

# INITIAL OPERATING MARKETPLACE

.....  
Deliverable 2.1

**CIRCULATION**

Confidential

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#### Document History

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<sup>1</sup> Integers correspond to submitted versions

## EXECUTIVE SUMMARY

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This document defines the basic building blocks and interaction flows of the Change2Twin marketplace, laying the ground for future work.

The concept presented, builds on the observation that digital product and service offerings are continuously evolving and offered via heterogeneous stores, marketplaces and platforms. The challenge turns into the discovery (based on meaningful assessment approaches) of products and services. The **Marketplace Model** presented provides the conceptual, knowledge representation and semantic mechanisms aimed to support and facilitate interoperability.

The first release of the marketplace is accessible from:

<http://marketplace.change2twin.eu>

and is integrated with the Marketplace Middleware via documented APIs enabling a wide range of Interactions.

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## 1 INTRODUCTION

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This document introduces the initial operating marketplace. To this end, Chapter 3 introduces the design principles aimed at addressing heterogeneity, enabling interoperability at a semantic level. Next, a layered architectural view is presented outlining the different Chang2Twin marketplace components and their integration.

Chapter 4 presents the initial offering currently available on the marketplace. To this aim, a simple yet effective taxonomy is presented and discussed, allowing for a semantic-based search and filtering of items. On the business front, Chapter 5 outlines a generic conceptual model, identifying potential stakeholders, interactions and applicable revenue streams.

Chapter 6 concludes the document, outlining some future design and development activities.

## 2 CONCEPT AND ARCHITECTURE

The concept and architecture of the C2T Marketplace is graphically shown below. Three core interaction flows are supported in the current release:

- *USE Marketplace item*: for DIHs, Pilots within the project and external/third party users. The available interactions allow to search, browse and discovery adequate items as an extension of exiting assessment methods or directly. The interaction flow aims to support this via the landing pages on one hand (interaction, search, browse, discovery, match requirements towards items) and deployment in the infrastructure and its use.
- *CONTRIBUTE Marketplace items*: provide processes for extension of the marketplace offering and sharing of content in the sense of an ecosystem of marketplaces.

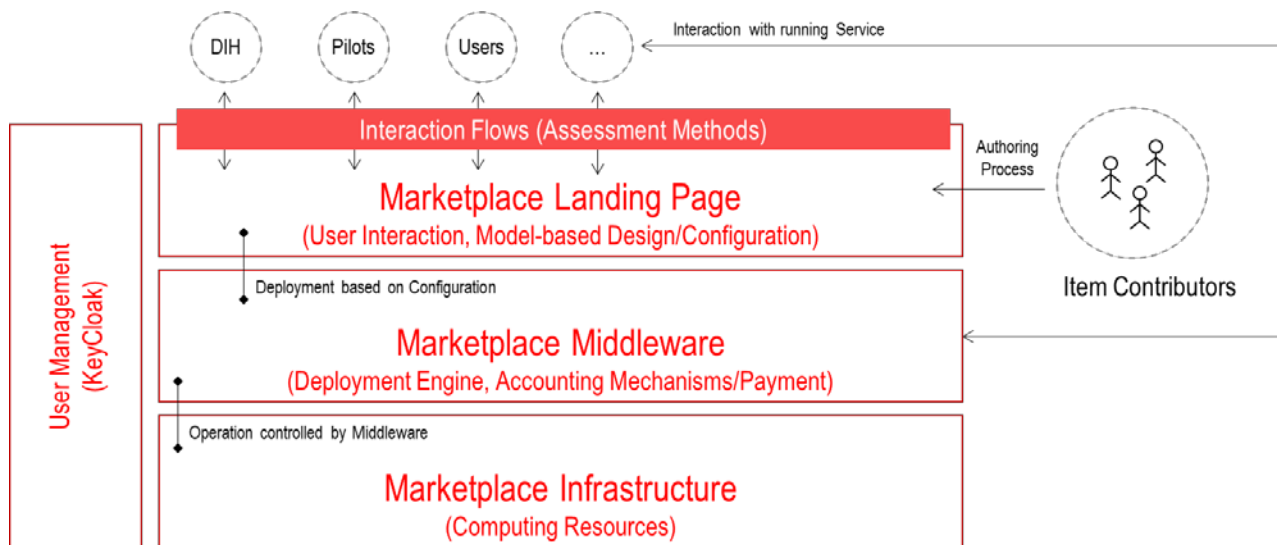


FIGURE 1 HIGH-LEVEL C2T MARKETPLACE ARCHUTECTURE

- *SUSTAIN Marketplace implementation*: means to deploy subsets or extension within DIHs. This deployment aims at DIHs that want to run their own, domain-specific marketplace instantiation. As such the marketplace is understood as an own innovation and exploitation item that is custom built for the purpose of the DIH. As a result, we envision a connected ecosystem of marketplaces, building on the same concept rather than a monolithic installation of the system and components.

### 2.1 DESIGN PRINCIPLES

The distinctive element of the Change2Twin Marketplace, in contrast with state-of-the-art systems aiming to establish digital offerings, relates to the aspects listed below:

- *Knowledge Representation*: a model-based approach has been selected to support intelligent interaction flows. The model itself acts on hand as the configuration artefact of the marketplace (landing page content representation, query and assessment/matching capabilities, deployment control, infrastructure provisioning, sustainability of results established). But it also represents the knowledge about an item and its usage/supported application scenarios. The model is therefore used for the interaction in two ways: (i) configuring the representation and (ii) enabling the user interaction

with the environment. This user interaction ranges from tagging/browsing and selection techniques to more advanced interaction such as discovery via dedicated assessment method. The approach on knowledge representation is based on the advances in conceptual modelling and metamodeling, where model artefacts pertain model value and are applicable for domain-specific representations [1]–[4]. In this initial release, a draft metamodel has been employed as input for the development of the marketplace model in D2.2 Marketplace Design and Methodologies.

- *Integrated governance mechanisms*: to control item provisioning, various techniques are explored to enable content governance process as a lifecycle of retrieval and continuous improvement (maturity, quality, adequacy of items offered). This requirement is a best practice, commonly employed in application scenarios that require technology, services and/or solutions in a creative and potentially in advance unknown manner. Such combinations of items can only be established when considering also early prototypes and innovation items as part of the marketplace offerings. Nevertheless, it is important to clearly identify the risk involved when selecting such solutions. The governance process is reflected in the provisioning of items (self-assessment of the provider) and also in its usage by DIHs and related SMEs as consumers,
- *Collective Intelligence*: domain-specific expert knowledge is continuously evolving and needs to be reflected conceptually as it impacts assessment results. This impacts the model elements and their characteristics (therefore an open model approach with agile adaptation is employed), but also the usage dimensions,
- *Middleware capabilities*: as an abstraction of the underlying infrastructure. Since users of digital technology are interested in the offering and not on the technology operating it (hardware, software), the middleware offers an abstraction layer over the infrastructure bringing gains in terms of flexibility.
- *Sustainable maintenance*: as the middleware layer acts exactly as the middleman between the user on the landing page and the CloudBroker platform that use the resource infrastructure, we would like to provide continuous enhancement with respect to the business needs of the user side and infrastructure layer that gives all necessary resources. Our goal is to ensure that middleware can extend its functionalities or enhance scalability in order to support manufacturing SME requirements or any activities related to the marketplace that middleware layer can handle.

This vision is subject to refinement based on the use within the project pilot projects.

## 2.2 MARKETPLACE LANDING PAGE

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The C2T Marketplace Landing Pages are established following the concept of micro front-ends which allow to separate different and heterogeneous behaviours from their representation as discussed in [5]–[7]. As an extension to the idea of micro-services towards frontends, we envision that each item in the marketplace is understood as a functional building block (microservice providing the functionality, not limited to technical realisation) and the marketplace representation acts as the front-end. Building upon the conceptual representation as an externalisation of knowledge about the item, the marketplace landing pages are generated on the fly, using open technologies and standards, as shown graphically in Figure 2, briefly discussed below from the perspective of a service/item provider.

1. Design: Item Contributors describe their items using the conceptual modelling environment as a means to formalize the knowledge representation. This is considered a creative design step, within

the boundaries of the marketplace metamodel and its method (further details are provided in the D2.2)

2. Transform: the model representation is transformed using graph-rewriting techniques. The conceptual model, provided in the form of an ADOxx-based implementation [8] are mapped to a markdown representation, whereas the properties of the model are either metainformation in markdown (frontmatter, to configure interaction, middleware behaviour and infrastructure requirements) or content to represent the elements. The content is stored in an open-source code management system (marketplace.change2twin.eu/git/)
3. Deployment of item: a continuous integration and deployment job picks up any changes detected in the source code (markdown) and updates the deployment of the marketplace. This relates on one hand on the representation (web-based/static websites) the search functionality (external service algolia) as well as the middleware of the marketplace.
4. Use: the item is available and can be purchased and used by interested parties. All capabilities of the items are exposed via the middleware.

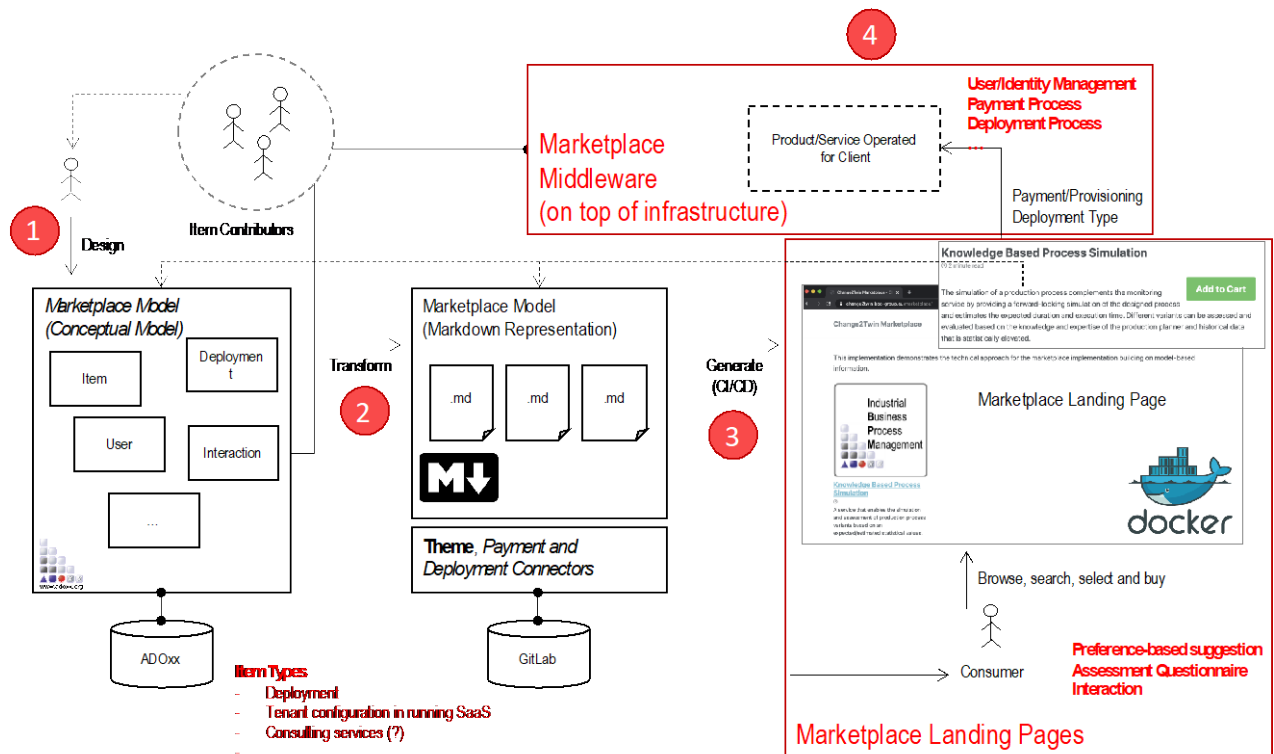


FIGURE 2 APPROACH: C2T MARKETPLACE LANDING PAGE

The conceptual representation of an item is transformed (using model-to-model transformation techniques) to the markdown standard. The configuration facets of the model are exposed as header information and corresponding content sections. The markdown repository is used for static page generation. The Jekyll engine is used to transform markdown to static HTML pages. Dynamic functionality is integrated via JavaScript (e.g. authentication flow to KeyCloak, registration and deployment flow to the C2T middleware).

Deployment of the marketplace is performed via continuous integration (generation) and deployment pipelines. The results of the integration job is either uploaded to a webserver or packaged as a docker image that can be deployed.



TABLE 1 C2T MARKETPLACE LANDING PAGES TECHNOLOGIES

| ID | Usage                                       | Technology  |
|----|---|---|
| 1  | Conceptual marketplace model representation | <p>Basic version: XLSX in Microsoft Teams</p> <p>Advanced version: Marketplace Modeller realized on ADOXX</p> <p>Download at<br/><a href="https://adoxx.org/live/web/change2twin/downloads">https://adoxx.org/live/web/change2twin/downloads</a></p>  |
| 2  | Model transformation                        | <p>ADOXX2Markdown: AdoScript-based implementation</p> <p>Download at<br/><a href="https://adoxx.org/live/web/change2twin/downloads">https://adoxx.org/live/web/change2twin/downloads</a></p>  |
| 3  | Landing Page Generator                      | <p>Jekyll Engine (Static HTML Generator) using Liquid Syntax for dynamic templating</p> <p>Read more:<br/><a href="https://jekyllrb.com/">https://jekyllrb.com/</a><br/>C2T Implementation:<br/><a href="https://marketplace.change2twin.eu/git/c2t/marketplace">https://marketplace.change2twin.eu/git/c2t/marketplace</a></p> |
| 4  | Integration and Deployment                  | <p>GitLab CI/CD Pipelines and syntax</p> <p>C2T Implementation:<br/><a href="https://marketplace.change2twin.eu/git/c2t/marketplace/-/pipelines">https://marketplace.change2twin.eu/git/c2t/marketplace/-/pipelines</a></p>   |
| 5  | Source code and persistency                 | <p>Gitlab</p> <p><a href="https://marketplace.change2twin.eu/git/c2t/">https://marketplace.change2twin.eu/git/c2t/</a></p>  |
| 6  | Search                                      | <p>Based on the model representation, using the Free-Tier Search Service of Algolia (<a href="https://www.algolia.com/">https://www.algolia.com/</a>)</p>   |

The user interaction layer based on the C2T theming are implementation for release 1 based on the project website template established.

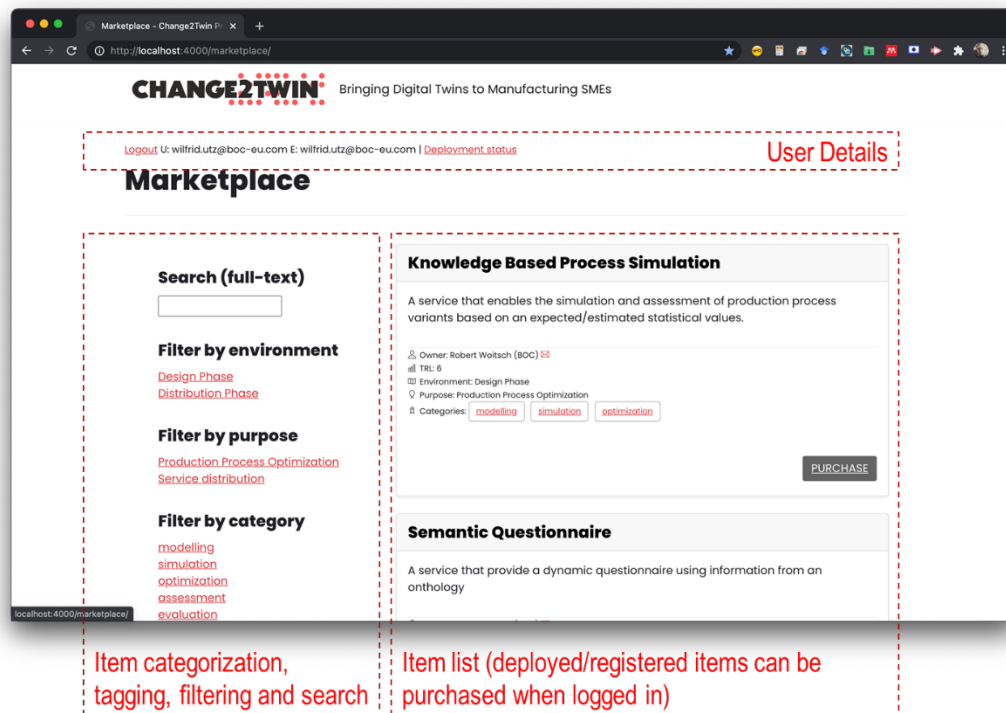


FIGURE 3 C2T MARKETPLACE: SEARCH, FILTER AND BROWSE

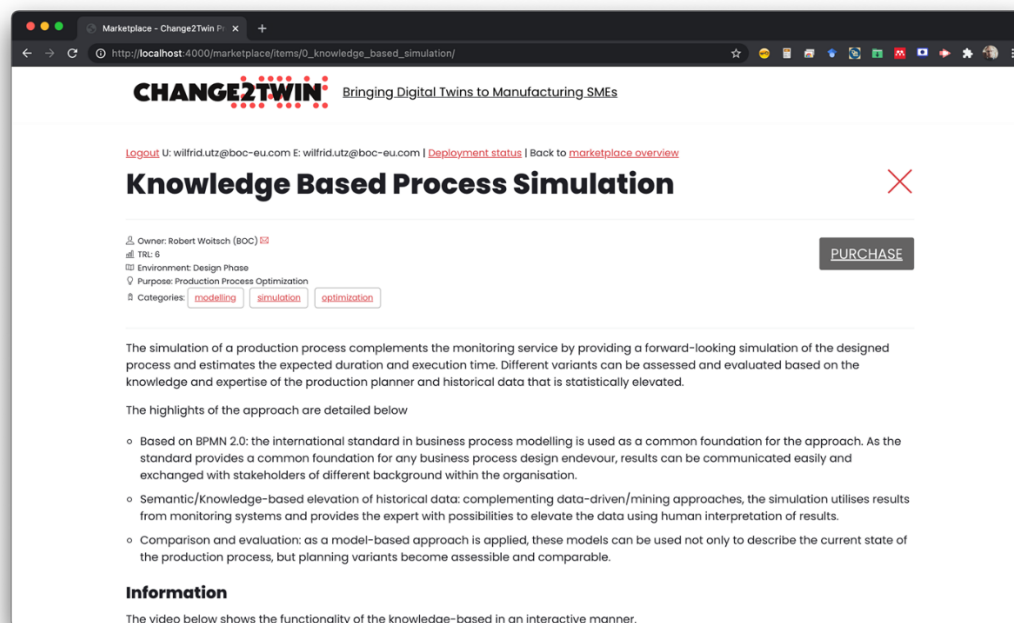


FIGURE 4 C2T MARKETPLACE: ITEM VIEW – PURCHASE

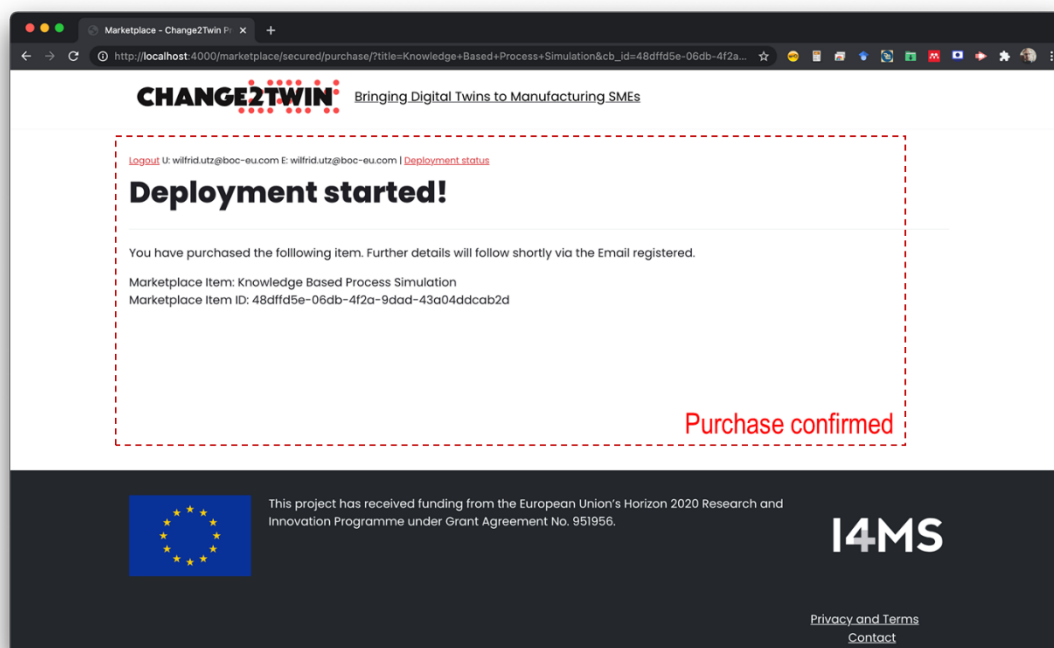


FIGURE 5 C2T DEPLOYMENT TRIGGER (INTEGRATION WITH C2T MIDDLEWARE)

The landing pages are connected to the API provided by the C2T Marketplace Middleware, detailed in section 3.4

## 2.3 MARKETPLACE MIDDLEWARE

The Middleware component is responsible for execution of auxiliary functional components such as authorization and authentication, shopping actions and software deployment within the Change2Twin solution.

Most of these functionalities made available in the marketplace are going to utilize the existing features of the CloudBroker Platform, properly customized to deliver digital twin and software solutions hosted on the Change2Twin marketplace.

CloudBroker Platform (CBP or "Platform") – is a web-based application for the deployment and execution of compute-intensive scientific software and workloads in the cloud. Cloud computing is a computing paradigm that can offer a huge amount of compute and storage resources to the DIH and SMEs [9].

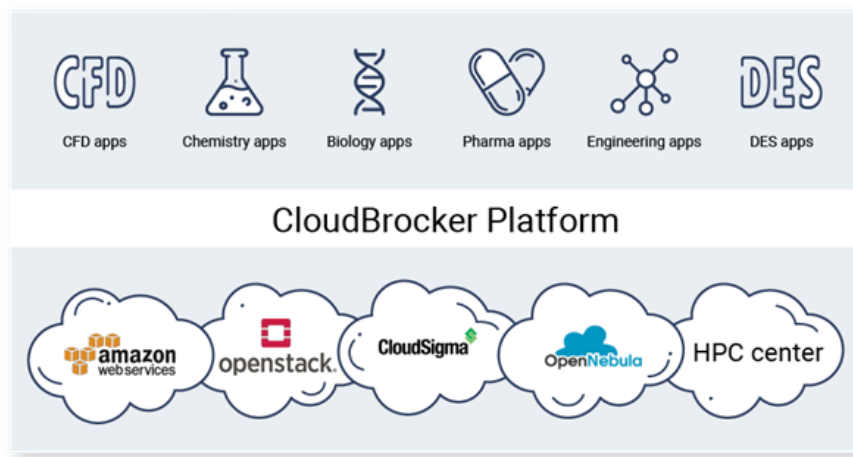


FIGURE 6 HIGH-LEVEL ARCHITECTURE OF THE CLOUDBROKER PLATFORM

It provides a platform where users can offer their own cloud resources and application software or use resources and software provided by others. The CloudBroker Platform uses IaaS (Infrastructure as a Service) from resource providers as Amazon EC2 [10], OpenStack [11], CloudSigma [12], OpenNebula [13] and provides PaaS (Platform as a Service) to software vendors and SaaS (Software as a Service) to end users. Offering virtualized resources (computation, storage, and communication) on demand is known as Infrastructure as a Service (IaaS) [14].

The middleware component acts as an abstraction layer that helps the marketplace to communicate with the CloudBroker platform and execute functions accordingly to the end-user request, whether it is already-prepared digital twin solution or need to receive the information.

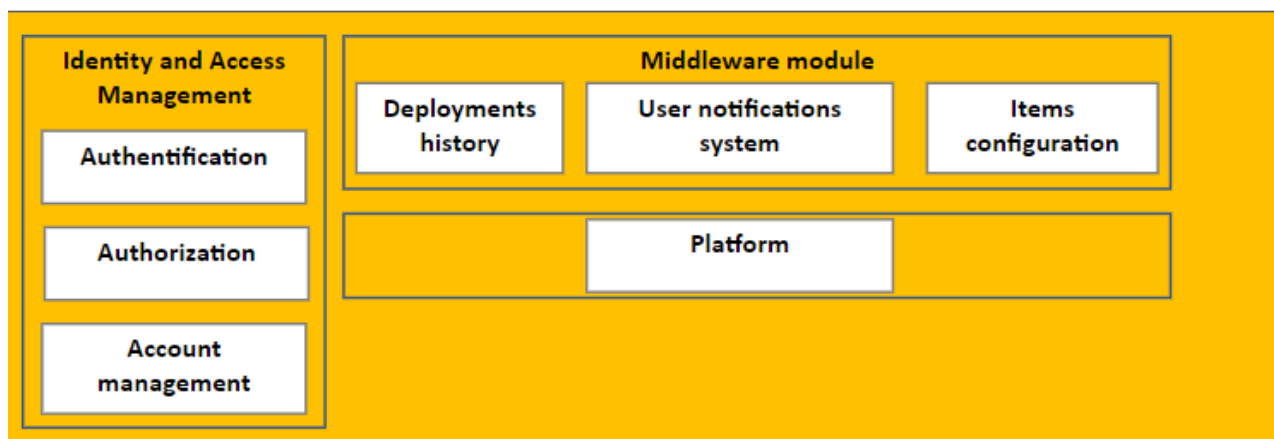


FIGURE 7 MIDDLEWARE COMPONENT AND ITS MODULES

“Identity and access management” (see Figure 7) module allows user to log in to the marketplace and work with all respective account management features as registration or password reset.

The next is the “Middleware module” (see Figure 7). Currently its main responsibility is the execution of the marketplace items. The execution depends on the type of item, for instance, docker image means deployment. Also, the middleware is able to provide user such item types as the human-service item (it might be a person’s contact) and content item that allows user to receive requested URLs or links for files. To make the Platform know what to run, a user provides all the necessary information: whether it is a docker type item and should be launched respectively, or what are the firewall rules to apply to the VM, etc. Middleware module also

contains deployments history and sends it to the marketplace where you may see the current status of virtual machines and their executions respectively.

Finally, the user notification system is responsible for account validation, sending notifications about organization's balance, user's status, executions errors, etc. via email.

At last, the third module (see Figure 7) is represented by "Platform" and it is responsible for starting VMs, deploying software/solutions on them, monitoring and reporting overall status to higher levels.

After clicking on "Purchase button", the landing page sends a request to the middleware that starts the deployment process and launches a respective virtual machine for it (see Figure 8). The middleware also receiving deployment status so a user can see if the deployment is starting/running/stopped.

### Middleware: current implementation

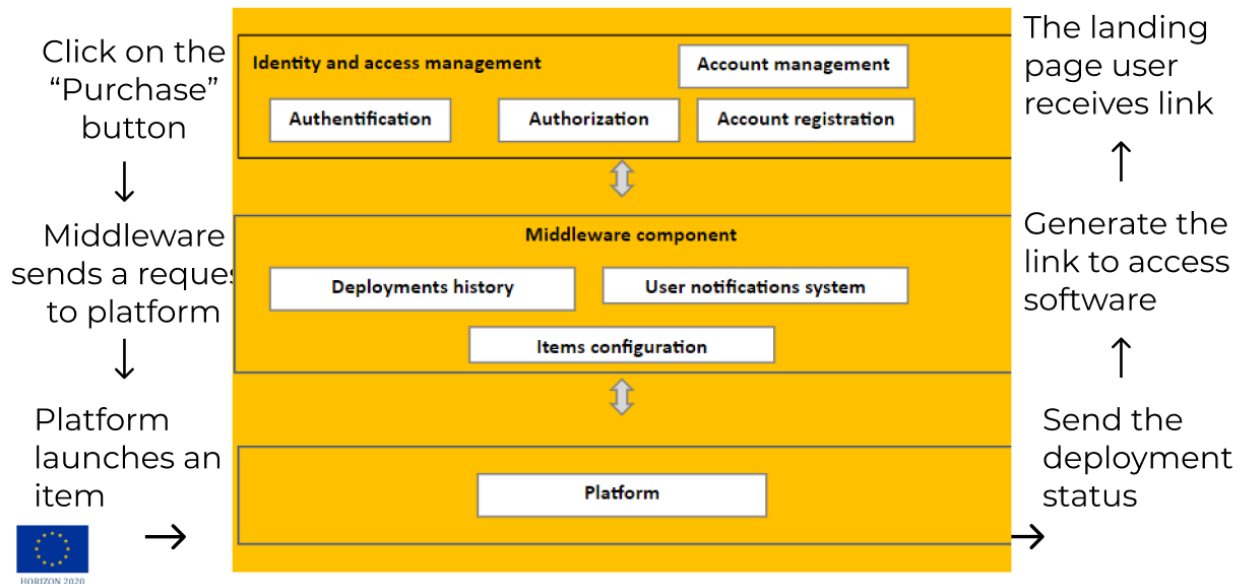


FIGURE 8 MIDDLEWARE IMPLEMENTED WORKFLOW

Eventually, the user receives the link on his email. After going to a page with it, the user can use the software in the new tab

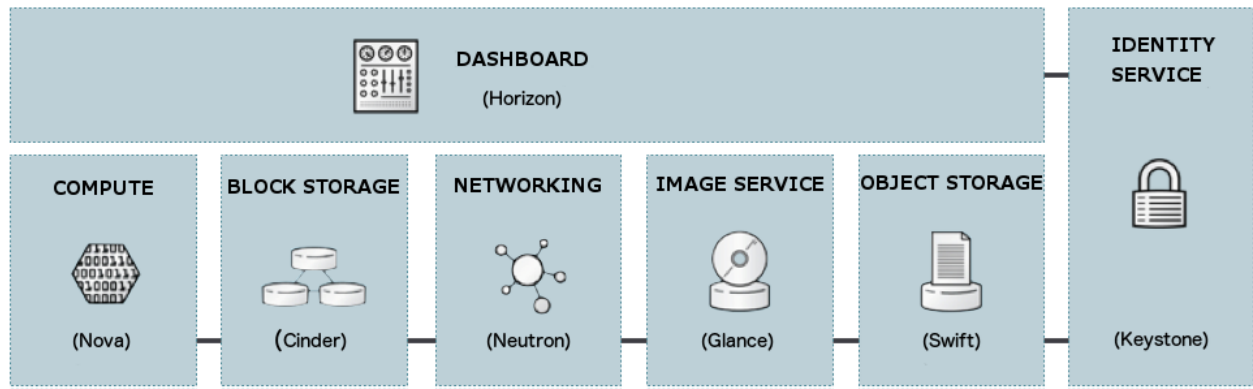
## 2.4 INFRASTRUCTURE LAYER

The Marketplace Landing Page abstracts the underlying middleware and infrastructure. In general, the middleware is linked to the dedicated instance of CloudBroker platform, which is then linked to the infrastructure – every instance launched via the middleware is launched on PSNC cloud. While the middleware provides functionalities such identity management or "usage", the infrastructure layer provides actual hardware resources such as computational power, storage, network, virtual machines, which are required for the marketplace offerings or the Marketplace Landing Pager operation.

PSNC cloud is a hosting environment for Change2Twin Marketplace services, including Landing Pages. It is based on OpenStack - a cloud operating system that controls pools of compute, storage, and networking resources, all managed and provisioned through APIs with common authentication mechanisms. A dashboard is also available, giving administrators control while empowering their users to provision resources through a web interface instead of API. Beyond standard infrastructure-as-a-service functionality, additional

components provide orchestration, fault management and service management amongst other services to ensure high availability of user applications. It allows us to run virtual machines with Linux (Redhat, Centos, Ubuntu, Debian, etc.) and Windows. It connects computing and application servers with data storage solutions and the network providing users fully virtualized infrastructures. Services and applications running on virtual machines become more resistant to hardware failures - in case of problems, the machines can be migrated to redundant servers. It is easy to adjust the amount of available resources to the changing needs of the applications.

**OpenStack high-level architecture (source: <http://www.openstack.org/>)**



Following PSNC cloud services can be used by Change2Twin via REST API or web portal:

- **Nova** – virtual machines (VMs), key pairs, server groups
- **Glance** - VM base images
- **Neutron** - networks, routers, ports, security groups and rules (VM level), floating IPs (like public ones)
- **Octavia** – network load balancers
- **FWaaS** - firewalls (router/network level)
- **Cinder** - volumes, snapshots, backups
- **Orchestration (Heat)** - stacks (automated project's resource management)
- **Object Storage** - containers and data objects via Swift or S3 API
- **Shares (Manila)** - NFS volumes which can be shared between VMs
- **Workflow (Mistral)** - workbooks, workflows, tasks
- **Horizon** - graphical access portal
- **Identity (Keystone)** - authentication and authorization service
- **Key Manager (Barbican)** - passwords, encryption keys and X.509 certificates

PSNC OpenStack is integrated with the Ceph storage cluster. Ceph is an open-source software storage platform which implements object storage on a single distributed computer cluster. It provides object-, block- and file-level storage. Ceph replicates data and makes it fault-tolerant using commodity hardware and requiring no specific hardware support. As a result of its design, the system is both self-healing and self-managing, aiming to minimize administration time. As a result, it offers a fast and secure storage service with data replication (3 replicas) which is failure resistant (it is hard to lose data). Thin provisioning allows for efficient utilization of storage space and makes it easy to scale the storage cluster. Object storage API offers S3 API compatibility which is important from an application level perspective as S3 API is de facto standard used in a common way.

The initial resources assigned to the Change2Twin and offered within the infrastructure project are presented in Table 2.

TABLE 2 INITIAL INFRASTRUCTURE RESOURCES ASSIGNED

| Resources             | Count  |
|-----------------------|--------|
| Instances (VMs)       | 30     |
| vCPU                  | 120    |
| RAM                   | 128 GB |
| Volumes               | 200    |
| Snapshots             | 300    |
| Storage               | 2,9 TB |
| Floating / public IPs | 20     |
| Security groups       | 200    |
| Security rules        | 200    |
| Networks              | 6      |
| Ports                 | 100    |
| Routers               | 6      |

The initial MarketPlace Landing Pages runs in VM configured with 8 vCPU and 16 GB RAM, while the rest of resources are used for instantiating services for WP3 pilots and potentially for Marketplace users.

### 3 MARKETPLACE OFFERINGS

In the following the collected items for release 1 from the project consortium are introduced. Following the governance process, a continuous improvement and adaptation of these items is foreseen. The initial collection of items is based on the background knowledge of partners, their expertise and application in funded or industrial projects.

The items are classified/structured by the supported categories within the C2T marketplace, related to the capabilities of the i) service/offering and ii) the marketplace middleware to deploy items of such type. For release 1 the following categorization has been established as presented in Table 2.

TABLE 3 MARKETPLACE ITEM CATEGORIES

| Category           | Description  |
|--------------------|--|
| Consulting Service | Services offered to support a consumer in uptake and application of digital twin technologies, e.g. <ul style="list-style-type: none"> <li>○ Consulting workshops</li> </ul> |

|                                 |  |
|---------------------------------|--|
|                                 | <ul style="list-style-type: none"> <li>○ Teaching</li> <li>○ Training</li> </ul>   |
| Information offering            | <p>Content-based services that build on pre-existing reference data and result, e.g.</p> <ul style="list-style-type: none"> <li>○ Reference Data Sets</li> <li>○ Reference Processes</li> <li>○ Studies and Analysis</li> <li>○ Success Stories</li> </ul>   |
| Software Application Offering   | <p>Software applications in various forms of operation such as:</p> <ul style="list-style-type: none"> <li>- Deployment artefacts (running on HPC resources and handled through the middleware)</li> <li>- Downloadable artefacts for own installation</li> <li>- Tenant-based deployments (running system and access provisioning)</li> </ul> |
| Digital Infrastructure Offering | <p>Infrastructure offerings such as</p> <ul style="list-style-type: none"> <li>- IoT Infrastructure</li> <li>- RFID tags</li> <li>- Edge Computing Environment</li> </ul>  |

The list of items below is subject to change based on the input received as a result of the continuously running governance and improvement process.

TABLE 4 MARKETPLACE ITEM OVERVIEW (RELEASE 1)

| Category                      | Item   |
|-------------------------------|--|
| Consulting Service            | <ul style="list-style-type: none"> <li>- MI06 Open Innovation Services</li> <li>- MI10 Training and Workshops on Digital Twinning</li> <li>- MI13 Assessment Service OMILAB Innovation Corner</li> <li>- MI15 "Design flexible marketplace models"</li> <li>- MI16 "Design of hybrid DT"</li> <li>- MI17 "Device DT edge/fog"</li> <li>- MI18 "Adapt and Develop edge/fog models / architecture"</li> <li>- MI21 Cloud Related Consulting Services</li> <li>- MI24 Development of digital twins to simulate physical products</li> <li>- MI31 "Improve and optimize our production chain"</li> </ul> |
| Information offering          | <ul style="list-style-type: none"> <li>- MI09 Methodology for Digital Twinning</li> <li>- MI11 Smart Connected Factory Framework</li> <li>- MI26 "Prespective"</li> </ul>  |
| Software Application Offering | <ul style="list-style-type: none"> <li>- MI01: GoTools</li> <li>- MI02: GoTools - Gateway: G22 to STEP, STEP to G22</li> <li>- MI05 Open Call Management System</li> <li>- MI07 Online Community</li> <li>- MI08 Assessment tool</li> <li>- MI12 Marketplace Model</li> </ul>  |



|                                 |   |
|---------------------------------|---|
|                                 | <ul style="list-style-type: none"> <li>- MI14 Production Process Digital Twin Offerings</li> <li>- MI20 "Individual Online Shop"</li> <li>- MI25 Low Code SW Development Platform</li> <li>- MI27 "Author-e"</li> <li>- MI32 SINTEF Spline Library (SISL)</li> <li>- MI33 EDMOpenSimDM</li> <li>- MI34 EDMTruePLM</li> <li>- MI35 EDMsdk</li> </ul> |
| Digital Infrastructure Offering | <ul style="list-style-type: none"> <li>- MI03 IoT Edge platform – NERVE</li> <li>- MI04 EXPRESS Data Manager™ (EDM)</li> <li>- MI19 "CloudBroker Platform's "</li> <li>- MI23 HPC Infrastructure</li> <li>- MI30 "Pallet Wrapper DT"</li> </ul>   |

## 4 BUSINESS MODEL

To create a marketplace that is sustainable, it's role in the ecosystem needs to be defined. The ecosystem comprises of SMEs, Solution providers, Digital Innovation Hubs and other marketplaces. Next to the role, the way the marketplace can generate value and the specific business models need to be defined. In liason with WP6 Sustainability this section provides a general model that will later be refined in the next version of the marketplace. The next version will cover the chosen sustainable business model and specific role in the ecosystem.

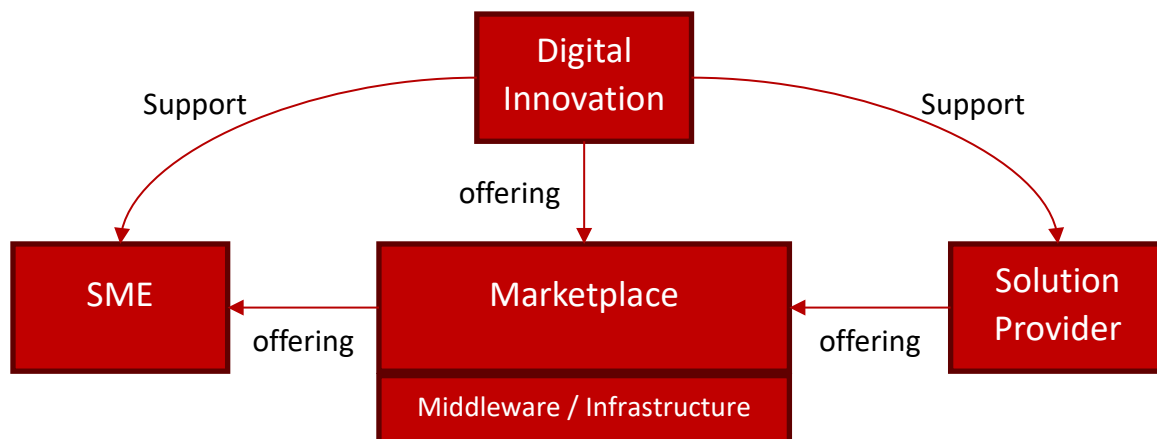


FIGURE 6, MARKETPLACE ECOSYSTEM

The ecosystem of the marketplace is described in Figure 6. It features the main actors: SMEs that want to adopt digital twinning technologies, Digital Innovation Hubs (DIH) that want to support SMEs in their region, Solution Providers (SP) that want to provide services to the SMEs and the marketplace where DIHs and SPs are available for SMEs.

**SMEs** are looking for solutions, assistance and support when adopting Digital Twin technologies. These can be in the form of the offerings listed in chapter 4. In return they offer financial compensation for the offering used. It can however be expected that SMEs would need support to find the appropriate solutions and decide on process to adopt DT. Therefore, the support and services offered by the local DIHs will be crucial and it is possible the DIHs will act as intermediaries for the SMEs and will be a main target group.\_

**Digital Innovation Hubs** want to help SMEs adopt technologies in their region and offer the SMEs support. This can both be directly to the SME since it's part of their region, or by offering services through the marketplace itself to SMEs outside their region. Sometimes this can result in financial compensation by an SME, but this might also be part of the hubs regular work. Digital Innovation Hubs can also support the Solution providers in the region to get listed in a European context and become able to provide offerings outside their region. By being part of the Marketplace and linking to other hubs they can expand their network and increase the impact for their region.

**Solution Providers** want to attract new customers and provide more products and services to get more revenue. They expect to be compensated for their offering and also get feedback on their offering from SMEs that are adopting Digital Twin technologies.

**Marketplace** wants to be a platform where useful offerings find their way to SMEs that want to adopt Digital Twin technologies. This could be related to solution offerings but should also be connected to services and possibly support.

**Infrastructure provider** want to get more usage of their SaaS/PaaS/IaaS offerings by having more services like this in the marketplace, their usage and revenue will go up. This can be in the form of a regular subscription or a pay-per-use basis.

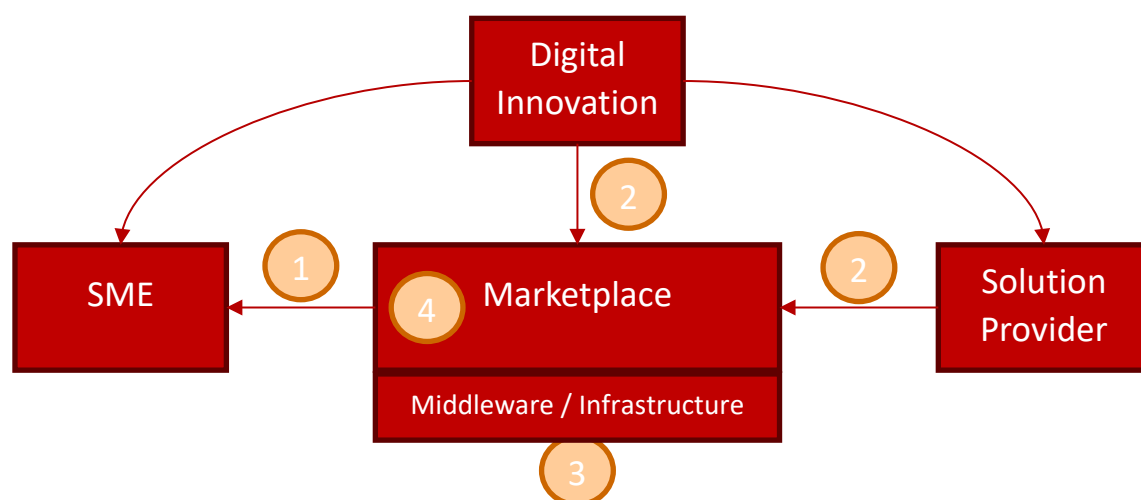


FIGURE 7, POSSIBLE MARKETPLACE REVENUE STREAMS

The Marketplace can create revenue in several ways:

1. SMEs pay a percentage of the services & solutions sold in the marketplace. This is similar to current existing platforms (Apple/Google/Amazon/Steam/...) that take a percentage, usually 30%, on top or from the original price.
2. DIHs, SPs or users pay a membership fee for being part of the marketplace and possible have differentiation for being listed on the marketplace.
3. SMEs pay specifically for the offerings listed as SaaS deployment where the infrastructure is needed to host their services.
4. The marketplace can also be funded as sunk-costs by a single or network of parties. (EU / EDIH / Region / Nation / ...)
5. Advertisement from solution provider or general advertisement could also provide a revenue stream
6. Optionally the marketplace can create revenue by linking to other marketplaces as affiliate system.

To become sustainable, it needs to be clear which kind of marketplace will be viable after the project based on the above possible revenue streams. Currently these three possible scenarios are being considered:

1. A marketplace that is able to fully fund itself based on the quality of the offerings and a combination of revenue streams 1/2/3. Any party could be responsible for this marketplace.
2. A marketplace where only the SaaS/PaaS/IaaS services generate revenue and other offerings are directly handled by solution providers themselves. Only vested parties will be interested.
3. A marketplace that refuses any additional costs, but is funded as cost function by a single party. This will mean it will not offer SaaS/PaaS/IaaS but will be very low-cost static webpage which has very low upkeep and maintenance but is able to provide good services.

Based on actual use by SMEs and by linking to other marketplaces these (and potentially other) options will be explored in year 2 of the Change2Twin project. Also, the discussion of the overall business model and services of C2T and the connection to the market place (as a deployment mechanism) will be explored.

## **5 CONCLUSION AND FUTURE WORK**

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Following an agile development and deployment process, the plans for each layer of the C2T Marketplace are briefly introduced below.

### **C2T Marketplace Landing Pages**

A core aspect of the landing pages relates to user interaction. The current approach on interaction is based on the model representation and basic search/browse mechanisms. In the upcoming release an extension is planned to provide standardized interfaces (to couple any kind of assessment method/tool). The format and interface technology are build using the same technology stack as discussed above and will utilize standard technologies.

In addition, the integration of the governance process (formalized in a ticketing system) will impact the evolution of the marketplace model, its concepts, characteristics and facets. The upcoming release will therefore reflect the model based on the content retrieved for version 1 and adapt the interaction flows accordingly.

### **Middleware**

From the middleware perspective, we would like to discuss the payment options of the Change2Twin marketplace in order to design and develop respective features. The idea is to provide component to the middleware that can calculate the cost of purchased items on the marketplace accordingly to the pricing model and create respective invoices or provide the other way of charging the user.

The user on the landing page purchases items; then, we need to design a model that includes all types of offerings available on the marketplace; therefore, calculating and bills might change, accordingly to the pricing models.

### **Infrastructure**

From the infrastructure perspective, plans concern mainly maintaining the infrastructure and solving technical issues for the marketplace and already running services. This includes further setting IT environment to instantiate services to WP3 pilots and potential marketplace users, based on their requirements. To support middleware in providing billing capabilities, we plan to deliver usage monitoring functionality.

## 6 ANNEX A: MARKETPLACE ARCHITECTURE

The architecture consists of the marketplace landing pages, the middleware which is connected to the CloudBroker Platform (CBP) and Infrastructure layer.

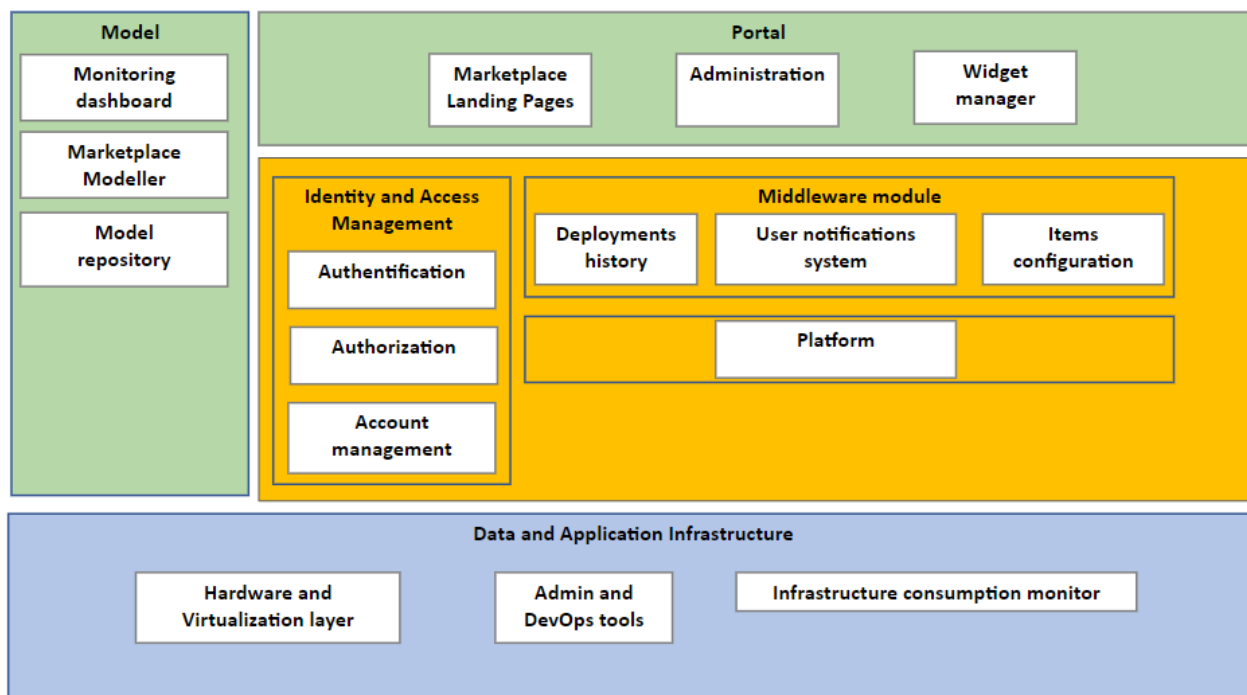


FIGURE 8 COMPONENT ARCHITECTURE OF THE C2T MARKETPLACE

By initial design, the marketplace landing page consists of three main modules as the Marketplace Landing Page (Model & Micro-Frontends), Middleware and the Infrastructure layer.

| Component            | Component Description  |
|----------------------|--|
| Monitoring Dashboard | Component responsible to measure and assess the design and operating effectiveness of the marketplace items and its deployment. The dashboard uses meta-information as well as operation information and provides meaningful assessment results for iterative improvement.<br><i>Status: planned for release 2</i> |
| Marketplace Modeller | Modelling interface for the marketplace, required to define and specify items and establish the knowledge representation required for assessment, operation and visualisation.<br><i>Status: initial version available for release 1, adaptation and release for D2.2</i>  |
| Model Repository     | Persistence layer of the modeller as an open repository of items. Different model representations are supported including interfaces for retrieval and discovery.<br><i>Status: initial version deployed and ready</i>   |

|                           |   |
|---------------------------|---|
| Marketplace Landing Pages | Generative approach for Marketplace Item Micro-Front Ends, based on the model definition and elevating the representation towards interaction<br><i>Status: initial version available</i> |
| Administration            | Support the governance process in an integrative manner<br><i>Status: initial, organisational implementation ready, planned for release 2</i>   |
| Widget Manager            | Composition manager to a) handle the interaction per item and b) as a composition of items  |

| Component                | Component Description  |
|--------------------------|--|
| Authentication           | <i>Responsible for the user identification on the Change2Twin marketplace during the authorization process.</i>  |
| Authorization            | <i>Responsible for the providing access and rights for the marketplace users.</i>  |
| Account management       | <i>Responsible for interaction with account e.g., changing the password, updating email etc.</i>   |
| Deployments history      | <i>Contain information – what user run and sends it to the marketplace where you may see the current status of virtual machines and their executions respectively.</i> |
| User notification system | <i>Responsible for sending notifications about organization's balance, user's status, executions errors, etc. via email.</i>   |
| Items configuration      | <i>Responsible for configuring the item: firewall rules, specific configuration related to the CloudBroker platform (region, instance type).</i>                       |
| Platform                 | <i>Responsible for starting VMs, deploying software/solutions on them, monitoring and reporting overall status to higher levels.</i>                                   |

| Component                          | Component Description  |
|------------------------------------|--|
| Admin and DevOps tools             | OpenStack components providing API interface, orchestration, fault management, dashboard<br><i>Status: operational</i>   |
| Infrastructure consumption monitor | Responsible for monitoring services availability and resource utilization to support billing<br><i>Status: initial, to be liaised with middleware requirements</i>   |
| Hardware and virtualization layer  | Responsible for providing i) infrastructure services: compute power, storage, network, and ii) virtual machines with variety of operating systems (e.g., Windows, Ubuntu Linux, CentOS Linux).<br><i>Status: operational</i> |

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