



ACTIVAGE PROJECT

ACTivating InnoVative IoT smart living environments for AGEing well

Marketplace Components

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Abstract

This document is the deliverable D4.3 “Marketplace Components” and presents the outcome of the activity T4.4 ACTIVAGE Marketplace which is part of Work Package WP4 “ACTIVAGE Application support tools and services layer”.

The document initially presents the development of the ACTIVAGE Marketplace – a one-stop-shop for developers to provide and monetize their applications and users to discover, obtain and deploy them. Initially, D4.3 provides the envisioned use case scenarios as well as a state-of-the-art survey of marketplaces within and beyond IoT. This provides the motivation and specification of the implemented ACTIVAGE Marketplace. The 1st version of the Marketplace implements most functions for users to browse, search, register and install applications, keep a wishlist and get overall insights. Developers may upload new applications, monetize them and access developer insights. However, lots of interactions with other Work Packages are needed and for this, an integration plan is provided. The 2nd version of the Marketplace is carved out to provide semantic search, recommendations with the AHA Advisor, Semantic Interoperability Layer capabilities, compliance with the Security and Privacy policy before bringing the Marketplace and all Deployment Site (DS) and Open Call applications online for within and beyond the project exploitation.

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1 About This Document

This deliverable reports the progresses made until M18 of T4.4 “ACTIVAGE Marketplace” as part of Work Package WP4 “ACTIVAGE Application support tools and services layer”.

The ACTIVAGE Marketplace is a one-stop-shop for providing, discovering and deploying applications built on AIOTES. As such, it is a high level deployment tool, very close to end-users. Specifically it is intended for applications users and developers alike. Developers, either internal from the Deployment Sites, or external, from the Open Call and beyond, can upload, promote and monetize their applications. Users, including healthcare professionals, carers and deployers at the Deployment Sites, external third parties and more, can search, discover get free or buy applications. Reviewing the state of the art shows a prevalence of marketplaces on the web: from item marketplaces (eBay, etsy), to smartphone app stores (Apple, Google, Samsung) and of course in IoT where some of the ACTIVAGE platforms already provide such a portal. However, the added value of the ACTIVAGE Marketplace is to provide a uniform portal for all platforms, those that already offer one and those who do not, with all functionality needed to fully exploit applications. Crossing the boundaries of the platforms, developers and users can take advantage of cross-site application deployment reaching new audiences and solving problems with existing solutions. While the Marketplace is a self-contained portal, lots of synergies with other Work Packages are needed for it to reach its full potential.

Table 1 summarizes the development of the Marketplace Components.

This 1st version of the deliverable and the Marketplace platform places it among state of the art, within IoT and beyond. It also formulates use cases and derives a specification for it. The integration plan with many AIOTES components is carved out and the web platform is implemented, covering most of the Application User and Developer functionality.

The 2nd version blueprint is given, planning for actual integration with AITOES components, increasing intelligent functionality such as the AHA Advisor and semantic search, provision of applications built at the sites and the Open Call, providing documentation and educational material to encourage adopters and, finally, evaluating the portal for usability and acceptability.

Table 1. Marketplace Plan of Development & Deliverable Versions

1st version - M18	2nd version - M36
<ul style="list-style-type: none"> – State of the Art review – Use Cases & Specification – Integration Plan with AIOTES, AHA Advisor etc. – Web Platform Implementation 	<ul style="list-style-type: none"> – Integration with AIOTES, AHA Advisor etc. – Multi-criteria/Semantic Search – Online & Open Source – Documentation & Evaluation

1.1 Deliverable context

Project item	Relationship
Objectives	To provide a common interface and a universal online platform as a one-stop-shop for all ACTIVAGE cross pilot end-user applications and services
Exploitable	D4.3 contributes to the creation the ACTIVAGE IoT Ecosystem Suite by

results	describing the Marketplace component, crucial to exploitation within the consortium and by/for third-parties
Work plan	Deliverable D4.3 is linked with T4.4
Milestones	M1 - BUILD - All DS ready and solution integrated. D9.1 Completed. M2 - DEMONSTRATE - Smart Living environments on each DS are deployed.
Deliverables	Deliverable D4.3 has to be delivered on M18 (first version) and on M36. It requires indirect input from deliverables D4.1 and D5.1 that provide tools and material for development and deployment as well as indirect input from the marketplaces that IoT platforms already have, the capabilities of the interoperability layer and data models, applications built for deployment sites, the open call and exploitation strategy.
Risks	WP4 is not related to risk management

2 Marketplace Use Cases

This section defines use cases and scenarios for the ACTIVAGE Marketplace that are used to derive the functionality described in Section 4. First, the section considers all discrete end-user roles before defining use cases for each of those roles.

2.1 End-user Roles

The ACTIVAGE Marketplace considers three distinct roles of end-users in relation to it:

2.1.1 Application Users

This category includes end-users that wish to **obtain, install and use** applications hosted in the Marketplace. Application Users, or simply Users in the context of this text, have the ability to register, manage their profile, maintain a wishlist and installed applications list, review and rate applications. They are neither developers nor administrators and may be related to the Deployment Sites (DSs) of ACTIVAGE e.g. as deployers for them. At the point that they wish to also develop they should create a respective developer profile, kept separate from the user profile, as in most online marketplaces currently (e.g. Google Play store). Naturally, to administer, they have to contact and alleviate their privileges in contact with the ACTIVAGE consortium WP4. Notably “application installers”, mentioned in D4.1, is identical to users as far as the Marketplace is concerned, since Users can both obtain and install, or else deploy, applications.

Identity	Relation to AIOTES	Registration	Abilities
Users	<ul style="list-style-type: none"> – DS Deployers, – Professionals, – Potential Adopters, – General web users browsing 	Optional (unlocks marked with an asterisk*)	<ul style="list-style-type: none"> – View and Search Applications – Buy/Install Applications* – Maintain Wishlist and Installed Application list, Receive Updates* – Comment, Review, Rate Applications*

2.1.2 Application Developers

This category of end-users is the consortium partners and third-parties that have the **knowledge and intention to develop** applications compatible with ACTIVAGE. In both cases, the Marketplace first of all provides **material** to educate and enable them to do so (coming from WP5 educational material). Developers have the ability to upload and host applications in the Marketplace, monetizing them and widening their reach while also growing the ecosystem of AIOTES. They can also track performance, receive ratings and review insights.

Identity	Relation to AIOTES	Registration	Abilities
Developers	<ul style="list-style-type: none"> – DS Developers – Third-party 	Mandatory	<ul style="list-style-type: none"> – Access Developer Educational Material Resources (public)

	Developers through Open Calls – External Adopters	– Upload and Provide Applications – Receive Payments – Receive User Comments, Reviews and Rating – View Insights regarding Downloads, Avg. Ratings etc.
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2.1.3 Marketplace Administrators

This category of end-users has full access to the Marketplace setup, meaning the ability to **add and remove applications or users** at will. Their main task for the Marketplace maintenance is the **validation** of Applications for compliance. To gain these privileges, this role is attainable by consortium members, at least in the context of the project, in contact with WP4 leaders CERTH in charge of Marketplace development.

Identity	Relation to AIOTES	Registration	Abilities
Administrators	<ul style="list-style-type: none"> – Marketplace Developers, CERTH – Business Cluster, Dissemination and Exploitation, Open Call drivers – Any other interested party identified within ACTIVAGE 	Mandatory	<ul style="list-style-type: none"> – Access Administrator Insights, Users and Developers Registered – Validate content and Applications with regards to the ACTIVAGE policy – Select top Marketplace picks or monetizing strategies (e.g. sponsored apps) – Add, remove or moderate content as needed (e.g. received through reports)

The following subsections present use case scenarios for each of the end-user roles.

2.2 Use Case Scenarios for App Users

This subsection considers end-user scenarios envisioned to be supported by the Marketplace. The scenarios remain general enough so as to include user external to the consortium, but they also support users that belong to specific ACTIVAGE DSs. The DSs are of high importance when it comes to this functionality, which later lead to the implementation plan as described in Section 4.3.

The first scenario considers a guest, or else, unregistered user browsing the Marketplace with search capabilities:

User Scenario 1: Browsing Applications

A user accesses the ACTIVAGE Marketplace online. They can immediately view applications at the home page at an order suggested by the Marketplace itself e.g. top-user-rated first, then administrator picks. The user wants to browse some more, so they pick a few filters such as a category from the available ones, name search or rating threshold. The page immediately displays a list of the respective applications.*

* More advanced and detailed search criteria will be available in the second version of this deliverable.

The second scenario considers a more engaged user wanting to install applications, either purchased or free, for now or for the future using the wishlist and, therefore, they need to register to the Marketplace:

User Scenario 2: Getting Free or Buying Applications and Using the Wishlist

The user has located an application that they want to install. The user is not yet registered; so to obtain the application the Marketplace directs them to register first. While the options to register with existing accounts on Google, Facebook and other services is there, the user wants to set up a new account solely for the Marketplace. By filling the form with their personal information, an email is sent to the user's inbox where they confirm their identity. They can also sign up for an email digest and notifications. The user is registered and now the link to buy or get the application for free is available.

The user buys their first application using PayPal. The application is added to their Installed Apps list and different options are available according to the application and vendor:

*They either obtain a binary installation file, which is automatically deployed at the target platform online or a unique licence key obtained can be copied to the right place**

The user locates an application from another DS and platform according to the tags shown next to it. The application is free, so they wish to try it for their installation. They immediately obtain it without paying.

The user realizes that they want to try more applications but later in time. Therefore, they add them to their wishlist. The wishlist as well as the Installed Application list are accessible through their profile, as are their personal information to be edited or removed at any point along with the account itself, the email digest subscription and notifications for wishlist and Installed Apps list updates.

* The exact mechanics on how to obtain or deploy an application will be available according to the work done for ACTIVAGE integration, particularly WP5, in the second version of this deliverable.

The third scenario considers a user that has already experienced an application and wants to provide feedback by reviewing and rating it:

User Scenario 3: Leaving Feedback and Removing Applications

The user has used an application for quite a while and is very satisfied with it. They log in and go to Installed Apps which links to the desired app. A textbox is available for them to write what they did and did not like about it as well as to enter a rating ranging from one to five stars.

The review immediately appears below past user reviews with the users nickname. The review can later on be accessed from there or their profile so as to be removed.

*Since they visited the Installed Apps list, the users wants to uninstall an app they did not like as much right from the list. If applicable, the App is immediately removed from the online platform they own, or, otherwise, just its reference from the list updating the statistics accordingly.**

* The exact mechanics on how to undeploy an application will be made available according to the work done for ACTIVAGE integration, particularly WP5, in the second version of this deliverable.

2.3 Use Cases for Developers

The use cases for developers are designed with ACTIVAGE partners in mind, especially IoT cluster providers and DS developers. Further on, they deeply consider third-party developers especially those reached through the Open Calls and later on the general public.

The first scenario considers an aspiring beginner developer browsing the Marketplace and wanting to start developing for AIOTES.

Developer Scenario 1: Starting to Develop

*A user with developer background is browsing the Marketplace out of interest and desire to start developing for IoT and AHA. The Marketplace seems an appealing way for them to monetize or even provide for free their future creations to be hosted and promoted in this very same platform. The developer section grabs their eye. Within that section they find links to documentation on the ACTIVAGE APIs, tutorials and e-courses on how to develop for AIOTES, which they immediately access without registration.**

* The strategy for providing educational material on the integrated AIOTES is provided in D5.1 and will be thoroughly specified in the second version of this deliverable.

The second scenario considers a seasoned ACTIVAGE developer with an application ready to be monetized and provided.

Developer Scenario 2: Uploading Applications

A developer has an ACTIVAGE application that they developed for a specific DS. Going to the developer section and following the upload link they are led to register as developers. Although they already own a Marketplace user account which they use to try out applications by others, they proceed to create a new Marketplace Developer account with elevated permissions for the separate developer section. While the option to fill in personal information is available, the user selects to authorize the Marketplace to use their Google account information through secure OAuth permissions.

The developer section is now open for user content so they immediately choose the Upload option. Filling the metadata information as accurately as possible, using text to describe the aims and functions, and tick/checkboxes to select platform, category, and DS, if applicable, will serve to better index and make the App discoverable. The executable or link to provide licences are provided, as well as the price. Legal policy is also signed to claim liability for the application's usage. The application now appears under the developers profile with a "Pending" status as it has to be validated for compliance and validity by the administrators. When this happens, the user receives an automated verification email. The user starts receiving payments directly to their PayPal account.

* The exact metadata that the developer provides are subject to the hosted applications within the project duration as well as the Data Model and the Marketplace model. Thus, they will be made available in this deliverables' second version.

The third scenario considers an application developer that already provides an application and wishes to receive feedback.

Developer Scenario 3: Receive Feedback and View Insights

A seasoned developer has hosted his applications for quite a while on the Marketplace. Accessing developer insights they can first of all, see their average statistics such as average rating and total downloads. A list of the applications shows downloads/purchases and average rating for each one. It seems that the application developed for a specific DS

is well accepted with high downloads and ratings.

However, the application created for general use to reach users outside DSs is not performing so well. Opening its page, the user can see all reviews by date or rating. It seems that their low rating reviews mention a bug that the developer did not consider earlier. Solving the bug, a new version is uploaded and the users are notified (according to their preferences). The developer can now expect ratings to grow again.

2.4 Use Cases for Administrators

The first scenario considers an administrator wanting to capture a report e.g. for dissemination and exploitation metrics.

Administrator Scenario 1: Monitor the Marketplace Operation

The ACTIVAGE Marketplace administrator wishes to monitor operations for reporting. They login to the Marketplace with their unique credentials provided by the consortium members in charge of the Marketplace. Consequently they are taken to the administrator dashboard, which shows items and statistics currently available including: the number and list of applications hosted, users and developers registered. Next to each item, its properties are shown: downloads, comments and average rating for applications, applications and average rating for developers as well as payments received. The administrator is interested in overall analytics as well, which are available through Google Analytics: page visits, navigation, regions and origin of the visits. The administrator takes the Google Analytics outcomes together with the overall number of downloads and applications hosted for the report they wished to catalog.

In the second scenario, the user wants to validate new applications pending for upload.

Administrator Scenario 2: Validate a Pending Application for Upload

The administrator performs their periodic check-in to the administrator dashboard. The dashboard this time notifies them that an application uploaded by a developer is pending approval.

The link takes them to the bundle uploaded together with metadata. The administrator selects to open the uploaded bundle, where they verify that the correct files have been uploaded. A virus scan is performed followed by a security check to comply with the ACTIVAGE security policy.*

The administrator then confirms the metadata for the application are not only well-phrased and non-offensive but also relevant and accurate to the content they have seen. Therefore, from the two available options, to approve or roll-back to the developer, they choose the former. The application immediately becomes available to the public and the mailing service notifies the developer.

* The exact process to approve application metadata being free of abusive or spamming content, which is pertinent to the marketplace, as well as the automated or manual process to examine the integrated bundles for security compliance, pertinent to WP5 and WP3 respectively, will all be provided in the next version of this deliverable.

In the third scenario, the administrator is a business cluster associate that wishes to promote certain material.

Administrator Scenario 3: Material Promotion

The administrator is a business expert that wishes to make sure that the ACTIVAGE Marketplace features the most interesting material aligned with current trends.

After logging into the administrator dashboard, there is an option to select editor picks to be featured in the Marketplace dashboard. The user knows that at this time, telemonitoring applications are trending in the international market in relation to other AHA applications. Using the same application search criteria as the users, they find and select the top-rated telemonitoring apps. To make sure all platforms are represented they pick three, one from each platform. The applications now appear as featured on the Marketplace homepage under “featured apps” next to “top rated apps”.

In the fourth scenario the administrator needs to moderate content.

Administrator Scenario 4: Moderating Content

The administrator has received an email notification regarding an offensive content report. The link takes them directly to the comment in question, where they see that it is indeed offensive and they proceed to delete it.

Taking this opportunity the administrator navigates back to the dashboard and to the moderation section where all reported content is shown. Many reports come from a single user. After deleting the comments the administrator deletes and blocks the user, who receives an email notification for the action.

3 Existing Marketplaces and Tools

This section explores state of the art in online marketplaces, within the ACTIVAGE platforms, similar R & D project efforts but also outside the IoT and AHA domain. It also explores discovery tools and open source solutions related to the infrastructure of the proposed ACTIVAGE Marketplace so as to place it in context and shape its specification, presented later in Section 4.

3.1 Marketplaces of the ACTIVAGE Platforms

Most, but not all, ACTIVAGE underlying IoT platforms provide a marketplace or store to provision their applications to end-users. The concepts are similar to the envisioned Marketplace: to enable developers upload and monetize applications and facilitate users with their discovery and procurement.

As ACTIVAGE unifies the platforms and offers the added value and reach of joining the respective ecosystems in Europe, so does the ACTIVAGE Marketplace, offering a provision and monetizing method for platforms that were previously lacking a marketplace, and complementing its functionality for those that were not.

The specific application procurement methods and marketplaces provided by the platforms are described below by the respective partners, first in an overall functionality checklist and then in detailed subsections.

Table 2 shows a functionality checklist for the marketplaces of the ACTIVAGE platforms. In cases that a marketplace or other type of online portal is not applicable, details are provided.

Table 2. Overall functionality checklist for all application provision actions through or outside of a marketplace for all ACTIVAGE platforms

	Marketplace Source	Open	Marketplace Online
universAAL	✓		✓
OpenIoT	✗		✓ (only for developers)
sensiNact	✗		✓ (Not a marketplace, but the Eclipse Project Page hosts sensiNact Studio and Studio Web)
Sofia2	✗		✗
FIWARE	✓		✓
IoTivity	✗		✓ (Not a Marketplace but the homepage hosts downloads)
SeniorSome	✗		✗
Supported Use Cases for Developers			
	Publish	Sell	Get insights
universAAL	✓	✓	✓ (Including requests and comments)
OpenIoT	✗	✗	✗

sensiNact	✓ (Outside of a marketplace, by contributing to the sensiNact Eclipse Project (Developer))	✓ (Outside a marketplace, using the commercial Eclipse Public License)	✓ (Outside of a marketplace at the SensiNact Eclipse Project)
Sofia2	✗	✗	✗
FIWARE	✓	✗	✓
IoTivity	✓ (Outside of a marketplace, by contributing to the IoTivity GitHub)	✗	✓ (Outside of a marketplace at the IoTivity GitHub)
SeniorSome	✗	✗	✗

Other Supported Use Cases						
	Search	App rating	User activity mgmt.	Get / Deploy apps	Get updates	
universAAL	✓	✗	✗	✓ (Through marketplaces and sites as well as Google Play for Android)	✓	
OpenIoT	✗	✗	✗	✗	✗	
sensiNact	✗	✗	✗	✓ (Outside of a marketplace as well as Google Play for e-alert Android)	✓ (Outside of a marketplace, the e-alert application can self-update)	
Sofia2	✗	✗	✗	✗	✗	
FIWARE	✗	✗	✗	✗	✗	
IoTivity	✗	✗	✓ (Outside of a marketplace, join the community , create new features in the task tracker)	✓ (Outside of a marketplace, users can download and build the platform from GitHub)	✗	
SeniorSome	✗	✗	✗	✗	✗	

3.1.1 universAAL IoT

The original marketplace for universAAL was called **The uStore** (universAAL Store). Its goal was, similar to App Store and Google Play store, a more B2C-central service to upload and download universAAL-based applications. Despite having been developed in open source, its deployment needed the licensing of IBM WebSphere because the uStore was built on top of this software.

As a matter of fact, the uStore never got operational, as the organizational and governance issues for its deployment and operation were not tackled during the initial EU project.

In ReAAL, the large-scale piloting project of universAAL towards ecosystem building and market penetration <www.cip-reaal.eu>, the initiated ecosystem was looking for alternative solutions. With its Marketplace events, the project could finally demonstrate that the concept of uStore was not mandatory anymore, but a Marketplace website with the presentation and discussion of the different types of the universAAL “COTS”¹ can also be exposed and exchanged between suppliers and buyers in a more B2B-centric approach.

This way, **the ReAAL Marketplace** was born as a Website using a standard Marketplace hosting service <www.reaalmarketplace.universaal.info>:

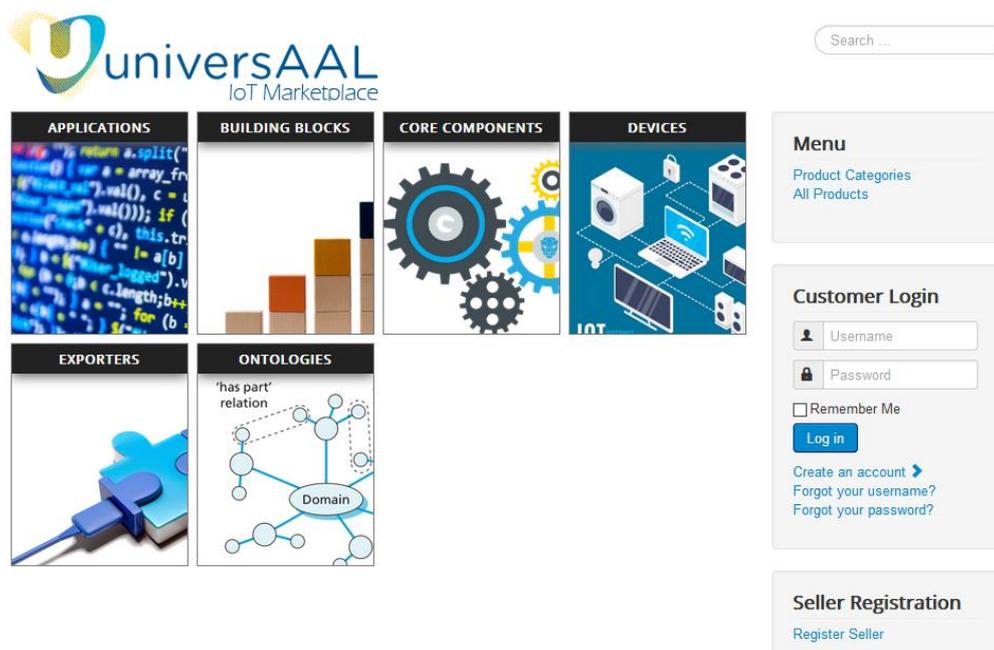


Figure 1. universAAL Marketplace product categories and user menu

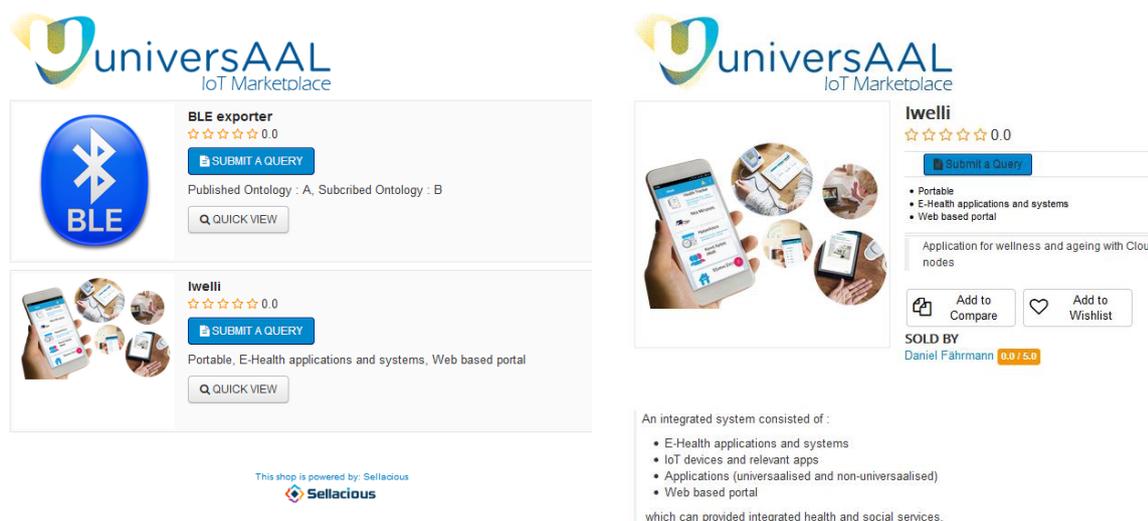


Figure 2. universAAL Marketplace product list and details

¹ Components, off-the-shelf.

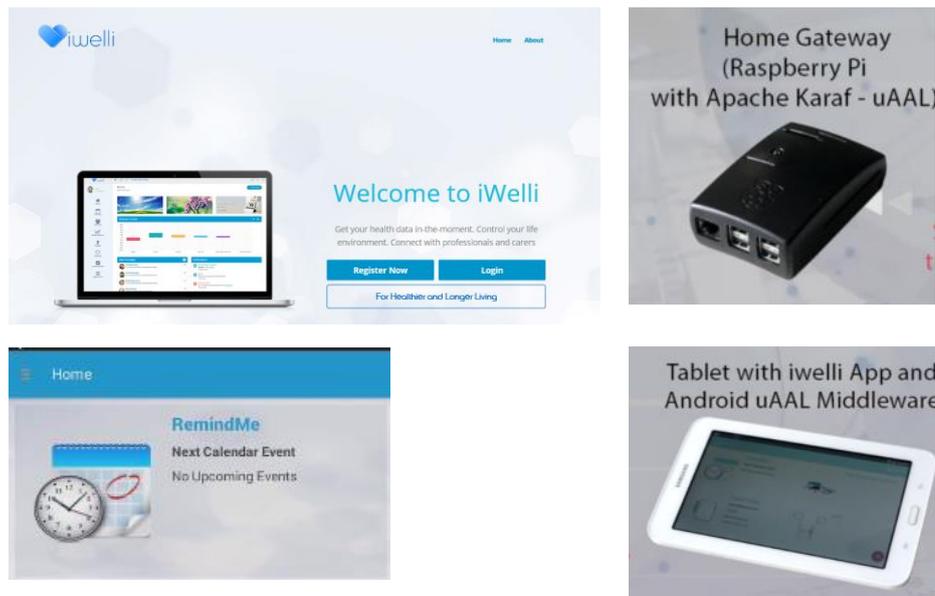


Figure 3. Presentation of applications, sometimes bundled with devices

With the incorporation of the open international non-profit association “The universAAL IoT Coalition (uIC)” <www.universaal-iot.org> in May 2018, this marketplace is being migrated to the uIC Website under <http://universaal-iot.org/marketplace>.

3.1.1.1 Application Delivery to Users

Originally, universAAL applications were distributed using the so called “ual packages”. A “ual package” was actually a zip file containing the necessary bundles and an xml file describing where and how these bundles could be deployed. The advantages were that applications could be automatically deployed in distributed environments and where each module would actually run would be determined by the deploy manager in the middleware. Unfortunately these features have not been maintained for a long time.

Currently, there are several forms of application distribution for universAAL:

- Together with the complete runtime environment, specifically for standalone applications, and cloud systems.
- Application developed as OSGi bundles can be distributed and installed by copying the bundle in a folder. Features are more advanced applications which coordinate several sets of bundles (along with more information on how to run them). Both bundles and features are typically distributed by deploying them to a remote Maven repository, which can then be found by the runtime; for this the runtime needs a) to be configured to find the remote repository and b) to know the URL where the artifact is hosted, so it can be loaded with a command.
- Android applications can be distributed through the Google Play store or custom methods.

3.1.1.2 Functionality for Users and Developers

The ReAAL Marketplace allows the following actions for the respective actors in the AHA domain:

- User: browse, buy, request, comment on services
- Informal Carer: do the same but delegated by a user.

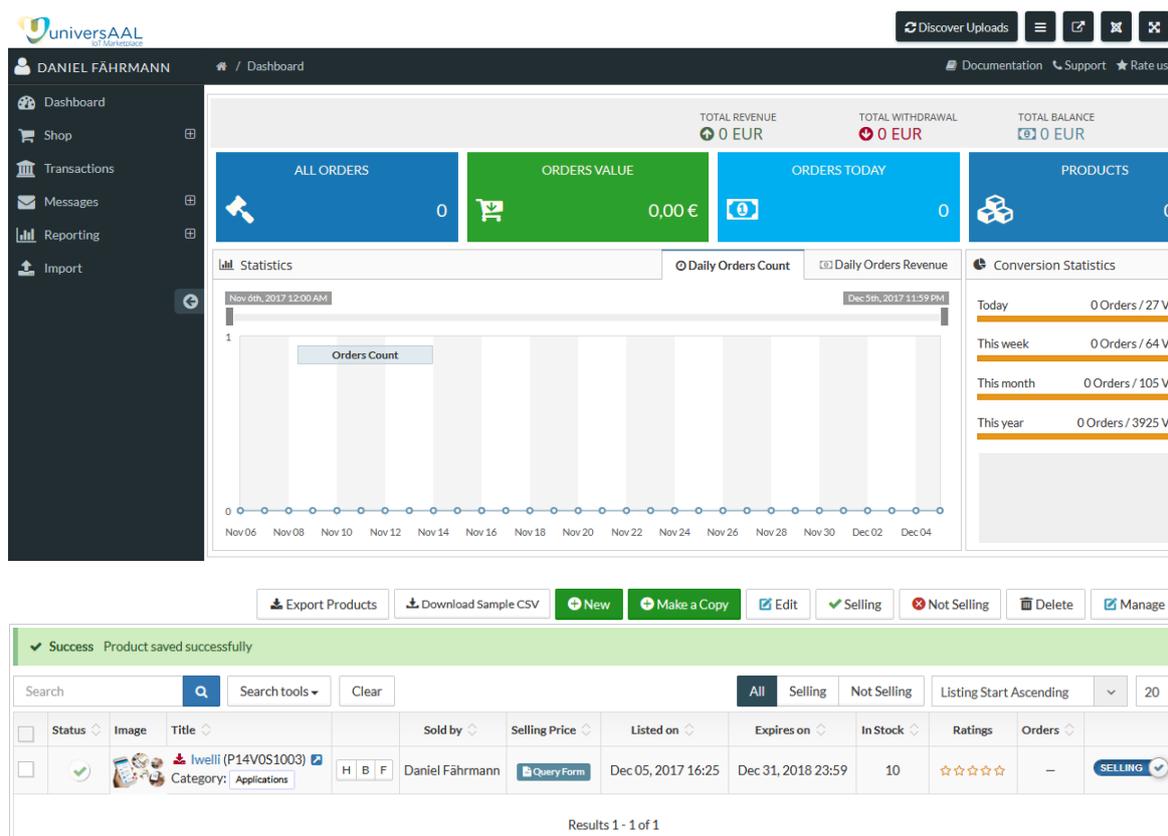


Figure 4. universAAL Marketplace Product Management Dashboard and Catalogue for sellers

- Developer: add, browse, use technologies and read requests and comments. To access the universAAL platform resources – such as the platform software modules, tools and documentation – the reference “marketplace” is available under
- Service Providers: compose services based on 3 main pillars: software, hardware, and human resources; thus the model for services are composed of a subset of these three types of components.

More specifically, the universAAL marketplace for users can display items, i.e. applications, services and devices, as a full list or per category, as shown on Figure 1. The same Figure also shows the user menu, with the ability to register, login or enter the seller section, described later on.

A sample of a full list of items is shown on Figure 2, as is the item view, with the ability to add to a compare or a wish list. The items also show their rating and the seller.

In the seller section, basically for developers and selling professionals, the marketplace offers a dashboard for product management and insights, shown on Figure 4. The dashboard offers monetization insights such as purchases and performance including ratings.

The full description of the marketplace is available in the ReAAL public deliverable D6.4.

3.1.1.3 ACTIVAGE Marketplace Added Value

The universAAL IoT marketplace stands as one of the most complete marketplace efforts among the ACTIVAGE platforms. They are open source, support users, carers and

developers and also introduce the discrimination between applications, services and devices to buy with the ability to compose services.

Still, the ACTIVAGE Marketplace can greatly benefit and complete them with the power to reach to more platforms, domains and adopters. Some functionality pertinent to them will not be directly supported, as it would not apply to the other platforms as-is, such as purchasing devices and composing services. However, the ACTIVAGE Marketplace remains more general and interoperable, with the ability to purchase applications cross-platforms and support all users, even clinicians and carers through the general identity of application user.

3.1.2 OpenIoT

There is no designated marketplace for OpenIoT applications.

3.1.2.1 Application Delivery to Users

OpenIoT is platform focused, which means it mainly aims to provide the middleware and ontology interoperability layer for applications. The developers, then, are free to build their own applications. Thus, there is no main channel for delivering them to users, except for the GitHub repository that hosts the entire platform.

3.1.2.2 Functionality for Users and Developers

Due to the lack of a marketplace there is no functionality for users and developers to be mentioned, except from the standard developer insights for the platform contributors on GitHub.

3.1.2.3 ACTIVAGE Marketplace Added Value

Due to the lack thereof, OpenIoT can greatly benefit from the ACTIVAGE Marketplace, offering a unified portal to provide and monetize applications reaching the ecosystems of other platforms and external potential adopters.

3.1.3 sensiNact

As application distribution channel, sensiNact benefits from the Eclipse Project web site and the Android application provision potentially through Google Play Store. Thus, there is no unified marketplace for providing and monetizing all sensiNact applications.

3.1.3.1 Application Delivery to Users

The sensiNact IoT platforms provide two kinds of applications: Generic applications and ACTIVAGE AHA dedicated applications. The sensiNact IoT platform already embeds two generic applications devoted to developers and installers, mainly at deployment, tests and maintenances phases:

- a) sensiNact Studio Web is a web application running besides the sensiNact server instance. It can be used to check the status of deployed devices and services. This web application makes it possible to localize devices through the 'Navigator' panel (see Figure 5). This Studio Web navigator gives the status of both installed devices and deployed services.
- b) sensiNact studio is a standalone application built on the top of the Eclipse RCP. As a tool on top of the sensiNact gateway API, it provides facilities for gateway monitoring and application creation. It provides views to monitor available devices, and an editor to create applications (see D4.1). Through the DSL (Domain Specific Language) editor, it is possible to program Event-Condition-Action scripts (called "applications") in a dedicated language.

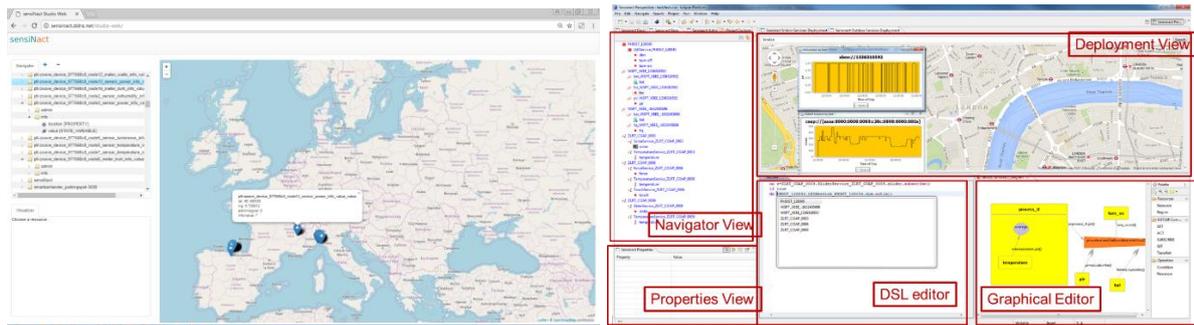


Figure 5: sensiNact Generic Applications Studio & Studio Web delivered via the Eclipse Project site

Both generic applications sensiNact Studio & Studio Web can be downloaded through the sensiNact Eclipse Project web site.

Three AHA applications have been developed on top of the sensiNact AHA API described in D4.1 section by Technosens (shown on Figure 6).

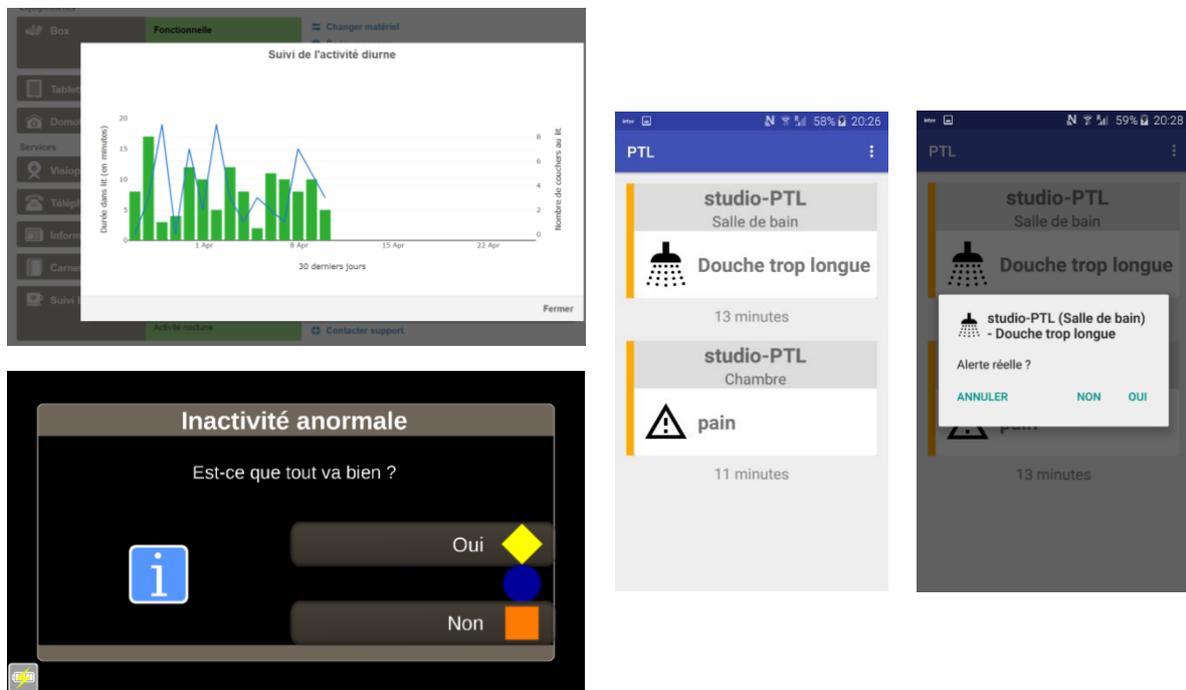


Figure 6: sensiNact AHA applications e-lio manager, e-lioBox TV notification and e-alert Android

a) e-lioManager is a web application dedicated to the configuration of AHA functions deployed in the elderly's living place (room in a health care building or at home). With this application though, it is possible to activate/deactivate AHA functions and parameterize them in agreement with the patient. The e-lioManager web app provides also historical plots of recovery and autonomy indicators dedicated to medical staff.

b) e-lioBox ACTIVAGE TV notifications, is a new feature of the Technosens e-lioBox that makes it possible to display notifications to the elderly patient inside their TV monitor. These notifications are incitation messages (for morning washing for instance), pain auto-evaluation messages triggered when necessary by the sensiNact AHA engine

c) e-Alertes, is an android native application dedicated to the carers that displays alerts that may be triggered by the sensiNact smart AHA engine when analyzing activity in the elderly living place. The e-Alertes Android app also provides a feature to acquit alerts and declare

eventual false alerts, then making it possible to compute false alert KPIs and, thus, further improve diagnostics and the sensiNact activity analyzer.

Regarding the delivery of AHA applications to the users, they are carried out directly by the provider. The Technosens e-lio manager and e-lio ACTIVAGE TV notifications applications are not publicly accessible. They are uploaded on a dedicated repository in the Technosens private cloud accessible by both e-lio boxes and servers for automated updates. However, the Technosens e-alert Android application will potentially become available through the Google Play Store marketplace.

3.1.3.2 Functionality for Users and Developers

Due to the lack of a Marketplace, developers are mainly supported through the Eclipse web site, and users via direct contact with the application providers.

3.1.3.3 ACTIVAGE Marketplace Added Value

All in all, the sensiNact platform could greatly benefit from the unified ACTIVAGE Marketplace, offering not only the ability to host, monetize and obtain both generic and AHA applications, regardless of vendor, but also to reach other platform ecosystems and user bases.

3.1.4 Sofia2

Sofia2 does not provide any public channel for users to obtain applications; in other words, there is no Sofia2 marketplace.

3.1.4.1 Application Delivery to Users

In Sofia2, applications are provided in an ad-hoc manner.

3.1.4.2 Functionality for Users and Developers

The platform does not provide a marketplace for users to obtain apps and also for developers to provide and monetize them.

3.1.4.3 ACTIVAGE Marketplace Added Value

Sofia2 could greatly benefit from the unified ACTIVAGE Marketplace, offering not only the ability to host, monetize and obtain applications but also to reach other platform ecosystems and user bases.

3.1.5 FIWARE

3.1.5.1 Application Delivery to Users

FIWARE offers a global, established marketplace to offer applications to the community.

The FIWARE Store, which can be accessed here: <https://store.lab.fiware.org>, offers the possibility to announce offerings, solutions and services based on FIWARE to the platform's community. More specifically, it is a global one-stop shop that gives access to a wide range of Powered-by-FIWARE solutions, FIWARE-ready technologies as well as related training, coaching, consultancy, integration and services.

The FIWARE Store, and in fact the entire FIWARE ecosystem, take into account that implementing a Smart Application requires gathering and managing context information, referring to values of attributes characterizing relevant entities. As a result, a crucial element

for the development of the Smart Solution is the existence of a public and royalty-free context information management API specification. FIWARE solves this need with the FIWARE NGSI API which interacts with the Orion Context Broker, the core component of FIWARE. This way, the open-by-design architecture permits plug & play integration of third parties' technologies. Therefore, the set of functionalities that the platform offers is enriched and improved making FIWARE more competitive and attractive. Figure 7 shows the FIWARE ecosystem where the Marketplace applications are located at the top of the FIWARE NGSI API, using it to communicate with the different components of FIWARE such as the Context Broker, the Complex Event Processing or the Big Data module.

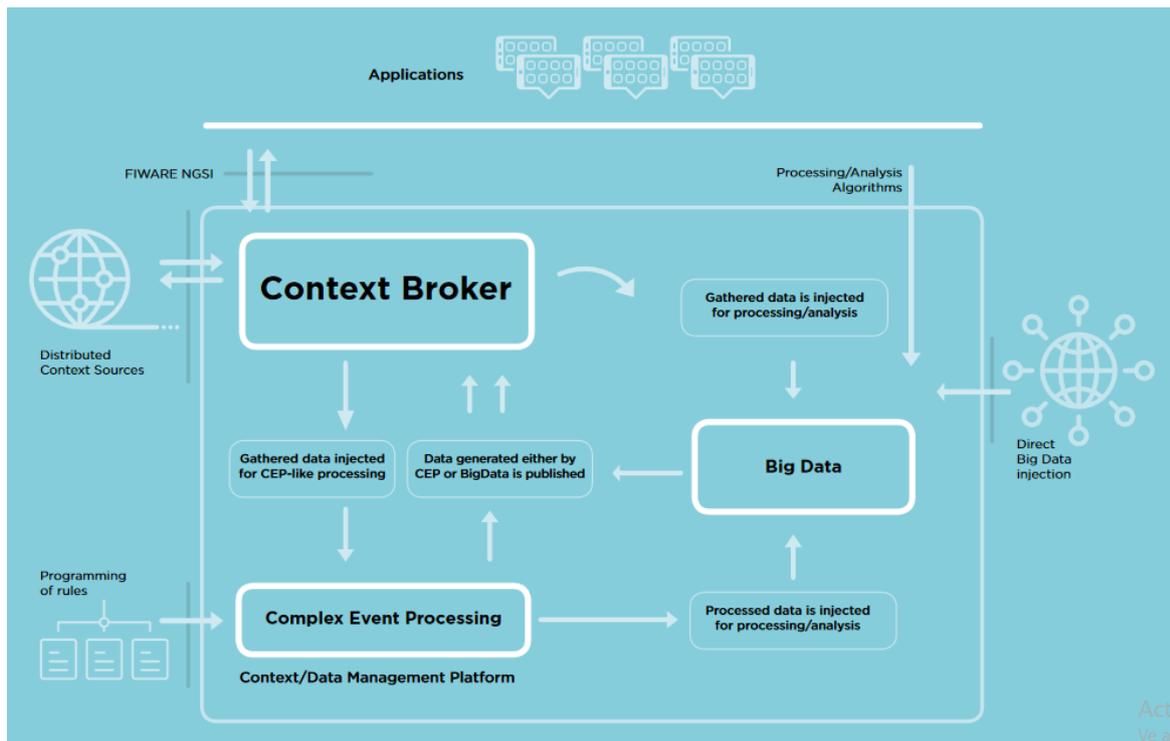


Figure 7: FIWARE ecosystem

For the sake of clarity, FIWARE also hosts a “Marketplace” which is different from the Store. The FIWARE Marketplace, which can be accessed here: <http://marketplace.fiware.org/>, is a global one-stop shop for solutions/platforms, FIWARE-ready technologies and related training/coaching material, consultancy, integration and support devices. Therefore, it is more of a hub with static content of applications and devices, rather than a dynamic-content of exclusively applications for the IoT platform. In the context of the ACTIVAGE Marketplace we are interested in the first one, hence, we remain more aligned with the FIWARE Store than the FIWARE Marketplace per se.

3.1.5.2 Functionality for Users and Developers

The Store is a hub for listing all FIWARE-based software as well as resources. It centralizes information of the existing FIWARE offerings in a uniform and clear way, but it does not offer more advanced features, such as search options, facilities to install applications or user account management options. Figure 8, shows an instance of the FIWARE Marketplace demonstrating listings of offerings of various types e.g. packs and widgets, the ability to keyword-search and to select a store of origin which functions similarly to a category.

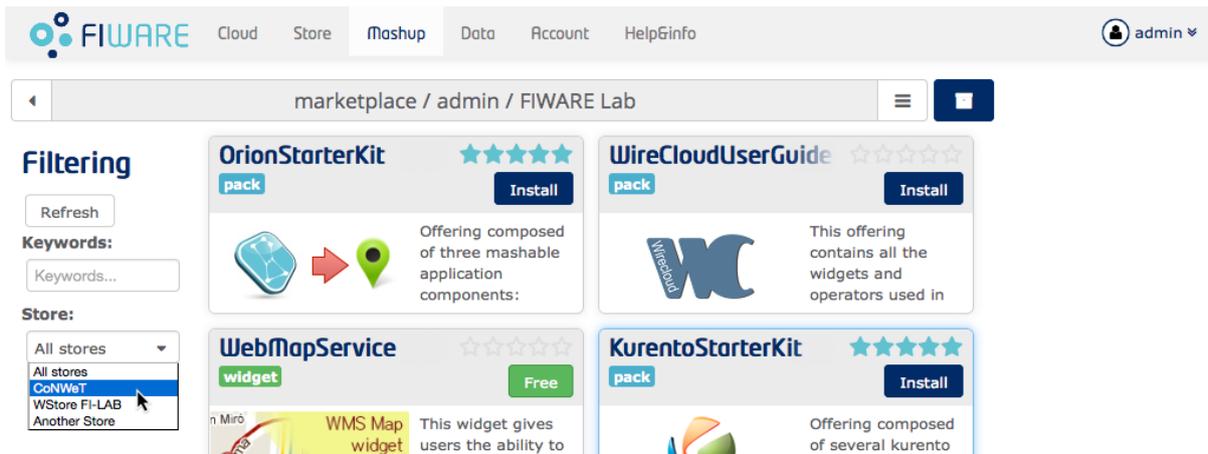


Figure 8. FIWARE Marketplace listing offerings

Figure 9 shows the view of a single offering in the FIWARE Marketplace, allowing users to see a description, tags, detailed data, download, publish or delete them in case they are administrators.

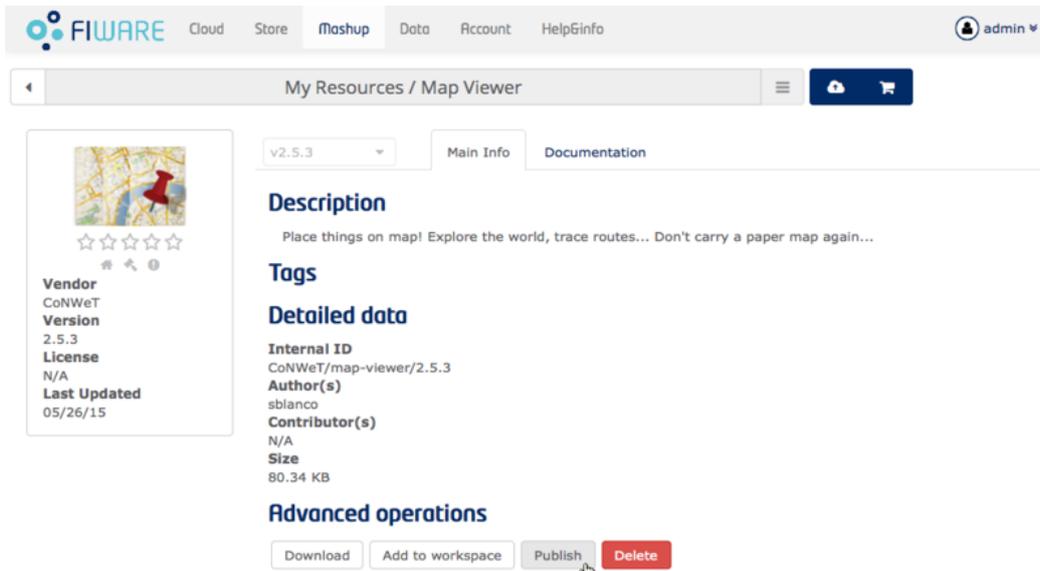


Figure 9. FIWARE Marketplace view of a single offering

3.1.5.3 ACTIVAGE Marketplace Added Value

While FIWARE already provides a functional Marketplace with many abilities to publish and monetize applications, it could still benefit from the ACTIVAGE Marketplace, offering unification and wider ecosystem building potential as well as penetration into the AHA domain. Regarding functionality it could benefit from more monetizing abilities, developer insights, user search and wishlist capabilities.

3.1.6 IoTivity

IoTivity does not provide any public channel for users to obtain applications; in other words, there is no IoTivity marketplace.

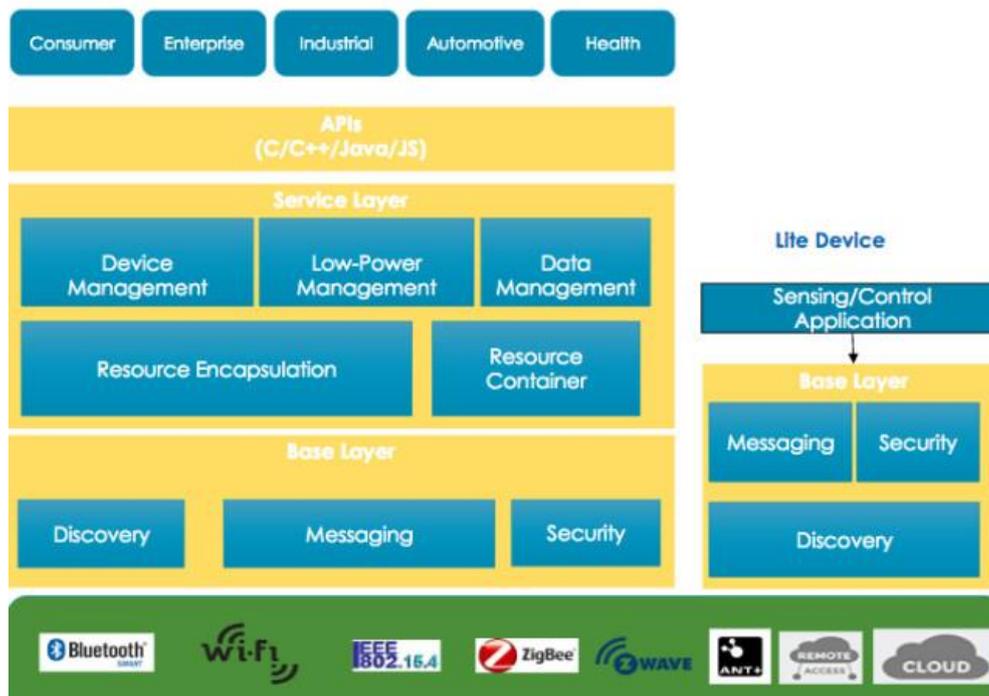


Figure 10. IoTivity Platform architecture

3.1.6.1 Application Delivery to Users

The website of IoTivity provides a page for downloading the latest IoTivity OS, i.e. the platform, releases at <https://iotivity.org/downloads>. IoTivity is platform dependent and needs to be built before it can be run by users. There is no specific channel to provide applications built for it to the users.

3.1.6.2 Functionality for Users and Developers

IoTivity is a framework for creating applications that enable seamless device-to-device connectivity to address IOT needs. That means that it is not a ready plug and play solution that can be used by a user. A developer is needed to create an application based on the API provided by this framework.

Specifically, developers can implement their own IoTivity servers and clients, register their own resources on the server and implement a resource discovery mechanism. Moreover, the provided API supports functionalities for querying and setting/observing resource states.

Instructions for building the downloaded code and a programming guide for developing are also provided by the IoTivity's Wiki website [1].

3.1.6.3 ACTIVAGE Marketplace Added Value

IoTivity is an IoT platform focusing on providing solid IoT functionality in the layers below applications, as shown on Figure 10, such as device, low-power and data management, messaging and security etc.

Therefore, the applications built for it will enjoy great value from a unified ACTIVAGE Marketplace, offering not only the ability to host, monetize and obtain applications but also to reach other platform ecosystems and user bases.

3.1.7 SeniorSome

SeniorSome does not provide any public channel for users to obtain applications; in other words, there is no SeniorSome marketplace.

3.1.7.1 Application Delivery to Users

SeniorSome provides applications to users in an ad-hoc manner.

3.1.7.2 Functionality for Users and Developers

The platform does not provide a marketplace for users to obtain apps and also for developers to provide and monetize them.

3.1.7.3 ACTIVAGE Marketplace Added Value

According to the above, SeniorSome could greatly benefit from the unified ACTIVAGE Marketplace, offering not only the ability to host, monetize and obtain applications but also to reach other platform ecosystems and user bases.

3.2 Marketplaces in European Large-Scale Pilots

The European Large-Scale Pilots Programme includes the innovation consortia that are collaborating to foster the deployment of Internet of Things (IoT) solutions in Europe through integration of advanced IoT technologies across the value chain, demonstration of multiple IoT applications at scale and in a usage context, and as close as possible to operational conditions [2]. The consortia currently include:

- ACTIVAGE
- AUTOPILOT
- IOF2020
- MONICA
- SYNCHRONICITY
- CREATE-IOT
- U4IOT

All of the above consortia aim to progress in IoT LSP and have, others more and others less, the intention to reshape or create markets in Europe. Central to this strategy is often a Marketplace as the one envisioned in ACTIVAGE and the objective of this deliverable.

AS THE PROJECTS RUN IN PARALLEL, IN THE TIME OF WRITING, PUBLIC RESOURCES TO PRESENT STATE OF THE ART FROM THE OTHER PROJECTS ARE VERY LIMITED AND, THEREFORE, THE CONTENT IS EXPECTED TO MATERIALIZE FULLY IN THE SECOND VERSION OF THIS DELIVERABLE. THE REST OF THE SECTION PRESENTS INFORMATION FOUND SO FAR.

The marketplaces are just now emerging: the IoT Week 2018 in Bilbao, hosted a session on this very topic – “IoT Marketplaces from EU Projects” [3], chaired by the European Commission. Indeed, almost all of the presented marketplaces belong to IoT LSP, except FIWARE (a platform included in ACTIVAGE). The related topics were:

- IoF2020/WAZIUP IoT Catalogue for Agri-food
- SYNCHRONICITY IoT Marketplace
- ACTIVAGE IoT Marketplace (presenting the current progress as in this deliverable)

- AUTOPILOT IoT Marketplace
- FIWARE Marketplace & IoT

While neither the presentations nor any content are available, there is a clear prevalence of Marketplaces accompanying every IoT aspect of life: agriculture, smart city, healthcare and transportation. Some objectives of respective projects are examined below.

3.2.1 SYNCHRONICITY

SYNCHRONICITY is one of the IoT LSP most clearly oriented towards providing a Marketplace, a portal where smart city users can offer their services or use those of others, promoting monetization above interoperability and standards.

This is apparent already from the main project description and goals, with Marketplace explicitly mentioned on the project's website to “support business interactions between SynchroniCity ecosystem data suppliers and consumers” [4]. Further on:

Cities have the opportunity to become catalysers for a multitude of data originating from smart devices connected to a gathering infrastructure. Data owners range from businesses that have information that is valuable to local authorities, to citizens or volunteer groups that have information that is valuable to businesses.

More specifics about the vision continue to entail an envisioned Data Marketplace [5]:

Our vision is to move from disparate data stores and city platforms to vibrant marketplaces for urban data and services providing adequate incentives for a variety of stakeholders to participate. For providers of IoT infrastructure and other urban data sources, this should provide a trusted environment to generate reliable revenue flows. For application and service developers, it should allow frictionless access to reliable and trusted urban data streams to be used as assets underpinning the innovation no matter what city is involved. We call this aspect “avoiding city lock-in”. Cities and infrastructure providers can benefit from an aligned environment with standardised interfaces to access a diverse pool of vendor solutions able to compete fairly on price and performance. We call this aspect “avoiding vendor lock-in”. Together, they form the robust underpinnings of a global market for IoT-enabled urban services.

...

Market place enablers. These should encourage sharing of urban IoT data and other relevant data sets among different stakeholders. By providing a market place as a one-stop-shop, it will become much easier for data consumers to discover and access urban data sources. The availability of a trusted market place with monetization mechanisms will allow third parties to generate easier revenue streams from their urban data sources. This will encourage more businesses to share currently closed data sources or incentivize deployments of new IoT infrastructure as secondary revenue streams can be generated, making more business cases viable. Data consumers may not require lengthy negotiations of license terms as data license terms can be negotiated from pre-configured options of the provider on the fly.

Overall, SYNCHRONICITY heavily relies on the Marketplace to enable providers and consumers in this emerging market for smart city products and services. However, it heavily relies, naturally, on the Data aspect of the Marketplace. Data is a valuable commodity in every market, much more within smart cities. But in healthcare and in ACTIVAGE, value is rather generated from services and applications, leaving more personal and sensitive Data from the LSPs untouched.

3.2.2 IOF2020

IOF2020 clearly quotes the call text related to providing access to valuable datasets for new market openings [6]:

Creation of opportunities for entrepreneurs by promoting new market openings, providing access to valuable datasets and direct interactions with users, expanding local businesses to European scale, etc.

This is aligned with the IoT Week presentation of an Agri-food catalogue. Whether the IOF2020 Marketplace is a Data Marketplace and/or Hub to find services remains to be seen.

3.2.3 AUTOPILOT

No material online has emerged from the AUTOPILOT Marketplace presentation nor the project deliverables. This section will be finalized in the deliverable's second version.

3.2.4 Other IoT LSPs (MONICA, CREATE IoT, U4IOT)

The other IoT LSPs do not clearly mention a Marketplace and no material has emerged yet. This section will be finalized in the deliverable's second version.

3.3 Marketplaces beyond IoT

Beyond IoT and long before its introduction, marketplaces for applications, services and even items, have been well-established on the web. Such examples include the revolutionary, for its time, item auctioning P2P (Peer-to-Peer) eBay platform [6] and Amazon hosting items from multiple sellers [6]. Another wave of marketplaces has initiated with electronic services this time, and primarily music in the iTunes store, giving way to applications for smartphones and the rise of the Apple App Store, Google Play store for Android, Samsung Galaxy Apps Store the Microsoft store and more. Lately, the P2P fashion of selling items and service is on the rise again with handcrafted items, pet services and more over Etsy, Rover, bonanza and lately even the Facebook Marketplace for items.

Another achievement of those marketplaces is the penetration to users who previously were not keen of technology. The necessity to leverage them, to sell their items and get apps for their phone, changing everyday life, gained them their users. But their ease-of-use and added value, is what maintained them. Their brands, now globally well-known to the majority of the population, are depicted on Figure 11.



Figure 11. Beyond IoT, early and late Marketplaces for items, services and apps

Regarding software which is most related to what is envisioned in the ACTIVAGE Marketplace, the smartphone app stores have revolutionized the way people obtain software. Developers directly upload, advertise and monetize their applications and get feedback. Users can quickly obtain, pay, use and review software much faster and easier than before. The need to quickly scale and effectively price also introduced micro-transactions and in-app purchases introducing novel marketing and business models. This fashion of software procurement is slowly transferred to desktops after decades via e.g. the Microsoft Store the Chrome Web Store, even shaping a new web-based desktop (Chromebook).

Smartphone app marketplaces have revolutionized the way people develop, distribute and use applications. Namely, the Apple App Store and recently the Android Google Play store, have the ability to host, describe, cater and monetize a wide range of mobile applications, which, in turn, brought about their widespread usage, increase of application developers and the rise of micro-transactions. Windows Store for Windows Mobile devices has followed.

Research and development trends, beyond IoT, are also picking up on the idea of marketplaces for apps and services. More recently, the BIG IoT project [6] started developing a marketplace to unite 8 IoT platforms through partners, and more through open calls, in one ecosystem. The marketplace is open-source and will offer an API for developers to integrate, publish and monetize their ideas e.g. by charging users per request. Figure 12 shows a pre-release of the Marketplace’s web interface, where users can browse offerings together with their ratings and prices “per Access”.



Figure 12. The BIG IoT Marketplace, listing offerings along with prices and ratings.

The ACTIVAGE Marketplace is inspired by and follows the concepts established by these trends even beyond IoT. This is apparent in the functionality itself as explained in the use case scenarios. Also the User Experience, as delivered in the implementation section, is directly inspired by the fast, easy, encouraging and inclusive for the users App Stores and Marketplaces.

3.4 Discovery Tools and Semantic Matchmaking

Besides marketplaces themselves, an underlying component of the envisioned platform is intelligent semantic search. This line of research has gained lots of momentum in the recent

years both within and outside R & D projects. This subsection provides a state of the art survey for what will be the basis for **semantic search** algorithm for **matchmaking** and **discovering** applications according to user needs.

The ACTIVAGE Marketplace is bound to provide intelligent, semantic search for users that wish to discover applications that match their needs in an efficient and intuitive manner. After the state of the art survey provided in this section, the most recent and available tools for semantic matchmaking have been pinpointed to be reused as-is for the 2nd version of the Marketplace.

NOTABLY, MOST EXISTING TECHNIQUES FOR MATCHMAKING HAVE BEEN APPLIED TO THE WEB SERVICE DESCRIPTIONS AND CONSEQUENTLY THEY ARE EXAMINED IN THIS SECTION. IN THE ACTIVAGE MARKETPLACE WE DETACH FROM WEB SERVICES AND USE THE SAME PRINCIPLES TO MATCHMAKING APPLICATION DESCRIPTIONS, AS THEY WILL BE DEFINED IN THE MARKETPLACE ONTOLOGY IN THE SECOND VERSION OF THIS DELIVERABLE.

3.4.1 Semantic Service Descriptions for Matchmaking

Web service description used for matchmaking, began with early works in the field, following a top-down approach of describing services using high-level ontological constructs, such as the OWL-S upper ontology for services [7] or the WSMO Web Service Modelling Language [8]. Ontological descriptions provide much flexibility and expressiveness, but are less strict towards bindings to actually invoke the Services in question. Additionally, their complexity and subjective interpretation has hindered their wide adoption by the industry. This led to the emergence of lightweight, bottom-up approaches, such as SAWSDL [9] and WSMO-lite [10], which provide compact annotations on service groundings themselves. Amongst them, SAWSDL became a W3C recommendation and a leading Semantic Web Service description methodology, which is increasingly adopted in industry and academia. Despite its low complexity and expressiveness, it has already been proven to be suitable for enhancing Web Service Discovery [11], Selection, Matching and Composition [12] [13]. Yet, these notions are just starting to penetrate the real-world with applications, e.g. [14].

3.4.2 Matchmaking Methods

As identified in this very recent study of efficient versus accurate algorithms, matchmaking and discovery methods can be classified in three categories: logic-based, non-logic (syntactic) and hybrid methods [15]. A deeper classification can be done into logic-based, syntactic or text-similarity-based, while structural similarity and learning are less common. Logic-based techniques range from straightforward series of few class-relationship rules to large lists of semantic conditions. Notice that, despite the name, this family of techniques mainly employs reasoning upon class subsumption and equivalence, avoiding more complicated inferences. Text-similarity mostly uses textbook algorithms from the field of Information Retrieval. When describing logic-based techniques offered (or provided) and requested services from now on will be denoted as O and R respectively. Input and output are denoted in subscript; e.g. R_i stands for requested input. Superclass and subclass relationships of a left-hand side entity to the right-hand side are denoted using $>$ and $<$ respectively.

3.4.2.1 Cloud4All, Prosperity4All, GPII

European projects have early-on pursued to build universal methods and tools for semantic discovery of services. Cloud4All [16] is creating instant, ubiquitous auto-personalization of interfaces and materials based on user needs and preferences, aligned with the Global Public Inclusive Infrastructure (GPII) [17], a project of Raising the Floor Consortium of academic, industry and non-governmental organizations and individuals. In order for

Cloud4All/GPII to provide auto-personalization, the underlying component developed, was indeed tools to semantically annotate and methods to search, discovery and rule-based matchmaking of web services. Its continuation, Prosperity4All [18], continues to evolve as part of GPII and is bound to provide such tools and methods. The respective component for matchmaking can be found here [16].

3.4.2.2 SAWSDL-MX, SAWSDL-TC, iSeM

The work in [19] presents two major contributions. First of all, the authors provided the first and largest dataset of more than a thousand SAWSDL files, namely SAWSDL-TC (Test Collection). To do so, they used expert manual labor combined with the OWLS2WSDL tool to map OWL-S descriptions (from OWLS-TC2.2) to lightweight format. The test collection's updated version, SAWSDL-TC3, found online [20], contains 1080 service documents, OWL ontologies, queries and relevant sets. Secondly, the authors present an initial approach to exploit this test collection towards automatic matching. Following the dataset's transformation, SAWSDL-MX is an adaptation of previous works OWLS-MX [21] and WSMO-MX [22].

The algorithm provides all standard matching strategies, namely logic-based, syntactic (text-similarity) and hybrid (logic-based and syntactic similarity). The strategies target service input, output and their underlying components (e.g. `ComplexType`), trying to find a match between a requested service (i.e. query) and all services offered in a set. Each offered service's operation is matched with every requested operation and rated with the maximum observed match. An offered service's overall rating is the worst (minimum) rating of all requested operations. The syntactic strategy applies IR (Information Retrieval) methods i.e. various text-similarity algorithms, provided by the SimPack [16] Java library (e.g. Loss-of-information, extended Jaccard, Cosine and Jensen-Shannon), between requested and offered semantic elements. Finally, the hybrid strategy offers two variants. The *compensative variant* lets syntactic-similarity “compensate” when logic-based fails to match. In the *integrative variant*, *Subsumed-by* matches are further constrained by a text-similarity-above-threshold requirement, and is, thus, more strict than logic-based. The algorithm is integrated along with a Service Registry, Ontology Handlers (which locate ontologies referred in services and host reasoning utilities) and an Ontology Registry. SAWSDL-MX has been evaluated over SAWSDL-TC, indicating the hybrid method (with Cosine text-similarity) as the most effective but also the slowest, followed by the syntactic and logic-based methods.

SAWSDL-MX2 [23], in addition to logic-based and text-similarity, measures structural similarity between WSDL file schema information (e.g. element names, data types and structural properties), using WSDL-Analyzer [16]. It also introduces an adaptive, learning layer where SVM training vectors consist of values for logic-based, textual and structural criteria and binary relevance: *{Exact, Plug-in, Subsumes, Subsumed-by, Fail, text-similarity, structural-similarity, and relevance}*. Logic and structural similarity (M0 + WA), adaptive (MX2) and logic + textual hybrid (MX1) show no significant difference on AP, while improving over plain methods. However, M0 + WA and MX2 require double per query response time than MX1. These findings support our decision to employ hybrid logic + textual methods in Tomaco.

iSeM [24] is an evolution of the MX series by the same authors. In principle, it applies SVM learning for the weighted aggregation of underlying algorithm rankings. The learning vectors are an extended version of the ones in SAWSDL-MX2, containing logic, structural and text-similarity in similar fashion to SAWSDL-MX algorithms. However, approximate logic matching was added, which captures more matches than the existing one, using looser criteria for subsumption. The algorithm is extremely precise in SAWSDL-TC and has ranked

first in AP, as measured in S3 (Semantic Service Selection Contest) [25] 2010 and 2012, with an expected trade-off in performance.

3.4.2.3 LOG4SWS, COV4SWS

XAM4SWS is a common framework, which derived two algorithms, LOG4SWS and COV4SWS [26]. Both algorithms perform operation-centric matching, targeting service interfaces, operations and I/O. LOG4SWS performs logic-based matching, in an SAWSDL-MX fashion, mapping ratings to numbers using linear regression. Meanwhile, COV4SWS rating measures are inspired from the field of semantic relatedness. It then performs regression to find weights for the aggregation of ratings (from underlying service elements to an overall service rating). Both algorithms fall back to WordNet similarity (inverse distance), if semantics are entirely absent. Both methods are highly effective on TC3, ranking first in nDCG (normalized Discounted Cumulative Gain for graded relevance) and Q-measure [27], while maintaining a fast response time. Tomaco, on the other hand, follows a different, heuristic approach, as previously discussed.

3.4.2.4 iMatcher

iMatcher [28] integrates interesting variations of well-known strategies. The first strategy includes three sub-strategies. It performs text-similarity (using Java SimPack) targeting either the WSDL service name field, service description field or semantic annotations. The second strategy selects the maximum rating between two sub-strategies. The first is a hybrid variant where the logic-based part rates inputs and outputs of operations with 1, if the requested concept is a parent of the offered concept ($R > O$). Hence, iMatcher's logic substantially differs from SAWSDL-MX, which requires $R_o > O_o$ in *Plug-In* and *Subsumes* and the opposite, $R_i < O_i$, in all cases (*Exact*, *Plug-In* etc.). If logic-based matching fails, syntactic matching is performed (in the spirit of the compensative variant). The second sub-strategy examines distance of two concepts originating from different ontologies using ontology alignment similarity as obtained from the Lily tool [25]. On top of that, iMatcher also implements an Adaptive Matching method. The user selects multiple strategies, the results of which form vectors of the training set. Learning is performed by selecting an algorithm from the Weka library. Regarding effectiveness, iMatcher's best strategies are Adaptive Matching with Logistic and e-SVR learning, followed by hybrid with ontology alignment. Tomaco tries to improve upon those ideas by proposing a more effective and less strict logic-based technique which we believe accounts for an improved hybrid method.

3.4.2.5 Skyline

The Skyline system [29] performs matching on OWL-S descriptions instead of SAWSDL, but its interesting strategy is worth mentioning. The strategy's target components are IOPEs, grouping Inputs together with Preconditions and Outputs with Effects. First, it performs logic-based classification to *Exact*, *Direct_Subclass*, *Subclass*, *Direct_Superclass*, *Superclass*, *Sibling* and *Fail* (selecting the best match). The homonymous Skyline algorithm is used to find the optimal trade-off of input versus output significance. E.g. a service of *Exact* input and *Fail* output and a second of *Subclass* input and *Direct_Superclass* output will prevail over a third service of *Direct_Subclass* input and *Fail* output. Ratings for multiple R_i, R_o are also supported through the Skyline algorithm. Users are able to request the next skylayer from the algorithm to get more services. Skyline (0.83 AP) has ranked well above OWLS-MX (0.71 AP) on OWLS-TC2 dataset. The Skyline technique has actually proven to be effective in the document retrieval domain. However, to adapt it in service matching, the authors had to consider semantic relationships as ordinal values, e.g. a superclass is worse than a subclass.

3.4.2.6 A Hybrid Strategy with WordNet

The SAWSDL matching system in [30], denoted by HSW, proposes a complex logic-based algorithm to classify Input and Output as *Precise*, *Over*, *Partial*, *Mismatch* according to different ratios of provided, matched and requested I/O. The algorithm entails a long series of rules for the classification (which arguably makes its practical meaning hard to grasp). E.g. when semantics are missing from the examined node but the parent node's semantics match, text-similarity and WordNet [31] distance on the examined node are used as a measure. No evaluation was performed to assess the system's effectiveness.

3.4.2.7 Object-Oriented Measures and OWLS-SLR

The work in [32], denoted as OOM, proposes a novel method for measuring semantic service similarity. Simple Property (datatype) similarity considers: *exact match*, *numerical-type match* (e.g. `xsd:int` and `xsd:float`) and *mismatch*. Relational Property (logic-based) similarity returns the distance of two concepts in a hierarchy, or through a common ancestor. If no common ancestor exists or classes are disjoint, their distance is infinite and, thus, similarity is zero. The total rating is the product of Simple and Relational scores. OOM evolved in OWLS-SLR [33], which considers relationships of both subsumption and siblings. It targets OWL-S signatures, looking into properties (roles) and classes. A merit of OWLS-SLR is its low response time, as it quickly finds an initial set of candidate descriptions.

3.4.2.8 IRS-III

IRS-III [34] is an integral system for creation, execution and selection of WSMO and OWL-S descriptions. A custom ontology representation, OCML, encodes service descriptions. Goal Mediator matches requested capabilities, i.e. input types, preconditions and assumptions to non-functional properties. Mismatches occur when requested (Goal) inputs are different or fewer in number than the ones offered i.e. $R_i \neq O_i \vee |R_i| < |O_i|$. A more recent version of IRS-III took part in the S3 2009, ranking low in JGD (Jena Geography Dataset) experiments on both effectiveness (AP=0.41) and performance (2.826s per query). IRS-III's logic-based strategy is unclear and is hard to investigate. Additionally, using predefined fields and criteria in descriptions, e.g. assumptions, and non-functional properties, is considered a non-universal practice.

3.4.2.9 Themis-S

Themis-S [35] focuses on syntactic matching, applying no logic-based method. The so-called enhanced Topic-Based Vector Space Model (eTVSM), a variant of classic TVSM, is extracted from WSDL. It uses WordNet to find linguistic relations and rate cases as *synonymy*, *homonymy*, *hyponymy* or *hypernymy*. Themis-S is evaluated over a custom dataset from programmableweb.com [36] and seekda.com [37], showing optimistic results, and in the S3 contest.

3.4.2.10 URBE

The work in [38] proposes the URBE/URBE-S system, which incorporates a hybrid SAWSDL matching algorithm. The logic-based strategy, named URBE-S, calculates *annSim* (annotation similarity) as the distance of two concepts in the same ontology (as in [32]). If semantics are non-existent (pure URBE case), *nameSim* finds linguistic similarity, targeting service name, operation name and I/O, using a domain-specific or general purpose ontology, such as WordNet in this implementation. In both cases, *DataTypeSim* calculates data type similarity between `xsd:types` in WSDL `simpleTypes` (only) according to a predefined table. Overall rating is set to the average of R_i, R_o ratings. Macro-averaging precision-recall diagram ranked URBE-S above plain URBE and various state-of-the-art algorithms in [38].

All in all, the URBE/URBE-S system, despite its long response time, justifies the effectiveness of semantics in matching algorithms.

3.4.2.11 Web Service Registries

Some past works have been more focused on providing service registries rather than effective matching algorithms. OPOSSum [39] is such a web-based registry of services, that also hosts large datasets e.g. JGD and OWLS-TC. However, the underlying retrieval technique is a keyword-based mapping to SQL queries and not based on semantics. A similar, but much more extensive effort can be seen in BioCatalogue [14], a large registry of services related to life science. BioCatalogue similarly does not support semantic queries, but extends keyword search with much more metadata search fields and a tag-cloud. Another similar example is WESS [40], a keyword-search service registry that discovers WSDL/SAWSDL and OWL-S files after targeted crawling over the Web. Finally, iServe [41] follows a different service description approach, using RDF/Linked Data to publish, analyze and discover services.

3.4.2.12 Tomaco

Tomaco (Tool for Matching and Composition) is a more recent work which provides accessible semantic service matching, using structured criteria i.e. desired input and/or output, high performance and low response time, tailored to the SAWSDL lightweight schema [42]. Most existing strategies can be classified in categories, such as semantic (logic-based), syntactic (IR-based), structural, learning and hybrid. Tomaco adopts, adapts and combines some of these elements, to optimize returning the most relevant results early (top of the list) with a low response time and over a dynamically changing service registry. To do so, Tomaco's hybrid technique employs a novel logic-based strategy, complemented by text-similarity measures on both semantics and textual descriptions. Evaluation over a large, public dataset, SAWSDL-TC3, has proven that the logic-based technique has the greatest impact on retrieving relevant services. These findings are in-line with works such as [43], where feature vectors extracted from semantic information for retrieval learning were found more effective than those originating from syntactic information. However, what Tomaco lacks opposed to learning techniques, it compensated with the hybrid method combining text-similarity, which is poor on its own, with the logic-based strategy. Additionally, syntactic methods in these combinations can matchmake non-semantically annotated descriptions.

FOR THE REASONS OF HIGH ACCURACY AND FAST PERFORMANCE AS WELL AS TO TOMACO BEING OPEN SOURCE, THIS TOOL WILL BE USED IN THE ACTIVAGE MARKETPLACE TO MATCHMAKE SEMANTIC USER QUERIES (DEMANDS) WITH OFFERED APPLICATIONS (SUPPLY) IN THE 2ND VERSION OF THIS DELIVERABLE.

3.5 Open Source Marketplaces

In order to accommodate the need for reusable implementations of marketplace portals, several open source solutions have emerged.

3.5.1 Sharetribe

Sharetribe [44] is one of the most well-known open source solution for marketplaces. Built on Ruby, this solution has a strong community. It is perfectly adapted for MVPs and proof-of-concept projects and is able to handle sales and services/rentals. Notable platforms using this technology are The Quiver [45] & Studiotime [46]. Its source code can be found online [47] as well as a demo [48].

3.5.2 Cocorico

Cocorico [49] is specially designed for service & rental platforms and possibly the most powerful solution in that field. Large community for a new project (3rd largest). It is built on PHP (Symfony) and is perfectly adapted to service & rental marketplaces (AirBNB, BlaBlaCar, Drivy). Notable platforms using this technology are TheHaircut.com [50] & WeFarmUp.com [51]. Its source code can be found online [52] as well as a demo [53].

3.5.3 Mayocat

Mayocat [54] is specialized in marketplaces that sell goods. Unfortunately, the project has been discontinued - they're looking for anyone that would like to continue working on the project. It is built using Java/Angular. Notable projects using this technology are Doble Skateboards [55] & Doolittle [50]. Its source code can be found online [54] but unfortunately support has been discontinued.

3.5.4 CloudCommerceFactory

CloudCommerceFactory [56] is specialized in marketplaces that sell goods. Notable projects using this technology are Mon Garde Manger & MyCréateur [57]. Apparently, the project has been built using ASP.NET [58] but has been discontinued since no source code can be found online.

3.5.5 BeYourMarket

BeYourMarket [4] is a very promising marketplace solution that handles sales & services/rentals. It is built using ASP.NET, but has been discontinued despite the activity on GitHub since then. Its source code can be found online [59].

Although many open source marketplace solutions seem promising, there is lots of effort needed to adapt them from their specialized domain, such as rentals and item, to applications. Also, compared to buying an off-the-shelf tailored service, this effort is better spent towards using robust software engineering building blocks and frameworks towards building an ACTIVAGE Marketplace that is tailored to our needs, the AHA application domain and integration with AIOTES. Its implementation is presented in the following section.

4 The ACTIVAGE Marketplace

4.1 Marketplace Specification

The ACTIVAGE Marketplace specification has emerged from the use cases, as presented in Section **Error! Reference source not found.**, and the existing state-of-the-art survey, resented in Section 3.

Regarding the former, the use cases and the scenarios have been used to produce mockups by system UI/UX designers. Two indicative mockups are presented below. The User Scenario 1 is supported by the mockup shown on Figure 13, where the Marketplace Home screen shows top-rated and featured/admin-suggested applications. There is also the ability for fast single-criteria search (filtering) and the ability to sign in and use an app list, a wish list and more.

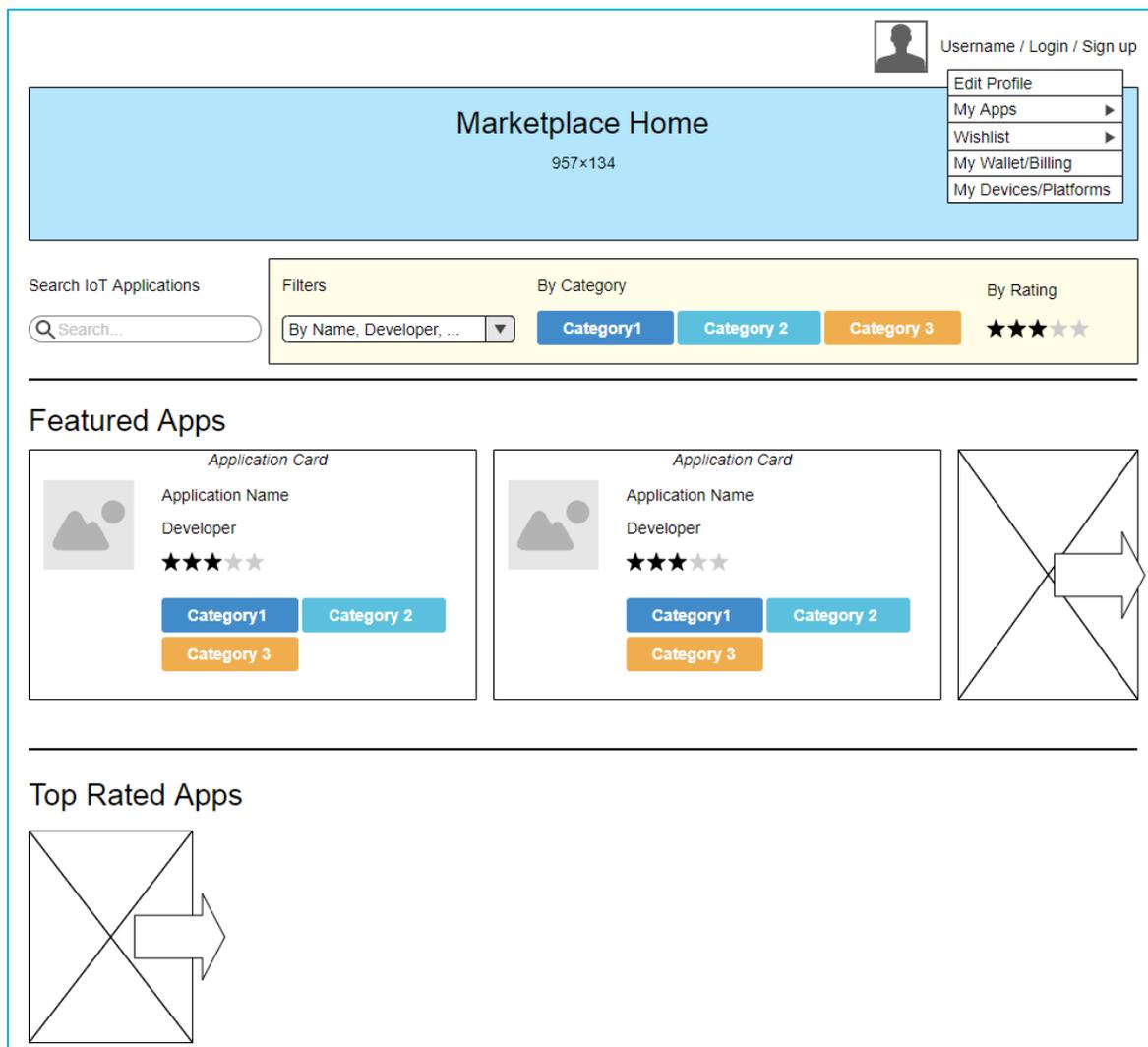


Figure 13. Mockup of the Marketplace home page, showing top-rated and featured apps, ability for fast search and filtering and user account options.

The second mockup supports the User Scenario 2, where a specific application has been located and viewed. The application shows all of its properties and the (registered) user can buy, review and rate it.

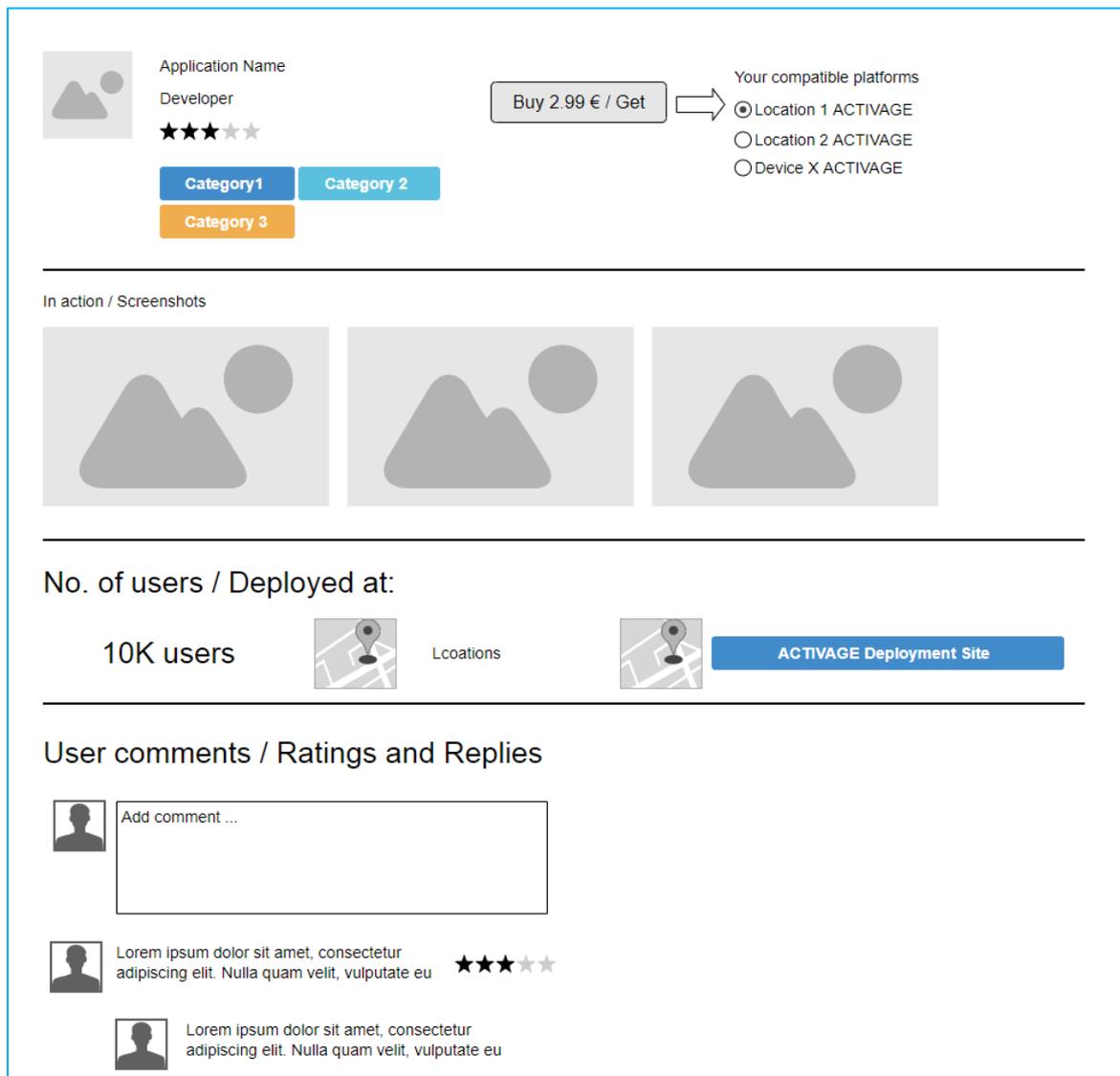


Figure 14. Mockup of the Marketplace Application view, showing its properties, rating and categories, the ability to buy and deploy the application, screenshots, number of users and deployment sites, user comments and ratings.

While the rest of the mockups are used and continuously evolved internally, Table 3 presents all functionality, discriminated in the 1st and 2nd version of the cloud platform.

Table 3. The ACTIVAGE Marketplace functionality in the 1st and 2nd version.

ACTIVAGE Marketplace	Marketplace Online	Marketplace Open Source			
1st version	✗	✓			
2nd version	✗	✓			
Supported Use Cases for Developers and Admin					
ACTIVAGE Marketplace	Publish	Sell	Get insights	Statistics & validation	
1st version	✓	✗	✓	✗	
2nd version	✓	✓	✓	✓	
Other Supported Use Cases					
ACTIVAGE Marketplace	Search	App rating	User activity mgmt.	Get Deploy apps /	Get updates
1st version	✓ (single-criteria search)	✓	✓	✗	✗
2nd version	✓ (multi-semantic and criteria search)	✓	✓	✓	✓

This table immediately links to conclusions drawn from the review of existing marketplaces. All in all the main idea of the ACTIVAGE Marketplace added value for the platforms is to:

Unify the ecosystems of platforms that have or do not have a Marketplace, with uniform, complete functionality that was often missing in order to publish, monetize and promote AIOTES applications.

This concept is depicted with particular platforms in Figure 15.

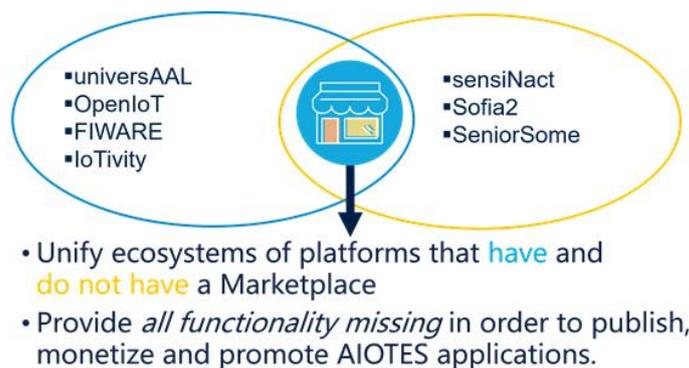


Figure 15. The concept of unification and functionality extension behind the ACTIVAGE Marketplace

The following subsections present how this comes into being by describing the Marketplaces' role and relations within AIOTES as well as its implementation.

4.2 The Marketplace within AIOTES

In this section, we first examine the Marketplace positioning within the architecture of AIOTES and then dive deeper into the exact relationships and integration with AIOTES components.

4.2.1 Within the AIOTES Architecture

The ACTIVAGE Marketplace within the AIOTES and the ACTIVAGE architecture is a relatively high-level application, close to end-users.

Specifically, it resides within the **Services Layer** of AIOTES on top of the IoT Interoperability Layer. Within this layer, it encapsulates **APIs**, **Services** and **Applications** already built by providing the APIs to developers, hosting and provisioning Services and Applications to end-users.

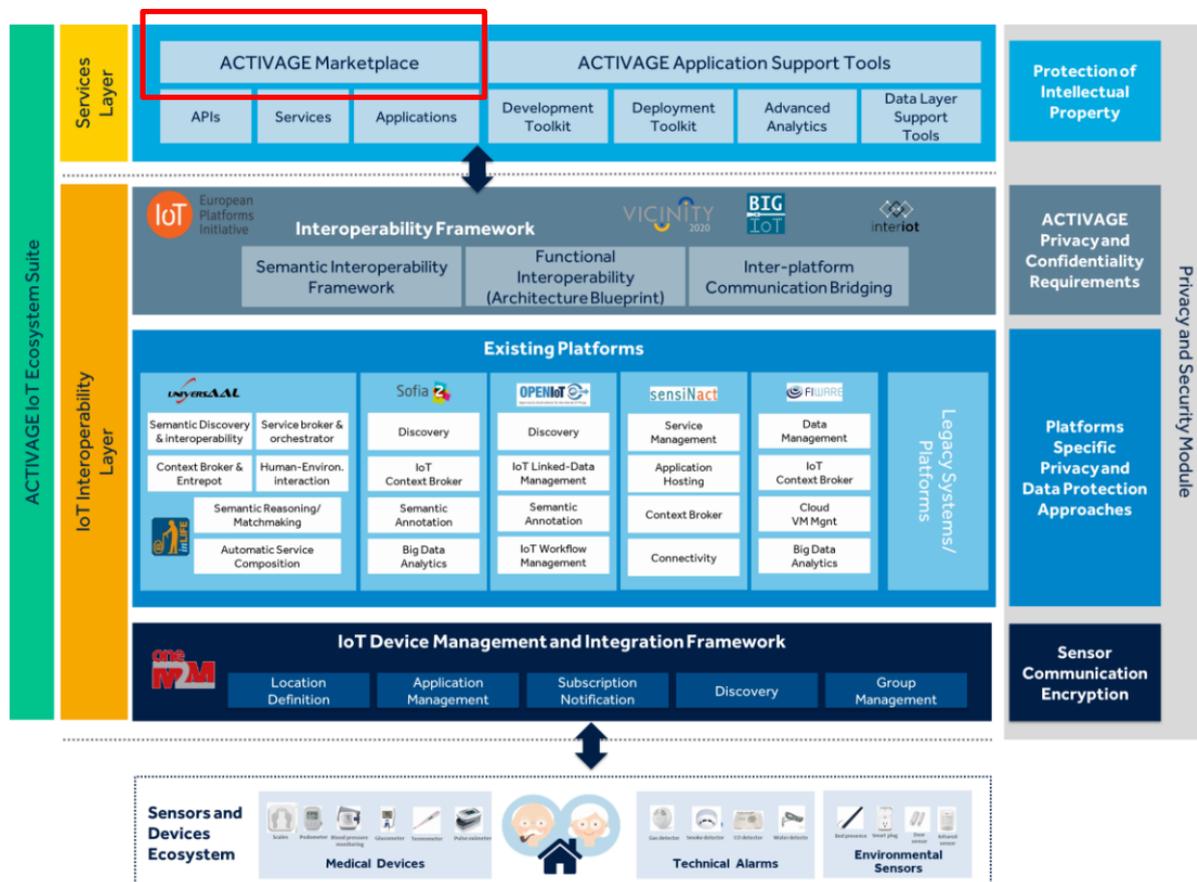


Figure 16: Positioning of the ACTIVAGE Marketplace within the overall ACTIVAGE architecture.

The **ACTIVAGE Application Support Tools** complement the ACTIVAGE Marketplace residing beside it to provide more specialized tools for developers and deployers, i.e. the **Development** and **Deployment Toolkits**, **Advanced Analytics** and **Data Layer Support Tools** intended for the professional users of the platform. Notably, in relation to the Toolkits, the ACTIVAGE Marketplace actively links to material for development, while it may also act as a very high-level and friendly deployment tool for end-users that obtain and install applications via its platform. This relationship is also explored in D4.1, where more information on Development and Deployment Tools can be found.

Regarding the **IoT Interoperability Layer** and the Marketplace, the interaction is two-fold: a) first the interoperability framework provides Data Models that will be used to shape metadata descriptions of the applications in the Marketplace and enable semantic search and b) to provide the format and functions of the integrated bundles themselves that are going to be hosted and provisioned to the users as applications. Provision of support material, links to development and deployment tools, the AHA Advisor and security/legal concerns are covered in the next section.

4.2.2 Relations to AIOTES Components

Diving deeper from the overall architecture, this section presents the exact relationship and integration with the AIOTES components, especially those depicted in Figure 17.



Figure 17. ACTIVAGE Marketplace and related AIOTES components from other WPs

AS THE COMPONENTS THEMSELVES ARE UNDER DEVELOPMENT, THIS VERSION OF THE DELIVERABLE PRESENTS AN INTEGRATION PLAN AND INTENTIONS REGARDING THE CROSS-COMPONENT INTERACTIONS.

4.2.3 Security and Privacy (WP3)

The ACTIVAGE Marketplace itself addresses security and privacy issues for its web platform. The frameworks and technologies used (described in Section 4.3) implement the latest protocols for secure encrypted storage, transport and authentication. Regarding privacy, the user provides consent and is able to view all personal and public comments, review and rating information. Users are also able to edit or delete them at any point while viewing a dedicated page.

While, the Marketplace's layer is self-contained and secure, the application layer opens up to more vulnerabilities. It is indeed the subject of WP3 to address all the security and privacy issues of ACTIVAGE and its applications to be hosted on the Marketplace. The Marketplace platform will interact with WP3 in the following ways:

- Approval of hosted content: The administrators have to approve each application uploaded, especially by third parties. A process and strategy to validate these applications/bundles for security threats has to be established, an either semi- or fully-automated one for the large scale.

- A legal security and privacy liability disclaimer has to be established for the Marketplace hosting third-parties and highlighting its role as a host but not the developer of the provisioned applications.

Currently, the former matter is subject to the final format and form of the integrated application bundles to be hosted in order to develop the respective validation tools. However, the Marketplace's 2nd version will provide the ability for all uploaded content to be validated, at least manually, before publication to decrease risks.

Regarding the latter matter, the know-how from existing marketplaces, not only from IoT platforms but also from Samsung as a marketplace host experience in legal matters, is sought to rebuild upon.

4.2.4 Development & Deployment Tools (WP4)

Development and deployment tools are already blueprinted in D4.1, where also the relationship to the Marketplace is carved out, with the latter being a particular case of a Deployment Tool for ACTIVAGE.

In detail, Development Tools for the Marketplace have a clear role. They are to be provided and linked through the right channel, i.e. the Developer section, in order to promote and facilitate the adoption of the platform and the enrichment of Marketplace content.

In this regard the Marketplace is ready to host and provide the tools when online, through the ACTIVAGE Git being deployed online by other task forces.

Regarding Deployment Tools, the Marketplace plays a role as one of them. While some tools go deep into the workings of the respective platforms, the Marketplace is a horizontal hub for all applications to be uploaded, discovered and obtained not only by consortium partners e.g. health professionals at DSs but also third parties. As a deployment tool, the Marketplace is uploaded, open-source to the ACTIVAGE private Git in the context of D4.1 to be later exploited as open source.

4.2.5 Interoperability & Integration (WP3, WP5)

The work in WP3 Semantic Interoperability Layer (SIL) is of great importance to AITOES and the Marketplace. The layer will provide a variety of tools and APIs for data retrieval and carrying out functions in an interoperable manner. For the Marketplace the most important aspect is the Data Models and SIL aspects which can be used:

1. To describe AHA applications. They will be utilized and extended to serve as the Marketplace ontology to define the Application metadata needed for semantic search and discovery of AHA Applications
2. To retrieve information about the deployed services and devices of a user for various purposes of the Marketplace functions

Finally, together with the synergy of the integration layer (WP5):

3. To provide the application bundle format to be uploaded, hosted and provisioned in the Marketplace
4. To provide documentation and educational material on development.

Regarding those points:

1. The Data Models and tools for them (such as the Ontology Explorer) are currently under development. As a failsafe, the Marketplace will use its own ontology but enriched with any AHA Application models that are known to be under development.

2. This ideal functionality to know the service and devices that a user hosts and to additionally be able to deploy on them is entirely depended on the SIL capabilities outside the Marketplace and, therefore, a work in progress.
3. The integrated bundles to be hosted are also a work in progress.
4. WP5 already provides the means and the blueprint for educational material for adopters in D5.1. The material itself, when ready, will be directly hosted and linked through the proper channels, either the Developer or the User section, along with the tools mentioned in WP4 synergies.

The second version of this deliverable will report on the implementation and synergies on all these issues. The synergy with the Privacy Analysis task (T3.2) is already under way.

4.2.6 AHA Advisor (WP6)

The AHA Advisor is a service provided by WP6 which will dynamically and intelligently provide personalized recommendations to AHA users to find the optimal AHA application for them. Naturally, this service fits perfectly in synergy with the ACTIVAGE Marketplace.

In this synergy, the Marketplace will play the role of an AHA Application host, providing all the necessary application & user metadata to the AHA Advisor.

The AHA Advisor will respond returning the suitable application list in a ranked order.

The Marketplace will also play the role of the end-user interface, providing access and the means for the registered Marketplace user to invoke the AHA Advisor and view results in a way that is seamless and intuitive for them.

As the AHA Advisor is currently under development, the exact mechanics e.g. the API, the data needed and additional data that it may use are currently unknown. However, the synergy between WP4 and WP6 for this exact purpose is already bridged in dedicated meetings.

4.2.7 DS, Third Parties and Exploitation (WP7, WP8, WP9)

The Marketplace is a high-level tool intended to be directly used by end-users, health professionals, deployers, home users and even some times elders and informal caregivers. Therefore, synergy with the DSs is needed in way that validates that the required content is hosted and delivered in a user-friendly and compatible manner.

In the 1st version of the platform, requirements were solicited from the user scenarios and mockups shaped from them and existing state of the art survey. All ACTIVAGE AHA applications as described in WP4 and WP9 work, have been processed to extract primary content such as their descriptions categories, locations, screenshots etc. so as to host realistic metadata and content in this 1st version.

In the 2nd version, actual applications will be bundled linked and provided in the Marketplace by the actual developers/providers.

The same goes for the beneficiaries of the Open Calls who will not only use the Marketplace to find material and resources but to also host and monetize their applications.

An evaluation of the online platform will be carried out, both in terms of free interview and systematic usability and acceptability instruments, such as SUS [60], polling all involved stakeholders.

Synergy with the Business Cluster and work on exploitation has already been established with WP8 in order to carve the Marketplace-inclusive business plans as a medium central to

dissemination, adoption and monetization to ensure post-project sustainability hand-in-hand with the growth of the Marketplace and its content.

4.3 Marketplace Implementation

This section presents the Marketplace implementation in terms of its architecture and actual online platform user interface presentation.

4.3.1 Architecture

The architecture follows a standard web application technology stack, using recent frameworks and tools validated and well-established in the industry. Specifically, as shown on Figure 18, the Marketplace is logically divided in Front-end and Back-end. The former provides user interfacing and experience for Application Users and Developers as well as Marketplace Administrators. The back-end implements logic and operations such as interfacing with external APIs which, in turn, include various 3rd party APIs but also the AIOTES components required. The technology and development stacks give a clear idea of the modern frameworks and tools used to build a robust marketplace web application and are deeply explored in the next section. More details on the technologies follow below.

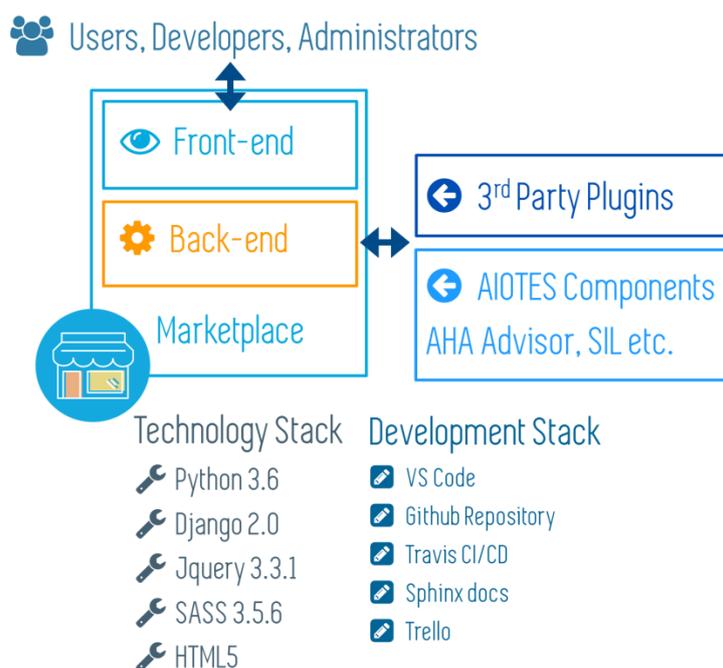


Figure 18. ACTIVAGE Marketplace Architecture

Table 4 shows all the frameworks and tools used in the implementation of the ACTIVAGE Marketplace.

- The technology stack contains the most central technologies to implement the Marketplace with Python Django being the core framework.
- The Development Stack presents all the tools used during the software engineering process, from code writing to issue tracking and project management.
- Front-end plugins consist of open source tools were used in order to build a modern responsive interface and provide a smooth experience to the end user.

- Back-end plugins are again open source python packages, included in the project to offer additional functionalities, such as a secure payment platform API to allow monetization and a social media authentication API for logins.

Table 4. All frameworks & tools in the implementation of the ACTIVAGE Marketplace

Technology Stack		Development Stack
– Python v3.6 ²		– VS Code (code editor) ⁶
– Django v2.0 ³		– Github Repository ⁷
– JQuery v3.3.1 ⁴		– Travis CI/CD ⁸
– SASS (Ruby) v3.5.6 ⁵		– Sphinx docs ⁹
– HTML5		– Trello ¹⁰

Front-end Plugins	Back-end Plugins	3rd Party Plugins
– Bulma CSS ¹¹	– Django Social ¹⁷	– Sendgrid Web API v3 ²³
– Flag-icon ¹²	– Django Countries ¹⁸	– Google Authentication
– Fontawesome 5 ¹³	– Django Paypal ¹⁹	– Github Authentication
– Clioboard.js ¹⁴	– Pylama ²⁰	– Twitter Authentication
– Parsley.js ¹⁵	– Pillow ²¹	– Facebook Authentication
– Chart.js ¹⁶	– Django Sendgrid v5 ²²	

² <https://www.python.org/downloads/release/python-365/>

³ <https://www.djangoproject.com>

⁴ <https://jquery.com>

⁵ <https://sass-lang.com/ruby-sass>

⁶ <https://code.visualstudio.com>

⁷ <https://github.com>

⁸ <https://travis-ci.com>

⁹ www.sphinx-doc.org/en/master/index.html

¹⁰ <https://trello.com>

¹¹ <https://bulma.io>

¹² <http://flag-icon-css.lip.is>, <https://github.com/lipis/flag-icon-css>

¹³ <https://fontawesome.com>

¹⁴ <https://clipboardjs.com>, <https://github.com/zenorocha/clipboard.js>

¹⁵ <http://parsleyjs.org>, <https://github.com/guillaumepotier/Parsley.js/>

¹⁶ <https://www.chartjs.org>, <https://github.com/chartjs/Chart.js>

¹⁷ <https://github.com/python-social-auth/social-app-django>

¹⁸ <https://github.com/SmileyChris/django-countries>

¹⁹ <https://github.com/spookylukey/django-paypal>

²⁰ <https://github.com/klen/pylama>

²¹ <https://pillow.readthedocs.io/en/5.1.x/>

²² <https://github.com/sklarsa/django-sendgrid-v5>

²³ https://sendgrid.com/docs/API_Reference/index.html

4.3.1.1 Technology Stack

These are the core technologies to implement the Marketplace with Python Django being key to it.

Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design. Built by experienced developers, it takes care of much of the hassle of Web development, so developers can focus on writing their app without needing to reinvent the wheel. It's free and open source and the core of the ACTIVAGE Marketplace.

jQuery is a fast, small, and feature-rich JavaScript library. It makes operations such as HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. With a combination of versatility and extensibility, jQuery has changed the way that millions of people write JavaScript and constitutes a natural part of the ACTIVAGE Marketplace web application.

SASS Ruby is the most mature, stable, and powerful professional grade CSS extension language in the world also used in the Marketplace.

4.3.1.2 Front-end Plugins

All the following plugins are used to provide a modern, responsive user interface look and feel but also an intuitive and smooth user experience, following best programming practices.

Bulma is an open source CSS framework based on Flexbox. It is used to shape the look and feel of the Marketplace.

Flag Icon is a collection of all country flags in SVG — plus the CSS for easier integration.

Fontawesome is a popular set of vector icons and social logos

Clipboard.js is a lightweight plugin to copy text directly from website to clipboard

Parsley.js is an HTML form validation tool with built-in validators offering dynamic validation out of the box

Chart.js is a simple yet flexible JavaScript charting tool, that builds customizable charts inside html canva elements.

4.3.1.3 Back-end Plugins

These plugins help extend the basic functions of Django and carry out additional needed backend operations from secure authentication via third-parties to secure payments and mailing service.

Django Social: Python Social Auth is an easy to setup social authentication/registration mechanism with support for several frameworks and auth providers.

Django Countries: A Django application that provides country choices for use with forms, flag icons static files, and a country field for models

Django PayPal: Django PayPal is a pluggable application that integrates with PayPal Payments Standard and Payments Pro.

Pylama: Code audit tool for Python and JavaScript. Pylama wraps a set of tools in order to provide all in one code auditing.

Pillow: Pillow is a fork of PIL (Pythons Image Library).

Django SendGrid: This package implements an email backend for Django that relies on SendGrid's REST API for message delivery.

SendGrid: SendGrid is a cloud-based SMTP provider that allows you to send email without having to maintain email servers. SendGrid manages all of the technical details, from scaling the infrastructure to ISP outreach and reputation monitoring to whitelist services and real time analytics.

Authentication APIs: Provide sign up and login functionality through the platforms of:

- Google
- GitHub
- Twitter
- Facebook

4.3.1.4 Development Stack

The development stack is comprised of all technologies that support the software lifecycle, from editors, to issue trackers and project management.

GitHub: GitHub Inc. is a web-based hosting service for version control using Git. It is mostly used for computer code. It offers all of the distributed version control and source code management functionality of Git as well as adding its own features.

Travis: Travis CI is a hosted, distributed continuous integration service used to build and test software projects hosted at GitHub.

Sphinx: Sphinx is a code generator for python source code files

Trello: Trello is a popular web-based project management application.

4.3.2 Marketplace 1st version

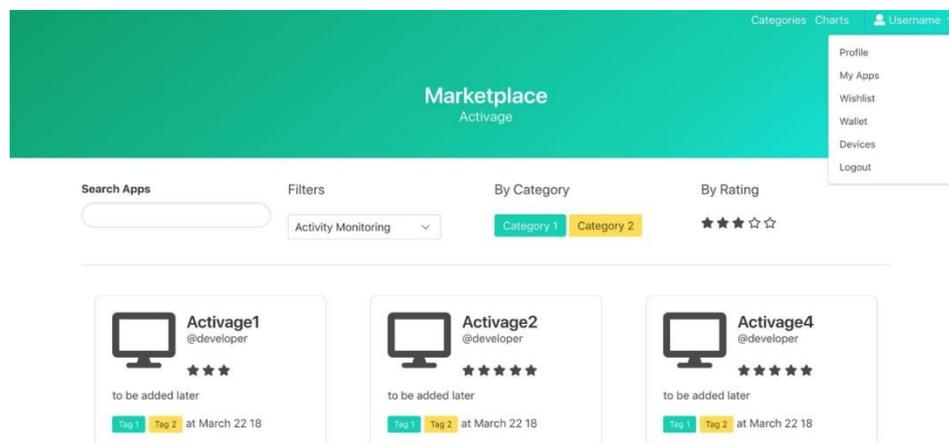


Figure 19. Initial translation of the mockups to a Marketplace UI

The first version of the Marketplace is implemented to carry out the operations defined in the use cases scenarios of this deliverable. This section presents the user interface of the Marketplace as an indication of its capabilities. All User and Developer functions are available, except those pertinent to the 2nd version extension and additional functionality needed from AIOTES, namely semantic search, administrator validation, AHA Advisor etc.

To begin with, Figure 19 depicts a direct translation from the mockup without specific content. It also shows a primary user menu for a registered user.

After content (metadata) from the actual applications of the DSeS was extracted the Marketplace was populated and the User Interface (UI) was thoroughly designed.

4.3.2.1 Login

Figure 20 shows the login screen, which enables registered users enter their credentials or to join using an email or a third-party account for secure authentications via Twitter, Facebook, GitHub or Google.

The figure also shows the message when logging out.

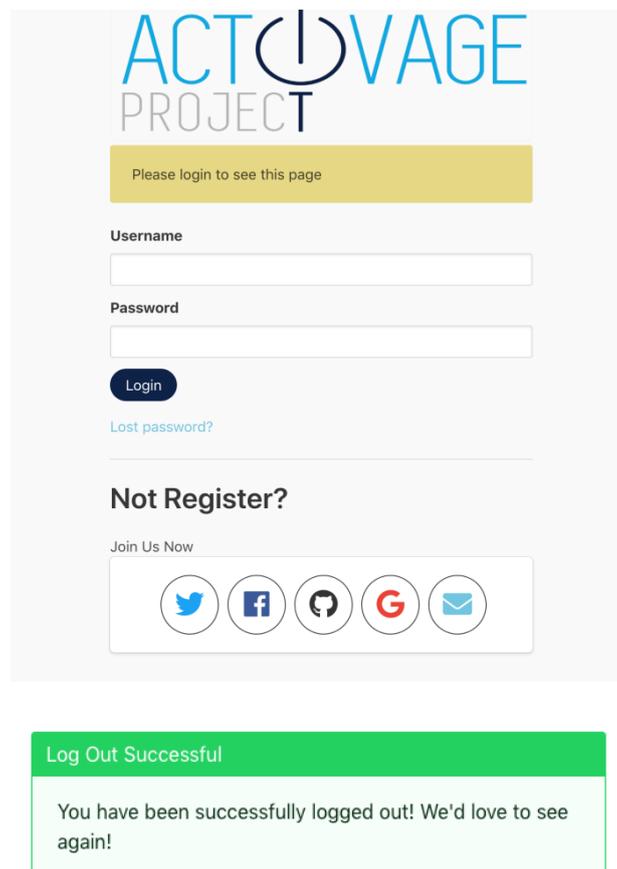


Figure 20. Marketplace UI: Login screen and Logout message

4.3.2.2 Public User View

Home Screen

The user does not need to login to view the Marketplace. The Marketplace home screen is shown on Figure 21. It shows top rated apps at the top and featured (administrator selected) applications at the bottom. A single-criteria text search is available for quick searches. The footer shows standard promotional and networking information as well as a Twitter feed.

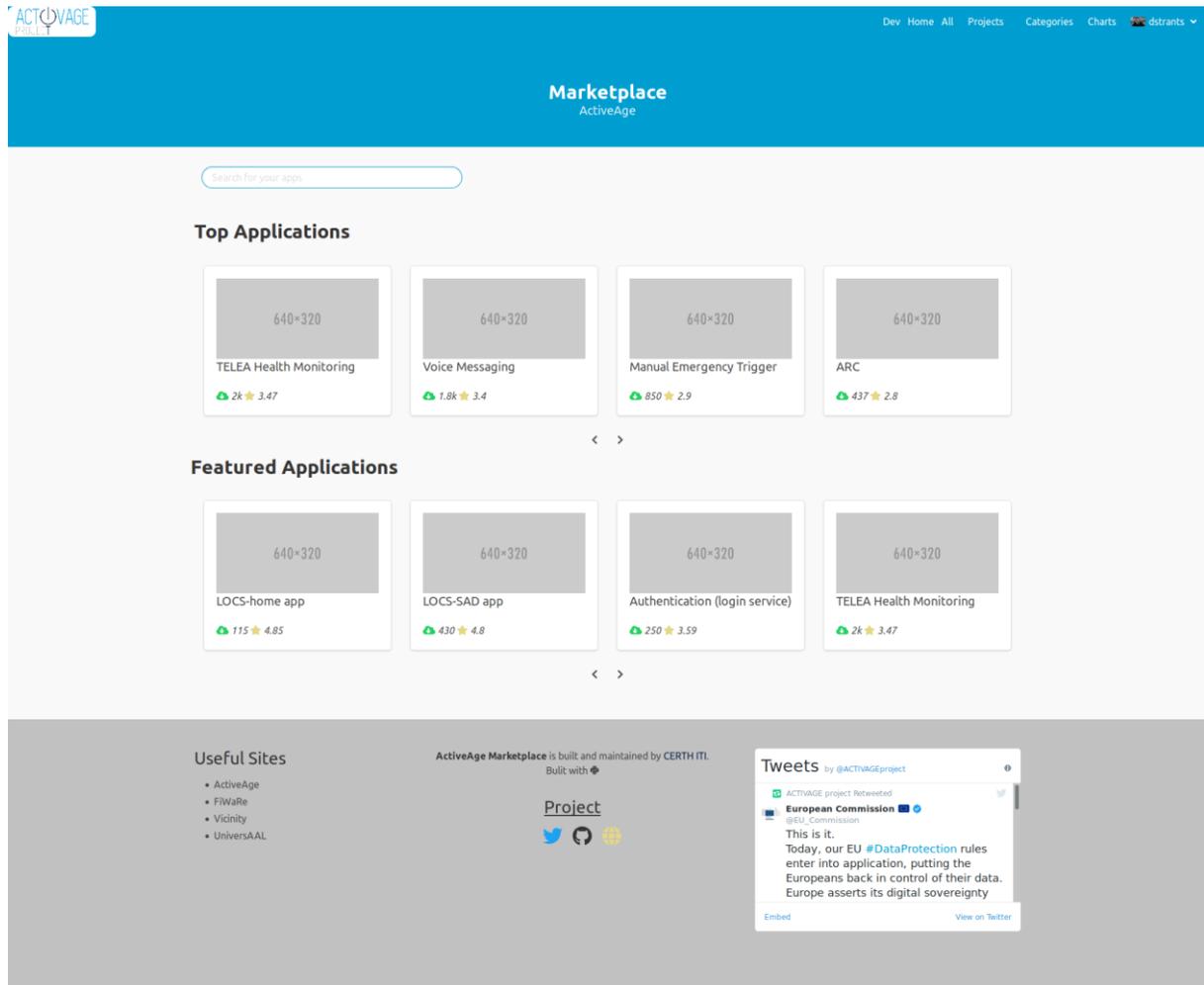


Figure 21. Marketplace UI User View: Home screen showing top rated and featured applications

All Apps Unfiltered

Figure 22 shows all apps unfiltered, with the ability to perform a single-criteria search: picking a single criterion immediately refreshes results without pressing a button or reloading the page or part of it.

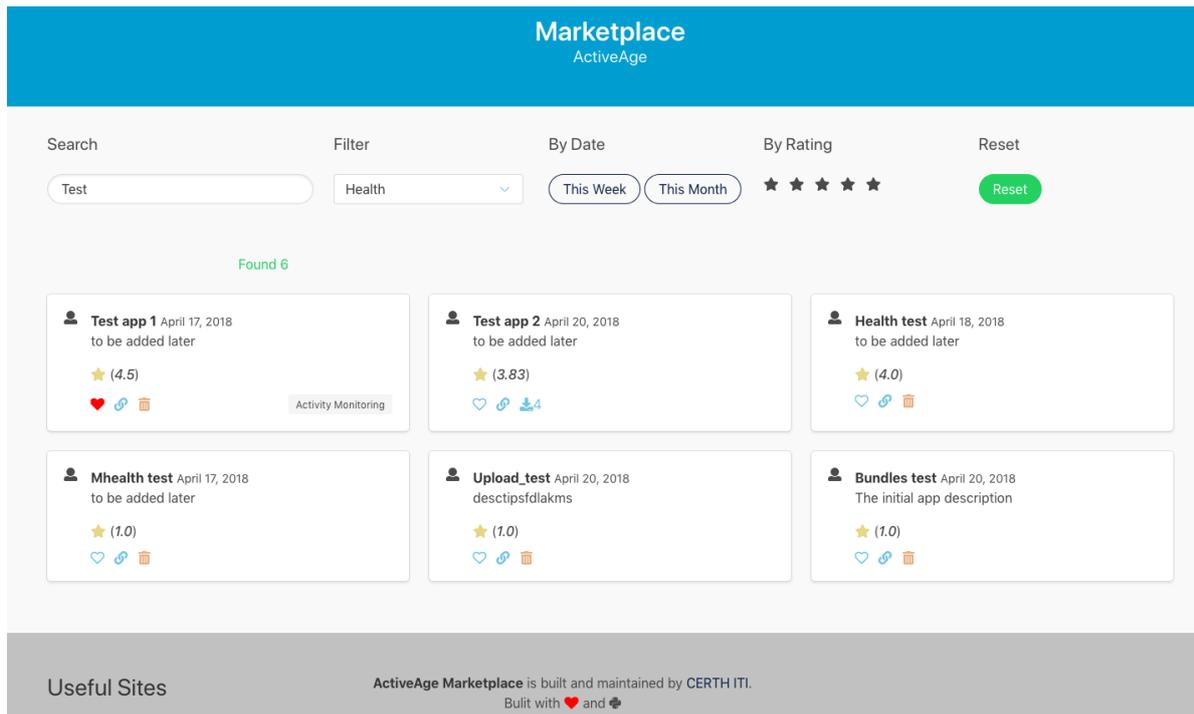


Figure 22. Marketplace UI User View: All apps, unfiltered and single-criteria search Category

Figure 23 shows the contents of a single category in a list for the user to pick.

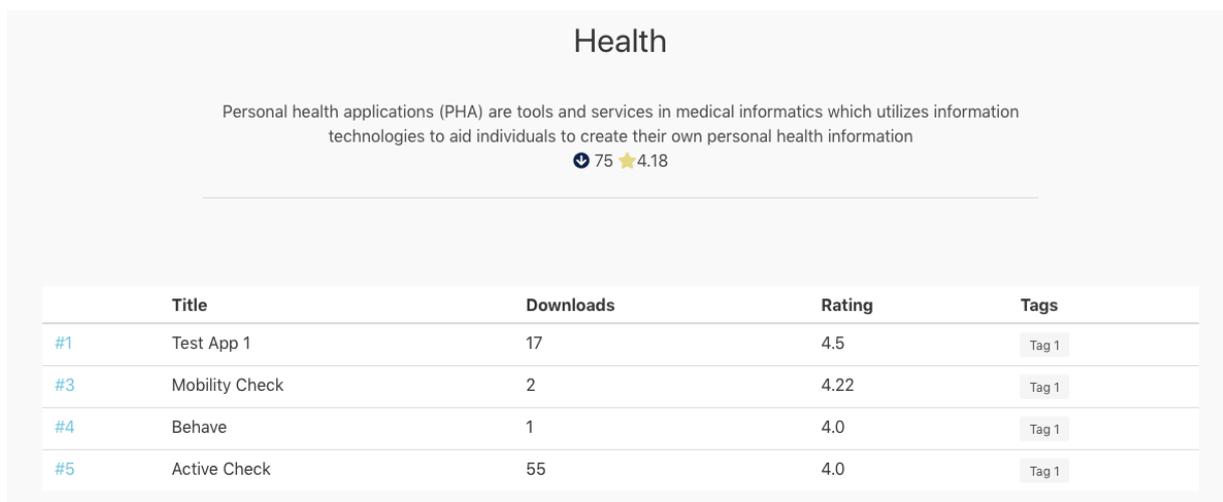


Figure 23. Marketplace UI User View: Single Category

Multi-Criteria Search

Figure 24 shows all apps and a left sidebar from where multiple criteria can be chosen. Then when search is performed the list refreshes by filtering the apps outside the user's constraints.

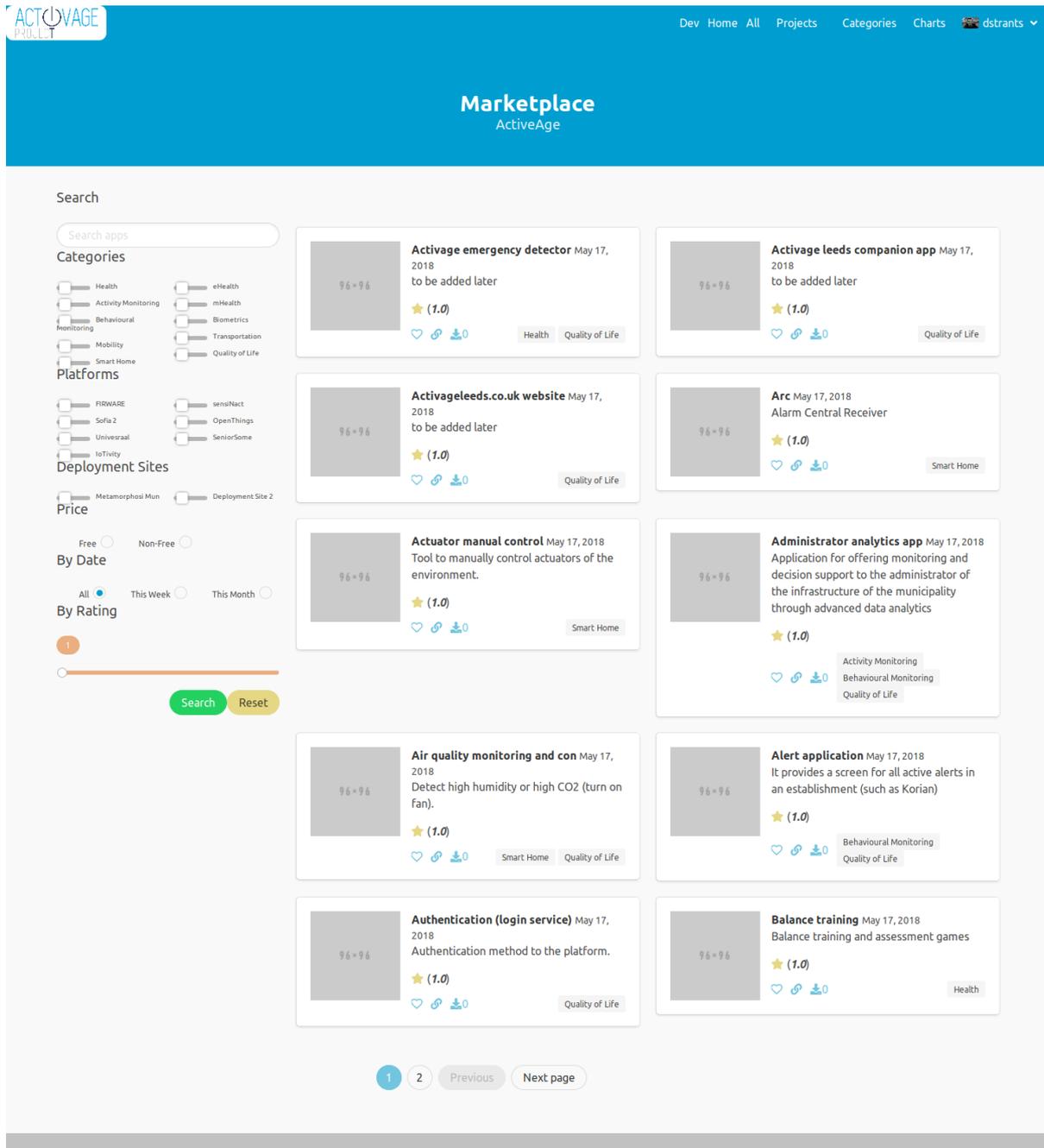


Figure 24. Marketplace UI User View: Multi-criteria search and results

Application View

Figure 25 shows a single application and all its properties such as developer ratings, screenshots, category, comments and reviews as well as the ability to get or buy it.

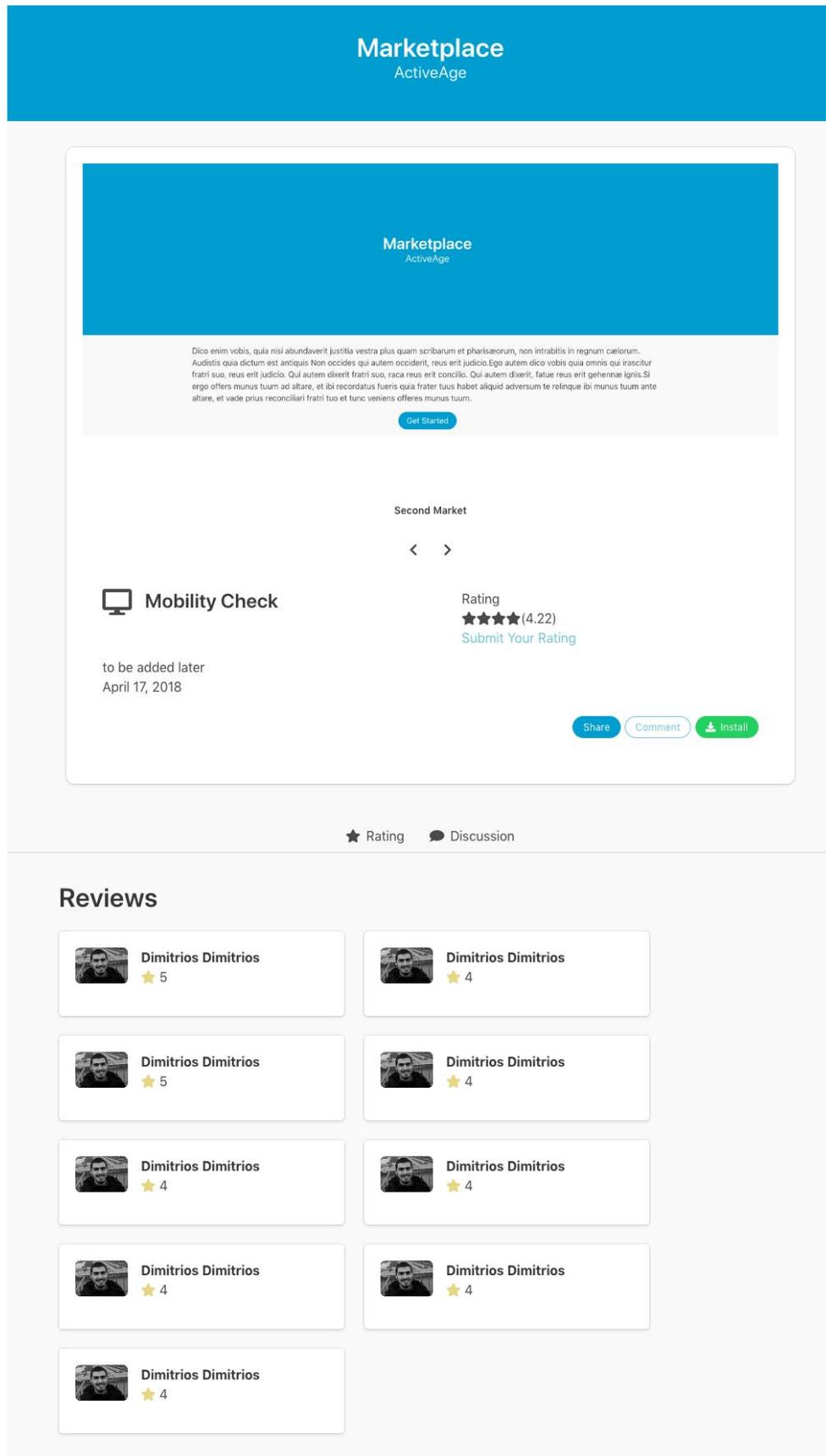


Figure 25. Marketplace UI User View: Application View

User Insights – Top Downloads

Figure 26 shows a view of the insights that are public and display total downloads in a chart and top downloads

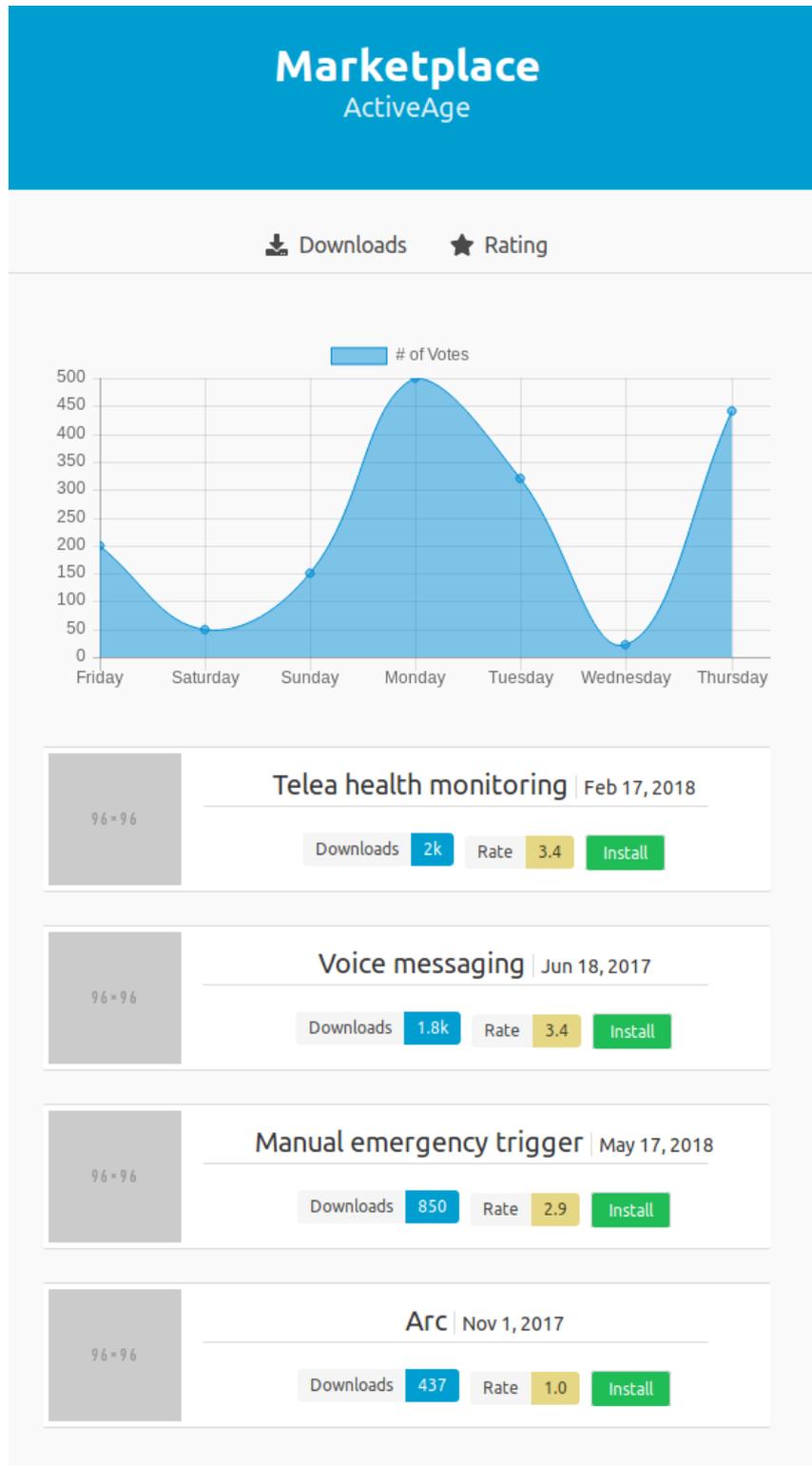


Figure 26. Marketplace UI User View: Public User Insights of App Downloads

User Insights – Top Rated

Figure 27 shows a view of user insights regarding ratings, again in a chart and top rated list.

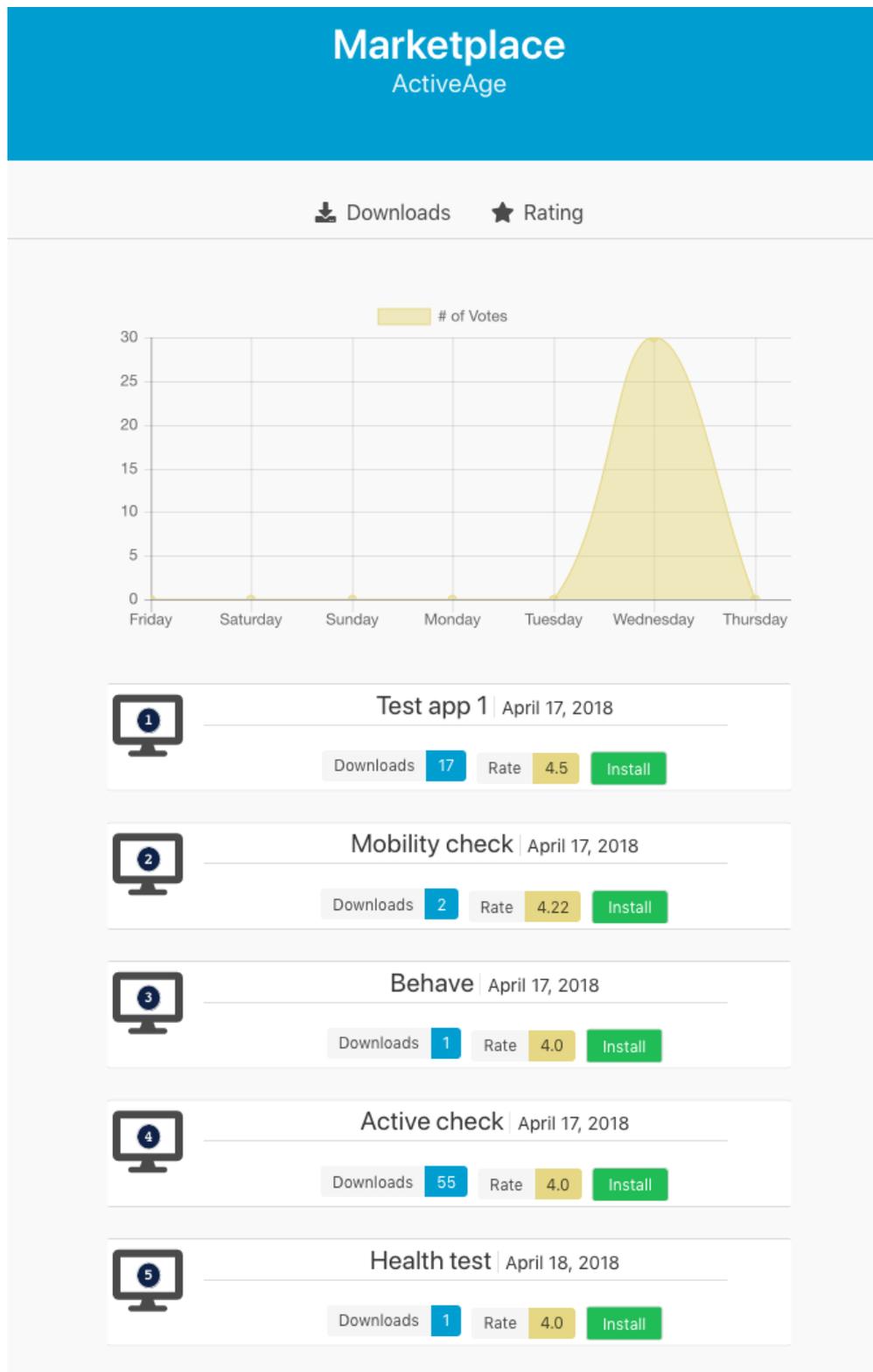


Figure 27. Marketplace UI User View: Public User Insights of top app ratings

4.3.2.3 Registered User View

User Profile

This is the first view that requires a user to register and login.

Figure 28 shows the user profile, the ability to edit their personal information and a list of the most recently installed apps.

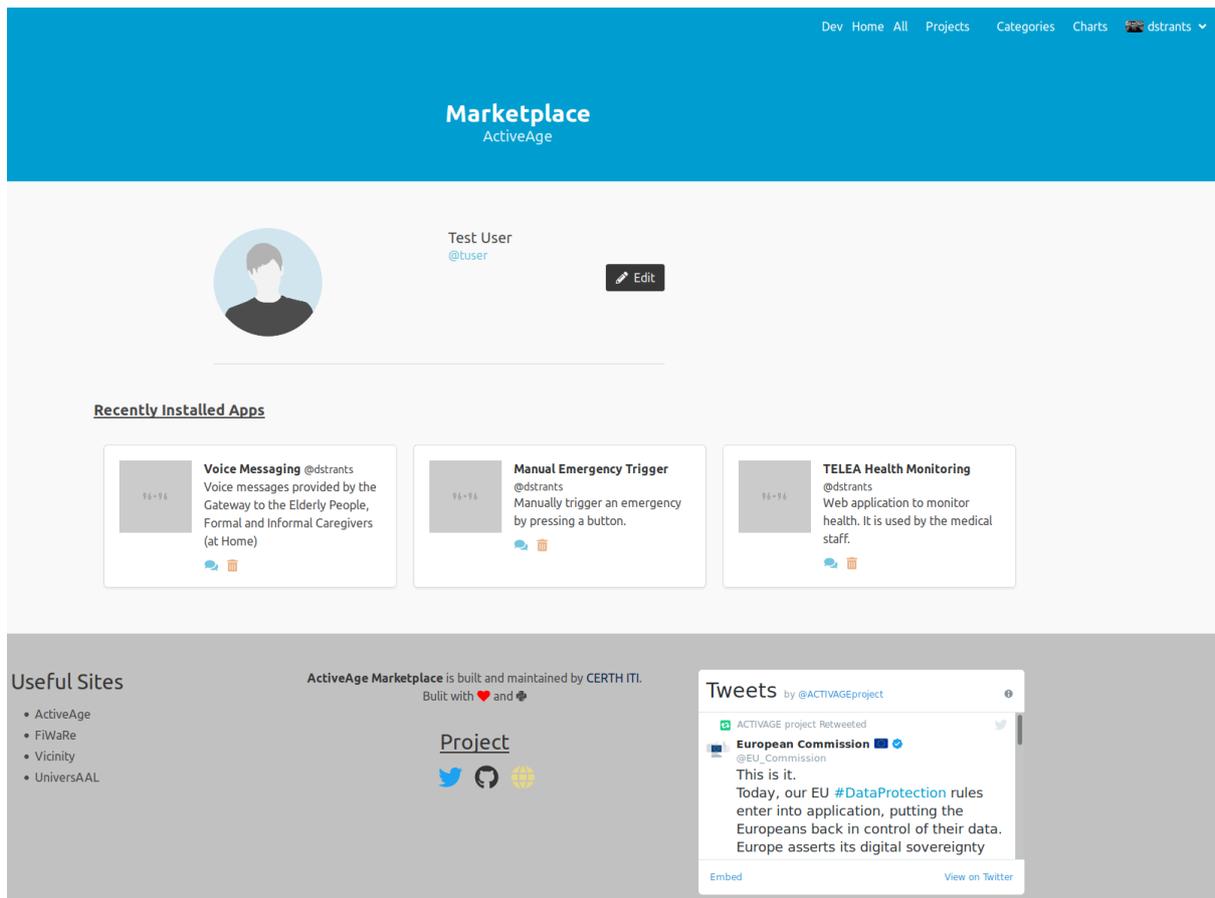


Figure 28. Marketplace UI User View: User profile home screen and recently installed apps

Installed Apps

Figure 29 shows the installed application list for a registered user, with ratings, links, categories and the ability to remove them quickly.

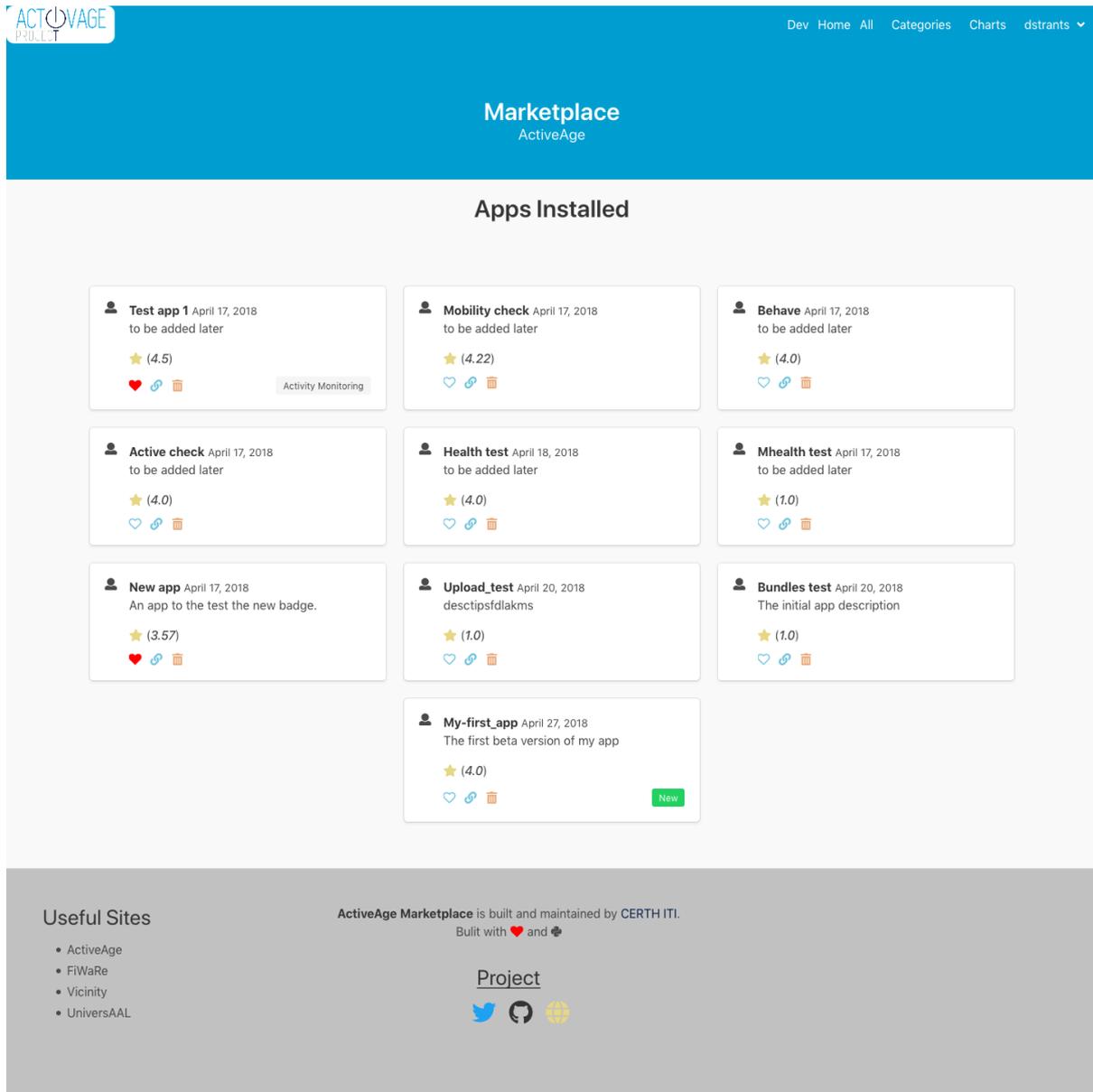


Figure 29. Marketplace UI User View: Installed Applications List

Wishlist

Figure 30 shows the wishlist, i.e. a favourites' list or else a list of applications that the user wishes to obtain later on.

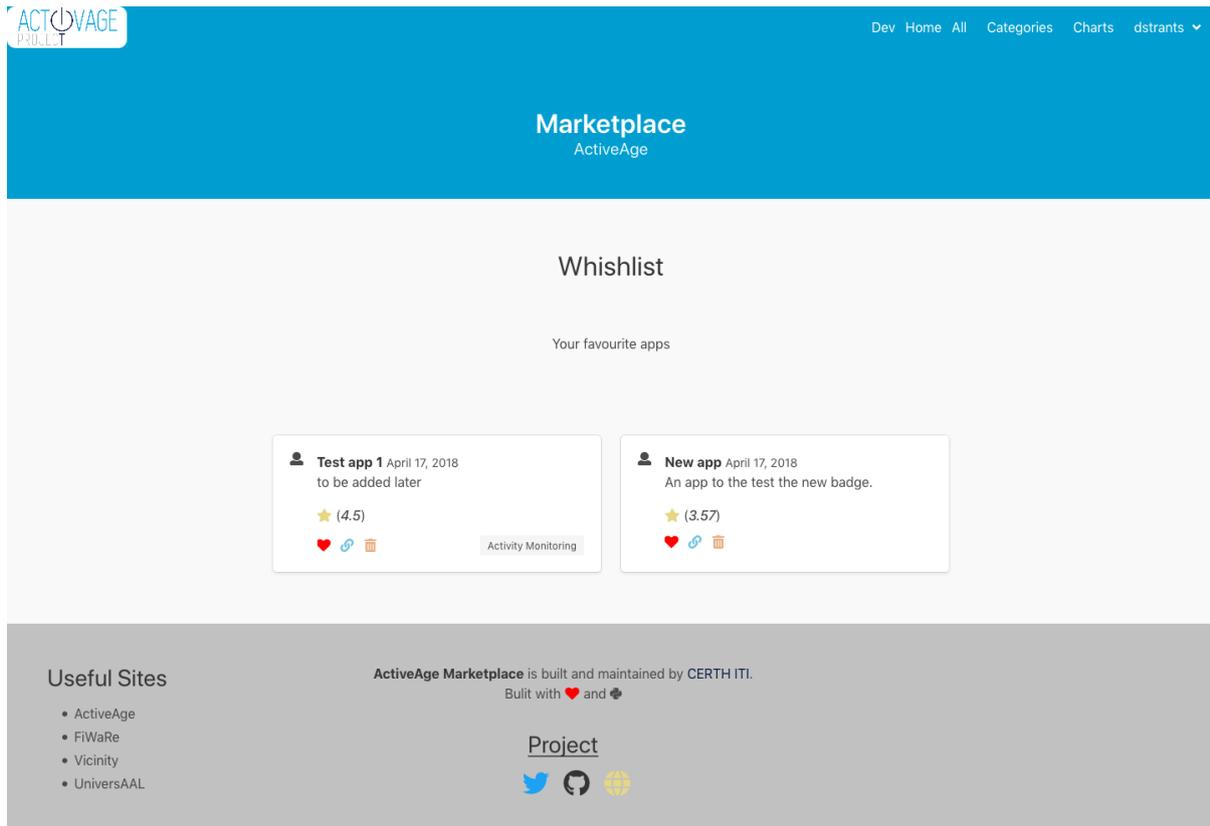


Figure 30. Marketplace UI User View: Wishlist

4.3.2.4 Developer View

A developer needs to register and login with a dedicated developer profile.

Developer Profile

Figure 31 shows the developer profile with average rating over all applications, total downloads, profile info and the latest applications uploaded.

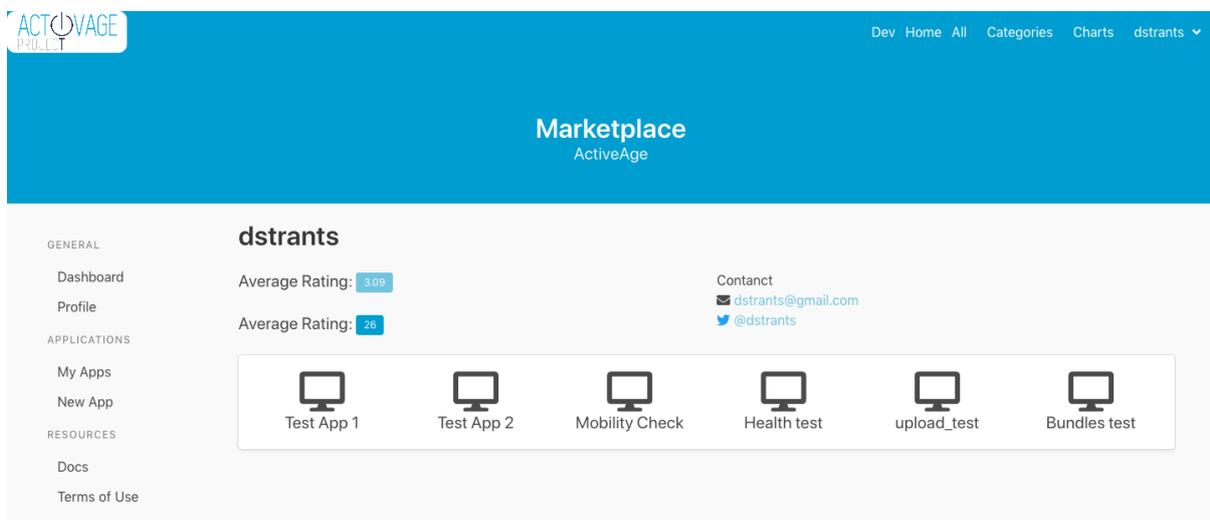


Figure 31. Marketplace UI Developer View: Developer Profile

Developer Resources

Figure 32 shows the developer resources available (to be enriched with tools and educational material from WP4, WP5)



Figure 32. Marketplace UI Developer View: Developer Resources

Upload Application

Figure 33 show the form for the developers to upload a new application. This basic metadata will later on be updated to reflect semantic information for user matchmaking queries.

Figure 33. Marketplace UI Developer View: Upload New Application Form

Upload Application

Figure 34 shows the interface for the developer to upload screenshots and images for a new application.

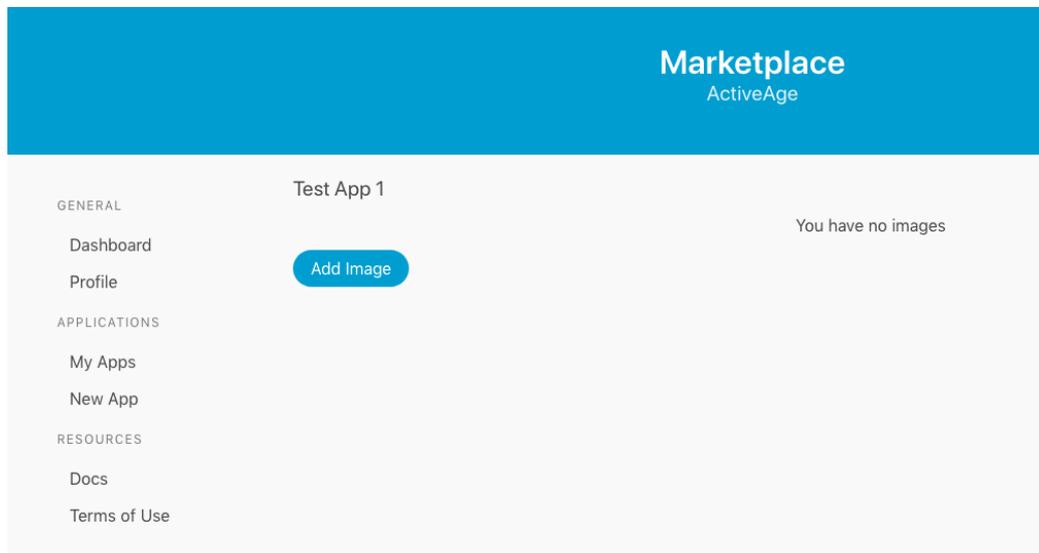


Figure 34. Marketplace UI Developer View: Upload Images for New Application Edit Application Info

Figure 35 shows the form to, this time, edit an uploaded application's info.

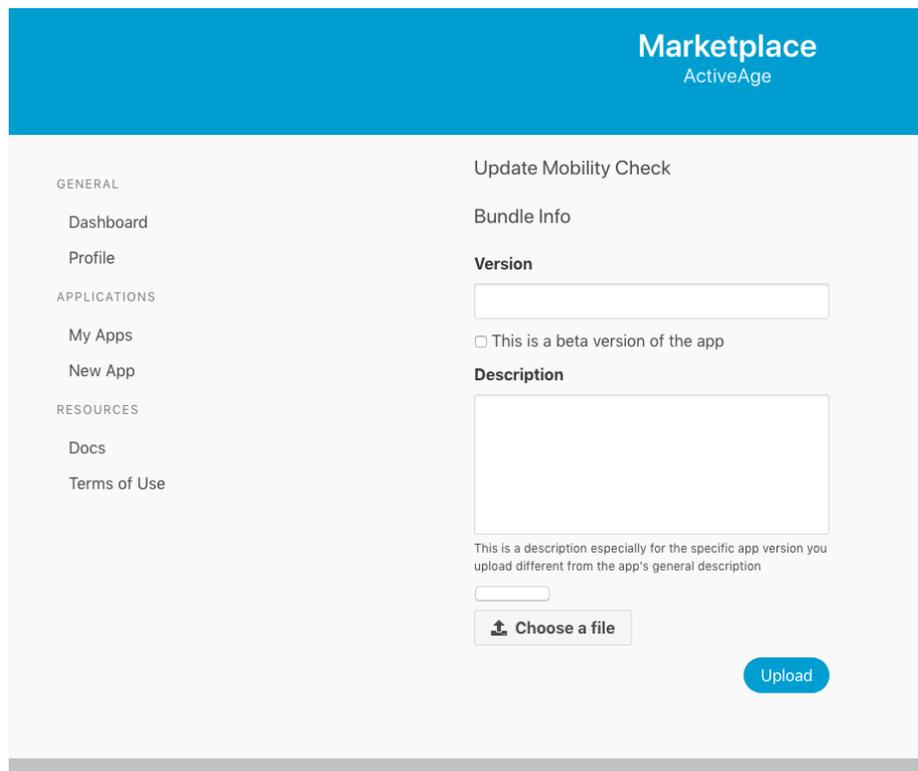


Figure 35. Marketplace UI Developer View: Edit Application Info

Upload Application

Figure 36 shows the respective interface for uploading more images or removing the existing ones for an uploaded application.

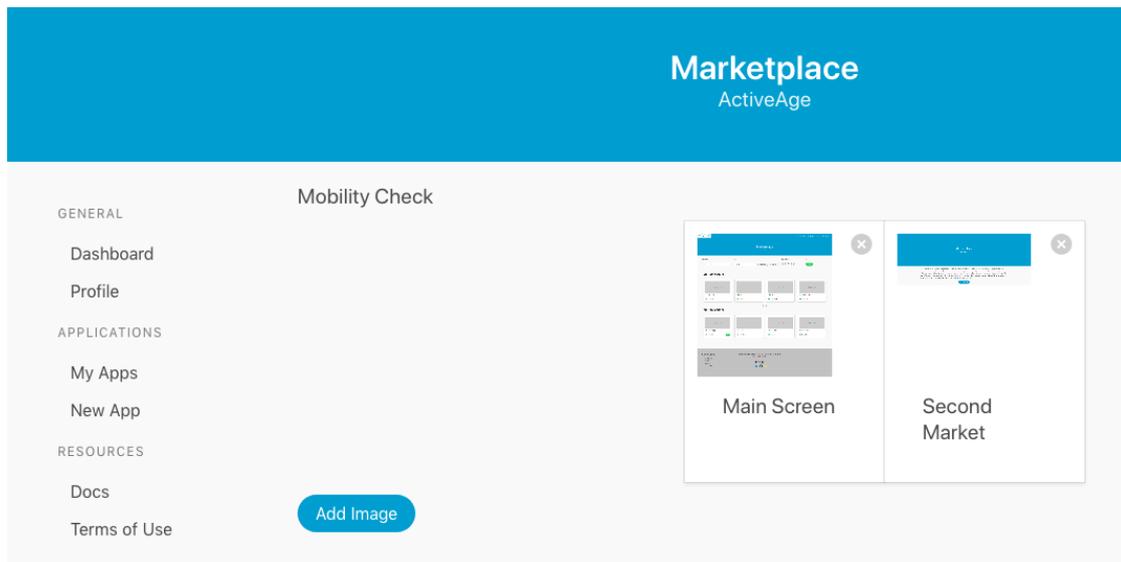


Figure 36. Marketplace UI Developer View: Edit Application Images

Developer Dashboard

shows the Developer Dashboard, performance and information for each of their applications: total downloads, current rating, number of ratings, comments, bundle version and ability to delete it.

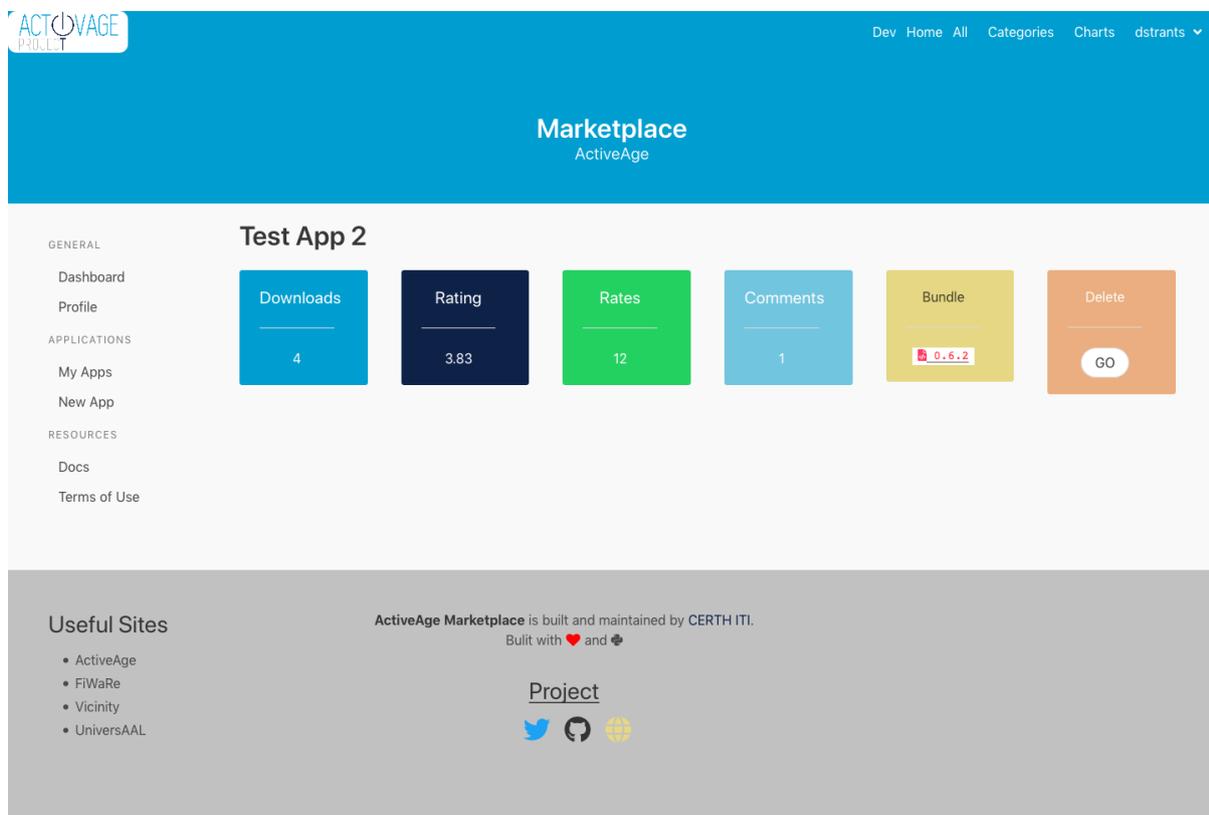


Figure 37. Marketplace UI Developer View: Developer Dashboard

Developer Insights

Figure 38 shows Developer Insights screen with overall statistics.

These include total apps deployed, total downloads, overall average rating, comments and reviews. Downloads are shown in charts and in a ranking of this developer's performance.

Rating charts and ranking is shown in a similar manner.

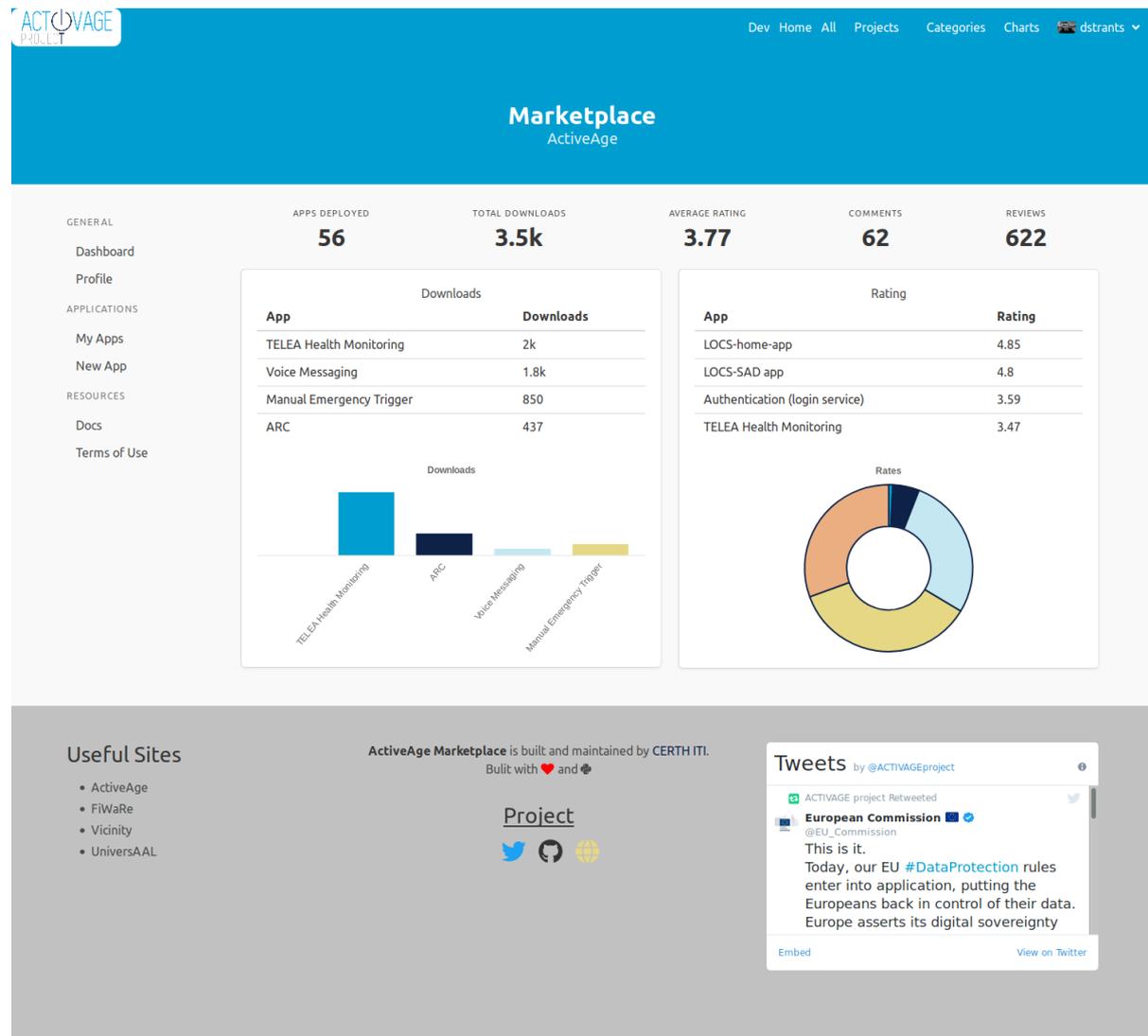


Figure 38. Marketplace UI Developer View: Developer Insights including deployed, downloaded apps, average rating, comments and review statistics.

4.3.3 Marketplace 2nd version

This is a placeholder and a section to describe future planning for the 2nd version of the Marketplace.

Besides the features and planning described in the previous sections, some technical developments on the web application itself include:

Development

- Finalization of the User interface with the ability to deploy integrated bundles and perform semantic search with the proper metadata
- Finalization of the Developer interface with the ability to upload integrated bundles and enter the complete metadata for semantic search
- Addition of the Administrator interface to moderate content and to approve and validate uploaded applications with the proper security/privacy and ethics compliance process

Integration with other components

- Integrate with the Data Models and the algorithms to perform semantic search
- Integration with AHA Advisor to recommend apps for a given user
- Explore integration options with SIL to discover available devices and to deploy applications
- Host all relevant support material from e.g. D5.2

Documentation

- Produce user documentation for Users, Developers and Administrators
- Produce Marketplace developer documentation for the Marketplace open source – now auto-generated with Sphinx

Interaction with End-Users

- Access the Marketplace online which will now host the actual applications from DSes and Open Calls
- Finalize User Interface and User Experience and perform usability evaluation with participating stakeholders

5 Conclusion

The ACTIVAGE Marketplace is a key component for ecosystem building but also for novel business models and the exploitation of AIOTES. The Marketplace is a Deployment Tool, one very close to the users as it is intended for any online user, deployment site or general healthcare professional, third party adopter, existing and potential developer, individual or business entity to develop, provide and obtain applications build for AIOTES. The 1st version of this deliverable has shown via a state-of-the-art survey the prevalence of marketplaces within the IoT market, where the ACTIVAGE platforms hold a significant place, but also outside it, in smartphone apps, items and services.

The added value of the ACTIVAGE Marketplace is to unify the ecosystems of platforms that do and those that do not yet provide an application marketplace as well as to extend and complement if needed, their functionality, enabling provision, search and discovery of AHA applications.

Components within AIOTES that are continuously progressing and would greatly benefit the Marketplace have been identified: a list of developer and deployment tools linked as resources to encourage adopters, interfacing with the AHA Advisor to provide users with personalized recommendations, the Semantic Interoperability Layer providing available devices and services and ensuring compliance with the ACTIVAGE Security and Privacy policy.

The 1st version of the Marketplace presented in this deliverable implements most of the Application User and Developer functions. Along with insights from the state of the art survey, use case scenarios were used to define and implement Marketplace functionality. The web platform provides public users with the ability to view, single- and multi-criteria search the application repository and access Marketplace insights such as application downloads and ratings. Registered users have the ability to, in addition, get free or buy applications, maintain a profile, a wishlist, rate and review applications.

The 2nd version of the Marketplace and this deliverable will greatly extend its functionality, provided the necessary synergies with other Work Packages. With the addition of an administrator, applications will be validated for compliance (WP3), while actual integrated bundles (WP5). The AHA Advisor (WP6), on top of semantic search, will provide users with personalized recommendations. The exploitation strategy for the Marketplace will take form and together with the Deployment Site stakeholders and Open Call third party beneficiaries the Marketplace will be evaluated for usability and acceptance (WP7, WP8, WP9).

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