D3.2.1
Market Design Specification

June 30th, 2017

EcoGrid 2.0 is a research and demonstration project funded by EUDP (Energiteknologisk Udviklings- og Demonstrationsprogram). The 9 partners in the project are:

Project Information:

Deliverable number:	3.2.1
Deliverable title:	Market Design Specification
Workpackage title:	WP3 Market place implementation and operation
Lead Beneficiary for this deliverable:	IBM
Work package leader:	Bernhard Jansen / IBM

Version Control:

Version	Date	Author	Description of Changes
0.1	2017-07-07	BJA	Initial version
0.2	2017-07-27	BJA	Incorporated comments from JME

Main Authors:

Name/Partner	Email
Bernhard Jansen / IBM	bja@zurich.ibm.com

TABLE OF CONTENTS

Scope and Content

The FLECH market platform and its base design described in this document dates back in its roots to the iPower project where the development started as flexibility clearinghouse for trading flexibility products between distribution systems operators (DSO) and aggregated distributed energy resources (DER) for the purpose, among others, of solving temporal distribution grid overload situations and prolonging grid component lifetime by omitting replacement by stronger parts. For EcoGrid 2.0 project the market platform is extended and adopted to the needs of the new stakeholder situation where now not only the DSO but also the Transmission System Operator (TSO) can trade flexibility products sourced from residential homes smaller distributed energy resources (DER) and offered to the EcoGrid 2.0 market by so called aggregators. The aggregators, developed in WP4 and WP5, are controlling the DERs to maximize energetic flexibility from DERs by not impacting the users comfort and offer the gained flexibility towards the FLECH market and handling the risk of non-delivery of a DER and other risks. The FLECH market platform would allow market participation by larger DERs directly but as the focus of EcoGrid 2.0 is on smaller DERs and aggregators this option is not demonstrated.

The products traded on the market platform are in detail described by work package 2, the market platform interface to the external stakeholders is described in *D3.1.2 Marketplace interface specification (full version)*. This deliverable focuses on the market platform design, technical interactions between the different components of the FLECH market platform and the extensibility to implement new tradeable products.

Market Environment

The FLECH market as it will be used in EcoGrid 2.0 is not operating in an isolated environment but is designed to be integrated in the current Danish market. Therefore, the EcoGrid 2.0 FLECH market will interact with different stakeholders of the current market environment. The different stakeholders and their interactions are described below.

1.1 Stakeholder Diagram

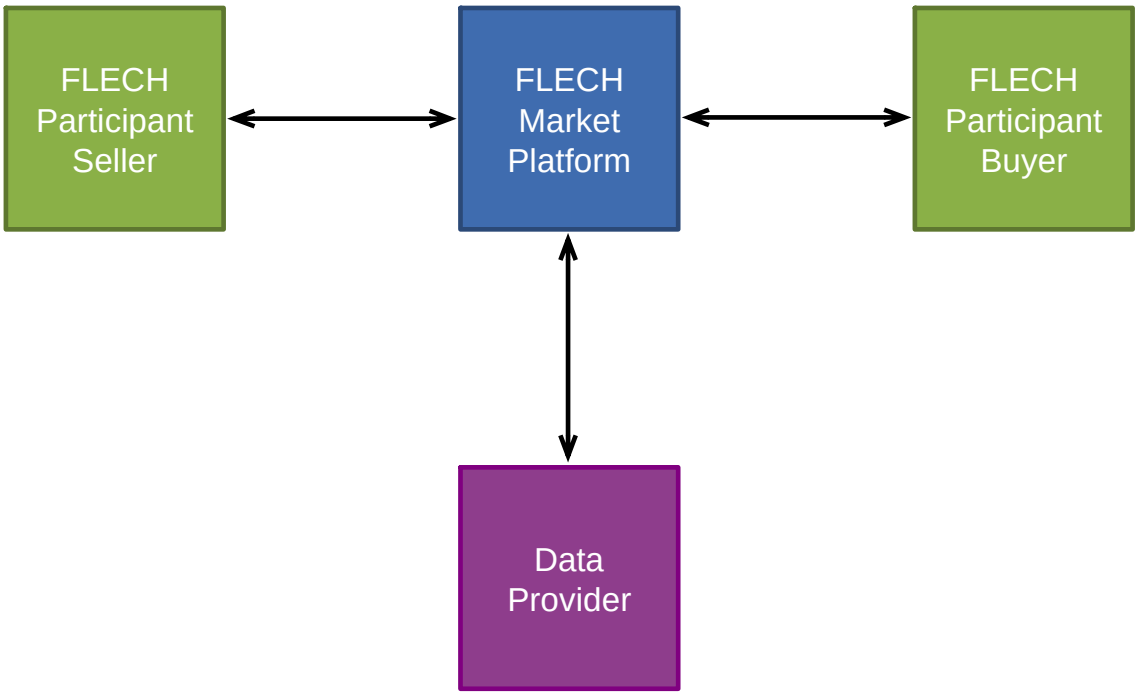

Figure 1 - FLECH Stakeholder diagram

1.1.1 Stakeholder Descriptions

FLECH Market Platform - The flexibility clearinghouse market platform (FLECH) is a generic platform for different established and new actors of the energy market to trade their energetic flexibility. The market platform provides common basic services like communication, authentication, settlement and other necessary services to FLECH market products on this platform. The FLECH market platform can host multiple requests

for flexibility markets of different products concurrently. Therefore, a flexibility market opened by a TSO as a buyer for nationwide use of flexibility for regulation power could compete with a local market for flexibility opened by a DSO as a buyer.

FLECH Participant Buyer – A buyer in the FLECH concept opens a market for a specific product and requests bids from the sellers via the FLECH platform services. The buyer can choose the FLECH product he is interested in and define time and date for bidding, clearing and delivery as well as further characteristics of the product as defined in the FLECH framework. In iPower the buyer was the DSO in EcoGrid 2.0 both the TSO and the DSO can take this role. As Energinet, the Danish TSO, is not a partner in the project the role of the TSO as a buyer is taken by the implementation of the toolset for the TSO (result of T4.2/T5.2) which will emulate the TSO needs. The role of the buyer for the DSO (result of T4.1/T5.1) will be developed in cooperation by DTU and the DSO represented in the project by Bornholms Energi & Forsyning.

FLECH Participant Seller – A seller in the FLECH concept reacts to bid requests which are sent out from the FLECH platform on behalf of the buyer. The seller is usually an aggregator representing an aggregated set of one or more DERs in one or more households/buildings. The aggregator outcome is an implementation of tasks 4.3 and 4.4 and implemented in T5.3 and T5.4.

Data Provider – The data provider provides data to the FLECH market platform, which can't be provided by the seller or the buyer themselves but are necessary for either clearing, activation or settlement. The data provider in the Danish case will be Data Hub. During the EcoGrid 2.0 project, the data warehouse will take this role for simplicity.

Market Design

The IBM Bluemix platform, a Platform as a Service (PaaS) cloud, builds the foundation for the implementation of the FLECH market. It provides different services like a database and message brokers for the implementation. These services are provided from a catalogue on an easy to use model where the developer and operator of the market platform can rely on availability and up-to-dateness of the offered services. This is a benefit over more traditional Infrastructure as a Service (IaaS) cloud or traditional server hosting were the developer and/or operator must take care of installation of necessary software components and/or operating systems as well as maintaining these components and apply security patches. As the platform maintenance is handled by a dedicated team it is also very likely that security fixes are applied earlier and in a more complete way then on self-serviced machines.

The use of IBM Bluemix was motivated by the decision that the FLECH market, a development started in iPower, should be reused for EcoGrid 2.0. The developers working in EcoGrid 2.0 responsible for the market were already familiar with IBM Bluemix and a porting of FLECH to a different PaaS cloud would result in extra effort with no gain in functionality. Other PaaS cloud offerings are available by Microsoft, Amazon, Google and others with a similar functionality.

1.2 Market Block Diagram

The below shown block diagram of the FLECH market shows the interactions between the FLECH Core and the services used from the IBM Bluemix platform. The different services and the purpose are explained as well.

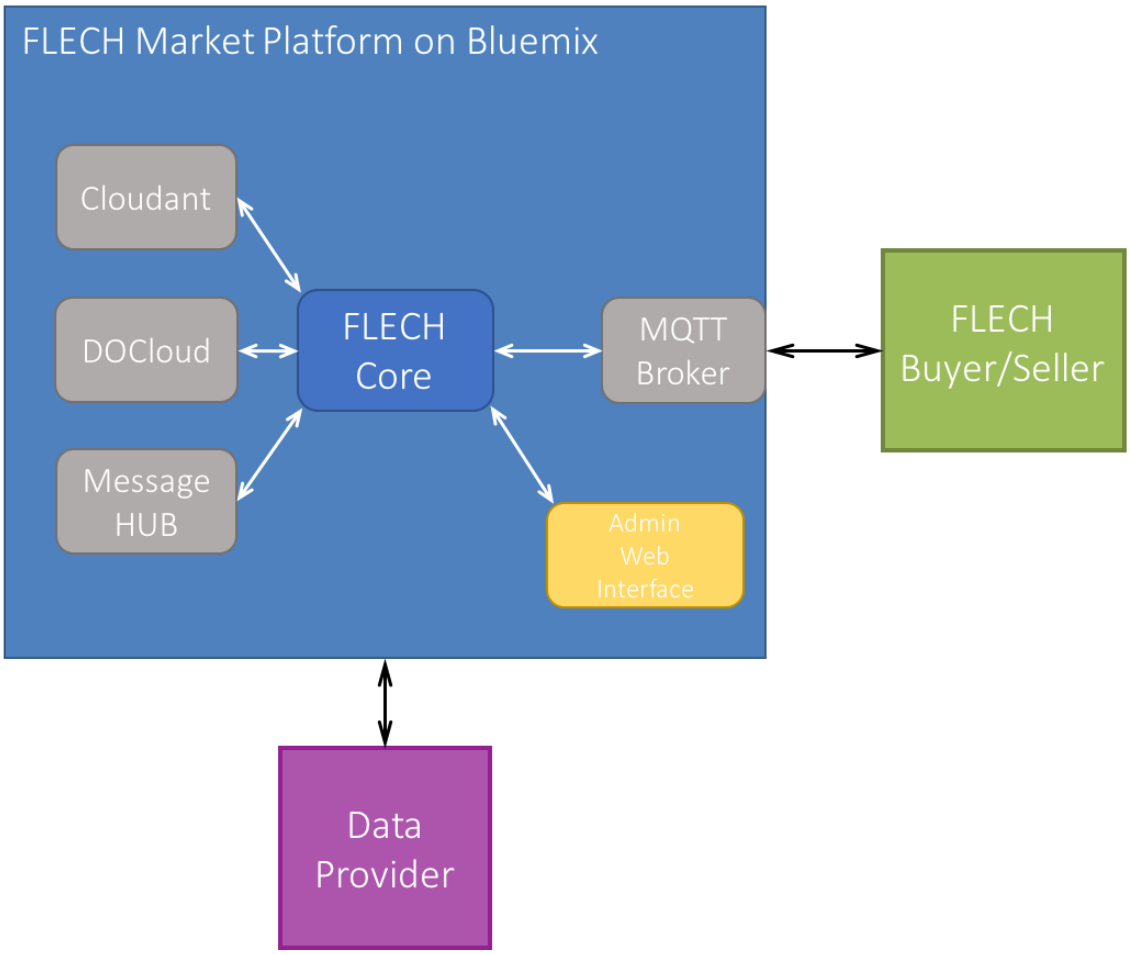

Figure 2 - FLECH component and services diagram

Cloudant – A modern NoSQL database used for persistency of all incoming market messages. All market open requests, bids into the market and the market clearing results as well as any other information objects to be persisted are stored in this database as JSON objects. The database is also used as a data source for the administrative web interface and as a historian for later evaluation.

DOCloud – The Decision Optimization Cloud service is a modern solver which is based on the world class IBM CPLEX optimizer. The DOCloud service is used as a solver for the market clearing. It ensures that the market clearing algorithms are solved in due time with the best possible result.

MessageHUB – MessageHUB is a message broker based on the open source Apache Kafka project running on the IBM Bluemix platform. It provides internal messaging services to the FLECH Core and for communication between the FLECH Core and the administrative web interface.

MQTT Broker – The Message Queue Telemetry Transport (MQTT) broker is a message broker specially designed for use in the IoT environment. MQTT is an open OASIS standard specialized on Machine-to-Machine communication. MQTT is used in FLECH for interactions with the different stakeholders like the TSO, DSO and aggregators. A direct interaction over MQTT to (larger) distributed energy resource would be possible.

Admin Web Interface – The web interface is used to give an admin the possibility to see which products where historically traded in the market and get on overview of the different currently open markets.

1.3 FLECH Core

The FLECH Core contains all the logic, the product implementations as well as the message marshalling, unmarshalling, sending and receiving. The core component also provides the framework for adding new product implementation easily. It runs as the services seen above on the IBM Bluemix platform and leverages the PaaS advantages so that no overhead of running and maintaining an operating system is needed.

The FLECH Core is designed in a way so that multiple concurrent markets for the same product implementation and/or different product implementations can exist.

The FLECH Core components are implemented in JAVA and run as a Cloud Foundary Java Liberty App on IBM Bluemix.

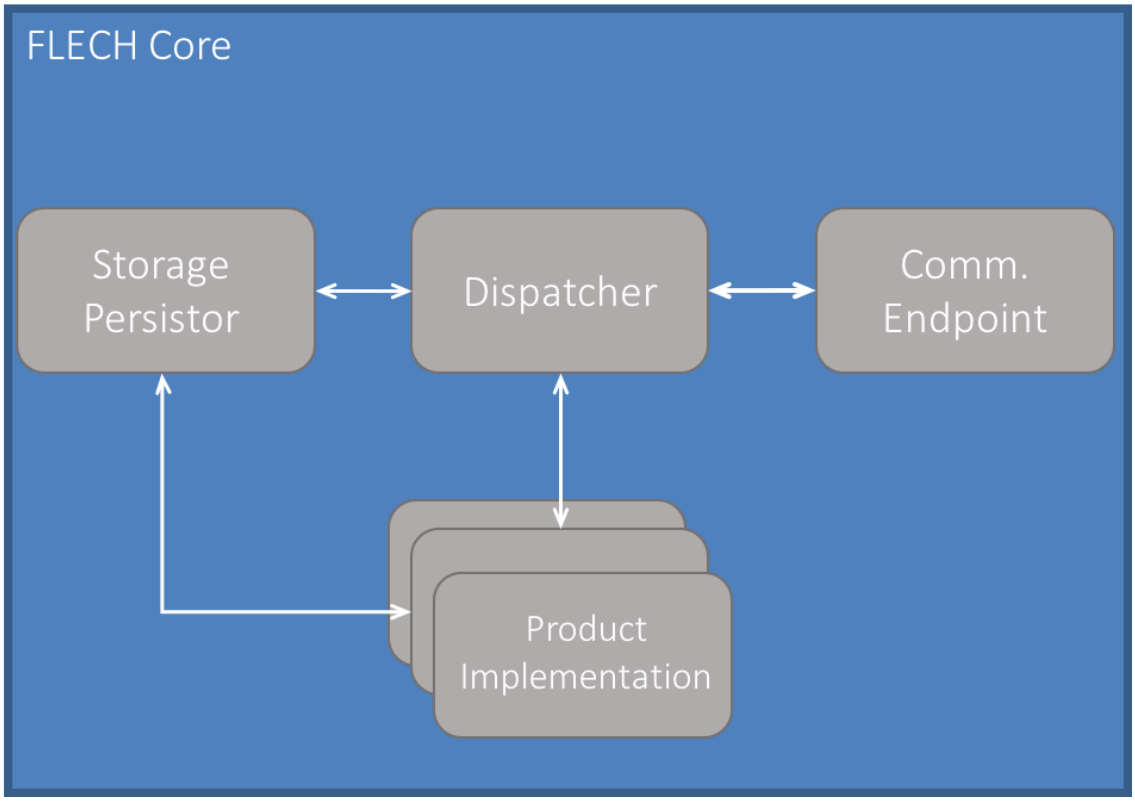

Figure 3 - FLECH Core components overview diagram

1.3.1 Core Component Descriptions

Communication Endpoint – The communication endpoint terminates all the incoming messages, received from the MQTT broker, from the different stakeholders like buyers and sellers. It unmarshalls the necessary information from the incoming messages and forwards the message with the product ID to the dispatcher for routing to the right product implementation. The communication endpoint also sends the product implementation response messages and notifications back to the buyer/sellers via the MQTT broker.

Dispatcher – The dispatcher receives the pre-processed messages from the communication endpoint and routes the messages based on the product ID to the fitting product implementation. It also routes the response messages and notifications via the communication endpoints back to the buyers/sellers.

Product Implementation – The market design allows for multiple different product implementations and each product implementation can handle multiple concurrent or

overlapping markets for one product implementation. The products for EcoGrid 2.0 were designed by work package 2. Details of the clearing algorithm and timing can be found in the respective deliverable of work package 2.

Storage Persistor – All the messages, bids and notifications as well as other details of the market and the product implementation need to be persisted to a database for later evaluation, audit (in a real-world setting) and to be displayed in the administrative web interface. Therefore, the storage persistor component is used as a single connection point to the database. This allows an efficient way to communicate with the database, especially for the different product implementations.

1.3.2 Extensibility for new tradeable flexibility products

The FLECH market platform was designed from the very beginning to be easily extensible to handle new flexibility market products. To extend FLECH to implement a new tradeable product one only must define a new product and its message flows, implement the product messaging and the clearing algorithm by respecting the internal interfaces to the dispatcher and the communication endpoint as shown above and make the communication endpoint and the dispatcher aware of the new product. The latter happens by defining the product ID and the product implementation in the FLECH configuration so the dispatcher and the communication endpoint know where to route the messages to.

In addition the market product message flows and the market clearing code need to be implemented and integrated. The market clearing algorithm can be implemented and solved using DOCloud but this is neither mandatory nor always the best solution. The market clearing could be fully reliant on a custom implementation, the use of other solvers or could call a third party web service for example. Currently the limitation is the use of a JAVA implementation for the flexibility product and therefore the use, if the clearing is not fully self-implemented in JAVA, of a solver which can be accessed from JAVA either by being a JAVA library, a JNI interfaceable library or a solver which can be accessed via a network interface.

1.4 FLECH Deployment on Bluemix

FLECH is deployed on the publicly available and accessible IBM Bluemix PaaS cloud, the two main applications FLECH Core and Admin Web Interface are deployed in the same Bluemix space.

The deployment itself is, thanks to the PaaS platform it runs on, very simple and driven by a deployment descriptor in the development environment. The deployment descriptor describes all the necessary attributes of the application running on the IBM Bluemix

cloud, like the number of instances of this application running and per instance the amount of memory, disk usage as well as the services it uses.

The three following figures below show the deployment descriptor of the FLECH-Core and two screenshots from the Bluemix dashboard showing the deployed FLECH-Core and FLECH-Web application forming the FLECH Market.

```
applications:
- services:
  - flechdb
  - flechhub
  - flechiot
  - flechdo
  disk_quota: 1024M
  name: FLECH-Core
  no-route: true
  path: FLECH-Core.jar
  buildpack: https://github.com/cloudfoundry/java-buildpack#v3.9
  domain: mybluemix.net
  instances: 1
  memory: 1G
  health-check-type: process
  env:
    FLECH_SERVICE: '{"userID":      , "serviceDestination":"backend", "guiDestination":"gui"}'
    FLECH_IOT_CLIENT_ID:
    USE_DOCLOUD: 'true'
    REQUEST_REPEAT_INTERVAL: '20000'
    MAX_NUMBER_OF_RETRIES: '1'
    FLECH_EXCLUDE: '["FLECH-Debug"]'
    FLECH_INCLUDE: '["FLECH-Client","FLECH-Clients","FLECH-INSERO"]'

```

Figure 4 - FLECH-Core deployment descriptor

The Bluemix dashboard gives an overview of the deployed applications and their status as seen in the screenshot below.

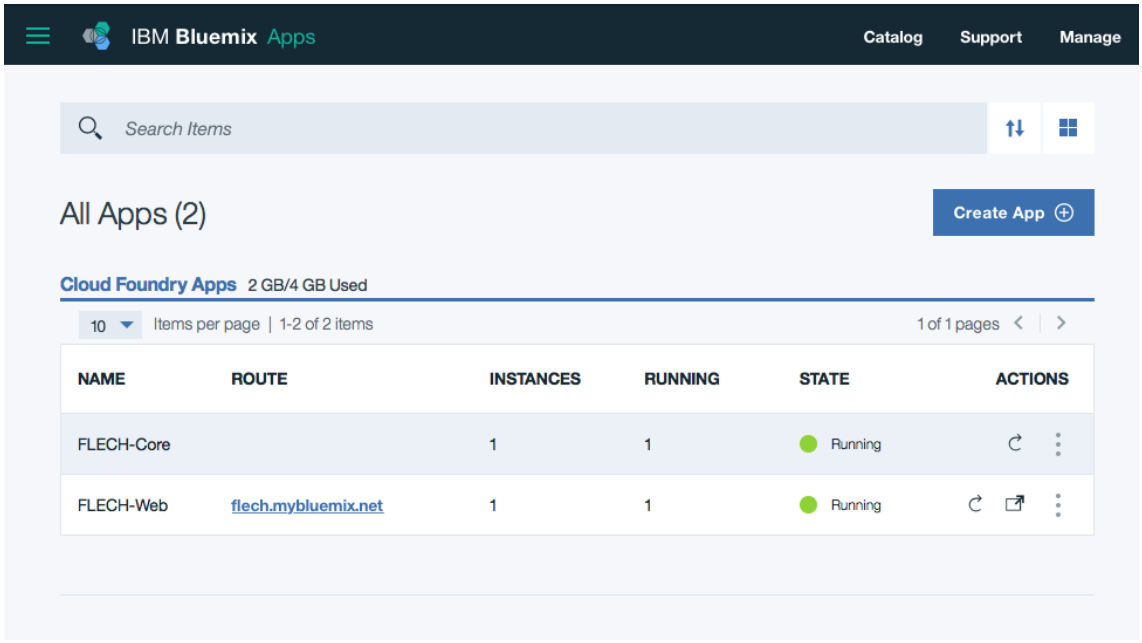

Figure 5 - Bluemix Apps deployment overview for FLECH

Both apps, FLECH-Core and FLECH-Web need support of different Bluemix services as shown above. These services are also deployed in the same Bluemix space.

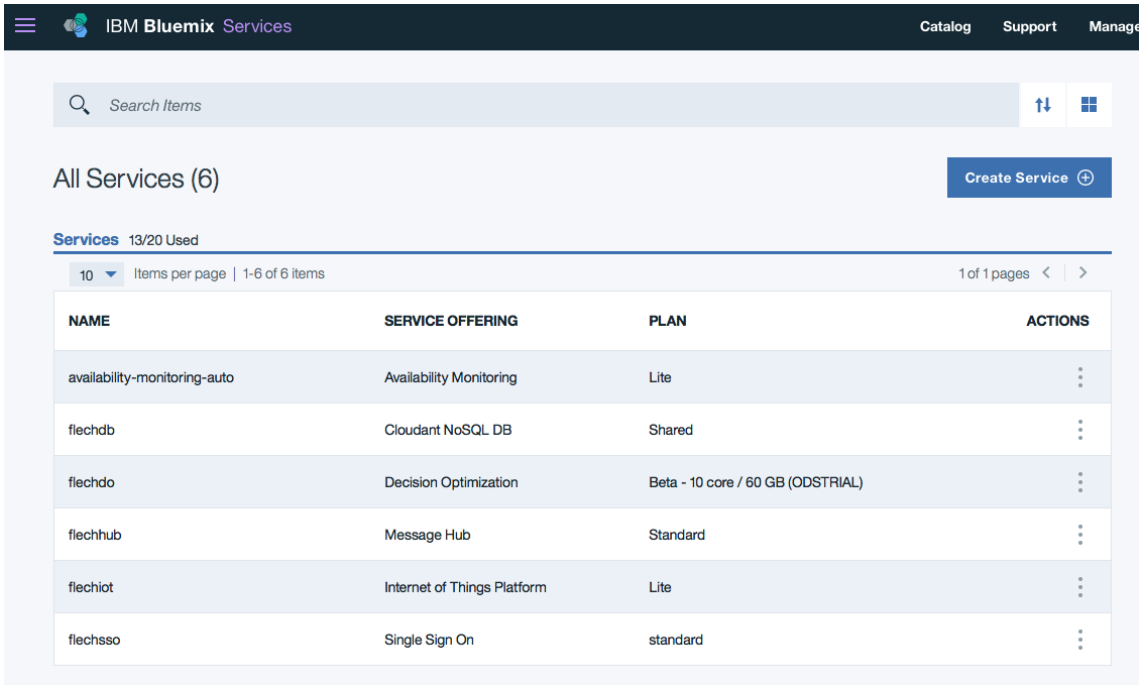

Figure 6 - Bluemix Services deployment overview for FLECH

Abbreviations

Abbreviations	Description
DER	Distributed Energy Resource
DSO	Distribution System Operator
FLECH	Flexibility Clearinghouse
IaaS	Infrastructure as a Service
MQTT	Message Queue Telemetry Transport
OASIS	Organization for the Advancement of Structured Information Standards
PaaS	Platform as a Service
TSO	Transmission System Operator

Read more at www.ecogrid.dk