able to run without interruptions for an extended period of time (>1 month) | 5 | 2 | 10 | We have had several crashes when running this GE in FI-LAB, that required a restart |
| 5.4 | R5.4.1 The GE shall be able to continue after a restart due to a fault or watchdog reset | 5 | 3 | 15 | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 The GE shall support authorization of requests. | 5 | 3 | 15 | |
| 6.2 | | 5 | 3 | 15 | |
| 6.3 | | 2 | 2 | 4 | There is no logging functionality |
| 6.4 | | 2 | 2 | 4 | There is no logging functionality |
| 6.5 | | 3 | 3 | 9 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 3 | 4 | 12 | |
| 7.2 | | 3 | 5 | 15 | |
| 7.3 | R7.3.2 The GE should provide end to end test for ensuring correct setup and deployment. | 4 | 4 | 16 | |
| **8** | **Portability** | | | | |
| 8.1 | | 4 | 5 | 20 | |
| 8.2 | R8.2.1 The GE shall be installable locally as a component in a system. | 5 | 5 | 25 | |
| 8.3 | R8.3.1 The GE shall be backwards compatible such that previous versions of the IoT Broker GE and Gateway Data Handling GE can communicate with it. | 5 | 4 | 20 | |
| | | | | | |
| | **Total Score** | | | **493** | out of |
| | | | | **630** | = **78,25%** |

## 3.15 Authorization PDP GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1. Functionality 1: Decision based on user's role<br>R1.1.2. Functionality 2: Decision based on user's ID<br>R1.1.3. Functionality 3: Decision based on complex user attributes (e.g., a list of owned items)<br>R1.1.4. Functionality 4: Resources can be expressed as URLs. Parts of the URL express the parameters of the resource, such as the resource's ID.<br>R1.1.5. Functionality 5: Block access by default for some URLs<br>R1.1.6. Functionality 6: Allow access by default for some URLs<br>R1.1.7. Functionality 7: Error reporting on incorrect formatting of request<br>R1.1.8. Functionality 8: It should be possible to delegate authorization to external service through http<br>R1.1.9. Functionality 9: Possibility of appending smaller policies to existing policy sets. | 5 | 5 | 25 | R1.1.9 This is not available from our understanding of the documentation and experiments with the GE. Updates of policy sets need to be made by downloading the current set, modifying it and uploading the modified set, overwriting the old. This is prone to human error. However, the current workflow is also acceptable. |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 1.2 | R1.2.1. F1: Only users with correct role can access role-limited resource<br>R1.2.2. F2: Only users with correct ID can access ID-limited resource<br>R1.2.3. F3: Only users who own a specific resource can access the resource<br>R1.2.4. F4: PDP has to be able to parse relevant attribute values of the requested resource<br>R1.2.5. F5: Access denied to blocked-by-default data when incorrect or missing credentials<br>R1.2.6. F6: Access allowed to allowed-by-default data even with incorrect or missing credentials<br>R1.2.7. F7: Error reported on incorrect formatting | 5 | 5 | 25 | |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2. Product is available for download<br>R1.3.3. Download is easily accessible<br>R1.3.4. An instance is available to use | 4 | 5 | 20 | At the time of evaluation, the product was not available for download, only a public instance was available. This has recently been fixed, so we have now raised the score to 5. |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1. Requests on test implementation are completed in expected time<br>R2.1.2 The GE shall have low latency (20 msec). | 4 | 5 | 20 | |
| 2.2 | R2.2.1. The GE shall have well defined requirements and maintain the resource usage according to them. | 3 | 5 | 1 | |
| 2.3 | R2.3.1. Tested policies are stored without exceeding capacity<br>R2.3.2. Several security policies can be stored by a single user<br>R2.3.3 The GE shall allow scale-out (multiple instances, avoid bottleneck) | 5 | 3 | 15 | The GE does not seem to offer scaling to multiple instances. Updating of policies is also cumbersome through modification and reuploading of XML documents. |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3 | 5 | 15 | |
| 3.2 | R3.2.1. Remote applications can perform requests<br>R3.2.2. Remote applications receive decisions<br>R3.2.3 The GE shall be able to communicate with any resource server that expose RESTful API | 5 | 5 | 25 | |
| 3.3 | R3.3.1. Support for XACML 2.0<br>R3.3.2. Support for XACML 3.0<br>R3.3.3. Support for JSON<br>R3.3.4. Includes RESTful API | 5 | 4 | 20 | Previously, we evaluated this as 3 due to missing support of JSON and XACML 3.0. The support XACML 3.0 seems to have been added recently. |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1. Quickly recognizable functionality<br>R4.1.2. Available demonstrations for testing<br>R4.1.3. Available documentation on functionality<br>R4.1.4. Available tutorials | 5 | 4 | 20 | While unit tests are available, they could include communication with a public instance to better demonstrate the functionality. |
| 4.2 | R4.2.1 The GE should provide tutorials for the most common scenarios involving other GEs and RESTful resource servers. | 3 | 3 | 9 | While tutorials are available, they could include communication with a public instance to better demonstrate the functionality. |
| 4.3 | R4.3.1. Usage learnable from the supplied documentation<br>R4.3.2. Text is written well enough to understand<br>R4.3.3. Short time from start to usage | 4 | 3 | 12 | It has taken us quite some time to implement our first policies and later to extend them into more complex rules. Modification of the XACML documents could probably be simplified with a structured GUI. |
| 4.4 | R4.4.1. Simplicity of policy definitions<br>R4.4.2. Simplicity of requests<br>R4.4.3. Ease of tutorial execution | 4 | 3 | 12 | It has taken us quite some time to implement our first policies and later to extend them into more complex rules. Modification of the XACML documents could probably be simplified with a structured GUI. |
| 4.5 | R4.5.1. Support is responsive<br>R4.5.2. Support is comprehensive | 3 | 5 | 15 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1. Requests always receive responses<br>R5.1.2. Correct requests always result in expected | 5 | 5 | 25 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | changes on the service | | | | |
| 5.2 | R5.2.1. Instance is always available on regular usage<br>R5.2.2. Instance is normally available even after a long time | 4 | 5 | 20 | |
| 5.3 | R5.3.1 The GE must not reveal, delete or corrupt any persistent data as a result of faults or errors. | 4 | 5 | 20 | |
| 5.4 | R5.4.1. Short times of unavailability do not affect state of data | 5 | 5 | 25 | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1. Only authorized applications receive successful responses<br>R6.1.2. Only authorized users may read the access control policies in Authorization PDP<br>R6.1.3. It should be possible to set the policies that permit access to resources only to the authorized users | 5 | 5 | 25 | |
| 6.2 | R6.2.1. Only authorized applications can modify the data on server<br>R6.2.2. Only authorized users may add or update the access control policies in Authorization PDP | 5 | 5 | 25 | |
| 6.3 | R6.3.1. The Authorization PDP should provide the log of changes of the policies showing the user, the time of change and the action performed<br>R6.3.2. The Authorization PDP should provide a log of the policy decision requested and the result of the decisions | 3 | 2 | 6 | We have been working with the public instance of the GE, therefore we cannot confirm whether it uses some separate logging mechanism, but based on the documentation, the GE implementation itself does not provide full traffic logs, mainly only errors. |
| 6.4 | R6.4.1. The logs from the R6.3.x should uniquely identify the users | 3 | 2 | 6 | See above. |
| 6.5 | R6.5.1. Support for exchange of authorization keys | 3 | 5 | 15 | |
| **7** | **Maintainability** | | | | |
| 7.1 | R7.1.1 The GE shall allow scale-out (multiple instances, avoid bottleneck) | 3 | 1 | 3 | We do not see from the documentation that the GE could be made to handle large amounts of traffic by scaling to multiple instances. |
| 7.2 | | 5 | 3 | 15 | The GE operation is limited to Glassfish server and Java environment. It is not apparent however, whether an instance might be moved between systems. |
| 7.3 | R7.3.1. A set of tests can be specified to test common usage patterns<br>R7.3.2. A set of tests is defined in the documentation<br>R7.3.3. A set of tests is available to download<br>R7.3.4 The GE should provide end to end test for ensuring correct setup and deployment. | 3 | 5 | 15 | A set of end to end and unit tests is provided in the documentation. |
| **8** | **Portability** | | | | |
| 8.1 | R8.1.1 The GE shall allow scale-out (multiple instances, avoid bottleneck) | 3 | 1 | 3 | We do not see from the documentation that the GE could be made to handle large amounts of traffic by scaling to multiple instances. |
| 8.2 | R8.2.1 The GE shall be installable locally as a component of a secure system. | 2 | 5 | 10 | |
| 8.3 | R8.3.1. API does not change or is backward compatible<br>R8.3.2. API has all functionality expected in the future | 2 | 3 | 6 | The current way of handling XACML policy sets (only downloads and uploads) hints that the API should probably be modified in the future with simpler approaches. |
| | | | | | |
| | **Total Score** | | | **467** | out of |
| | | | | **565** | = 82,65% |

## 3.16 Identity Management GE

The first table below gives the evaluation results for the IdM Keyrock GE. The second table gives the scores for the IdM GCP GE.

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE must support provide standard based authentication to clients who require to access data in the COS DSE system.<br>R1.1.2 The GE shall support automated or semi-automated registration and deregistration processes.<br>R1.1.3 The GE shall allow resource servers to validate OAuth access tokens without communicating with the GE.<br>R1.1.4 The GE shall support registration of apps that may validate their users through the GE API.<br>R1.1.5 The GE shall support assigning users to organizations.<br>R1.1.6 The GE shall support user roles.<br>R1.1.7 The GE shall support custom user attributes, such as data sources owned by the user.<br>R1.1.8 The GE shall provide user information based on received authentication tokens.<br>R1.1.9 The GE shall support registering as an organization. | 5,0 | 4,0 | 20,0 | KeyRock:<br>R1.1.7 The KeyRock GE does not support custom attributes.<br>R1.1.9 There is no possibility of access as an organization. |
| 1.2 | R1.2.1 The GE shall correctly authenticate a user based on his username and password<br>R1.2.2 The GE shall supply authentication tokens that allow validation<br>R1.2.3 The GE shall correctly supply the user information linked to a specific token.<br>R1.2.4 The GE shall supply all the information linked to a specific token.<br>R1.2.5 The manipulation of user attributes shall correctly affect only the corresponding user. | 5,0 | 4,0 | 20,0 | KeyRock:<br>R1.2.4 Roles of organizations seem to be missing when supplying a token from Wirecloud to retrieve user information. Conversely, when logging in through the API with the username and password, the opposite seems to happen: the users global roles are missing when checking the token. |
| 1.3 | R1.3.1 The GE shall be available as Open Source<br>R1.3.2 The GE shall be available for download<br>R1.3.3 The GE shall have an easily accessible download<br>R1.3.4 The GE shall have an instance available to use | 4,0 | 5,0 | 20,0 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall have low or no latency (up to 10 msec is acceptable for non-time sensitive operations).<br>R2.1.2 The GE shall support quick registration to client (up to 1 min).<br>R2.1.3 The user interface of the GE shall be responsive | 4,2 | 5,0 | 21,0 | |
| 2.2 | R2.2.1 The GE and its dependencies shall have low resource overhead.<br>R2.2.2 The GE shall be scalable to accomodate operations supporting registration, authentication and other related functions for large number of users. | 3,8 | 5,0 | 19,0 | |
| 2.3 | R2.3.1 The GE shall allow a large (1000+) number of user to be created per tenant | 4,0 | 5,0 | 20,0 | KeyRock: We have not used the GE to such an extent to check these limits and the we do not have admin rights for the public instance which we are using to quickly add a larger number of users through the API, so |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | we exclude this score.<br>GCP: IdM GCP GE is only available as an online service which could have scalability implications. Current business usage scenario of the service is aimed towards authenticating limited number of SME clients. |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1. GE operates in a virtual machine as expected<br>R3.1.2. GE operates as a service that can coexist with others on same system | 3,4 | 5,0 | 17,0 | KeyRock: We are evaluating the public instance of the GE, therefore we cannot give a complete score here, but we have not observed any failures with it and the installation documentation indicates that it should operate as a service without any limitation to other services on the system (except taking over port 80 for web page hosting). |
| 3.2 | R3.2.1 The GE shall use standard language independent interfaces and data formats.<br>R3.2.2 Other GEs shall be able to use the API for authentication without trouble. | 4,6 | 5,0 | 23,0 | |
| 3.3 | R3.3.1 The GE must be based on security and authentication standards and best practices.<br>R3.3.2 The GE shall support OAuth2<br>R3.3.3 The GE shall support JSON data retrieval | 4,6 | 5,0 | 23,0 | |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1. Quickly recognizable functionality<br>R4.1.2. Available demonstrations for testing<br>R4.1.3. Available documentation on functionality<br>R4.1.4. Available tutorials | 3,0 | 5,0 | 15,0 | KeyRock: Most functionality can be quickly seen by registering an account and seeing the basic documentation |
| 4.2 | R4.2.1 The GE should provide a tutorial for enabling OAuth2 clients<br>R4.2.2. Interface is intuitive enough to use without an extensive read of documentation<br>R4.2.3. API is well designed to be quickly used by programmers | 3,6 | 4,0 | 14,4 | KeyRock: The KeyRock GE does have a tutorial, but an example account in the public instance is needed which would demonstrate every type of retrieval in the API. |
| 4.3 | R4.3.1. Usage learnable from the supplied documentation<br>R4.3.2. Text is written well enough to understand<br>R4.3.3. Documentation is comprehensive<br>R4.3.4. Documentation is well structured<br>R4.3.5. Short time from start to usage | 4,6 | 3,0 | 13,8 | KeyRock: The KeyRock documentation pages on GitHub, the open source specification and the user guide need to become more consistent and directly usable with the public instances as we had to experiment with the request URLs to find out which are usable and in what form. A more complete list of requests and replies is needed for the API.<br>GCP: The IdM GCP GE provides suitable documentation regarding the integration and usage of the GE. All functionality that is described in the documentation does actually work correctly in the implementation. |
| 4.4 | R4.4.1 The GE shall allow tenant administrators to create other tenant administrators.<br>R4.4.2 The API is simple to use<br>R4.4.3 The graphical interface is user-friendly | 3,8 | 3,0 | 11,4 | KeyRock: Some parts of the KeyRock GUI are not immediately obvious, e.g. the Edit button on an application page which is not visible unless scrolled over with the mouse and app links that take you to a different address than the icon beside them. The API is also not perfect as mentioned in the previous comment. |
| 4.5 | R4.5.1. Support is responsive<br>R4.5.2. Support is comprehensive<br>R4.5.3. Support issue database is available | 4,4 | 4,0 | 17,6 | KeyRock: The KeyRock support does reply promptly, and some webinars are available, but they do not offer a FAQ or other database of regular issues. |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | GCP: Developers of the GE provided technical support for the integration and created admin access to COS DSE developers in order to configure the IdM GCP online service. |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall be stable and accurate at least regarding basic authentication functions with appropriate error handling. | 5,0 | 5,0 | 25,0 | KeyRock: No significant errors were apparent.<br>GCP: The GE is a mature component with high reliability. No faults or errors are experienced. |
| 5.2 | R5.2.1 The GE shall have an availibility of 99% | 4,6 | 5,0 | 23,0 | KeyRock: No dropouts have been experienced for the public instance. |
| 5.3 | R5.3.1 The GE must not reveal, delete or corrupt any persistent data as a result of faults or errors. | 4,6 | 4,0 | 18,4 | KeyRock: Some errors have been observed during GUI manipulation, although they do not seem to affect the operation. |
| 5.4 | | 4,5 | 5,0 | 22,5 | KeyRock: No failures have been observed, therefore we cannot evaluate this part. |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 The GE must not cache or retain any unnecessary PII data after its processing including logs containing any element of that data. The GE must also delete unnecessary PII immediately after deregistration other than data required for accountability and non-repudiation. | 5,0 | 5,0 | 25,0 | KeyRock: We cannot give an opinion for the KeyRock GE as we have not used a private instance of the GE to check its logs.<br>GCP: IdM GCP GE supports authentication and authorization of customers using common security protocols including OAuth, OpenID and SAML. As an online service with no access to the internal structure or code there needs to be an element of trust regarding its security. |
| 6.2 | | 4,6 | 5,0 | 23,0 | KeyRock: The GE seems to perform its main functionality properly. |
| 6.3 | | 3,2 | 5,0 | 16,0 | KeyRock: Evaluation requires access to logs, we cannot give an opinion for the KeyRock GE as we have not used a private instance of the GE. |
| 6.4 | | 3,2 | 5,0 | 16,0 | KeyRock: The GE seems to uniquely report correct user info based on their tokens and a token should identify who performed a certain action. |
| 6.5 | | 5,0 | 5,0 | 25,0 | KeyRock: The GE seems to report correct user info based on their tokens. |
| **7** | **Maintainability** | | | | |
| 7.1 | | 1,2 | 5,0 | 6,0 | GCP: IdM GCP GE is an online service with no view of the modularity of its internal structure. However, the online administration interface is well structured and allows enabling and disabling features as required. |
| 7.2 | | 1,2 | 4,0 | 4,8 | KeyRock is intended to run on the Ubuntu Linux platform and there seems to be no plan to port it to other systems. However, Ubuntu is quite widespread so this represents an appropriate solution. |
| 7.3 | R7.3.1 The GE shall be testable for the correctness and accuracy of its secure authentication functions.<br>R7.3.2 The GE should provide end to end test for ensuring correct setup and deployment. | 2,4 | 5,0 | 12,0 | KeyRock: The GE offers short procedures for checking its installation, but the testing of the API is limited to a small number of examples without automatization or directly testable request-result pairs<br>GCP: As an online service with no access to the internal structure or code there needs to be an element of trust regarding its security. |
| **8** | **Portability** | | | | |
| 8.1 | | 2,0 | 4,0 | 8,0 | KeyRock: The source code for the GE is |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | available, so it should be adaptable to incompatible systems. It is also already based on quite widely used software dependencies. However, scaling is not mentioned in the documentation, so it is lacking in this area.<br>GCP: No flexibility except being an external service with standard interfaces. |
| 8.2 | R8.2.1 The GE shall be installable locally as a component of a secure system. | 4,0 | 5,0 | 20,0 | KeyRock: The KeyRock GE offers source code and instructions for local installation.<br>GCP: As an external service, IdM GCP GE has no limitation as to installation or usage environment. However, a locally installed component would provide better control and transparency. |
| 8.3 | | 4,4 | 4,0 | 17,6 | The KeyRock GE can probably be replaced with a newer version without much trouble if the database remains intact. However, it does not seem to have any built-in upgrade mechanisms. |
| | | | | | |
| | **Total Score** | | | **517,5** | |
| | | | | out of | |
| | | | | **564,5** | |
| | | | | 91,67% | |

The following table gives the scores for the IdM GCP GE. The "Specific FINESCE Requirements" texts and the "Comments" column from the above table apply here also, but are left out for space reasons.

| | | | IdM GCP | |
|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** |
| **1** | **Functional suitability** | | | |
| 1.1 | | 5,00 | 5 | 25 |
| 1.2 | | 4,33 | 5 | 25 |
| 1.3 | | 4,67 | 5 | 20 |
| **2** | **Performance efficiency** | | | |
| 2.1 | | 4,33 | 5 | 21 |
| 2.2 | | 5,00 | 5 | 19 |
| 2.3 | | 3,67 | 3 | 12 |
| **3** | **Compatibility** | | | |
| 3.1 | | 3,67 | 3 | 10,2 |
| 3.2 | | 4,00 | 5 | 23 |
| 3.3 | | 2,33 | 5 | 23 |
| **4** | **Usability** | | | |
| 4.1 | | 5,00 | 4 | 12 |
| 4.2 | | 5,00 | 4 | 14,4 |
| 4.3 | | 5,00 | 4 | 18,4 |
| 4.4 | | 5,00 | 4 | 15,2 |
| 4.5 | | 5,00 | 4 | 17,6 |
| **5** | **Reliability** | | | |
| 5.1 | | 5,00 | 4 | 20 |
| 5.2 | | 5,00 | 4 | 18,4 |
| 5.3 | | 5,00 | 4 | 18,4 |
| 5.4 | | 4,33 | 5 | 22,5 |
| **6** | **Security** | | | |
| 6.1 | | 5,00 | 3 | 15 |
| 6.2 | | 5,00 | 3 | 13,8 |
| 6.3 | | 3,33 | 3 | 9,6 |
| 6.4 | | 3,33 | 3 | 9,6 |

| | | | IdM GCP | |
|---|---|---|---|---|
| **Label** | **Specific FINESCE Requirements** | **WF** | **S** | **WF*S** |
| 6.5 | | 5,00 | 3 | 15 |
| **7** | **Maintainability** | | | |
| 7.1 | | 3,00 | 4 | 4,8 |
| 7.2 | | 2,67 | 4 | 4,8 |
| 7.3 | | 1,00 | 2 | 4,8 |
| **8** | **Portability** | | | |
| 8.1 | | 2,67 | 2 | 4 |
| 8.2 | | 4,33 | 1 | 4 |
| 8.3 | | 5,00 | 4 | 17,6 |
| | **Total Score** | | | **438,1** |
| | | | | out of |
| | | | | **564,5** |
| | | | | 77.6% |

## 3.17 Backend Template Handler GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 Implement a BPMN-based workflow system allowing each involved stakeholder (Aggregator, DSO, Energy Retailer, Market Regulator) to approve or reject specific energy marketplace outputs such as an “Issue Resolution Plan” or an “Incentives/Disincentives Plan”<br>R1.1.2 Specific energy marketplace outputs (such as an “Issue Resolution Plan” or an “Incentives/Disincentives Plan”) to be represented by NGSI10 entities<br>R1.1.3 Integration with ORION GE (as underlying NGSI Server)<br>R1.1.4 BPMN administration/operation user interface to be natively integrated into WIRECLOUD GE<br>R1.1.5 Authorization system for BPMN-based workflow "actors" | 5 | 3 | 15 | R1.1.1 covered<br>R1.1.2 covered<br>R1.1.3 covered<br>R1.1.4 not covered<br>R1.1.5 not covered |
| 1.2 | R1.2.1 accomplishing R.1.1.1<br>R1.2.2 accomplishing R1.1.2<br>R1.2.3 accomplishing R1.1.3<br>R1.2.4 accomplishing R1.1.4<br>R1.2.5 accomplishing R1.1.5 | 5 | 3 | 15 | R1.1.1 working<br>R1.1.2 working<br>R1.1.3 working (but a bit tricky to be set up)<br>R1.1.4 not available<br>R1.1.5 not available |
| 1.3 | R1.3.1. Product is Open Source<br>R1.3.2. Product does not need to be installed at user's premise | 5 | 5 | 25 | GE is open source and does not need to be installed at user's premise |
| **2** | **Performance efficiency** | | | | |
| 2.1 | | | | | |
| 2.2 | | | | | |
| 2.3 | | | | | |
| **3** | **Compatibility** | | | | |
| 3.1 | R3.1.1 An instance of the GE can be deployed on a dedicated VM created on a FIWARE cloud region ("common environment and resources to be shared with other GE instances)<br>R3.1.2 An instance of the GE on a dedicated VM created on FIWARE Cloud does not affect the behaviour of other GE instances (deployed on VMs in the same cloud region) | 3 | 5 | 15 | R3.1.1 covered<br>R31.2 covered |
| 3.2 | R3.2.1 Integration with ORION GE (as underlying NGSI Server)<br>R3.2.2 BPMN administration/operation user interface to be natively integrated into WIRECLOUD GE | 3 | 3 | 8 | R3.2.1 covered<br>R3.2.2 not covered |
| 3.3 | R3.3.1 BPMN administration/operation activities to be performed by using REST methods<br>R3.3.2 Underlying NGSI server operation to be performed by using REST methods | 3 | 3 | 8 | R3.3.1 covered<br>R3.3.2 not covered |
| **4** | **Usability** | | | | |
| 4.1 | R4.1.1 The enabler(s) satisfies requirements based on available | 3 | 3 | 9 | R4.1.1 covered |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | documentation | | | | |
| 4.2 | R4.2.1 Learning how to use the enabler(s) can be started from available documentation | 3 | 1 | 3 | R4.1.1 not all the functionalities are well explained in the Users and Programming Guide |
| 4.3 | R4.3.1 Documentation is satisfactory | 5 | 2 | 10 | R4.3.1 it should be enhanced |
| 4.4 | R4.4.1 Availability of BPMN logs | 3 | | | R4.4.1 not covered |
| 4.5 | R4.5.1 Availability of support via e-mail/skype | 5 | 5 | 25 | R4.5.1 covered |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 Access to BPMN definition and related services are granted under authentication<br>R6.1.2 Roles and privileges of users are governed with an authorization process | 5 | 5 | 25 | R6.1.1 covered<br>R6.1.2 covered |
| 6.2 | R6.2.1 Unauthorized users cannot use services offered by the enabler(s) | 5 | 5 | 25 | R6.2.1 Unauthorized users cannot use services offered by the enabler(s) |
| **8** | **Portability** | | | | |
| 8.1 | | | | | |
| 8.2 | R8.2.1 Instance of GE can be downloaded and installed on a VM in a FIWARE cloud region | 5 | 5 | 25 | R8.2.1 covered |
| | **Total Score** | | | **207** | |
| | | | | out of | |
| | | | | **290** | |
| | | | | 71,4% | |

## 3.18 DB Anonymizer GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE must support protecting sensitive data to be partially disclosed externally or with unauthorised personnel through anonymisation.<br>R1.1.2 The GE shall provide data anonymisation functionality.<br>R1.1.3 The GE shall be able to validate the correctness of a anonymisation policy | 5 | 2 | 10 | DB Anonymizer GE facilitates protection of privacy during data disclosure through data anonymisation and helps to improve anonymisation policies. It receives a raw dataset together with the disclosure policy. It then analyses the policy and evaluates its effectiveness in ensuring privacy protection. At the end of the evaluation process, it returns a percentage of the original dataset that an attacker can reconstruct. The higher percentage the more possible to reconstruct the anonymized data and hence, it is necessary re-evaluate the anonymisation policy with more restrictions. |
| 1.2 | | 5 | 2 | 10 | Despite its name, the GE does not currently perform anonymisation of data. However, the GE developers reported that they are working on adding this function in future versions. Therefore, the name of the GE is a bit misleading. Although, the GE does not include performing anonymisation of data, it fits the COS requirement for evaluating anonymisation policies. |
| 1.3 | R1.3.1 The GE shall be available as a service or as binaries. | 3 | 3 | 9 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall have low latency (up to 500 msec is acceptable for a small database e.g. 100 users).<br>R2.1.2 The GE shall be able to process data sizes of multiple GBs within acceptable timeframe. | 5 | 3 | 15 | During the evaluation of this GE, it requires an unanonymised dataset to provide as an input and a specific anonymisation policy which will be used as dataset disclosure policy. The unanonymised dataset will be any SQL database and anonymisation policy will include as a XML policy file. These two inputs are necessary to evaluate the effectiveness of the dataset disclosure policy. This can cause performance and |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | scalability problems in case of big data sets. |
| 2.2 | R2.2.1 The GE and its dependencies shall have low to moderate resource overhead (processing of a single request at a time to process 1GB of data shall not require more than a low end server with 520MB RAM and 80GB storage).<br>R2.2.2 The GE shall be scalable to accommodate large datasets of several GBs of PII. | 5 | 4 | 20 | |
| 2.3 | | 5 | 3 | 15 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3 | 3 | 9 | |
| 3.2 | R3.2.1 The GE shall use standard language independent interfaces and data formats. | 3 | 4 | 12 | DB Anonymizer provides RESTful interfaces allowing integration with other systems and components regardless of their implementation language. |
| 3.3 | R3.3.1 The GE shall support data from Microsoft SQL. | 3 | 3 | 9 | The data being anonymized in WP2 Insero is stored in an Microsoft SQL Server. It would be impractical first having to convert it into another format. |
| **4** | **Usability** | | | | |
| 4.1 | | 3 | 3 | 9 | |
| 4.2 | | 3 | 3 | 9 | |
| 4.3 | R4.3.1 The GE shall provide thorough and accurate documentation on functionality and usage. | 5 | 2 | 10 | GE developers provide moderate level of documentation on the supported functionality and integration. Further details below. |
| 4.4 | | 3 | 3 | 9 | |
| 4.5 | | 5 | 3 | 15 | GE developers provide support for testing and evaluating the GE. |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall be stable and accurate at least regarding basic anonymisation functions with appropriate error handling. | 5 | 1 | 5 | GE developers provide moderate level of documentation on the supported functionality and integration. However, no discussion is provided regarding the scientific basis of the anonymisation evaluation and scoring except a published article (Trabelsi, 2009). This may cause uncertainty regarding the validity and reliability of the resulting scores without feedback from the security community. Possibly, additional measures are required to further ensure anonymity. In addition, current version of DB Anonymizer features faults and errors. |
| 5.2 | | 5 | 3 | 15 | The online service (https://dbanon.lab.FIWARE.eu/) allows uploading datasets and policies for anonymity evaluation. The services frequently experience errors and unavailability problems. |
| 5.3 | R5.3.1 The GE must not reveal, delete or corrupt any persistent data as a result of faults or errors. | 3 | 3 | 9 | |
| 5.4 | | 3 | 3 | 9 | |
| **6** | **Security** | | | | |
| 6.1 | R6.1.1 The GE must not cache or retain any data after its processing including logs containing any element of that data. | 5 | 3 | 15 | |
| 6.3 | | 3 | 2 | 6 | |
| 6.5 | | 5 | 1 | 5 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 1 | 2 | 2 | |
| 7.2 | | 1 | 3 | 3 | |
| 7.3 | R7.3.1 The GE shall be testable for the correctness and accuracy of its anonymisation functions including their scientific foundation particularly regarding reversibility of anonymised data that is | 5 | 1 | 5 | DB Anonymizer GE currently provides single function using an anonymisation scoring algorithm and RESTful interface. The lack of discussion on the rigour of the anonymisation algorithm may cause uncertainty regarding the validity and reliability of the resulting |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | given a high score on anonymisation by the GE. | | | | scores without feedback from the security community. Possibly, additional measures are required to further ensure anonymity. |
| **8** | **Portability** | | | | |
| 8.1 | | 1 | 3 | 3 | |
| 8.2 | R8.2.1 The GE shall be installable locally as a component of a secure system. | 5 | 3 | 15 | DB Anonymizer GE runs in a Web server and provides REST API. Therefore, it is flexible in terms of the installation environment and usage scenarios. |
| 8.3 | | 5 | 3 | 15 | |
| | **Total Score** | | | **268** | |
| | | | | out of | |
| | | | | **515** | |
| | | | | 52,0% | |

## 3.19 Data Handling GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The DH GE must ensure adherence to principles of privacy (e.g. consent, minimisation, etc.) of PII stored and handled by the system. R1.1.2 The GE shall support PII to be stored within the system and privacy obligations allow control and detailed notifications of third party access to the data. | 5 | 4 | 20 | |
| 1.2 | | 5 | 3 | 15 | Data handling GE appears as a work in progress with several bugs such as linking individual sticky policies to their respective files as well as the lack of appropriate documentation on the supported functions. |
| 1.3 | | 3 | 4 | 12 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall have low latency overhead on data handling and processing operations (up to 100 msec is acceptable for processing a single record). | 5 | 4 | 20 | |
| 2.2 | R2.2.1 The GE shall have low resource overhead on data handling and processing operations (read and write functions for up to 10000 users shall not require more than a low end server). | 5 | 3 | 15 | |
| 2.3 | | 5 | 3 | 15 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3 | 3 | 9 | |
| 3.2 | R3.2.1 The GE shall use standard language independent interfaces and data formats. | 3 | 4 | 12 | |
| 3.3 | | 3 | 3 | 9 | |
| **4** | **Usability** | | | | |
| 4.1 | | 3 | 3 | 9 | |
| 4.2 | | 3 | 2 | 6 | |
| 4.3 | R4.3.1 The GE shall provide thorough and accurate documentation on functionality and usage. | 5 | 1 | 5 | DH GE provides less than good quality documentation. Errors exist in the documentation of the GE such as specifying wrong parameters. |
| 4.4 | | 3 | 2 | 6 | |
| 4.5 | | 5 | 1 | 5 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall be stable and accurate at least regarding basic privacy-preserving functions with appropriate error handling. | 5 | 1 | 5 | Even considering the current maturity level of DH GE, it would be expected that the GE provide available functions with no major bugs. However, reliability problems are frequent such as returned |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| | | | | | errors from the API in the form of Java and Hibernate stack traces which is inappropriate practice for a Web based API. |
| 5.2 | | 5 | 2 | 10 | |
| 5.3 | R5.3.1 The GE must not reveal, delete or corrupt any PII as a result of faults or errors. | 3 | 2 | 6 | Cannot be assured of this requirement given the bugs and errors in the implementation. |
| 5.4 | | 3 | 2 | 6 | |
| **6** | **Security** | | | | |
| 6.1 | | 5 | 2 | 10 | No evidence of satisfactory security testing and assurance regarding security properties. |
| 6.2 | | 5 | 2 | 10 | |
| 6.3 | | 3 | 2 | 6 | |
| 6.4 | | 3 | 2 | 6 | |
| 6.5 | | 5 | 2 | 10 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 1 | 3 | 3 | |
| 7.2 | | 1 | 4 | 4 | |
| 7.3 | | 1 | 2 | 2 | Reason of lows score explained above. |
| **8** | **Portability** | | | | |
| 8.1 | | 1 | 4 | 4 | |
| 8.2 | R8.2.1 The GE shall be installable locally as a component of a secure system. | 5 | 3 | 15 | |
| 8.3 | | 5 | 3 | 15 | |
| | | | | | |
| | **Total Score** | | | **270** | |
| | | | | out of | |
| | | | | **535** | |
| | | | | 50,5% | |

## 3.20 Content-based Security GE

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| **1** | **Functional suitability** | | | | |
| 1.1 | R1.1.1 The GE must protect sensitive data to be transferred together with its metadata at its source using secure encryption algorithm and key management to ensure confidentiality and integrity and shall also integrate access control to the data. | 5 | 5 | 25 | |
| 1.2 | | 5 | 4 | 20 | |
| 1.3 | | 3 | 3 | 9 | |
| **2** | **Performance efficiency** | | | | |
| 2.1 | R2.1.1 The GE shall have low latency overhead on data communications (50-100 msec is acceptable for non-delay sensitive secure transmission of data). | 5 | 4 | 20 | No performance issues are identified in either of the tools in terms of time or capacity utilisation. |
| 2.2 | R2.2.1 The GE and its dependencies shall have low resource overhead (encryption/decryption functions using secure algorithm and key sizes for slow data stream shall not require more than a low end server). | 5 | 4 | 20 | The GE requires limited memory and disk space. Resource consumption highly depends on the load i.e. number of concurrent requests. |
| 2.3 | | 5 | 4 | 20 | |
| **3** | **Compatibility** | | | | |
| 3.1 | | 3 | 4 | 12 | |
| 3.2 | R3.2.1 The GE shall use standard language independent interfaces and data formats. | 3 | 3 | 9 | |
| 3.3 | | 3 | 4 | 12 | covered by requirement 3.2.1 |
| **4** | **Usability** | | | | |
| 4.1 | | 3 | 2 | 6 | |
| 4.2 | | 3 | 2 | 6 | |

| Label | Specific FINESCE Requirements | WF | S | WF*S | Comments |
|---|---|---|---|---|---|
| 4.3 | R4.3.1 The GE shall provide thorough and accurate documentation on functionality and usage. | 5 | 2 | 10 | CBS GE provides documentation on the installation as well as on the architecture of the GE. It also provides description of unit testing of the GE security features. The documentation quality and level of detail can be improved. |
| 4.4 | | 3 | 2 | 6 | |
| 4.5 | | 5 | 1 | 5 | |
| **5** | **Reliability** | | | | |
| 5.1 | R5.1.1 The GE shall be stable and accurate at least regarding basic encryption/decryption functions with appropriate error handling. | 5 | 2 | 10 | It is hard to claim high level of maturity of the GE given the available documentation and usage experience. We also experienced errors during decryption of the data. The dependency on Access Control GE and IdM GE may reduce fault tolerance and add complexity to its usage and exposure to errors in theses GEs. |
| 5.2 | | 5 | 3 | 15 | |
| 5.3 | R5.3.1 The GE must not reveal, delete or corrupt any data as a result of faults or errors. | 3 | 3 | 9 | Cannot be assured of this requirement given the bugs and errors in the implementation. |
| 5.4 | | 3 | 3 | 9 | |
| **6** | **Security** | | | | CBS GE aims to ensure access control and protection of sensitive data through encryption and digital signature. This helps protect confidentiality and integrity of data. Authentication relies on the Access Control GE. Assurance regarding those security functions requires wider user community and feedback regarding potential vulnerabilities. |
| 6.1 | | 5 | 3 | 15 | |
| 6.2 | | 5 | 3 | 15 | |
| 6.3 | | 3 | 3 | 9 | |
| 6.4 | | 3 | 3 | 9 | |
| 6.5 | | 5 | 3 | 15 | |
| **7** | **Maintainability** | | | | |
| 7.1 | | 1 | 4 | 4 | CBS consists of multiple modules i.e. consumer, producer and broker. However, further component modularity cannot be confirmed. |
| 7.2 | | 1 | 3 | 3 | It can be reused in multiple scenarios and different environments. Its dependence on specific components i.e. GEs, may hamper its reuse. |
| 7.3 | | 1 | 3 | 3 | CBS GE provides details on testing of its features. Testing is vital to assuring the effectiveness and robustness of the GE security functions. As above assurance regarding those security functions requires wider user community and feedback regarding potential vulnerabilities. |
| **8** | **Portability** | | | | |
| 8.1 | | 1 | 3 | 3 | |
| 8.2 | R8.2.1 The GE shall be installable locally as a component of a secure system. | 5 | 3 | 15 | CBS GE runs in a Java Web server and is flexible in terms of the installation environment and usage scenarios. No major issues regarding replicability and adaptability are identified. |
| 8.3 | | 5 | 3 | 15 | |
| | | | | | |
| | **Total Score** | | | **329** | |
| | | | | out of | |
| | | | | **535** | |
| | | | | 61,5% | |