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DELTA

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DELIVERABLE D6.2
Innovative and Customer Engaging Tools

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Executive Summary

This document presents the results of Task 6.4 Award-enabled Collaboration Platform describing the developed Collaboration Platform as well as the awards given to users as also consumed by users. The main points of this task lie on the awareness over Demand Response services as well as on the improvement of customer engagement, while offering a playful and pleasant interactive environment.

To deliver an online environment that can meet both market and user expectations, the DELTA web platform has been implemented towards providing access to all DELTA stakeholders to the tools and services provided from the project. Going beyond just a simple monitoring framework, the web platform introduced offers a diverse set of functionalities that offers pervasive learning on all aspects related to the DELTA project and its solutions.

In general, the DELTA Platform aims to offer, to both Aggregator and Customers an effective online environment for optimally handling DR-related information within current DR markets and the Smart Grid. Within the literature, interesting technologies have been identified for delivering such tools, and the introduced design and development followed and expanded well-known practises for providing a user friendly, easily accessible, knowledge rich, and interactive framework. As user involvement in general, in DR in particular, is crucial and necessary, all tools developed followed a user-centred approach.

Further emphasis is denoted to three individual tools that have been produced through T6.3 and T6.4. Starting with the Context-aware Visualisation Kit, a lot of different views and dashboards have been created to properly visualise DR-related information, allowing an accurate and fast interpretation of both technical and business perspectives. Following, the award-enabled collaboration platform, there is a forum, where all DELTA stakeholders can discuss and share knowledge, with Aggregators having a valuable channel towards their entire portfolio. This tool is also supported by a simple chat feature. The forum is expected to act as an important tool to the user engagement and active participation during the pilots, as it will not only provide valuable information on the trials and tools, but also allow a more efficient troubleshooting process.

Finally, the DELTA game engine is also presented. A dynamic engine that allows the Aggregator to create custom games for the end-users and deploy them over a period of time, further enriching engagement activities. As stated in previous experiences, gamified services may offer additional added value to the participation of small and medium customers to current and future DR markets. The present document detail these methodologies and how they have been implemented in DELTA.

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List of Acronyms and Abbreviations

Term	Description
ANN	Artificial Neural Network
CIM	Common Information Model
CSV	Coma Separated Values
DER	Distributed Energy Resource
DR	Demand Response
DSO	Distribution System Operator
DSS	Decision System Support
DVN	DELTA Virtual Node
FEID	Fog-enabled Intelligent Device
GIS	Geographical Information System
HVAC	Heating Ventilation and Air Conditioning
PV	Photovoltaic
SoC	State of charge
UI	User interface

1. Introduction

1.1 Scope and objectives of the deliverable

This document describes the Innovative and Customer Engaging tools that have been designed, developed, and integrated in DELTA. These tools are the result of activities performed in *"T6.3 - Real-Time Context-Aware DR Visualisation Kit"* and *"T6.4 - Award-enabled Collaboration Platform"*. The goal of this document is to describe the approach and the strategies utilised to engage users and increase their activity, specifically concerning participating in DELTA DR requests.

The current deliverable details 3 user-centered tools from the DELTA Architecture: the DR Context-Aware Visualisation toolkit, the Collaboration platform and the DELTA Gamification Engine, all part of one uniform web platform. All components are interlinked and interact with each other towards presenting a highly enriched experience to the DELTA end-users.

1.2 Structure of the deliverable

The work presented in this deliverable is structured as follows:

- **Chapter 2** presents some literature and commercial findings in regard to solutions relevant to the DELTA project for end-user engagement and enhanced visualisation.
- **Chapter 3** introduces the DELTA web platform as developed to provide access to all identified end-users and for all DELTA tools. This sections also covers some added-value services that the platform incorporates and haven't yet been presented in other technical reports.
- **Chapter 4** presents in detail, the DR context-aware visualization kit, including all the visualization aspects that have been designed and implemented towards facilitating not only monitoring of DR-related information, but also to promote easy and effective participation.
- **Chapter 5** presents the collaborative aspects of the DELTA web platform, which mainly consists of a forum and a chat engine.
- **Chapter 6** presents the gamified services that have been implemented for DELTA, with a dedicated game engine supporting various aspects of the functionalities provided, either on the platform or through other components.
- **Chapter 7** concludes the report.

1.3 Relation to other tasks and deliverables

The work contacted through activities of T6.3 and T6.4 are closely related with the requirements defined through T1.1 and the architecture defined in T1.2. Through these, an initial set of user and business requirements have been defined and, lead the design of the tools covered within this report. Moreover, results from WP2 are utilized not only to define the games but also to investigate efficient ways to engage users in DR participation taking also into consideration business models and energy market strategies.

In addition, within this report the visualization of various technical components developed by activities performed in tasks of WP3, WP4, and WP5, is also delivered. Hence, there is close

relation with their results, as well as their use towards further promoting end-user engagement. This link is also present through other integration activities within WP6.

Finally, as the DELTA web platform will be the main tool that end-users, in both pilots, will be using during the pilot activities (T7.3), this task is also related to WP7.

2. Customer-oriented services for improved DR management

It is generally acknowledged that Demand Response services can be rather difficult to use on small and medium customers, mainly due to their small revenue margin and the high complexity in contracting them in the current DR markets. Nevertheless, as the markets are changing to more distributed and dynamic schemes, it is inevitable that flexibility services will also be provided to such end-users. Their reliable response however is still a difficult task, as their upwards and downwards flexibility could be more volatile than RES. As a result, a lot of effort has been given to identifying tools and technologies that cannot only raise awareness but also introduce approaches that can increase participation and ensure increased reliability in both explicit and implicit DR signals.

Within the following sections a short introduction to the two most applied technologies for raising user awareness and incentivize participation are covered, in an effort to better describe the overall picture around the tools selected, designed and implemented within the DELTA project.

2.1 Visual Analytics

There has been a lot of effort to utilize visualizations techniques in Smart Grids. This has led to categorizing them in three main categories: low dimension techniques, multivariate high dimensional techniques, and Geographical Information System (GIS) techniques [1]. Also, in [2] a classification of visualization methods in terms of goals is presented. In general, these techniques produce complex graphs, and some simplified variations may be used [1].

Alternative ways to exploit visualization methods in Smart Grids are still explored. In [8] the utilization of Virtual Reality for Smart Cities is presented aiming in presenting big data in more intuitive ways. In [9] a Visual Analytics System is depicted monitoring energy data, especially big data collected in Smart Cities.

In [3] some visualization techniques are proposed aiming to analysing DR outcome in terms of load efficiency (Figure 1) as also in profit (Figure 2). The goal is to achieve DR effectiveness analysis through 3D load graphs depicting temporal displacement of the scheduled loads, or by a 2D representation of the price difference between actual and forecast market prices [3].

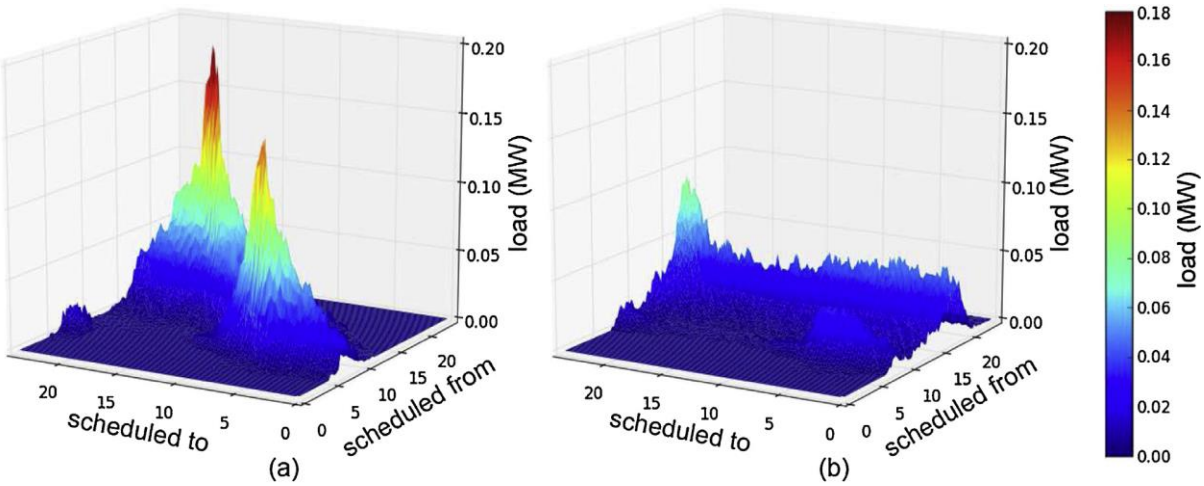


Figure 1. Image from [3] depicting the 3D load graph of the temporal displacement of schedulable loads for both (a) constrained and (b) unconstrained cases.

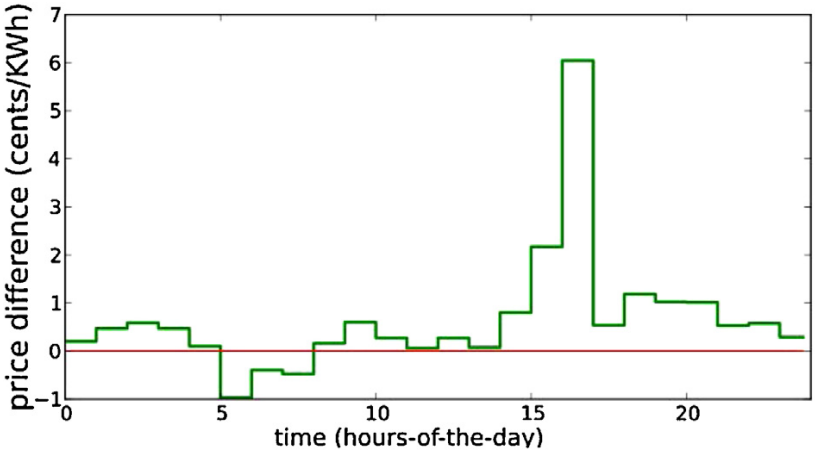


Figure 2. Image from [3] depicting the price difference between the actual and the forecast spot market prices

Usually, the so-called traditional visualization techniques are used [1][2][4] for example, line graphs of power loads, as they are simple but provide useful insights. In DELTA's case taking into account the three layers (Aggregator, DVN and FEID), traditional visualization have been chosen that focus on different DELTA layers, thus offering a holistic view in case of Aggregator, an intermediate view in the layer of DVN and a more focused view in the layer of FEID.

However, when scaling up, such traditional methods aren't always optimal. An interesting example is the case of [5], where in an effort to identify DR opportunities some simple visualization techniques are employed (Figure 3). Even though it becomes easy to identify overall statistics, it becomes quite cumbersome to identify details and extract key aspects that can lead towards actual dynamic DR optimization.

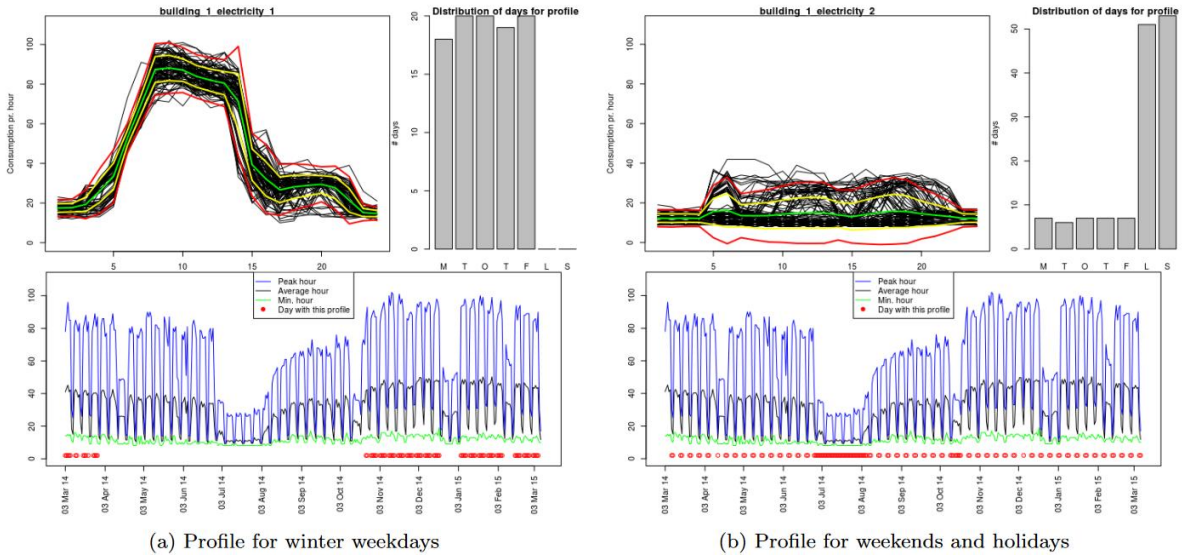


Figure 3. Day type profiles computed over one year of data from a public school [5].

Various other techniques have been researched. By leaving traditional methods behind and exploring more sophisticated methods to visualize DR-related information, when coupled with big data, there are various methods that may provide valuable information mainly for the Aggregators and Utilities.

Reviewing such techniques for the smart grid, authors in [6], have found a variety of multivariate high dimensional visualization techniques, such as scatter plots, parallel coordinates, Andrew curves, as well as geographic information system (GIS) based ones. In a bit more recent review [7], a general classification of visualization methods for the smart grid is presented, covering from single to multiple dimensions methods. Interestingly enough, even though a wider range of methods is initially described, when exploring the smart grid in particular, quite less have been actually applied. From these surveys, one interesting visualization technique that has been identified but not mentioned in the smart grid context is the radial tree. As will be shown in the following sections, it provides an overview of an Aggregator's portfolio in an easy and condensed manner.

Finally, since DELTA also utilizes not one, but two clustering approaches, several different visualization techniques have been explored, solely for evaluating and validating their functionality and performance. Nevertheless, both results provide quite interesting findings that could prove to be extremely beneficial to Aggregators, Utilities, or retailers.

2.2 Gamification Principles in Demand Response

Gamification, in general, is the application of game-design elements and game principles in non-game contexts in order to improve user engagement [12][14]. It's an alternative way to engage and motivate people in a variety of tasks. Gamification is used in a wide range of applications and domains, such as education [15], health [25], and businesses [17]. In recent years, the focus has been turned in the energy domain and more specifically in the demand response scheme. The use of gamification, as a social mechanism, in this area could be justified by two main reasons: (i) the EU recommendations that explicitly mention the importance of residential customers engagement in the efficient planning and use of electricity using smart metering systems [3], and (ii) the fact that smart metering systems alone do not necessarily drive residential customers to use energy in a more sustainable manner [13]. Therefore, more attention is now being paid to customer engagement in addition to technology.

Looking in more detail at some of the literature findings, an interesting discussion on the application of gamification in DR is found in [10]. Such solutions are expected to encourage customers, especially residential ones, to provide high flexibility and active participation in DR programs. Different game design elements can offer different results, such as raising awareness, educate, or being incentivized to actively and reliably provide their flexibility. A good example provided, is the case of Gnauk et al. [12], in which "green" titles are assigned to customers according to their participation. Within the proposed framework the customers were declaring their flexibility on specific loads (i.e., a washing machine) for a specific timeframe through a user interface. Through an interactive approach, the customers were rewarded with points based on their time-dependent flexibility.

Following a similar approach, a set of daily and monthly goals was proposed in [17]. Based on the monthly average consumption and peak hour consumption, the proposed system aimed at reducing the energy consumption in general, either at peak time or on a monthly basis. As a result, customers are expected to shift their flexible loads i.e. towards night hours where energy pricing is cheaper. Providing a specific timeframe for each goal would make its application similar to that of a DR request.

Focusing once again on residential customers, authors in [11] introduce a game that aims towards raising awareness. Based on the "know" and "care" approach, the game revolves around CO_2 emissions (the carbon game) and customer's energy consumption. Users can log-in through a mobile app and accept challenges. The least CO_2 emissions, wins. This approach could be quite interesting if applied to DR scenarios, especially if challenges are coupled with critical cases.

Going specifically on DR-related gamification approaches, an interesting application is the use of a Stackelberg game in [16], which automatically leads assets to perform optimal changes in the context of a game-theoretic framework for participating in DR energy markets. Even though the results are

promising, such approaches are applicable mainly to explicit control and do not actively engage users to the overall flow.

On the other hand, in a large scale deployment of a game (i.e. GenGame[1]) in the UK, interesting results have proven the potential to significantly boost consumer engagement with energy and free up capacity on the grid[2]. Combining both hardware and software tools for the end-users, it is an excellent example of how games and gamified services can actually be a powerful tool for DR-enabled households.

In summary, one of the key limitations of existing game engines provided to aggregators is that they do not support the dynamic creation of new games by them, also they do not provide any adaptive characteristics. Following on Zichermann statement [27], such an approach doesn't provide a lot of room for improvement based on understanding the factors and drivers that affect human behaviour and could lead to better performance. DELTA works towards this direction providing tools to the Aggregator to dynamically create new games, or alter old ones (e.g. change the points awarded for a certain action) to maximize the impact that a gamified service can have onto their portfolio, especially for small residential implicit customers. Such actions, could increase awareness, participation, and ultimately the success of a DR request.

By informing end-users about price changes, or other related incentives (e.g., CO2 emission reduction), end-users have successfully changed, by a small percentage, their behaviour leading to the desired results. Even though there is a lot of research on game mechanics for Demand Response, their application on real world environments with real-life users is rather limited. Nevertheless, experience so far has shown that this technology could be the way to unlock the DR potential of small customers.

[1] https://www.gengame.co.uk/
[2] https://openenergi.com/news-posts/gengame-partnership-demonstrates-power-gamification-drive-domestic-dsr-success/

3. DELTA Web Platform

To enable Aggregators, Customers, as well as other third-party users in using the DELTA framework, a unified web-platform has been designed to give access to all stakeholders. Building upon the requirements defined in WP1 as well as features and functionalities required during the implementation process, and through the end-user engagement, a constantly evolving web-based tool has been implemented and deployed under https://delta.iti.gr. Besides incorporating information from all core functionalities of the DELTA framework, the web platform also includes some added-value services. These are listed below.

As a reminder, DELTA consists of three layers, namely the Aggregator, the DELTA Virtual Node (DVN) and the Fog-enabled Intelligent Device (FEID), whereas Aggregator is the top layer and groups multiple DVNs, DVN is the middle layer and groups multiple FEIDs and FEID is the bottom layer and is directly correlated to a specific customer where it is actually installed.

These layers have been considered extensively during the design and implementation of the DELTA innovative and customer engaging tools, but also for the entire DELTA web platform. For example, in the Visualization Kit the provided views and information is structured according to these three layers offering a holistic view for Aggregator and specific view for Customer, which is for a specific FEID.

3.1 Notifications / Alerts

As the DELTA web platform supports a wide range of different tools and functionalities, as well as user roles, different types of notifications/alerts are supported and provided to the end-users.

3.1.1 Demand Response

One of the most critical type of notifications is the one related to DR requests. Both the Aggregator and the Customers are informed for upcoming DR Events. The time frame of the DR, the issuer, the target and the relevant awards for participating in the DR are included in each notification. According to the type of the DR request (Load Dispatch, Time of Use, etc.), there is a distinction in the information included in the notification body.

Depending on the type of the customer and level of automation selected on the FEID, DR notifications notify customers for new DRs and especially for explicit DRs they offer a menu where Customers can accept or reject the DR. As described later in this document the period between DR notification and customer acceptance is used in a DELTA Game, where customers receive points depending on how fast the acceptance took place.

3.1.2 Gamification

When a user performs a gamified action inside the platform, a payload is sent to the server. As a next step, the gamification server processes the payload and is responsible to assign the customer points. When the server has completed its internal processes (calculating the points for each game the user is a participant, storing the action as historical data), the user should be informed, and real time notifications have been proven to be quite effective. So, when all calculations and processes are finished inside the server, a notification is sent to the User Interface through a socket.

3.2 Reporting

The DELTA web platform offers a lot of information to users including various tables summarizing data especially for Aggregator and DVN layer, as well as several graphs in all three layers. For all these

tables and graphs users can download the relevant information in CSV format. In this way users can then process and manipulate these data and for example easily examine several time series.

3.3 Visual Analytics

As discussed in section 2.1 DELTA Visualization Kit is based on the three DELTA layers. Hence, for Aggregators it offers an overview of the system e.g. a radial tree on the Dashboard, as well as views with information in the DVN layer and, in the FEID layer. With this approach Aggregators can focus on the layer of their choice and explore information with the desired detail. Therefore, for Customers it offers views focused on their FEID data.

As mentioned in Section 2.1 visual methods used in Smart Grids are usually complex and this complexity could increase taking into consideration the three DELTA layers. Usually traditional visualization methods are utilized. Graphs and diagrams should be simple and easy to comprehend, especially for Customers. Thus, DELTA employs mostly traditional visualizations techniques, as explained in detail in Section 4.

3.4 Collaborative services

Exploring the potential and the principles of pervasive learning, DELTA introduces a forum section within the web-platform, along with a simple chat engine, towards raising awareness, expanding users' knowledge, and instigating collaboration among customers, while also providing a well-known channel for communication among the DELTA stakeholders. Covering a lot of different aspects and information, the collaboration platform developed within DELTA is presented in Section 5.

3.5 Award-enabled services

As identified in the literature, gamified services can provide significant added value to the active engagement of end-users, especially in large scale deployments of small and medium customers. To that end, DELTA has designed and developed a game engine, which allows Aggregators to create ad-hoc games based on a predefined set of rules, actions, etc. and provide various incentives/rewards around a new point system. The game engine interacts not only with the end-users/customers directly but also indirectly through other DELTA components, such as the collaboration platform or the DR services. Section 6 provides a full outline of the design and functionalities offered, covering a wide range of capabilities within the overall framework.

3.6 User management

As any platform, the DELTA web platform has incorporated a set of user management services that allow a more scalable, secure, automated and interactive access to the platform.

3.6.1 Registration

One of the basic functionalities of the web-platform is the registration of users. The registration process is divided into two steps. At first, the user visits the official website of the project, under the registration section. A form containing personal information (email, password, name) about the user, must be fulfilled. Captcha is also supported. When the user registers, a confirmation email is sent to the user's email address. As a second step, in order to complete the registration process, the user has to click to the link provided in the confirmation email which redirects him to the login page of the official site of the project.

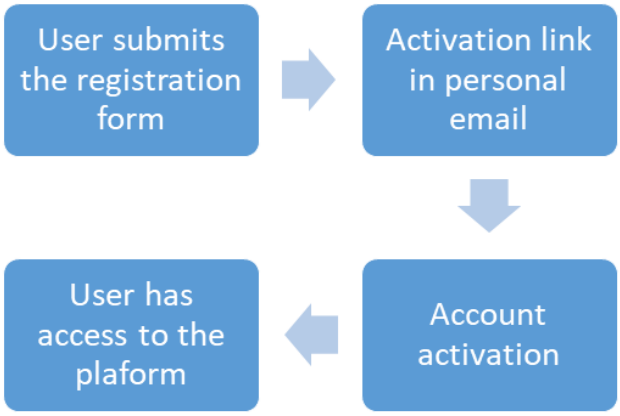


Figure 4. Registration Process.

As shown in the below image, the registration form consists of an email, a password, the name of the user and reCAPTCHA[3]. The email address the user submits has to be a valid email in order for the registration procedure to continue. In other cases, the user will not have access to the confirmation link and the account will not be activated.

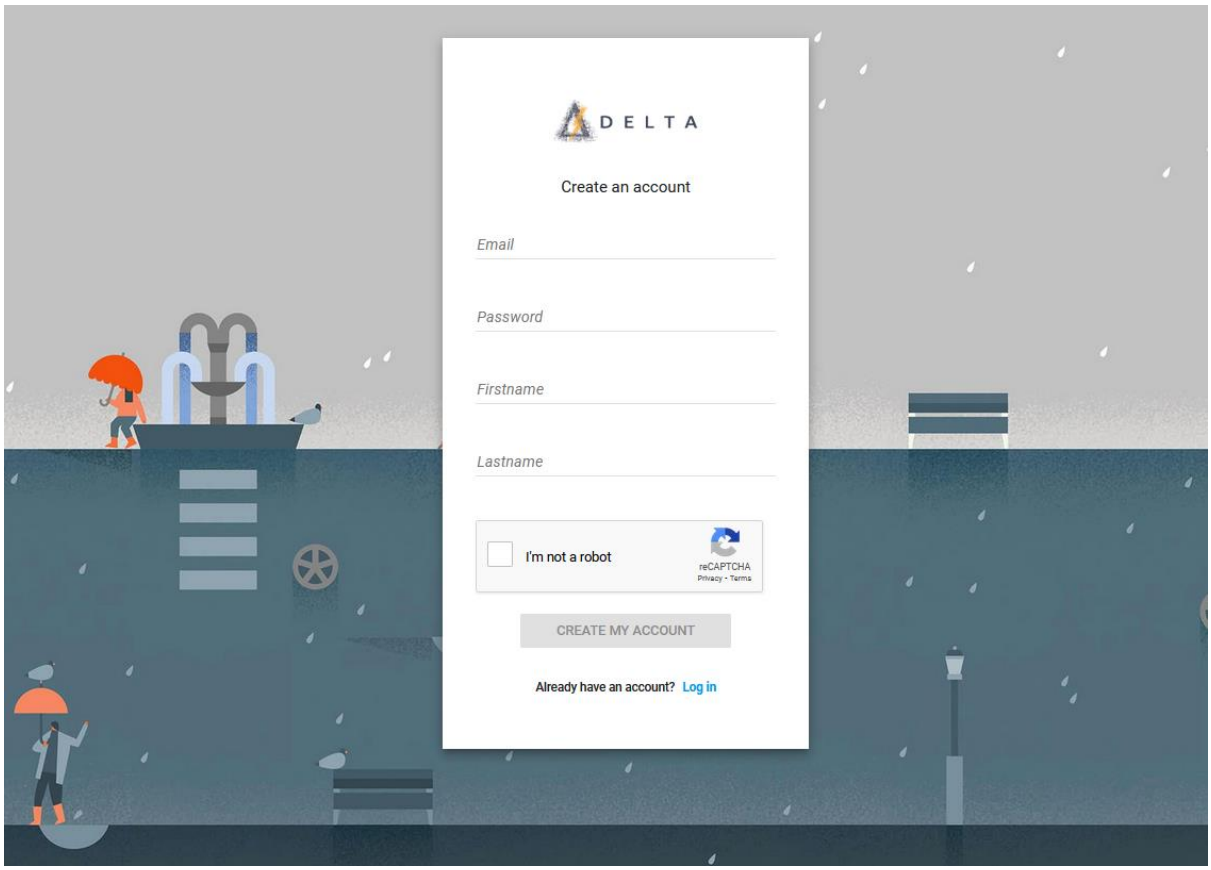


Figure 5. Registration Form.

As with any complete web-platform, it also provides a "Forgot Password" functionality, so that the users can retrieve their password.

[3] https://www.google.com/recaptcha/about/

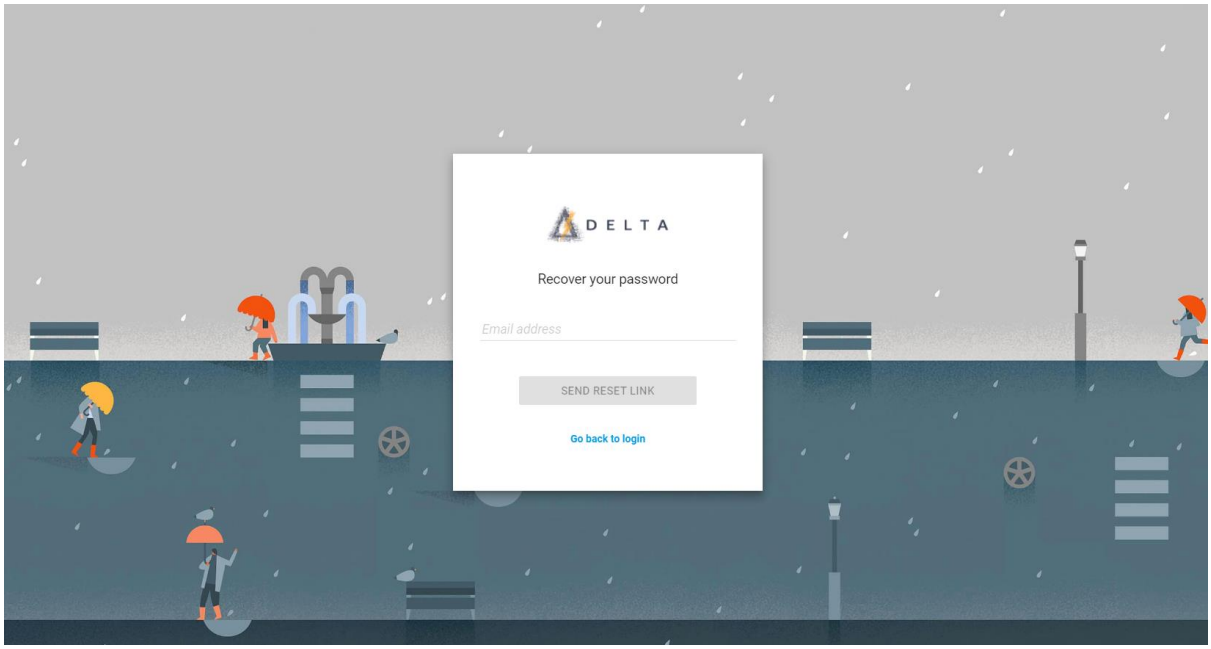


Figure 6. Forgot Password form.

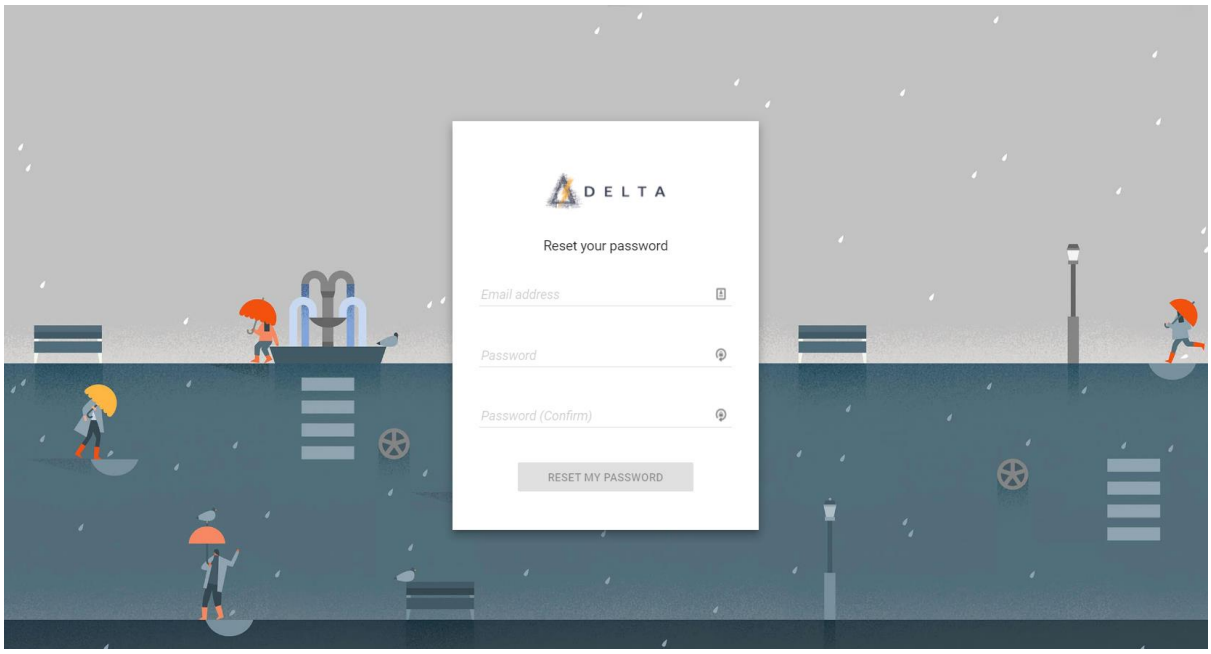


Figure 7. Reset Password form.

3.6.2 Roles

Within DELTA there are three main user types (roles), namely Aggregator, Full Customer and Guest Customer. A brief overview of their description is provided below, mainly in terms of access and information provided to each role.

- **Aggregator:** Aggregator refers to a user with various privileges in DELTA, compared to other user types, as it is responsible for various DVNs and through them to the relative FEIDs. Aggregators have a more holistic view of the overall system as described in the relevant

subsection. They can administer several DELTA aspects and have access to various tools via the Visualization Kit.

- **Full Customer:** Full Customer refers to typical DELTA customers that that have been registered in DELTA and have a FEID installed on their premises and properly configured. These users have access to specific information inside DELTA Platform mainly focused on their FEID and their premises. Therefore, they have access only to specific information inside DELTA as described in the relevant subsections (i.e., subsection 4.2.1).

- **Guest Customer:** Guest Customer refers to users that have registered to DELTA and have limited access to DELTA Platform but enough to let them decide whether they want to be promoted to Full Customers, which is to fully participate as members of DELTA. The process of their registration and promotion is described in this document.

3.6.3 Invitation

To extend user engagement while also allowing improved business potential, core functionalities like the forum and its games, are available also to Guest Customers. Hence, it has been considered valuable to be able to include as many users as possible to the web platform in an effort to create a community that can leverage from knowledge and experiences shared through these tools.

Towards that direction, an invitation feature has also been included, allowing all user roles to invite people to the DELTA web-platform, initially as guest customers, and potentially in the future as full customers.

It is also within our scope to create a demo experience for these users, so that they can explore the functionalities offered by being part of the DELTA family.

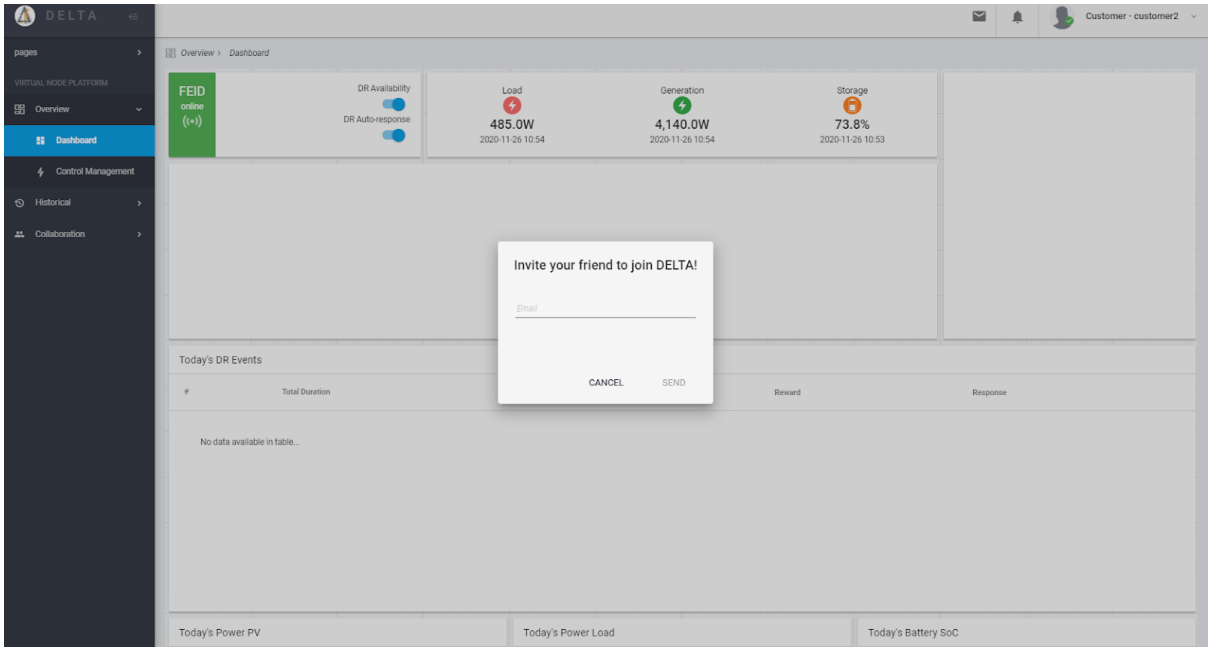


Figure 8. Invitation form to invite a friend to join the DELTA web-platform.

4. DR Context-Aware Visualisation Kit

In order to enrich the visualisation of DR related information provided by the various components on all the layers of the DELTA architecture, the DELTA web-platform includes a set of visual analytics tools, as part of a larger DR Context-Aware Visualisation Kit. These tools aim to provide a more user-friendly representation of DR related information, towards increasing the overall success rate, while raising user awareness and participation.

The latter is responsible to present DR information both in real time and for historical DR requests. Based on the level of the actor/user, the presented information is selective, targeting only essential parts of the visualised data. For example, customers can access information about DR applied to them, but not the applied strategy to the DVN, while the Aggregator has access to visualised data over the entire distribution grid stability but not the DR applied to each customer. The following sections depict the views of both actors.

The Visualization Kit is a Web Application built on AngularJS (v6) and NodeJS (v10.16.3), and SaSS for the styling. All visual components such as graphs and diagrams are illustrated utilising the widely used d3js (https://d3js.org/). The Visualization Kit does not utilise any database but integrates gamification back end Web API, described in this document, to store and retrieve any necessary information.

4.1 Aggregator Holistic View

Aggregator is responsible for managing all DVNs and through them all FEIDs. Therefore, it is imperative for the Aggregator to have a holistic view of the entire DELTA framework. The DELTA web platform offers access to all DVN aggregated data but also information such as customer lists and tools. Especially concerning gamification, Aggregator can manage and configure the gamification engine i.e. create new games, configure games and its participants etc.

4.1.1 Aggregator Overview

In order to make it easier for the Aggregator to have a high-level holistic overview of the entire portfolio, with specific key metrics and functionalities to better understand the overall performance, the engaged customers and issues, three overview pages have been created for the Aggregator.

A general dashboard has been introduced as the DELTA Aggregator UI homepage. As Figure 9 illustrates, a radial tree diagram has been used as a representation of the entire Aggregator's portfolio. In the centre of the radial tree the current Aggregator is denoted. In the next layer the DVNs that Aggregator handles are depicted and for each DVN the FEID clusters generated based on the FEID clustering algorithm. On the final layer the FEID of each cluster are illustrated.

This view has been selected to summarize the three aforementioned DELTA layers while keeping the visualization as simple as possible and easy to interpret. It also offers a quick preview of DVN magnitude in terms of number of FEIDs.

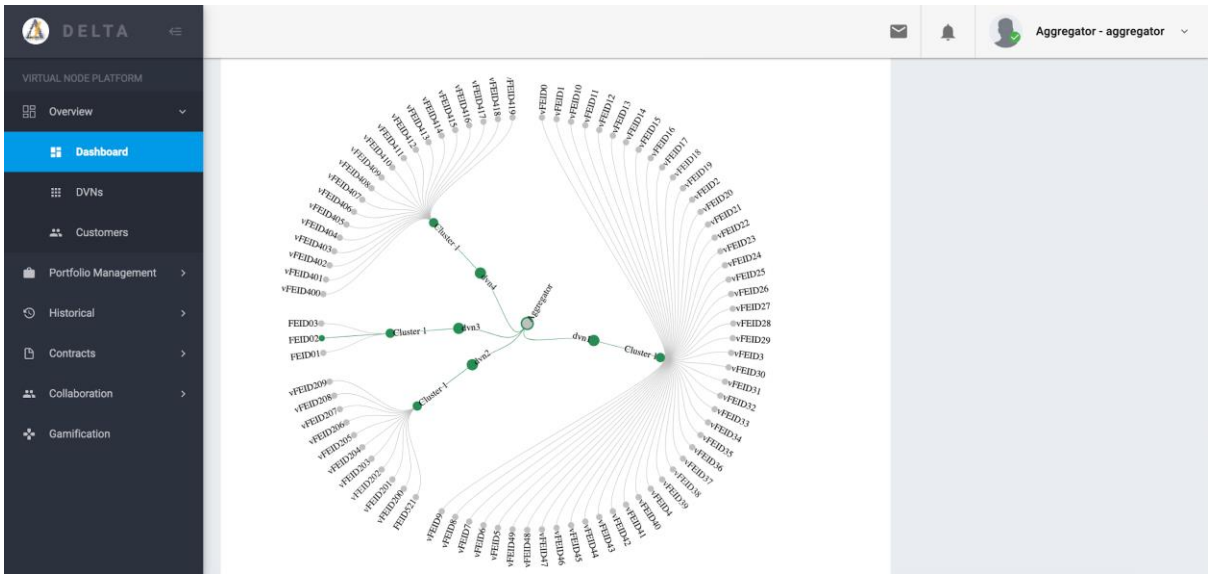


Figure 9. Aggregator Dashboard – Radial Tree Portfolio Overview

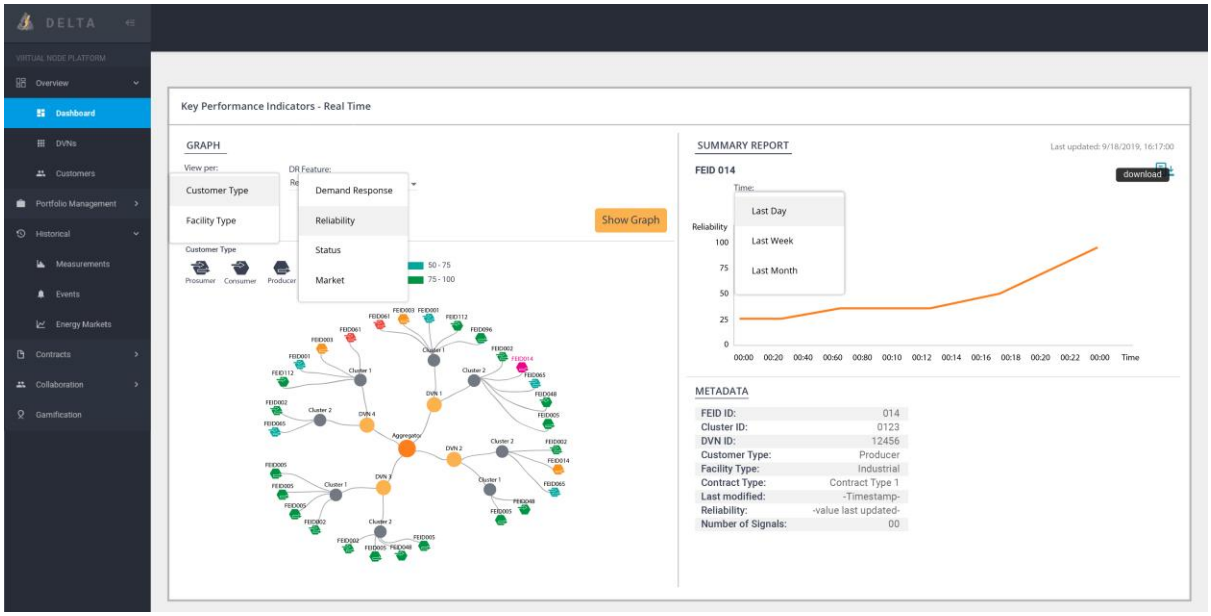


Figure 10. Aggregator Dashboard – Full view

Besides a high-level representation of the entire portfolio, the Aggregator is also able to see all formed DVNs, with their aggregated data, as well as more detailed information about daily DR events. To further facilitate the navigation through the multiple DVNs, a set of filters is also provided.

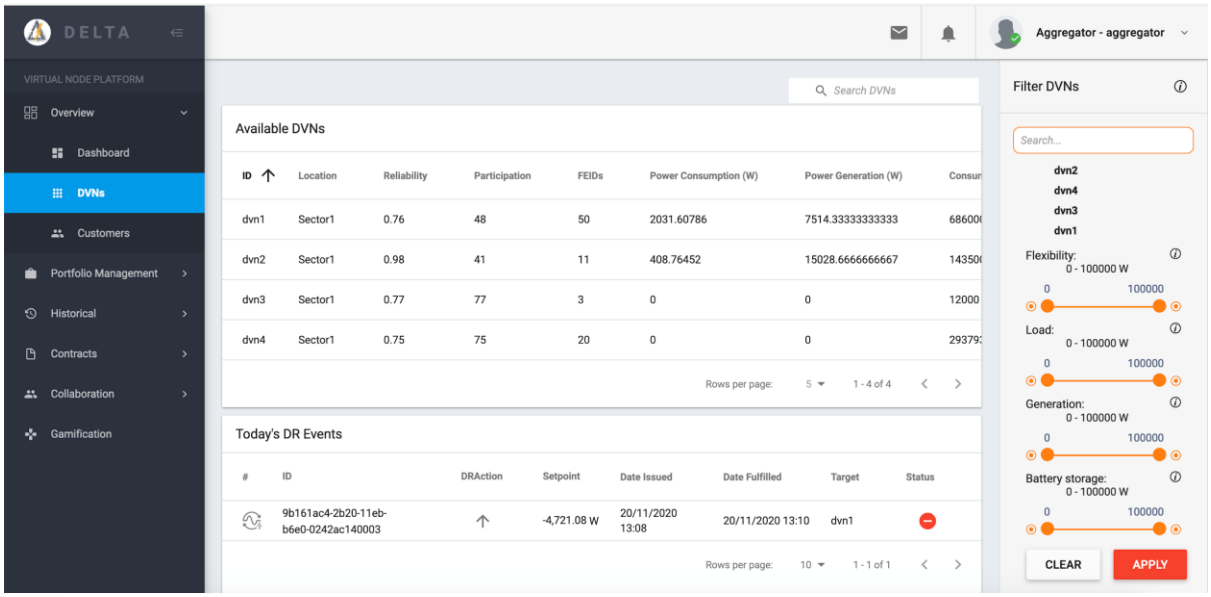


Figure 11. DVNs and DR requests overview tables, including selection filters.

In more detail, DVN features such as reliability, sector, power consumption and generation are displayed for all Aggregator DVNs as well as today's DR Events for all DVNs. To present more information, the Aggregator can select a specific DVN (e.g., dvn3) and obtain info on FEID level as depicted in the following figure.

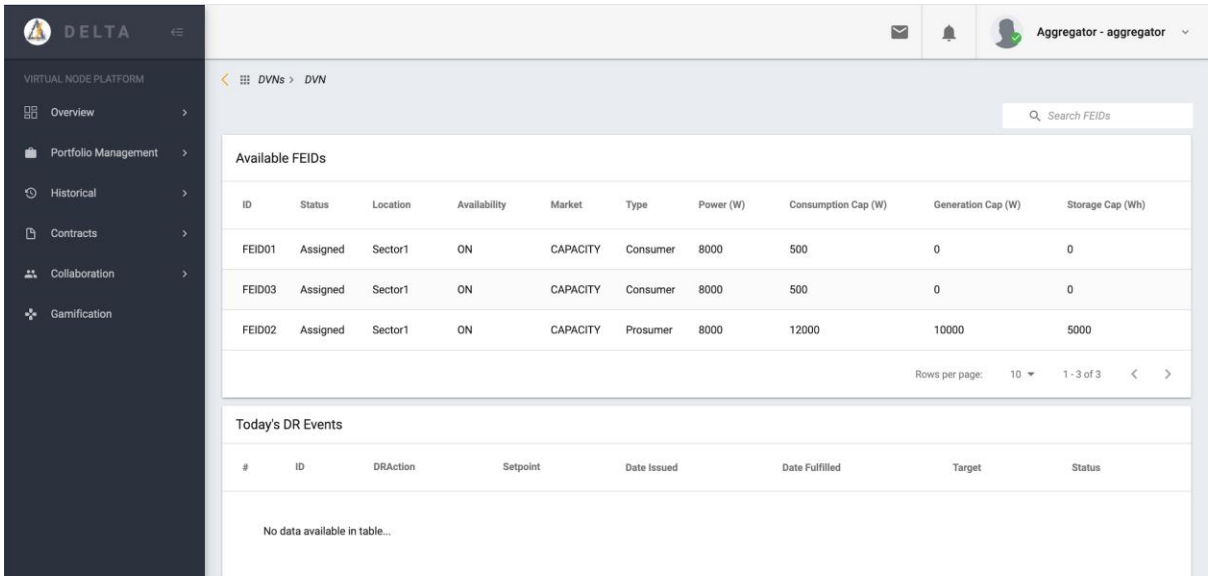


Figure 12. Available FEIDs within DVN3, and daily DR requests for the same DVN.

The Aggregator is informed for all FEIDs on the selected DVN and their characteristics such as Type (Consumer/Prosumer), power, consumption, and storage capacity. Also, today's DR Events for the selected DVN are displayed.

Moving deeper into the "tree", the Aggregator can select any of the available FEIDs and obtain more detailed information on that specific FEID (e.g. FEID02). The Aggregator gains access to load, generation, and storage information of that customer or customers connected to the FEID, its current status and availability for DR, as well as whether this is actually an explicit or implicit user.

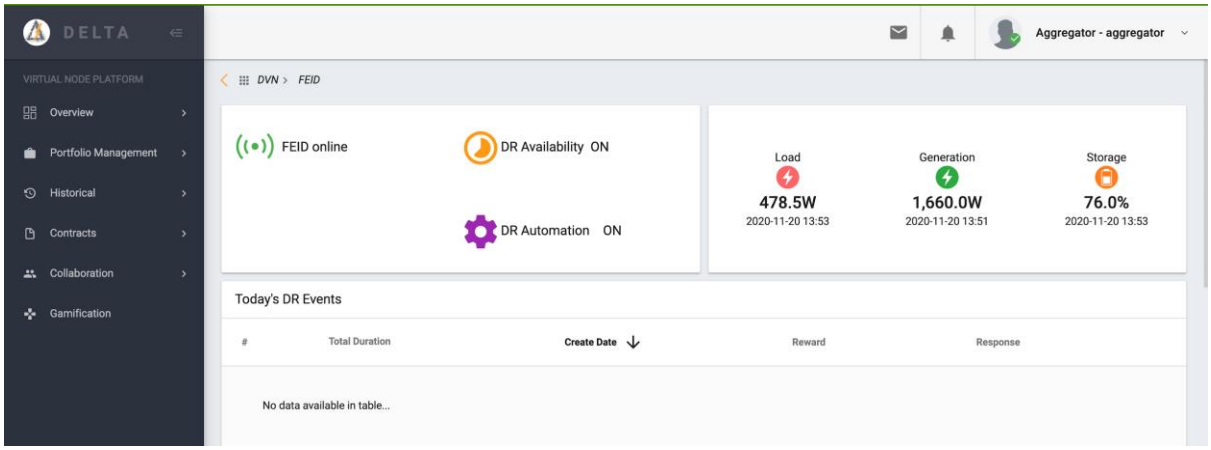


Figure 13. FEID Overview illustrating FEID Status and current basic metrics like Power Load, Power Consumption and Power Storage (if any)

Furthermore, the current day is further presented through a series of graphs that can provide further insight on the customer's performance throughout the day (Figure 14). This is considered quite an interesting feature as it helps towards identifying rather quickly some unexpected behaviour, especially when compared with the forecasted values.

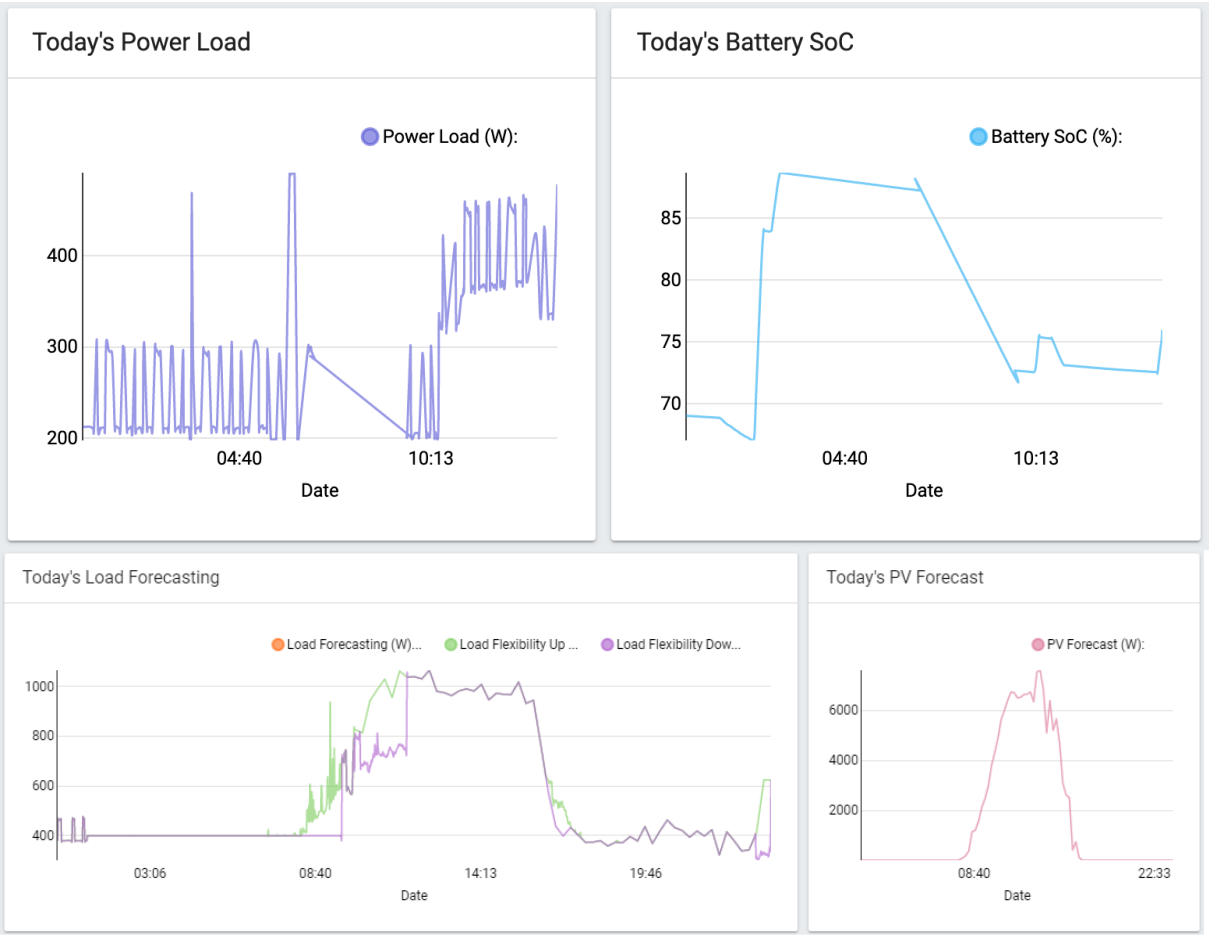


Figure 14. FEID measurement graphs.

Of course, the Aggregator can view existing customers as well as existing FEIDs both unregistered and registered to customers. Also, the Aggregator can manage and modify FEID registration to customers. Figure 15 depicts how the Aggregator can handle its customers.

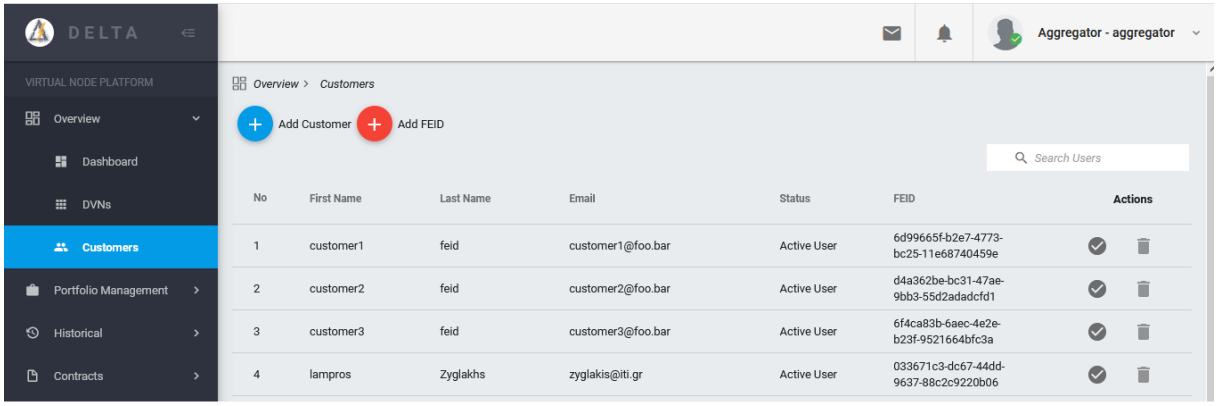


Figure 15. Customer Management.

4.1.2 DELTA Portfolio Management

The DELTA project has developed and introduced an arsenal of novel tools for Aggregators. In order to be able to evaluate and validate their performance, but also to allow a better experience to an Aggregator user that wants to understand how each of the tools works, the DELTA Visualisation Kit offers a set of interfaces specifically for Aggregators. These tools offer a better understanding of the DELTA Platform as well as valuable information of how the overall framework works. The Portfolio Management wraps these tools that are presented in this subsection.

The first tool is DR Emulator, where Aggregator can send new DR Events to one or more DVN. Figure 16 illustrates this tool. DR details and the relevant outcome are available in another view presented later in this document.

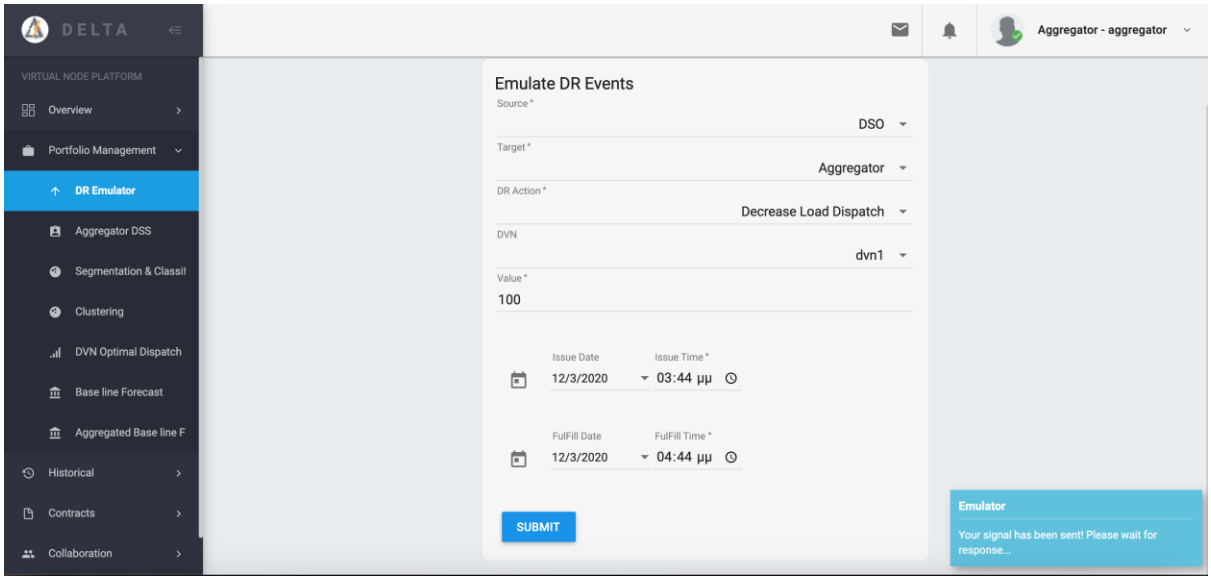


Figure 16. Portfolio Management – DR Emulator

Aggregator also includes a DSS algorithm and the Visualisation Kit contains the relevant view. The latter allows Aggregator to trigger the process and optimise its settings. The image below illustrates the DSS tool.

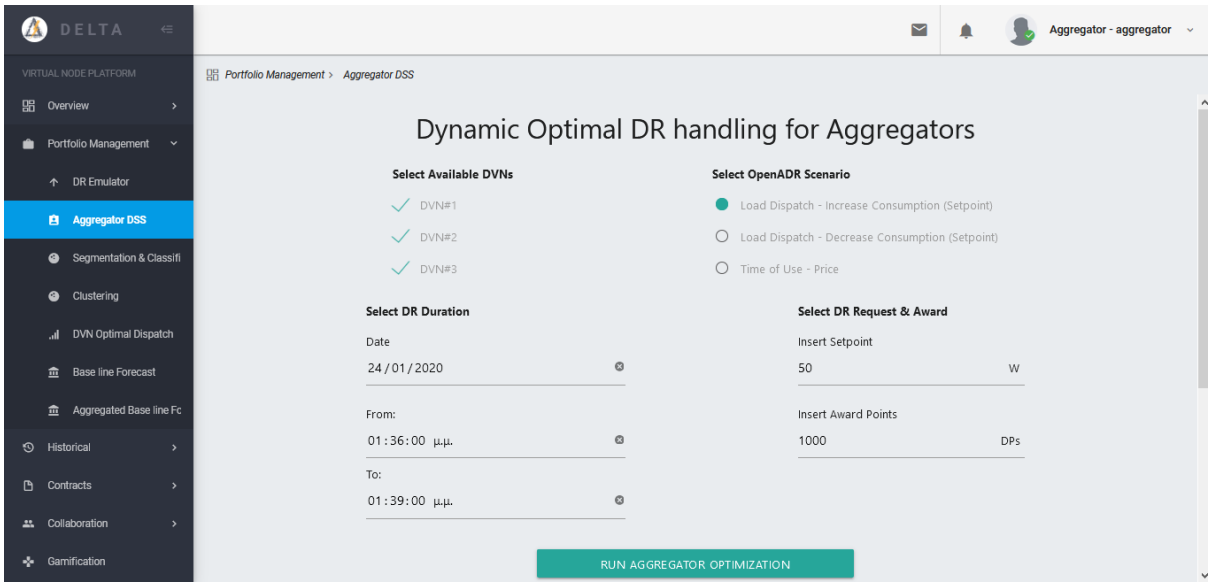


Figure 17. Portfolio Management – Aggregator's DSS

Given the arsenal of components developed within the DELTA framework, two more useful tools for the Aggregator, depicted in the next figures, are the Portfolio Segmentation and Multi-factor Clustering engines that are used as its name suggests creating segments and clusters and concerning FEIDs. Given the different nature and goal of the two tolls, different parameters are allowed for exploring different clustering results. Just like other tools within this section of the web platform, the main goal is to provide an evaluation, validation, and education oriented graphical interface.

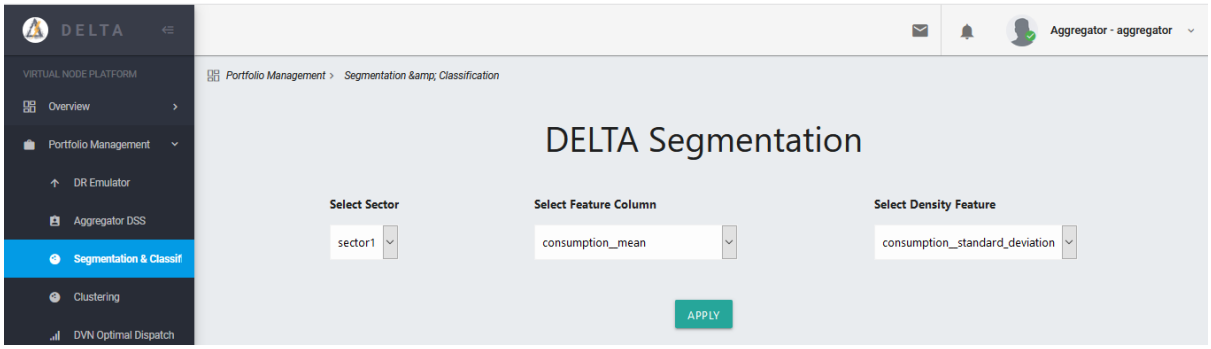


Figure 18. Portfolio Management – Aggregator's Segmentation engine

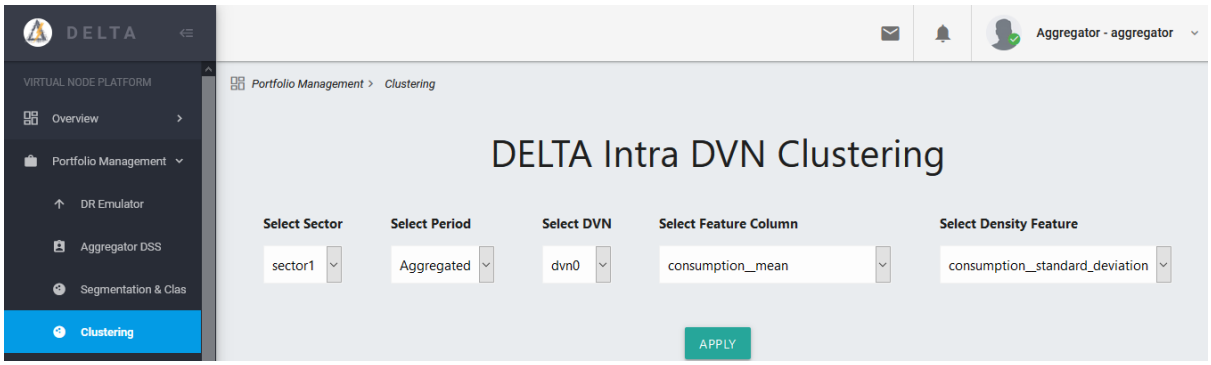


Figure 19. Portfolio Management – Intra-DVN Multi-factor Clustering engine

Furthermore, the Visualisation Kit offers Aggregator a tool for DVN Optimal Dispatch. The UI depicted in the figure below allows the Aggregator to trigger and execute optimal dispatch scenarios, enabling once more the evaluation of the developed component.

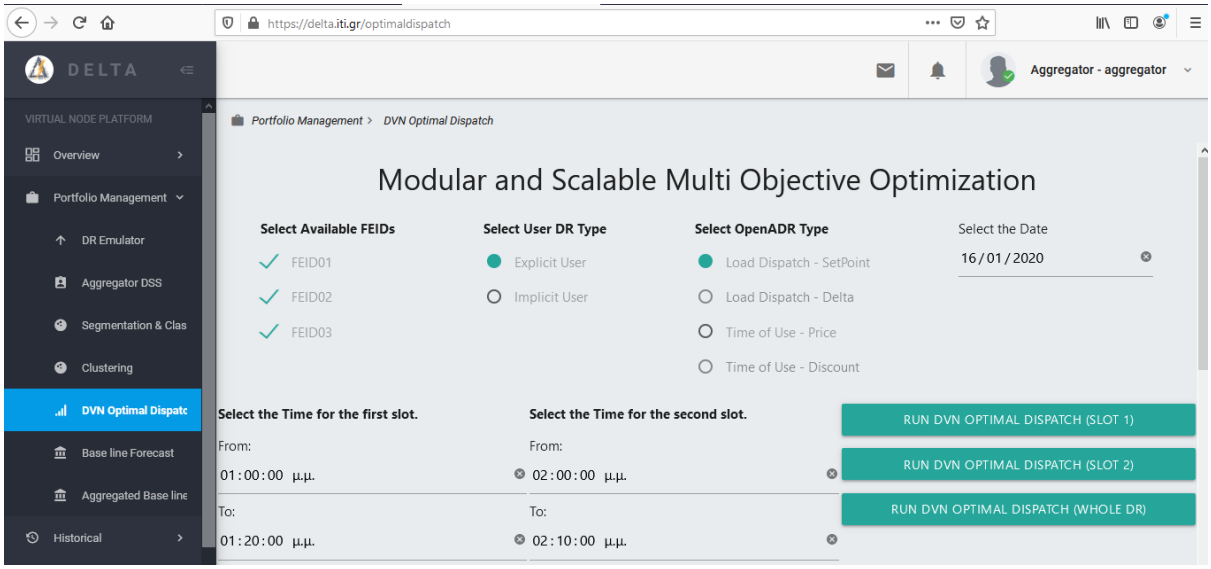


Figure 20. Portfolio Management – Intra-DVN Optimal Dispatch (OptiDVN)

Finally, to evaluate the performance of the forecasting engines developed and deployed on two layers of the DELTA architecture, two dedicated views have been provided. More precisely, there is one view (Figure 21.) for Baseline Forecast where the Aggregator can train DVNs and FEIDs based on baseline measurements and a view (Figure 22.) for Aggregated Baseline Forecast where forecasting based on FEIDs data is compared to forecasting based on DVN aggregated data.

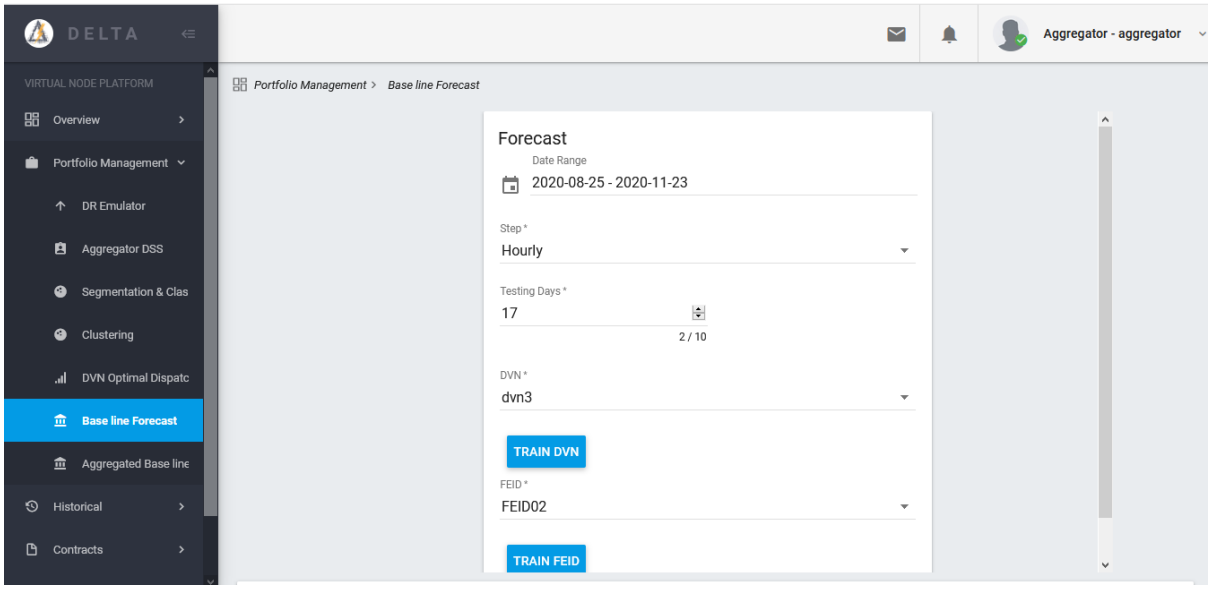


Figure 21. Portfolio Management – DVN/FEID Individual Forecasting Engine

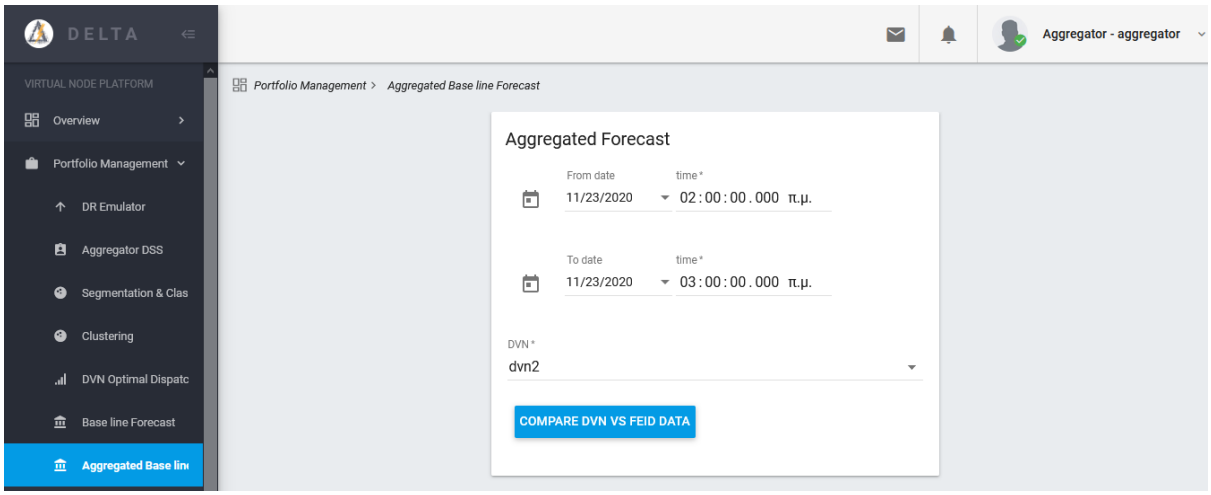


Figure 22. Portfolio Management – DVN Forecasting vs FEID Aggregated Individual Forecasting

Results from this section of the DR Visualisation Kit have already been presented in the evaluation scenarios in D6.3, whereas new features will be showcases in D6.4 as well.

4.1.3 Historical Information

Accessing historical information is imperative for Aggregator to take a glimpse at past events and e.g. investigate how the system responded or handled DR requests. For this, several views are available.

The first view concerns historical measurements. As depicted in the next figure there are various graphs. Initially today's data are displayed, while Aggregator can request data for custom time frame.

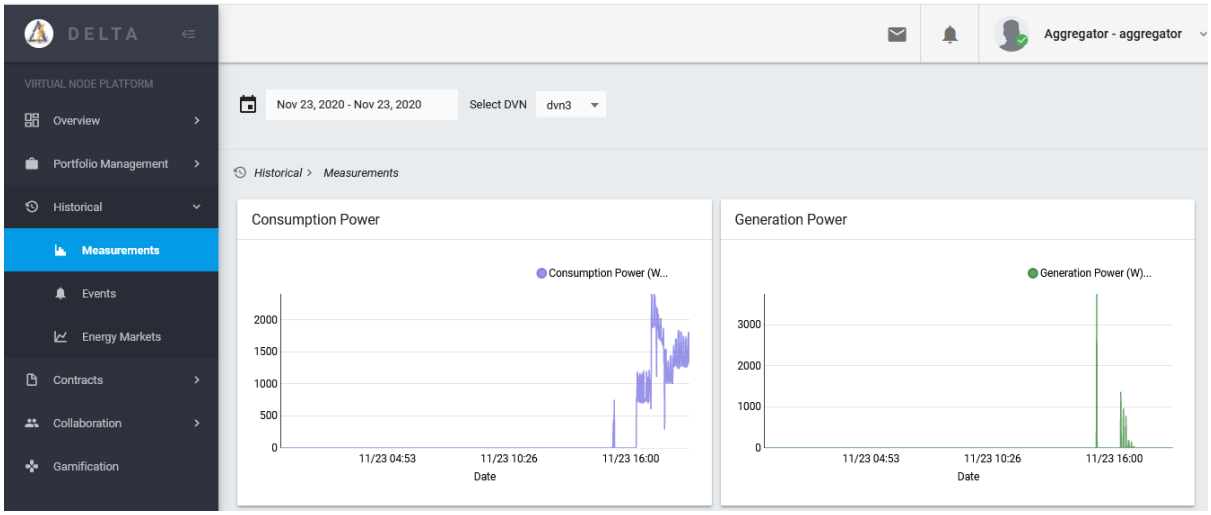


Figure 23. Historical – DVN Measurements

Another historical view depicts historical DR events as it can be seen in the image below. This offers an overview of DR executed e.g. its type, the relevant time frame as also the status as the image below illustrates.

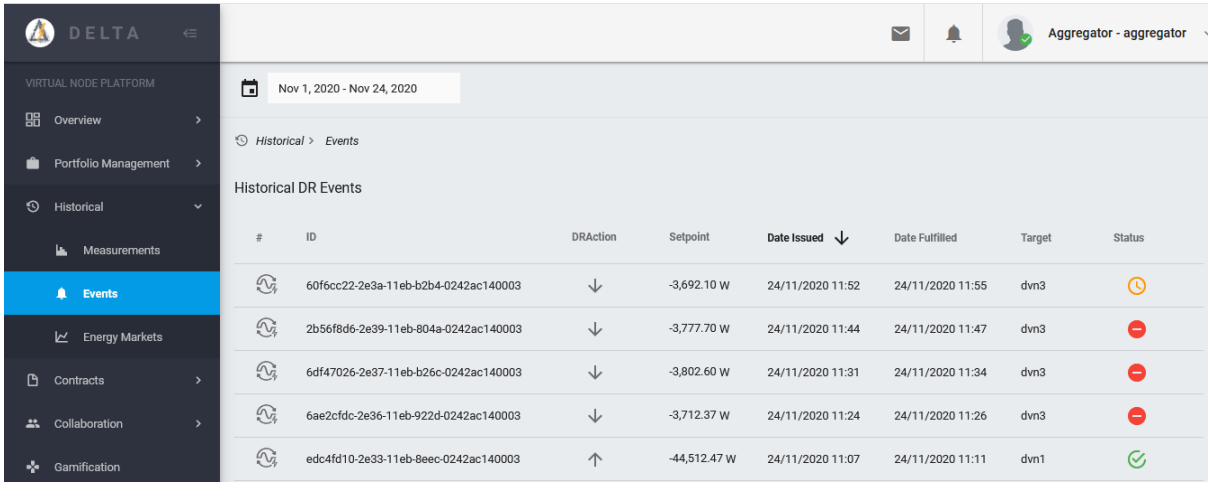


Figure 24. Historical – DR Events List

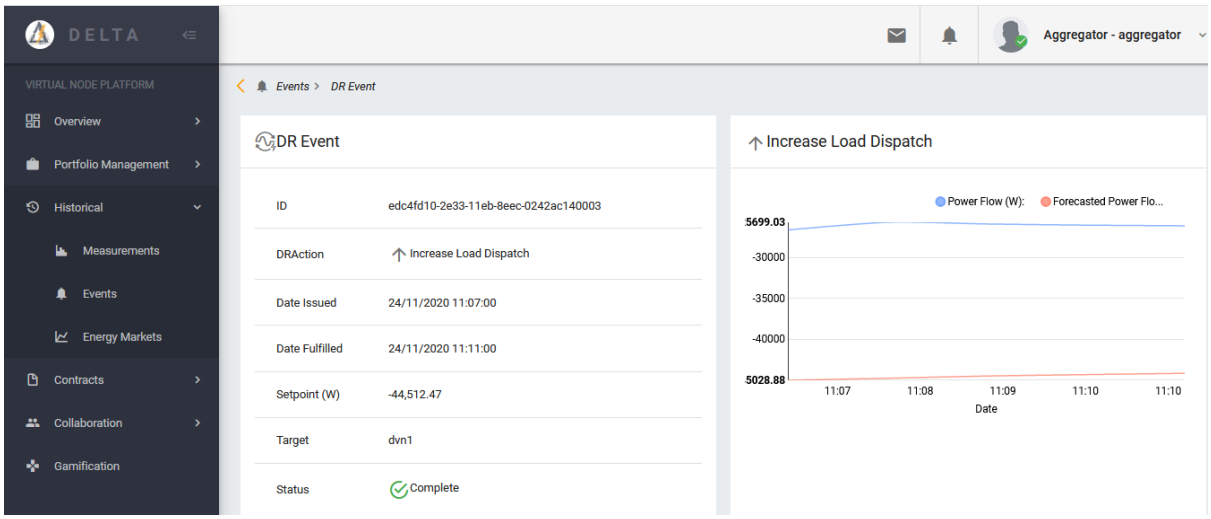


Figure 25. Historical – Details of a specific DR Event

As the figure above illustrates Aggregator can select a specific DR Event and view details about the request and a graph for power flow and forecasts for the relevant DVN.

The Aggregator can also access historical information concerning energy pricing and forecasts. More precisely there are dedicated graphs depicting the Day-Ahead, Intra-day, and Imbalance Markets' prices.

This particular information is valuable for Aggregator in order to gain insights about the profit during the selected time period.

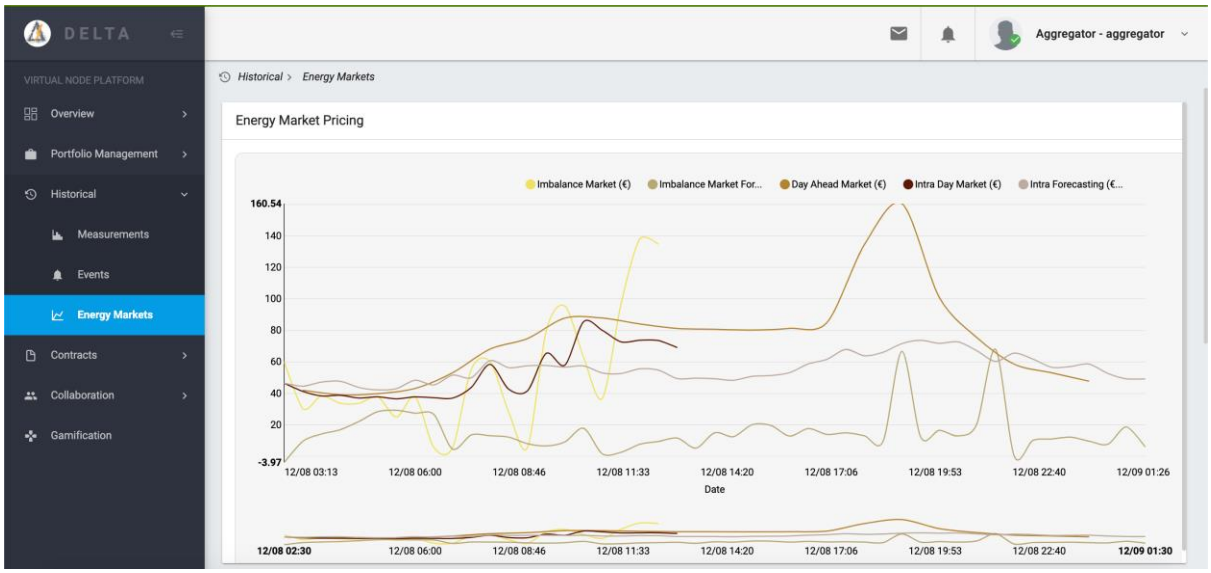


Figure 26. Historical – Energy Market Prices. Forecasted and Actual data.

Complementary to the prices, DELTA has also delivered a forecasting component for the Net Imbalance Volume of the UK market. Visualizing such information allows a better understanding on the prices' real and forecasted performance.

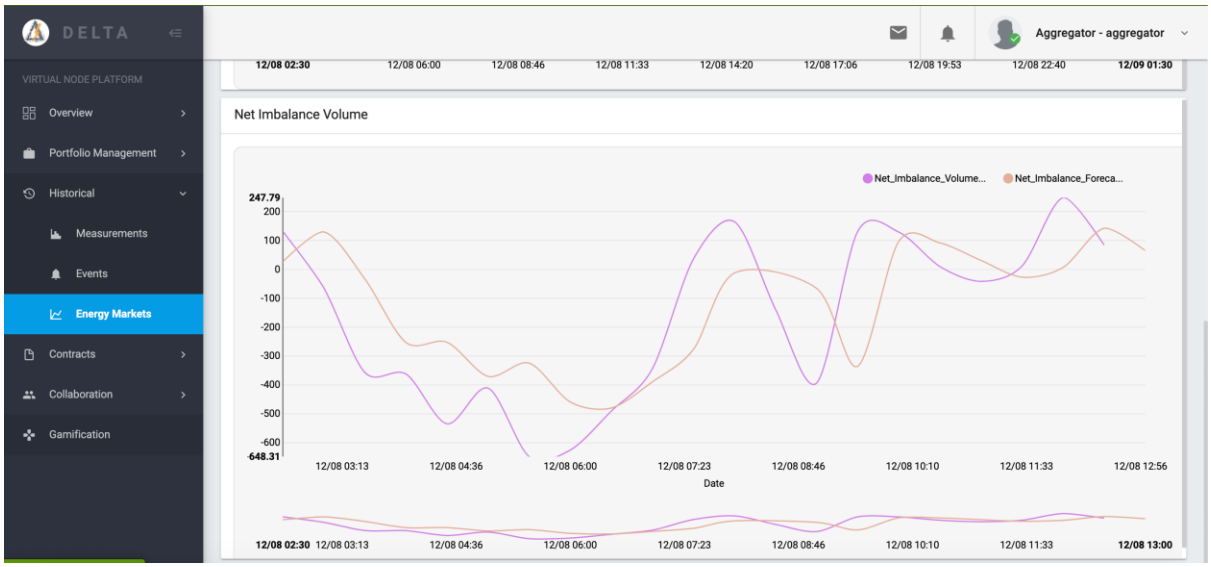


Figure 27. Historical – Net Imbalance Volume. Forecasted and Actual data.

Of course, there are also more views for Aggregator concerning Gamification that are detailed in Section 6 of this document.

4.2 Customer Specific View

DELTA Visualization Kit also offers to Customers information focused on their FEID, which is a more specific view of the DELTA system compared to Aggregators' holistic view. More precisely, Customer can access valuable information focused on the specific FEID that has been installed on his/her premises.

Since the implementation follows a cross-platform approach, by using the Ionic platform (https://ionicframework.com/) this allowed a version of the Customer UI to be built as a mobile app, as presented in D3.4 - Fog-enabled Intelligent Device. This particular software is an open source UI toolkit for building performant, high-quality mobile and desktop apps using web technologies - HTML, CSS, and JavaScript - with integrations for popular frameworks like Angular, React and has plug-ins like Apache Cordova that enables web developers to use their HTML, CSS, and JavaScript content to create a native application for a variety of mobile platforms. Following this approach, it was feasible to convert the web CustomerUI to a responsive mobile application. It incorporates all the functions of WebUI effortlessly and without reductions. Development was done by using TypeScript as the programming language and Cordova to build/deploy our application. The application is built and tested locally and then it is shared for internal testing with other users.

4.2.1 Customer Overview

The Visualization Kit offers an overview of FEID and its status. More precisely, as it can be seen in the following figure, first of all it presents general information such as FEID status (online, offline), if it is available for DR and whether it auto responds to DRs or not. The latter denotes whether Customer accepts DRs explicitly or implicitly.

The view also presents Customer's Power Load, Power Generation, Power Storage (if any).

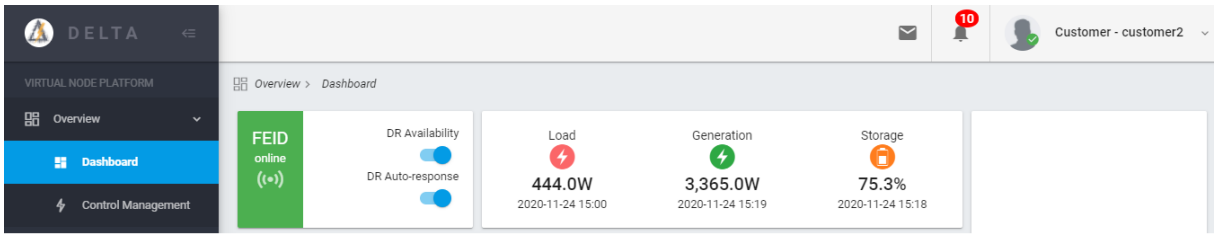


Figure 28. Customer Dashboard View

Customers can also view today's measurements of the current FEID. For example, as the following image illustrates, the Visualization Kit offers today's Power PV, Power Load and Battery SoC.

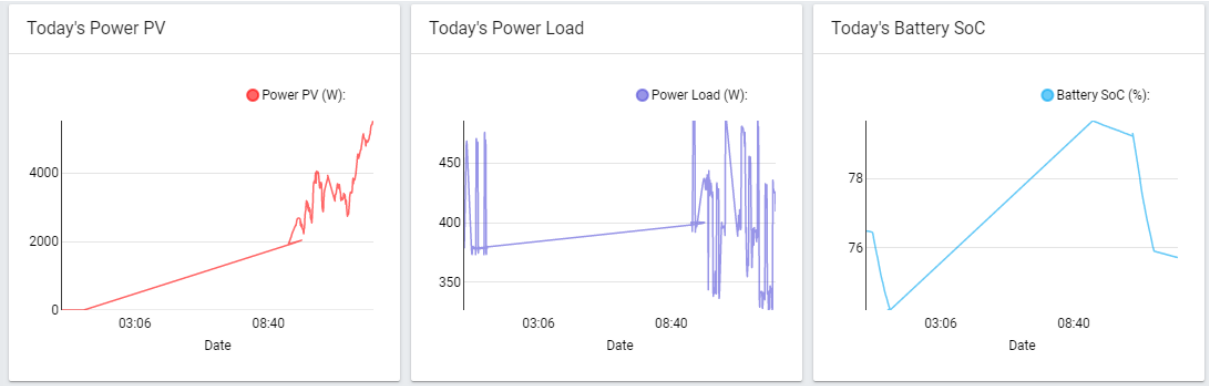


Figure 29. Customer Measurements

Finally, in Customer's overview, the Visualization Kit depicts today's forecasts as it can be seen in the image below. These forecasts are Load forecast and PV forecast and they are scheduled to be calculated daily for the next day.

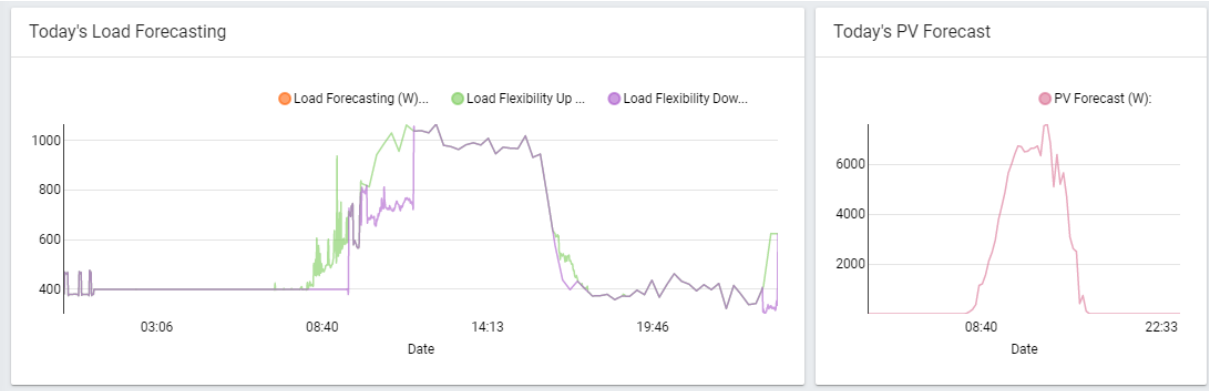


Figure 30. Customer's forecasting results.

4.2.2 Historical Information

Customer can access historical information focused on the FEID registered to him/her. This means that customer can only view historical information on the layer of FEID. The first view depicted in the following figures illustrate how user can select a time frame and retrieve several graphs. More precisely Figure 31 depicts basic FEID measurements for the selected time frame, while Figure 32 illustrates

FEID Power consumption and Real Time Price. Finally, in Figure 33 customers can view Power Load Forecast, Flexibility Up and Down Forecast, and PV Forecast.

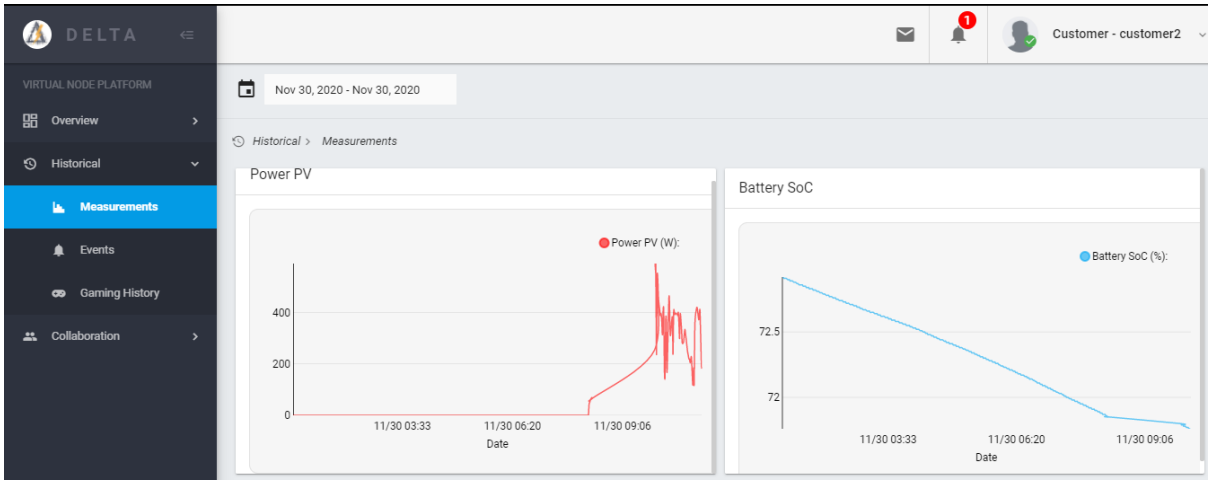


Figure 31. Customer Historical - FEID basic measurements.

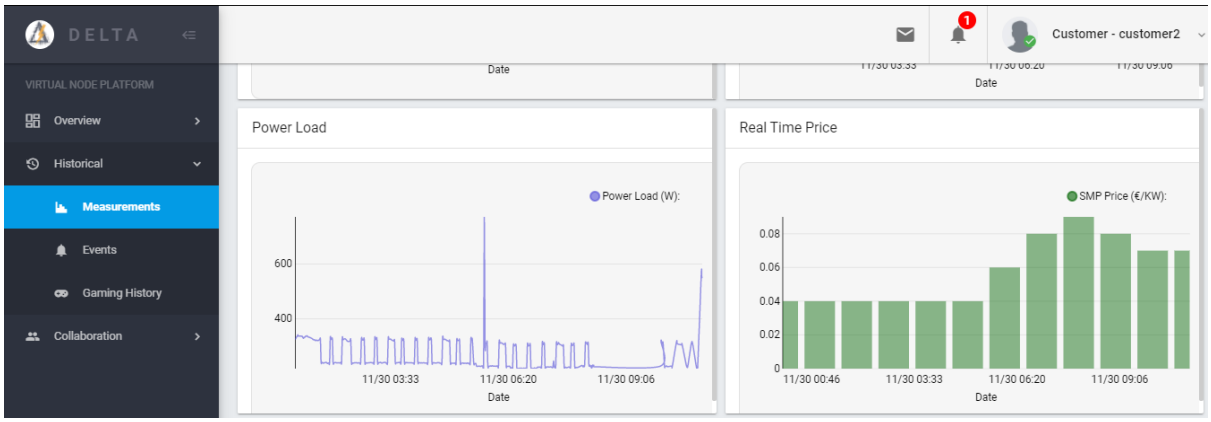


Figure 32. Customer's FEID power demand and the relevant real-time price.

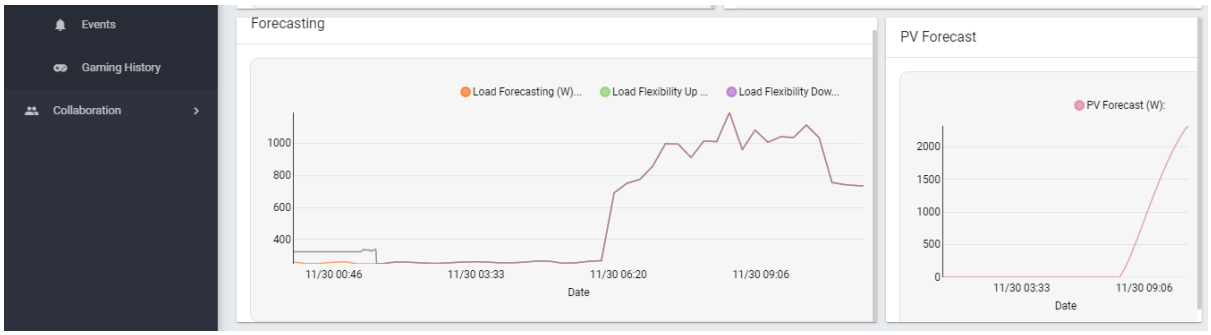


Figure 33. Customer's FEID Power Load Forecast, Flexibility Up and Down Forecast, and PV Forecast.

Customers can also view the DRs they have participated in during a period. The relevant view seems like Aggregator's view for DR events, but it is focused on the specific FEID. Figure 34 depicts the list

of DRs that customer's FEID participated and their outcome. To obtain more details for a specific DR, customer can select one and view them in Figure 35. Note that customers cannot view other DR FEIDs as aggregators can.

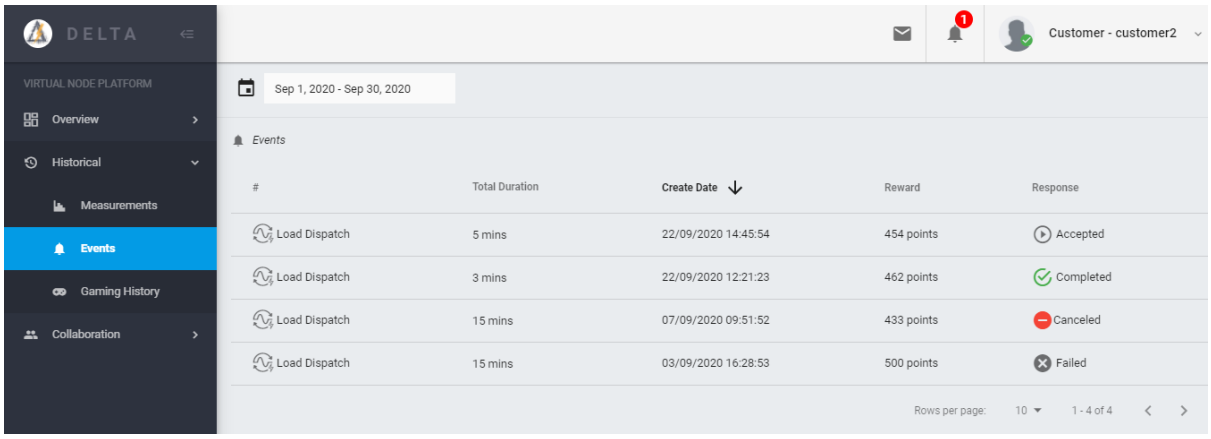


Figure 34. Overview of DR events that Customer's FEID has participated in the selected time frame

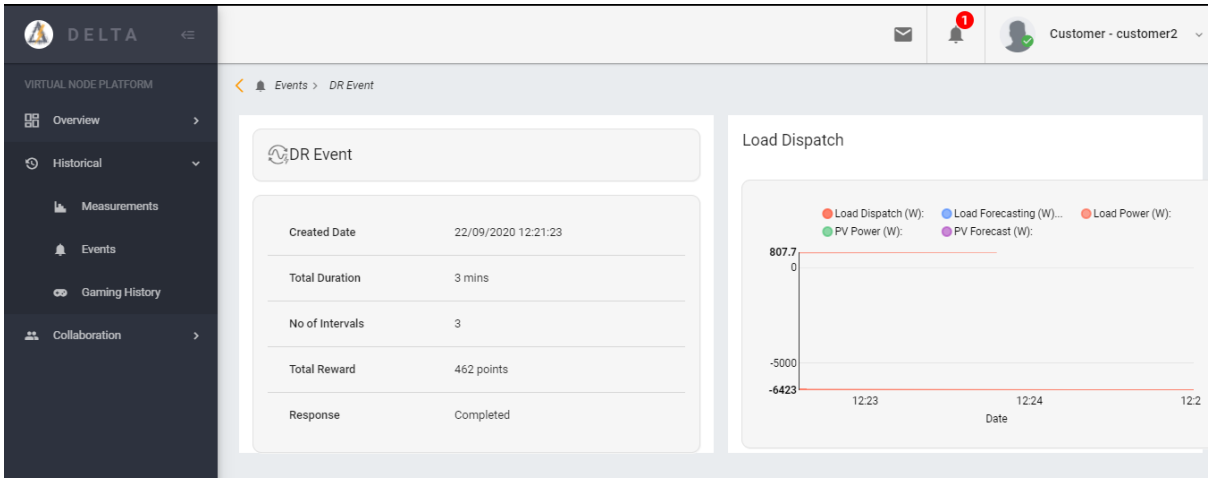


Figure 35. Customer's DR Event details

Finally, customers can also access the collaboration tools and their gaming history, as will be explained in Section 5 and Section 6, respectively.

5. Collaboration Platform

Within DELTA, user engagement and responsiveness is crucial as the target audience refers to a rather large portfolio of small and medium customers. Due to their scale and rather volatile behaviour, the success of a DR request may be jeopardized. As a first step towards raising awareness and instigating higher responsiveness from end-users, DELTA introduces tools that aim towards enabling collaboration and knowledge transfer following pervasive learning principles.

To support collaboration not only between the Aggregator and its portfolio, but also among Customers, and even Aggregators, DELTA has designed a collaboration platform that includes a variety of tools and is also linked with award-enabled services. With a *forum* as a foundation, all DELTA end-users are able to effectively interact, learn, improve, and even respond to DR request collectively, targeting a more sustainable ecosystem.

5.1 Forum

A forum, and more appropriately an online forum, is an online discussion site where users can hold conversations in the form of posted messages. Widely used in various domains, vastly supporting community-based interactions, a forum can become a cornerstone of knowledge and discussion, allowing a series of positive outcomes to the end-users participating within.

The DELTA Forum is divided in five distinct sections:

- DELTA News
- FAQ
- General Discussion
- Gamification
- DR Best Practices
- Offers/Vouchers

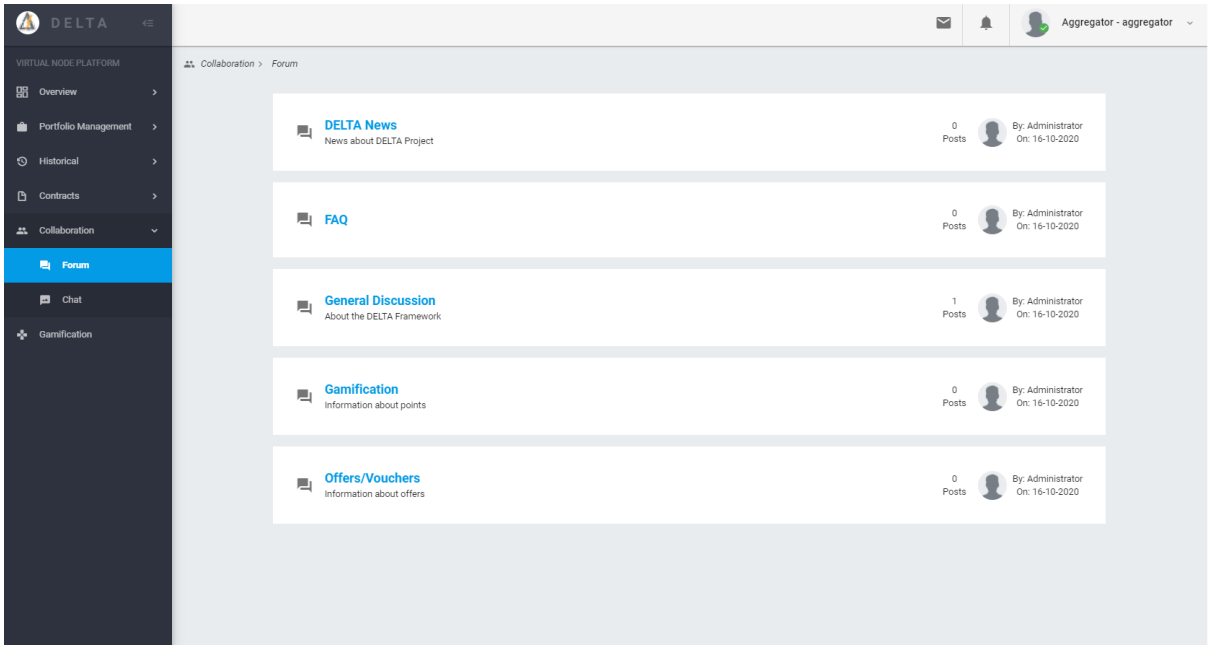


Figure 36. DELTA Forum - Main page

5.1.1 *DELTA News*

In this section the aggregator can post various topics regarding the project, the platform and its components, in order to inform the customers about the latest news. As would be expected, the customers can only view these items of news and comment, like, reply accordingly. This section has been implemented to facilitate the information diffusion to the portfolio in a collective yet massive manner.

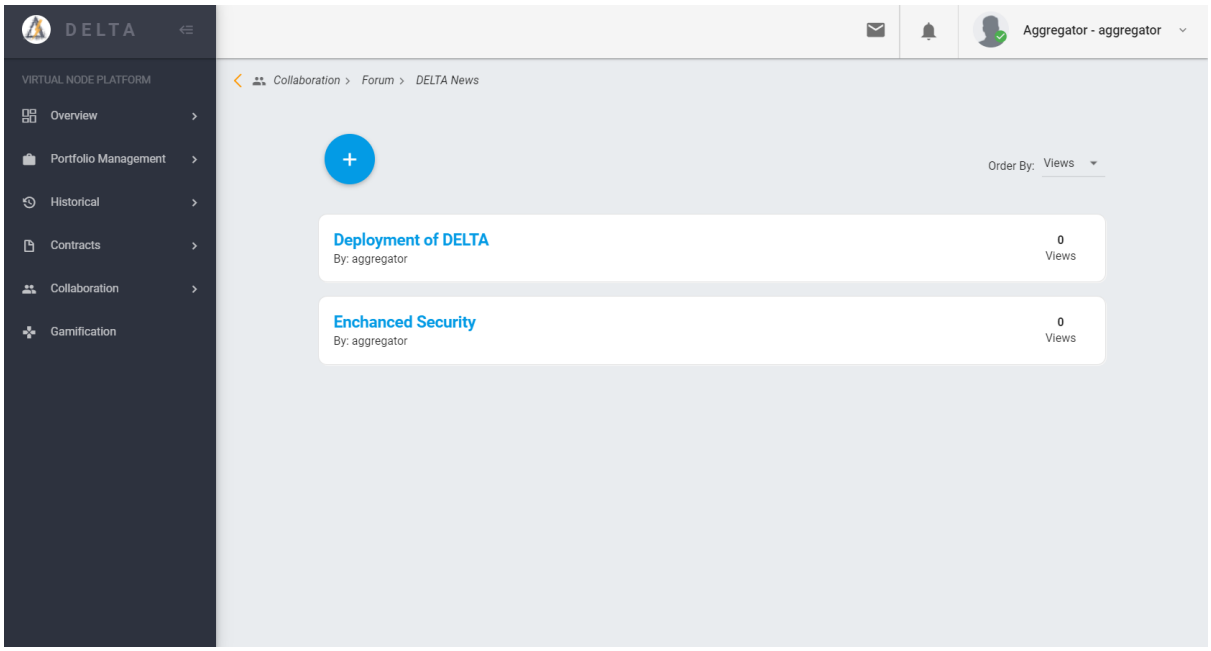


Figure 37. DELTA Forum – DELTA News – Aggregator's View

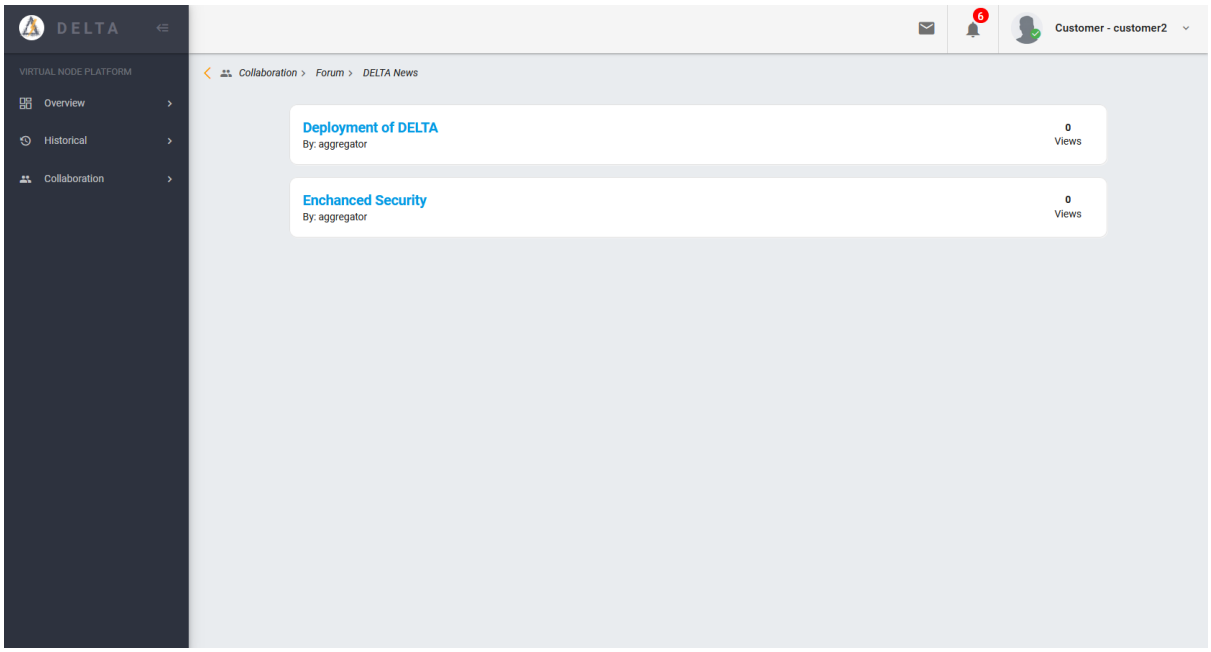


Figure 38. DELTA Forum – DELTA News – Customer's View

5.1.2 *Frequently Asked Questions (FAQ) and Answers*

The goal of this section is to help customers with frequently asked questions. Acting both as a knowledge base and a short wiki, this sections aims to collect common questions that tend to occur within other sections of the forum. Although static at this point, effort has been denoted to generate the fields of this section automatically from the activity observed. Description about all the main capabilities and functionalities inside the platform are also listed.

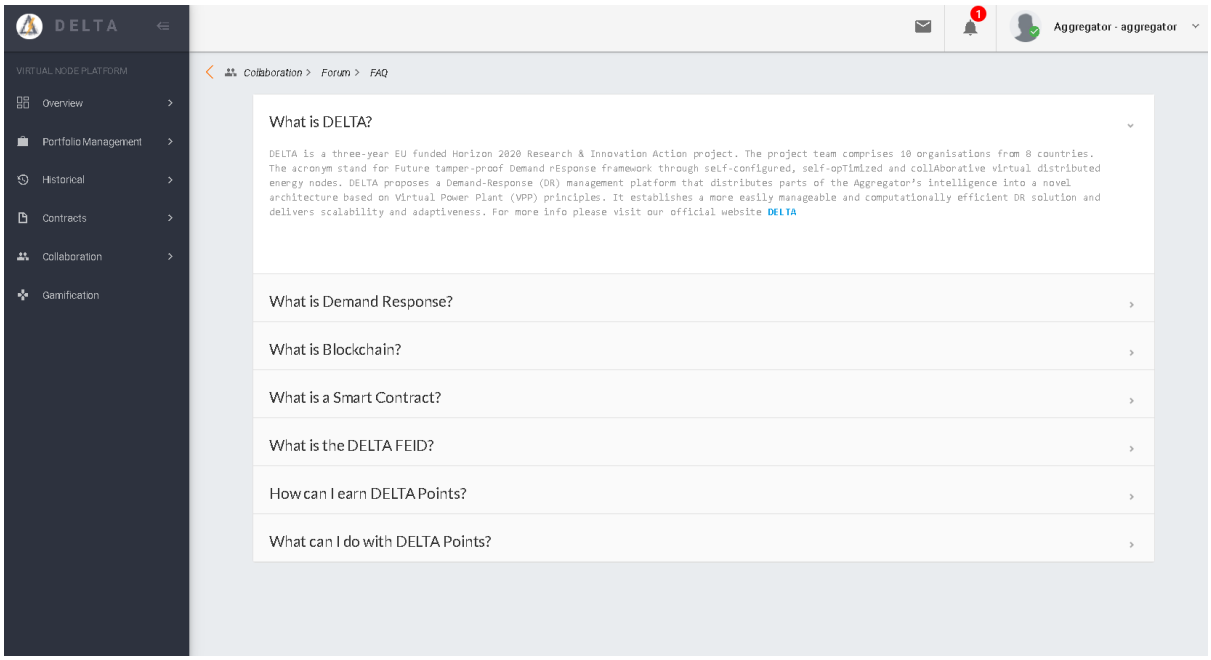


Figure 39. DELTA Forum - FAQ section

As the project progresses additional questions will be generated to support end-users.

5.1.3 *General Discussion*

In this section, DELTA users can post questions on various issues they faced. In addition, they can also reply to topics created by other users. The goal of this section is to engage customers to seek or give assistance in any issue that might come up. A topic consists of a title, a description and a tag. All three fields must be fulfilled in order for the topic to be valid (Figure 40). Once a topic is ready, it is then stored in the database. By selecting a topic, the user can view all the replies, if any, and post their own. Being active in this section by placing topics and replying to them, users are awarded through gamification.

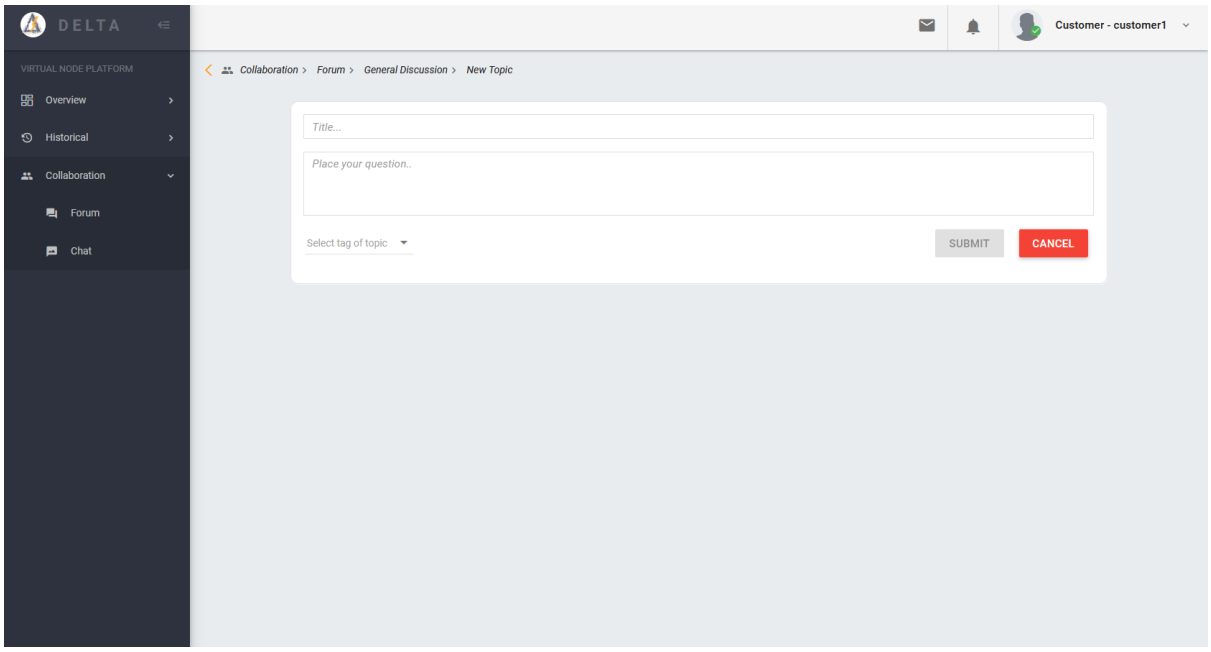


Figure 40. DELTA Forum – New Topic Creation

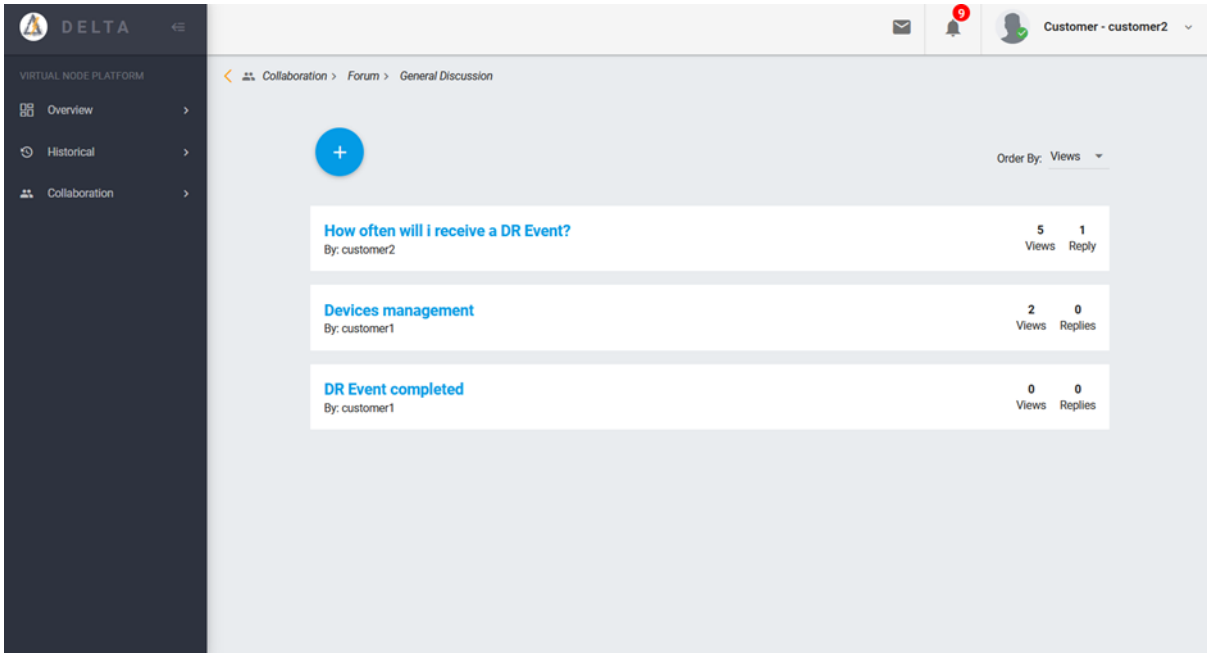


Figure 41. DELTA Forum – General Discussion

5.1.4 DELTA Gamified Services

In this section, the customer has access to information about the games that he participates in. More specifically, he can gain information about the game elements of a game and his performance. The actions and rules that the aggregator created for this game are listed to the user, in order to find out the gamified actions that he can perform inside the platform. The leader board and his latest actions are also presented to the user.

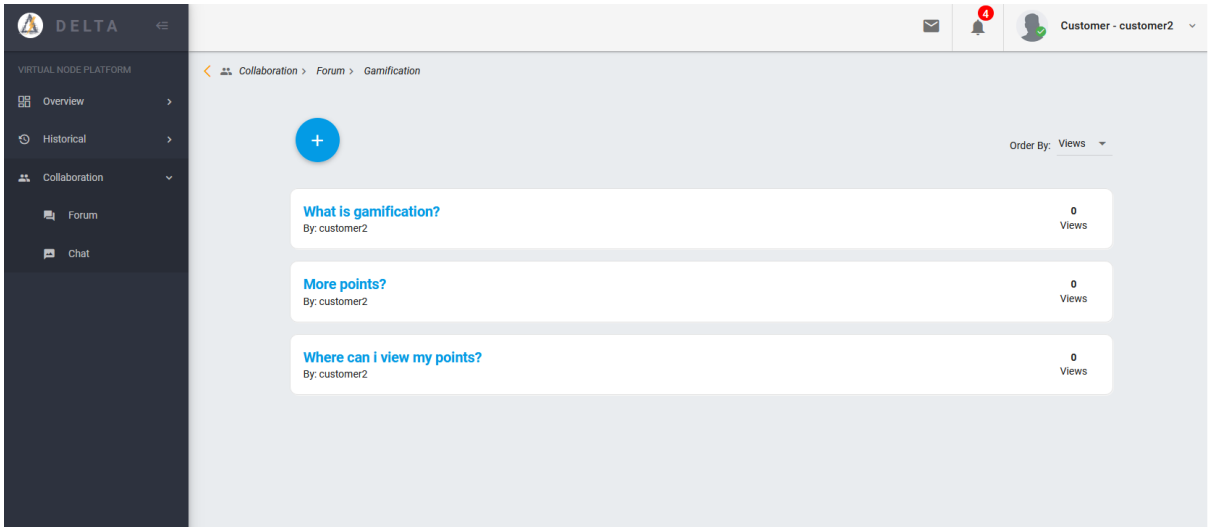


Figure 42. DELTA Forum – Gamified Services – Main View

5.1.5 Offers/Vouchers

We have included this section where the Aggregator has the ability to inform customers about new ways to redeem their points and get their hands on vouchers and offers for products and services, either related to the Aggregator or by third party collaborations. The purpose of this section is to give the aggregator the ability motivate even further motivate the customers with tangible awards. To further facilitate users towards identifying an interesting offer or voucher, while also keeping competition active, the leader board is provided in the same view.

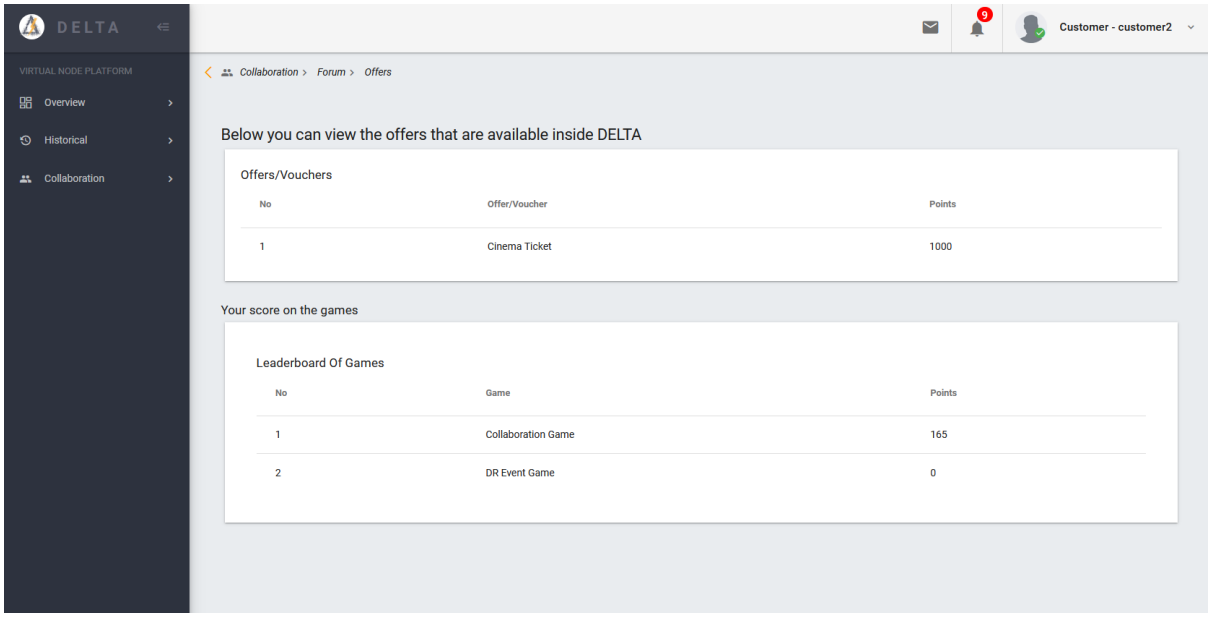


Figure 43. DELTA Forum – Offers/Vouchers

5.1.6 Best Practices

In order to help the customers be active, responsive, and reliable, a session about best practices has also been enabled. As it is important to provide both aspects, Aggregator and Customer users can publish their experiences in an effort to further enrich the DELTA framework and its real-life use.

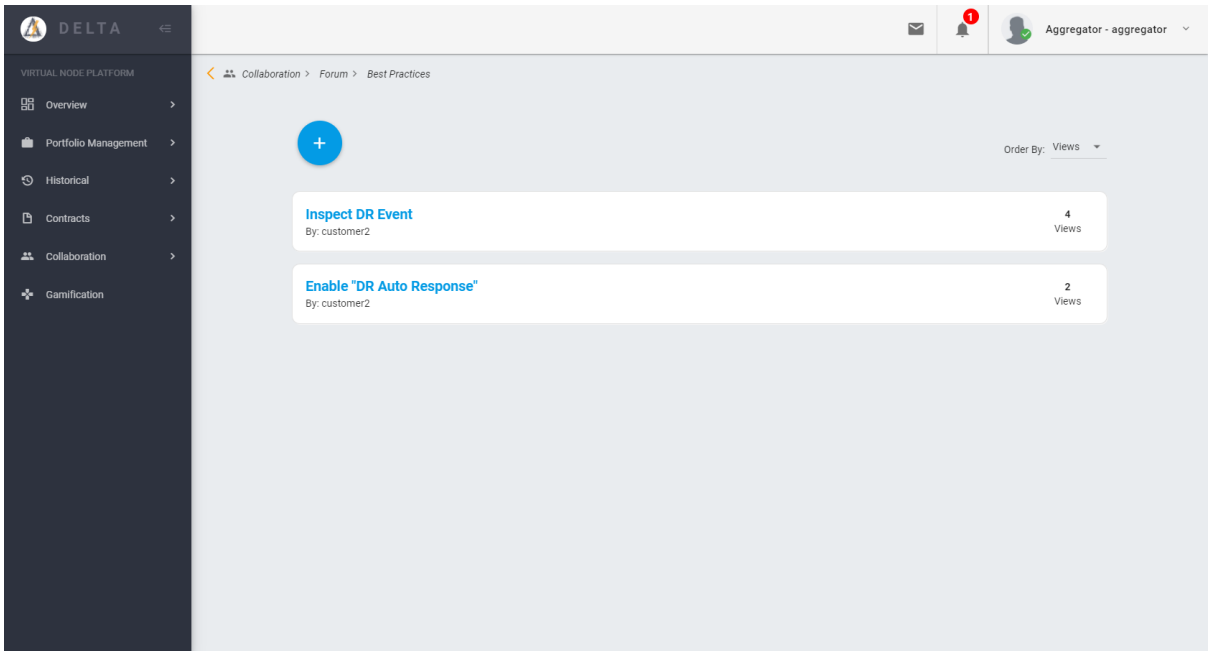


Figure 44. DELTA Forum – Best Practices.

5.2 Chat

Following a very simplistic design, a direct chat feature has also been included to allow an additional discussion channel that supports privacy and may even accelerate certain issues (e.g. technical problems). The current version of the chat is presented in the following features.

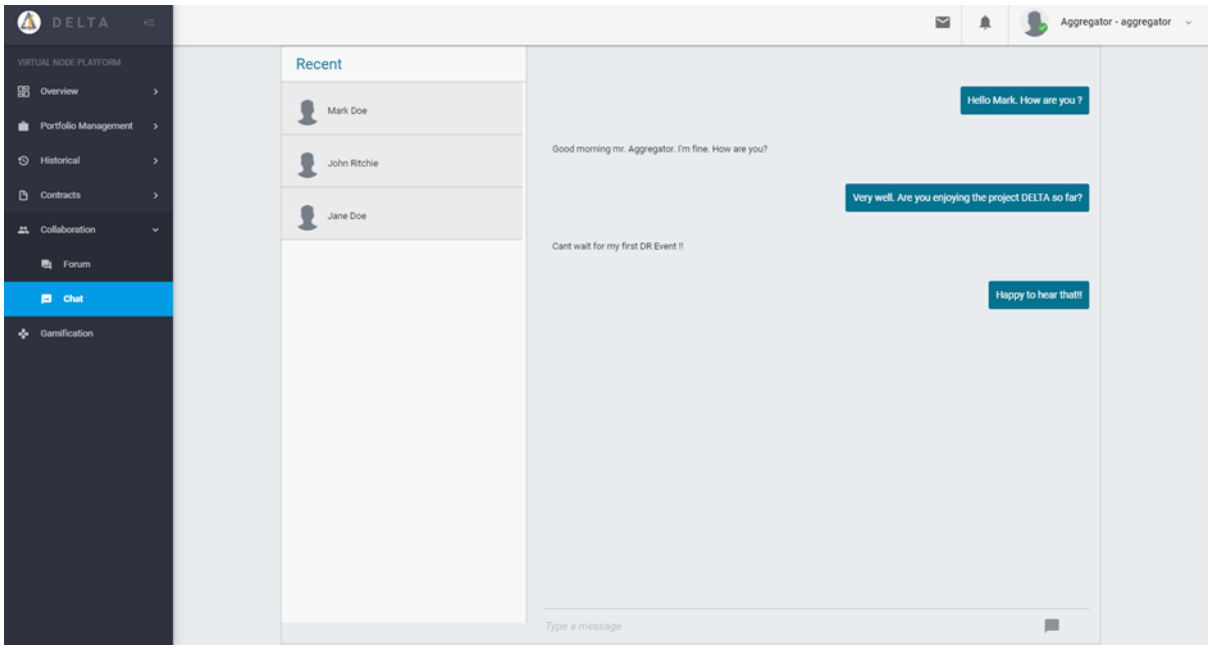


Figure 45. DELTA Chat – Aggregator's side

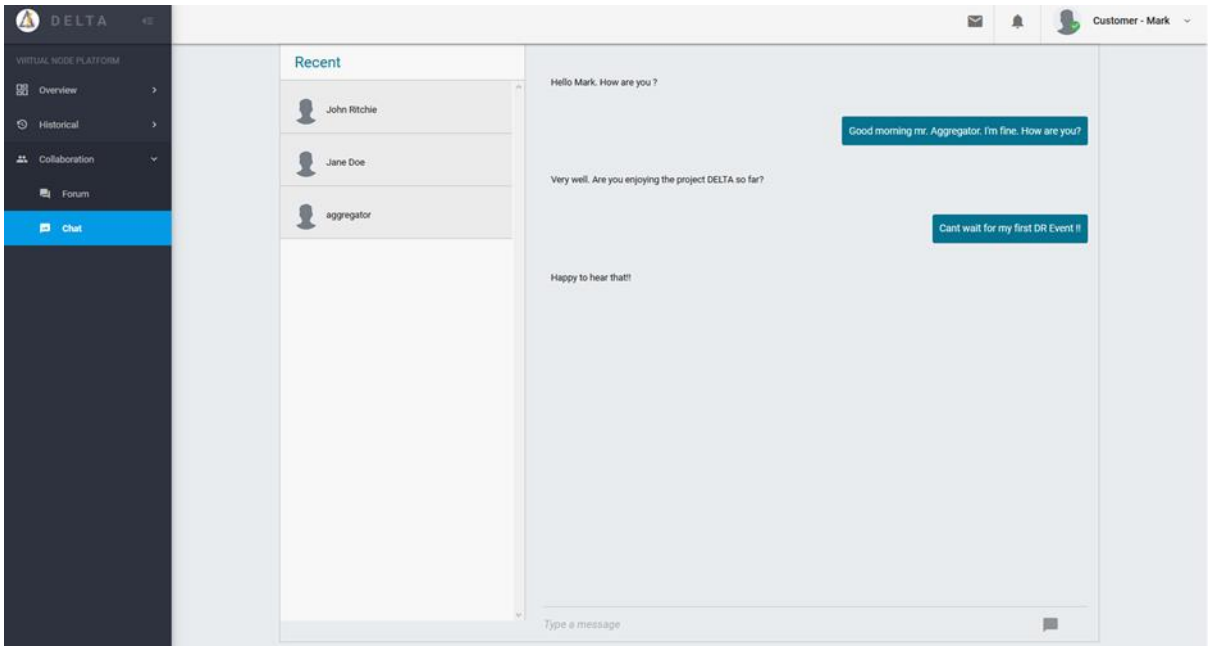


Figure 46. DELTA Chat – Customer's side

6. Award-enabled Services

As presented in Section 2, gamified services have already been thoroughly investigated in the context of smart grid and even specifically for DR programs. With successful examples already available in the markets, the DELTA project continues and evolves by creating a new game engine that unlocks several opportunities for Aggregators.

6.1 Game Engine Architecture

Scaffolding the gamification architecture, the technological side should be described. It contains three components, a database, a back-end server and the user interface. The user interacts with the official site, sending payload to the server when he performs a gamified action. Afterwards, that server processes that payload extracting information about the user and the action he performed. The necessary computations are performed in order to assign the points to the customer. When the calculations are done, a notification is sent back to the customer to inform him that he is granted points. Any useful information is stored in the database. For the data management system, PostgreSQL is selected as a database since the data are relational. The server exposes RESTful APIs in order to communicate with the outside world and is a Node.js Express application. For the database communication, the library knex.js is used. The gamification server can also run inside a Docker container.

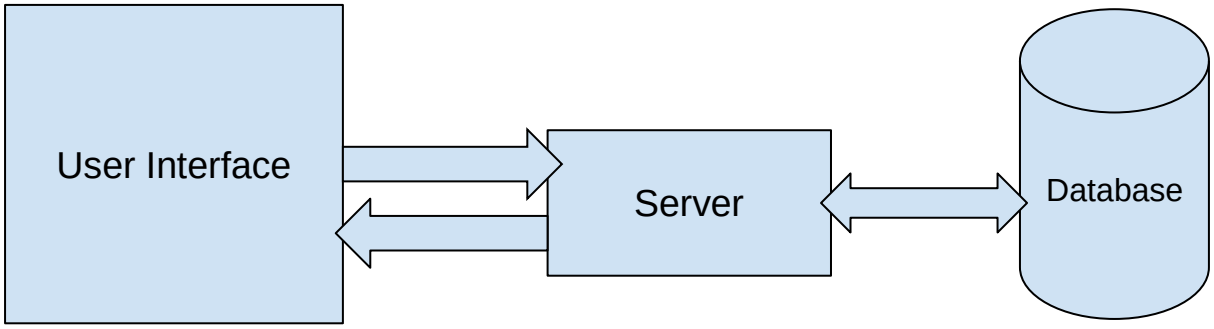


Figure 47. Visualization of the DELTA gamification architecture.

6.2 Game Engine Implementation

All the capabilities of the game engine designed and implemented within DELTA is detailed in the following sections.

6.2.1 Game Creation

Aggregator has the ability to create games based on a defined set of actions and awards. The creation of the games is a two steps process. As a first step, details about the game must be defined. The name of the game, the participants of the game, the max achievable score and the expiration date of the game are parts of the first step. The second step contains the definition of the actions, awards and rules.

Figure 48. Flow diagram of the process of defining a game.

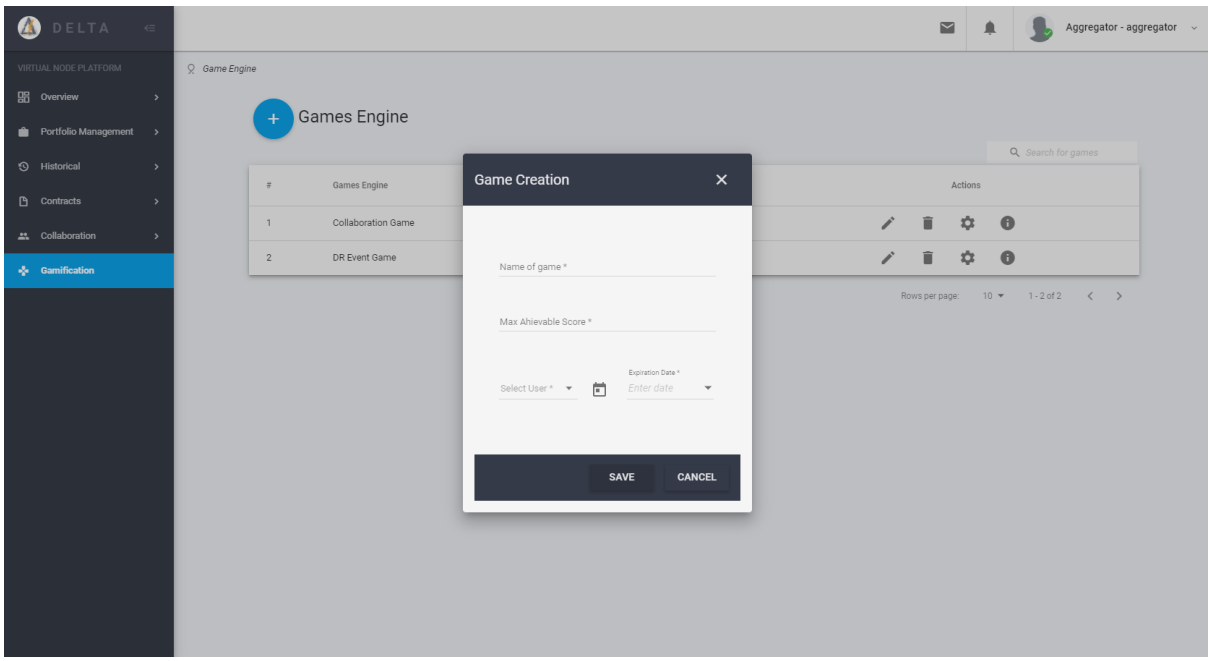


Figure 49. DELTA Game Engine - First step of Game Creation.

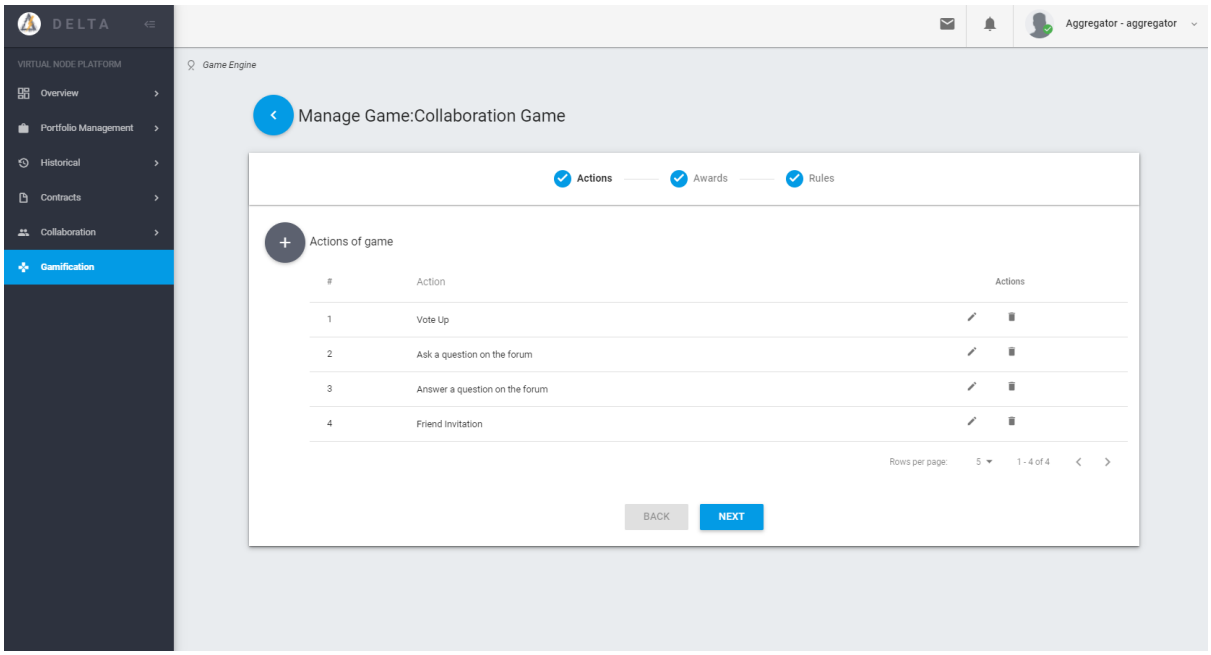


Figure 50. DELTA Game Engine - Second Step of Game Creation.

6.2.2 Actions

Currently, within the DELTA game engine a predefined set of actions are available for the Aggregator, when creating a new game. This set is consisted of the following actions:

1. Vote Up
2. Post a topic on the forum section
3. Reply to a topic
4. Friend Invitation
5. Accept a DR Event within x minutes

As any engine, there is also a game administrator (in this case the DELTA team), where additional actions, rules, etc., can be included in the engine upon request.

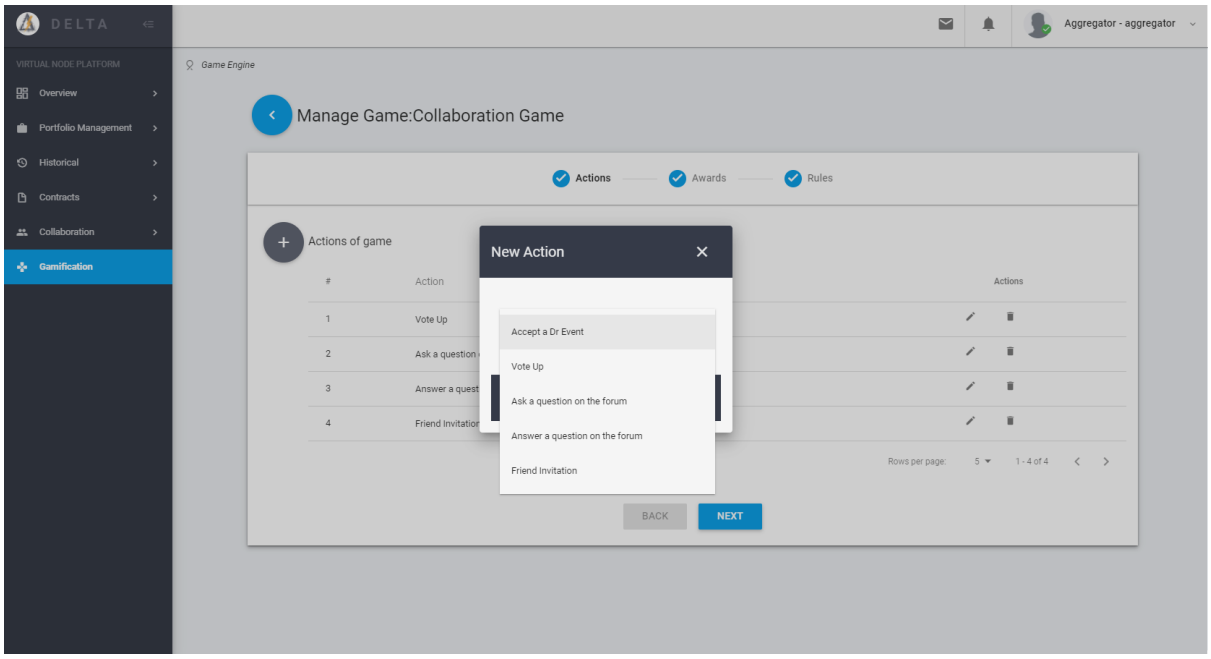


Figure 51. DELTA Game Engine - Action Selection from a predefined list of actions.

6.2.3 Awards

DELTA has adopted a point system in order to be able to apply all gamified strategies as well as DR-related incentives. As a result, awards in all the services and games developed are in the form of points. Each rule, for each action, can have a different amount of points assigned, whereas each user/customer has a central pool were all points are added. The Aggregator can change the points at any given time, whereas the users are informed for any change regarding the games that they are included in.

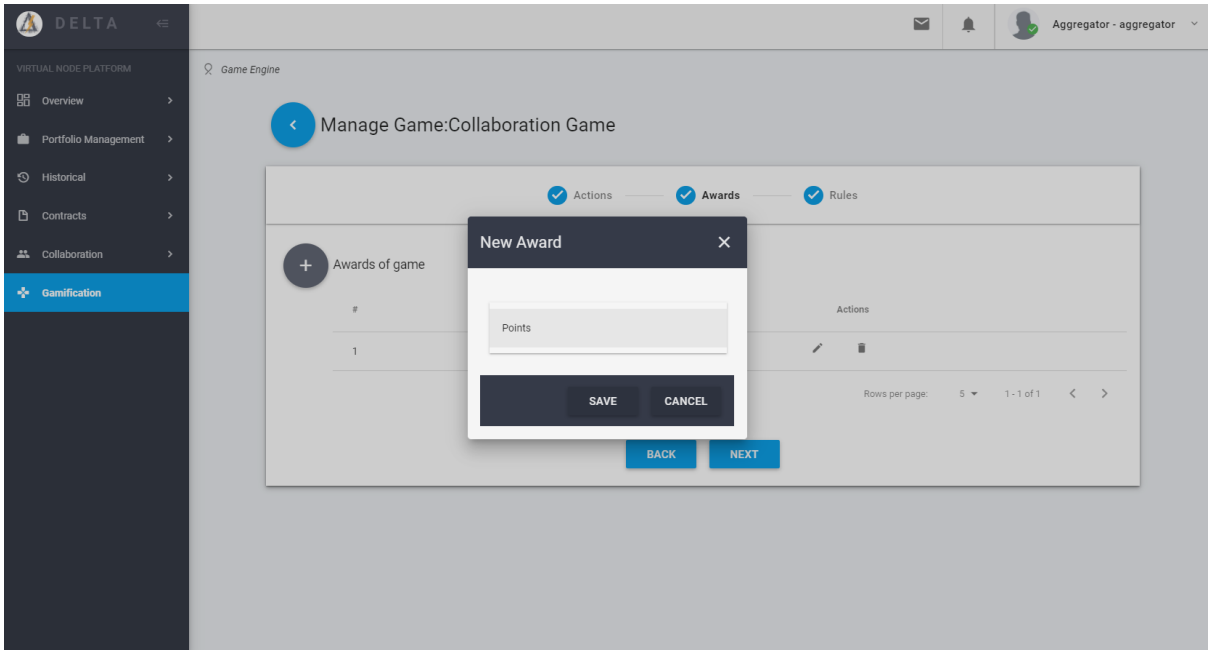


Figure 52. DELTA Game Engine - Award Selection.

6.2.4 Badges

Badges have been proven to be an effective game element that engage and motivate the user. The purpose of a badge is to reward the participant of the game when he completes a milestone in order to fulfil the ultimate goal. For that reason badges are included in the gamification platform. Whenever the aggregator creates a game, three badges are created by default, the bronze badge, the silver badge and the golden badge. On game creation, the max points of the game is being defined. Dividing that score in three equal segments, we identify on how many points the user should be awarded with a badge. E.g. if the aggregator creates a game with max achievable score 1000 points, the bronze badge will be granted to the user when he reaches 333 points, the silver when he is granted another 333 points and on a 1000 points the user will receive the golden badge.

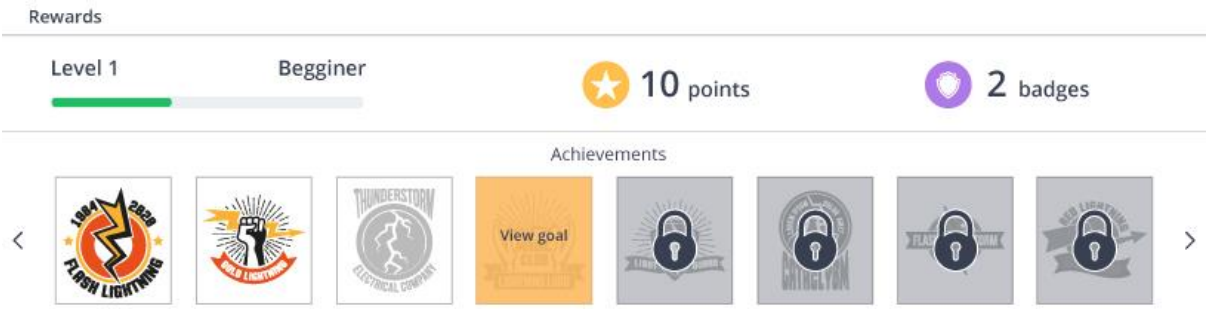


Figure 53. DELTA Game Engine – Customer Badges

6.2.5 Rules

This component is the most essential part of gamification. The rules component integrates the other two components together and is responsible for assigning points to customers. When defining a rule, the aggregator has to specify how many awards he wants to grant the user when he performs an action. The rules component is the connecting glue between the actions and the awards. Whenever a user performs a gamified action, a payload is sent to the server containing important information. Extracting that information, the gamification server performs a search in all rules, in order to assign awards to the user. This is the only way for the gamification server to assign points to users and for that reason this component is so crucial. When the aggregator creates a new rule, he is obliged to fulfil all fields in order to ensure the integrity of the gamification server.

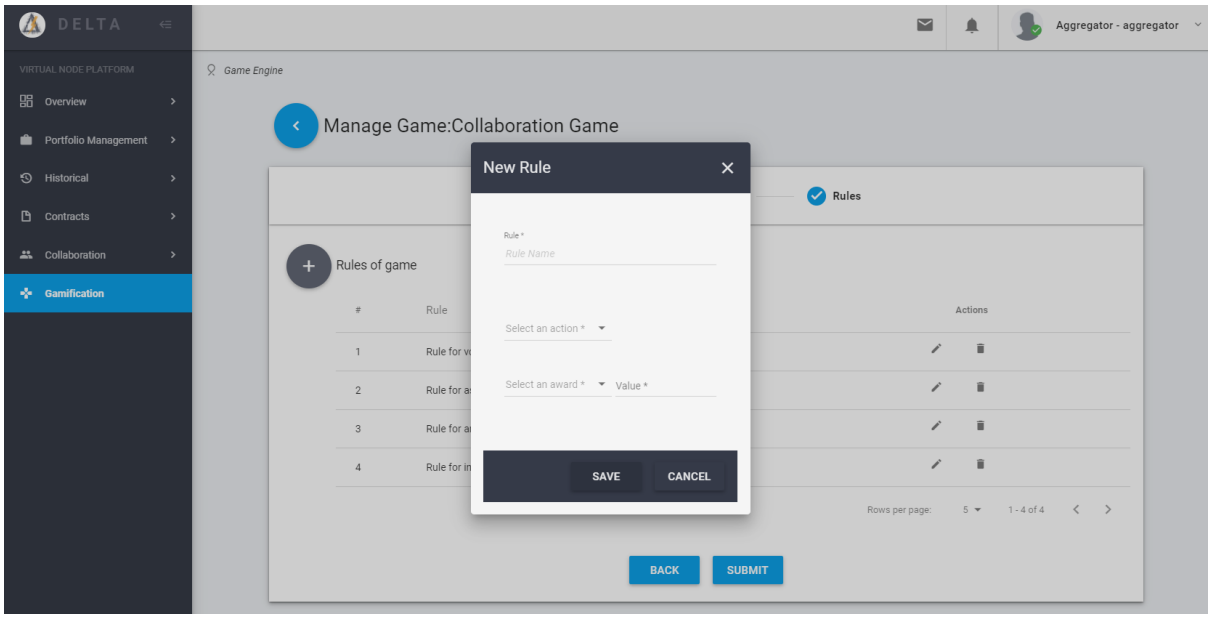


Figure 54. DELTA Game Engine - Rule Creation.

6.2.6 Vouchers / Check-out

While badges, points and the leader board can have a big impact regarding the motivation of the customer, we have also included the functionality of the tangible awards. Tangible awards can be considered cinema tickets, or a discount on the electric bill. The awards mentioned above aim at motivating the customer even further, since the customers eventually can earn money or have access to services that require payment.

The Aggregator has the ability to create offers for his customers. The Aggregator creates a tangible award and defines an amount of points for that award. When a customer reaches that amount, he has the ability to check out his points and collect the reward that its “cost” is equal to that amount of points. In this section, as an Aggregator, it is also possible to view all the offers/vouchers that have been previously created, The Aggregator can also view the total scores of the customers. On the other hand, the customer, can view the available vouchers and how many points he has on each game that she/he participates in.

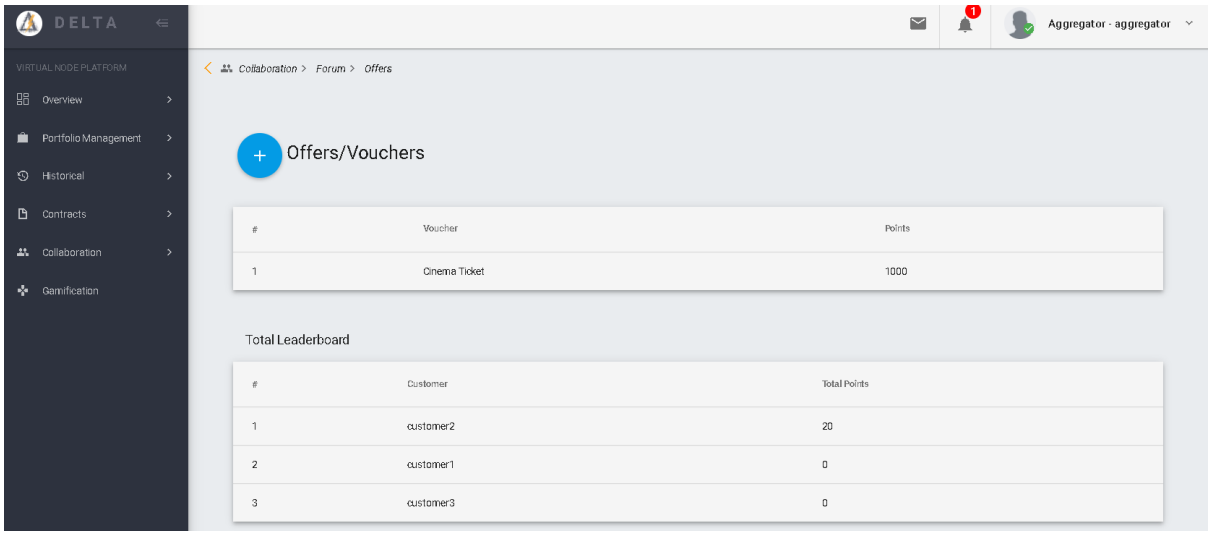


Figure 55. DELTA Game Engine – Voucher/Offer Creation

6.2.7 Assigning Points

Whenever a user performs an action that is gamified, for example the 'Vote Up' action, a payload is sent from the user interface to the back-end gamification server. The next step is to identify all the games that include this action and the user is a participant. Consider the two games, "Collaboration Game" and "Social Game". Both of these games contain the gamified user action "Vote Up", which is triggered when the user likes a topic on the forum. In the first game, a rule is defined for this action, which defines that the user should be awarded with 5 points. In the second game, a similar rule exists, with the difference that the user is awarded with 10 points. The server will identify these different rules and will assign the corresponding points to the user, for each game assuming that the user is a participant in these games. The flow diagram below explains this process:

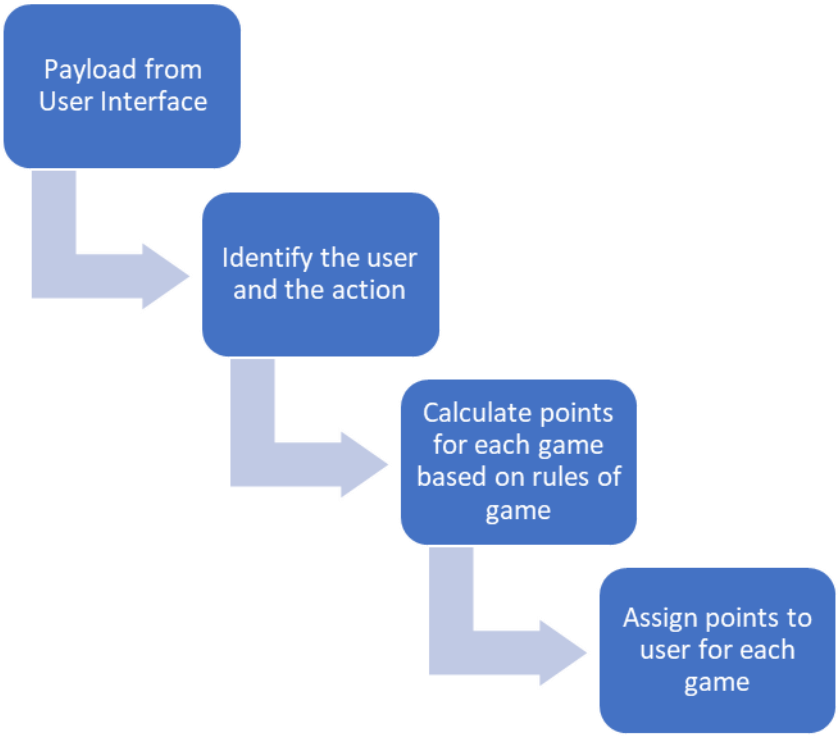


Figure 56. DELTA Game Engine – Assigning Points Process

It's crucial to understand that there might be multiple games which contain the same set or subset of actions. In order to assign the correct amount of points to a user for a specific game, the component "Rules" has a critical role in his procedure. There is no difference if the user participates in one or many games that contain the action he performed. It is stated clearly by the rules of the game how many points he should be rewarded.

6.3 Game Monitoring

Three components are provided for the end user in order to track down the progress of the game. Those three components are leader board, statistics and historical actions (Figure 57).

Figure 57. Game Monitoring layers

6.3.1 Leader board

Leader boards are the number one visualization that describes the status of a game. There can't be a game without a leader board, where the participants can have a clear overview of the progress of each player. For that reason, we have implemented this functionality into the Game monitoring section.

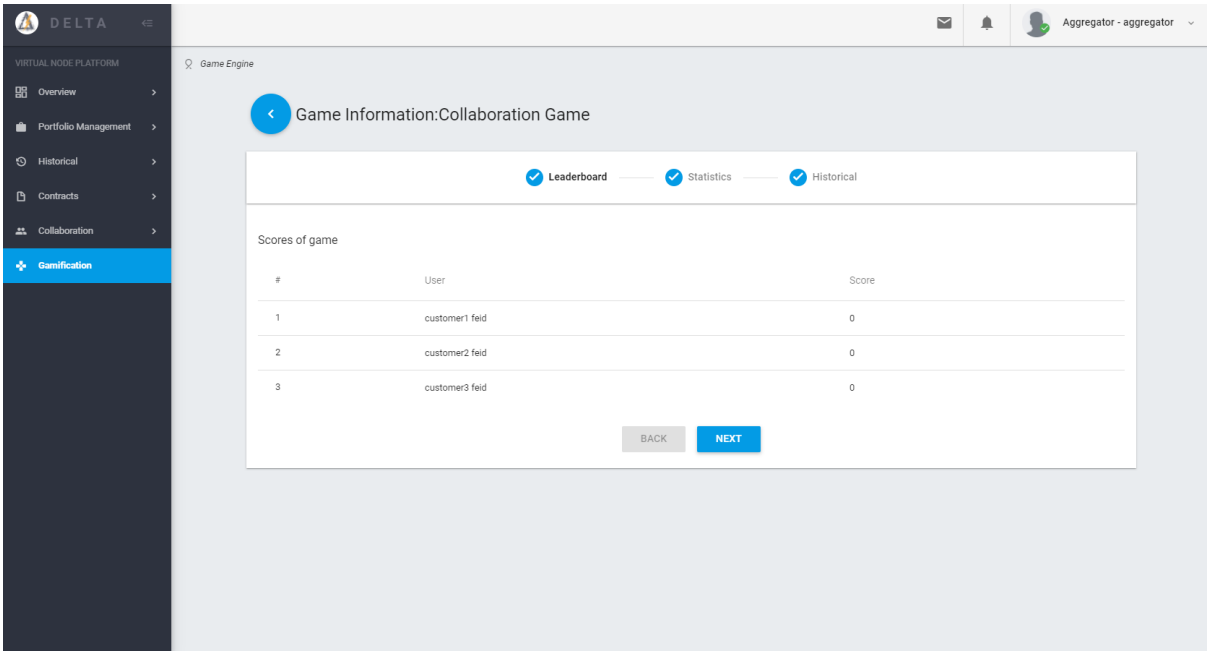


Figure 58. Aggregator's Leaderboard View

6.3.2 *Statistics*

Historical data is being created whenever a customer performs an action. Using these data, we can have access to meaningful insights. Both the aggregator and the customer can view statistics. The aggregator has access to the statistics of the games and the customer the games that he is a participant.

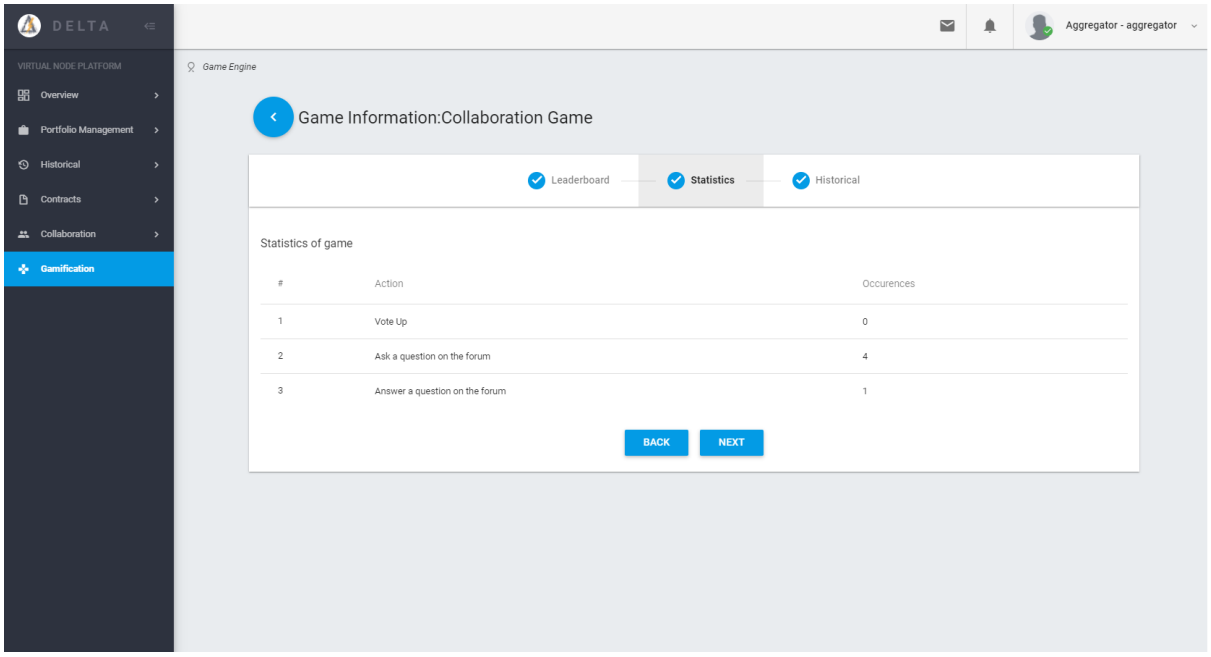


Figure 59. Aggregator's Statistics view

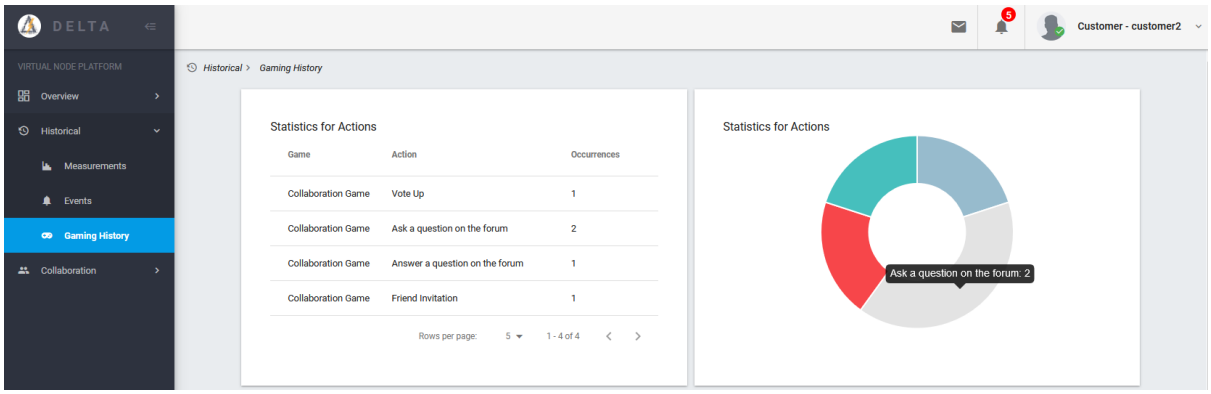


Figure 60. Customer's Statistics view.

6.3.3 Historical Actions

Whenever a user performs a gamified action, a payload is sent to the server in order to calculate the corresponding points of that action. Afterwards, the server stores into the database various information about that event. Some of that information is from when a performed a specific action at a given point in time. In that way, historical data are generated and both the aggregator and the customer can have access to them. More specifically, the aggregator has the ability to view all historical data for all players for every game he created, by visiting the game monitoring section. On the contrary, the customer has the ability to view only his action and only for the games that he is a participant by visiting the gaming history in the historical section.

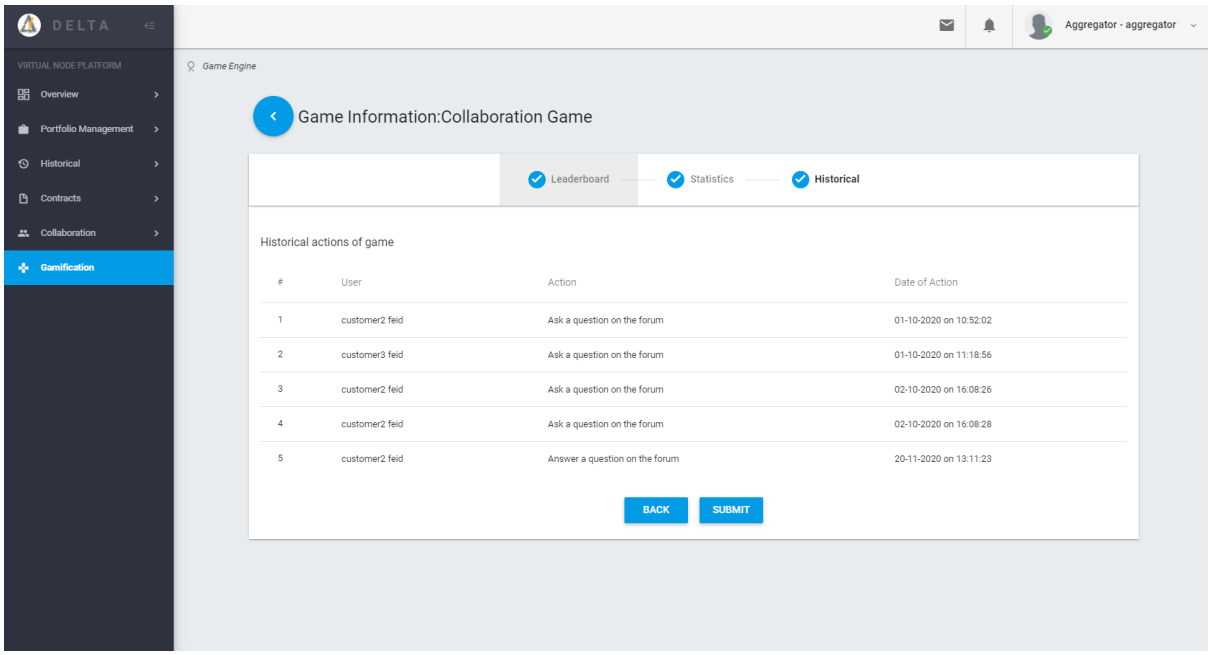
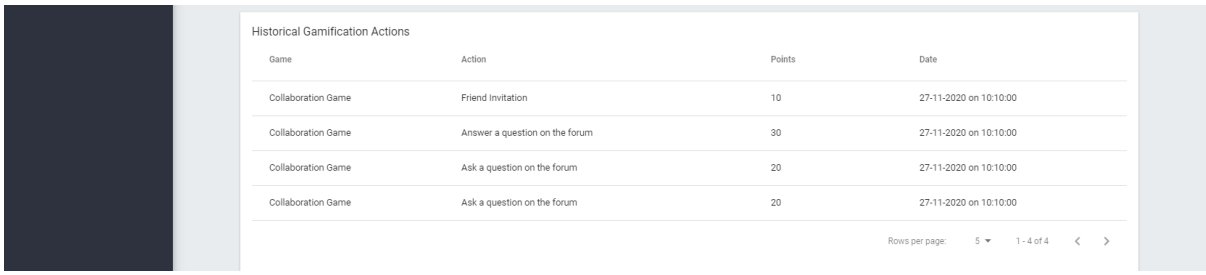


Figure 61. Aggregator's Historical View.



Historical Gamification Actions

Game	Action	Points	Date
Collaboration Game	Friend Invitation	10	27-11-2020 on 10:10:00
Collaboration Game	Answer a question on the forum	30	27-11-2020 on 10:10:00
Collaboration Game	Ask a question on the forum	20	27-11-2020 on 10:10:00
Collaboration Game	Ask a question on the forum	20	27-11-2020 on 10:10:00

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Figure 62. Customer's Historical View.

6.4 DELTA Games

Based on the set of actions that are provided to the aggregator, DELTA games can be distinguished into two major categories, the Collaboration games and the DR Event Games. Below follows a brief description about each type of game.

6.4.1 Collaboration Games

Collaboration games mainly contain actions that engage the user to be an active member in the forum section. Using the forum, the users have the ability to post any question they might have about the DELTA project. Such questions could be from what a DR Event is, what the FEID installation included and any other question the user may have.

When a user visits the forum, he can also answer a post helping other members of the community. For that reason, those actions have been gamified. When a user is posting or answering a question, she/he is helping the community and for that reason she/he should be awarded.

6.4.2 DR Games

In this type of games, we emphasize on engaging the customer to respond quickly to DR Events. A DR Event might be sent to the customer that isn't automated and his response is mandatory. The sooner the customer responds to the DR Event the better and for that reason we have gamified this action. The aggregator has the ability to create actions "Accept a DR Event in x minutes", where x is at his will. E.g. the aggregator can create the action "Accept a DR Event in 2 minutes" or "Accept a DR Event in 10 minutes" and so on. As a next step the corresponding rule for the action "Accept a DR Event in 2 minutes" should reward the user with 100 points and the rule for the action "Accept a DR Event in 10 minutes" should reward the user with 50 points.

At this point, it is reminded that every DR request is also accompanied with a specific amount of DELTA points as a reward. These are also added to the same point system, making it easier for the users to collect points, compete and earn multiple rewards.

6.5 Social Engagement Calculation Tool

Customer engagement has been recognized as an emotional connection between stakeholders and its customers focused on interaction with customers and their participation. The key element to customer engagement is knowledge exchange, so information and communication technologies provide immense opportunities for organizations to exchange knowledge and engage with customers. Below we propose a new metric where the reliability of the user and the actions that the user performs inside the platform, are taken into consideration.

As also presented in D3.3, the social engagement metric has been defined as:

$$\text{SocialEngagement}_{user} = 0.5 * \text{Reliability}_{user} + 0.5 * \text{Actions}_{user}$$
$$= 0.5 * \text{Reliability}_{user} + 0.5 * [0.5 * (\text{DR Events}_{user}) + 0.5 * (\text{Social}_{actions})]$$
$$= 0.5 * \text{Reliability}_{user} + 0.5 * [0.5 * (\text{DR Events}_{user}) + 0.5 * (0.60 * \text{answers}_{user} + 0.40 * \text{topics}_{user})]$$

Where:

$$\text{DR Events}_{user} = (\text{number of DR Events the user answered}) / (\text{total number of DR events of user})$$

$$\text{answers}_{users} = \left(\sum_{k=0}^{topics} \frac{replies\ of\ user}{total\ replies\ of\ topic}\right)/\text{topics}$$

$$\text{topics}_{user} = (\text{topics of user}) / (\text{total topics})$$

Besides evaluating whether end-users are sufficiently engaged or not, this metric is also used as a clustering feature within the DVN. By grouping together people with similar social behaviour, especially in terms of DR requests, and not solely demographics (which can be difficult for customers with multiple users) improved results are expected in terms of DR success rates.

7. Conclusions

This report presented the results of activities performed within T6.3 and T6.4, creating the DELTA web platform, including the innovative and customer engaging tools. As the user is in the center of the design and implementation of these tools, detailed information has been presented for the functionalities and general features of the web platform in general, in particularly for the award-enabled collaboration platform in particular.

The Visualization methods used in DELTA especially concerning DR context have been presented in detail for both the Aggregator and the Customer. Due to the three DELTA layers and in order to avoid complex visuals especially for customers, traditional visualization techniques have been mostly adopted. To ease users, these visualizations are focused on one of the three layers at a time and users can focus on the level of abstraction of their choice.

The online forum has been designed towards providing a lot of different features, allowing a more interactive communication between the Aggregator and the Customers, as well as the Customers among themselves. Having concentrated a lot of knowledge and with different levels of representation, the forum materialises in full pervasive learning principles, aiming to raise awareness, increase participation, improve DR success rate and as result produce better revenues for all involved parties.

Specifically for revenues, DELTA has adopted a point system for additionally rewarding the customers. A game engine developed specifically for the DELTA framework, has been integrated to the web platform and allows an enriched experience for the DELTA users. Since the aggregator has the ability to create games based on the actions and rules that he wants, he can monitor the performance and participation of the customers on each game. Let's consider the scenario where two games consist of the gamified action "Ask a question in the forum", but with the difference that in the first game that action is rewarded with 10 points and in the second game the customer is rewarded with 40 points. As it is reasonable, the customers will most likely be more active on the second game. Through the various games the aggregator can create and by examining the historical actions of those games, the aggregator can have meaningful insights about the profiles of its customers. By assessing results of the gamified services provided, valuable findings are extracted, one of which is the social engagement metric, which is used for further improving clustering results.

All tools presented in this report are expected to evolve even more through the pilot activities, and perhaps even new functionalities may be introduced through the interaction with the end-users, in order to maximize their effect as well as to improve the overall user experience. Hence, effort is expected to continue beyond activities of T6.3 and T6.4, throughout the pilot activities and until the end of project.

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