

DECENTER

Decentralised technologies
for orchestrated Cloud-to-Edge intelligence

D2.3

DECENTER Business Models

22/07/2021

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The content of this document is the result of extensive discussions within the DECENTER © Consortium as a whole.

More information

Public DECENTER reports and other information pertaining to the project are available through DECENTER public Web site under <http://www.decenter-project.eu>.

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1. Executive Summary

This document contains the report on the final version of the DECENTER business models and describes the full process carried out to obtain them. Additionally, it also provides updates on the market context, which has slightly shifted from purely edge computing to the “AI at the edge” domain where DECENTER results fit better. This deliverable includes all the work carried out in task T2.3 during the third reporting period.

The document is related to D2.2, which included the preliminary version of business models and market analysis. It also relates to D3.4, as a competitors’ analysis in the AI at the edge market segment was elaborated in that document. And finally, this work is intertwined with D6.5, which documents the current and future exploitation activities of DECENTER results.

The goal of Task 2.3 was to create a portfolio of application, service and infrastructure **deployment scenarios** in which DECENTER fits for **real world business models** and goals.

The task roadmap shows how from the initial market analysis based on the DECENTER results, the business models can be identified in collaboration with partners (workshop) and validated with external stakeholders through surveys and interviews to finally produce a final validated version of the business models and an adoption roadmap of them in the use cases.

During last year of the project, the architecture was evolved to provide more relevance to on top services and then project results were classified as platform-oriented results (fog, IoT and brokerage platforms) and add-on services (digital twin, AI, security and data management). This new view changed also the market segment where the project results were fitting. Now, we have realised that the AI at the edge segment is closer to the project than pure edge/IoT segment. In the conducted market analysis, several analysts’ reports confirm the positive trend for Edge AI market. DECENTER fits in many of the market segments.

There have been two iterations in the definition of DECENTER business models. In a first stage, DECENTER as an overall and monolithic platform was considered, so the elaborated business models were oriented to explore the way to make profitable the platform itself. This was the work reported in D2.2 and the seed for the internal remote workshop which is described below in section 5.1. In part, thanks to this workshop, but also to the evolution of the technical developments in the use cases, it was realized that the project results were indeed of two types (as described in section 5.2): a core platform that provides the baseline functionality for doing AI at the edge and a set of surrounding services that provide specific functionalities for advanced features. Thus, the business approach was revisited, and new business models were elaborated as described in section 5.3.

Based on the final architecture and the expected outcomes of the project in terms of functional blocks, the initial business models were reviewed and produced again. It was also considered the adjustment made in the target market, moving from edge/IoT platforms in general to solutions more focused on AI at the edge. These elements conducted to redefine the value proposition of the overall solution and to consider not only the global solution as the unique exploitable asset, but also the modular set of services as an alternative choice for future profitability. Four types of business models were analysed: Full Solution (platform + services) BM where all components were in place; Minimal Viable Product (MVP) BM for generic scenarios which use essential functionality of DECENTER (mix of platform and services); some examples of applicable scenarios beyond the project use cases in order to demonstrate the validity of DECENTER beyond the project use cases; and use cases BMs for the specific pilots in project.

After the theoretical analysis about potential Business models for DECENTER solution, a validation in the real world with external stakeholders and use cases was required. The survey has been a very useful instrument to assess the assumptions about possible impact and adoption of DECENTER in potential customers. It has showed the relevance of DECENTER results in the market, the value it brings to the business and the requirements are needed to set up DECENTER in a real scenario.

In parallel to the survey for external stakeholders, personal interviews with the project use cases were conducted by the business models team. The goal of these interviews was to discuss about preliminary business model, update it in case of need and define the realistic adoption path that each use case owner expected to apply.

2. Introduction

The present deliverable describes the detailed analysis of DECENTER business models corresponding to the Task 2.3 in WP2. A preliminary version was already depicted in deliverable D2.2 at M24. In D2.2, it was defined the roadmap of the activities, described a first market analysis and identified a set of possible business models for DECENTER solution. During this last year a series of activities have been carried out to go step further in the identification of suitable business models for DECENTER and will be detailed along the report. In this process, the recommendation provided by the reviewers in the first review has been carefully considered by extending and extensively challenging the preliminary business models and by defining an adoption roadmap for the use cases to contribute to the fruitful exploitation and marketing of DECENTER results.

As described in the description of action, the goal of Task 2.3 was to create a portfolio of application, service and infrastructure **deployment scenarios** in which DECENTER fits for **real world business models** and goals. In order to achieve this goal, following activities have been carried out:

- **Study existing and emerging value chains.** By analyzing the current solutions in the market for edge computing and for deployment of AI artifacts in the edge, we have observed what exists and what is emerging to cope with the demand of users and edge/AI services providers. A preliminary market analysis was conducted and included in D2.2. In this deliverable, we have revisited that analysis to update it to the final DECENTER results and context.
- **Identification of novel business models.** By looking at the DECENTER solution and exploring the possible deployment in real scenarios, we have elaborated several examples of Business Model Canvas which describe the potential customers, value proposition for them, key activities, partners and resources, cost and revenue streams. A first set of business models were included in D2.2 with the information and results status we had at that time. In this deliverable, we come up with some new examples and revisions to the ones already produced beforehand.
- **Create incentives towards the competitors.** By identifying and analyzing the pros and cons of DECENTER solution with regards to other similar solutions in the market. A preliminary competitors' analysis was included in D2.2 for edge in general. D3.4 includes a more focused and complete analysis of DECENTER versus other solutions for AI at the edge, which we think is the concrete domain of project results.
- **Check satisfaction of stakeholders' requirements with such business models.** By selecting a group of external stakeholders to the project to present them DECENTER proposed solution and possible business models and get their feedback and advice for further development and exploitation after project end.
- **Adoption of new business models by the use cases.** By exploring with the four project's use cases the actual deployment of DECENTER in their real scenarios and how the proposed business models fit into their businesses and possible adaptations they may have.
- **Mapping of business models into partners' exploitation plans.** By providing the business models produced in the context of T2.3 to T6.2 which is dealing with the exploitation plans of the partners, so they decide how they deploy DECENTER results

into their own businesses and by leveraging in proposed business models to make some profits from the project results.

Along the document, in the different sections, all the above-mentioned points have been developed. In section 3, the overall roadmap and planning for the task is presented. Section 4 is an update of the market context in which the project is developed. In Section 5, the DECENTER results are summarized to be used as the technology behind the value proposition in the business models. A set of business models are described by using Business Model Canvas technique as a result of an internal workshop that took place in autumn of 2020. A final group of business models is described after final revision and adaptation to the final outcomes of the project. Section 6 is devoted to the validation of the results and business models by the stakeholders including the followed process, the actions carried out with them and the analysis of the obtained feedback. Finally, in section 7, the work with use cases about their adoption roadmaps is reported. The document is closed by some conclusions and take away for the readers.

3. Activity roadmap

The present report covers the work in T2.3 carried out till end of the project, basically last year of execution. The previous work was reported in D2.2, so this deliverable is an update and extension of what was described there. In order to organize the work in this second iteration of the task a work plan was elaborated at the beginning of the period as it is shown below. Basically, this work plan tried to implement the activity roadmap which was decided at the beginning of the task and that is also included here again for the convenience of readers.

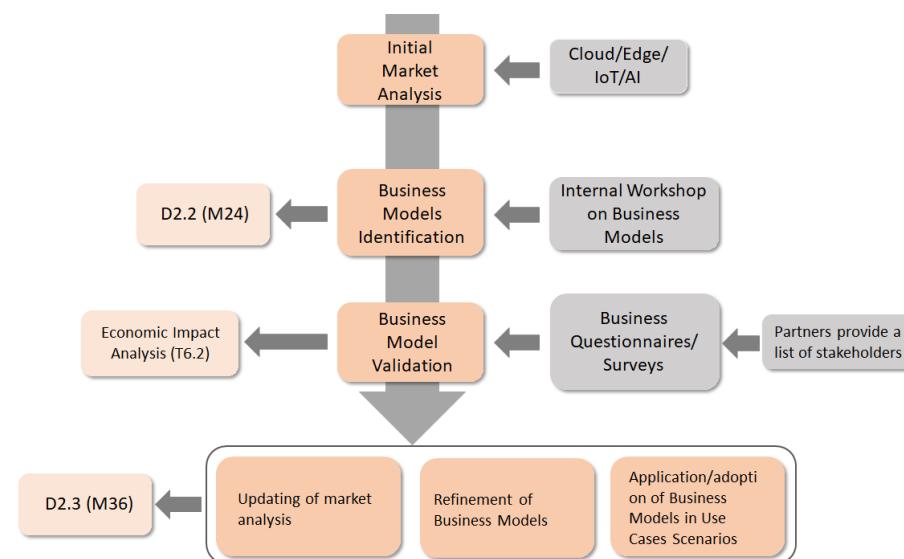


Figure 1. Activity roadmap

The roadmap shows how from the initial market analysis based on the DECENTER results domain, the business models can be identified in collaboration with partners (workshop) and validated with external stakeholders through surveys and interviews to finally produce a final validated version of the business models and an adoption roadmap of them in the use cases.

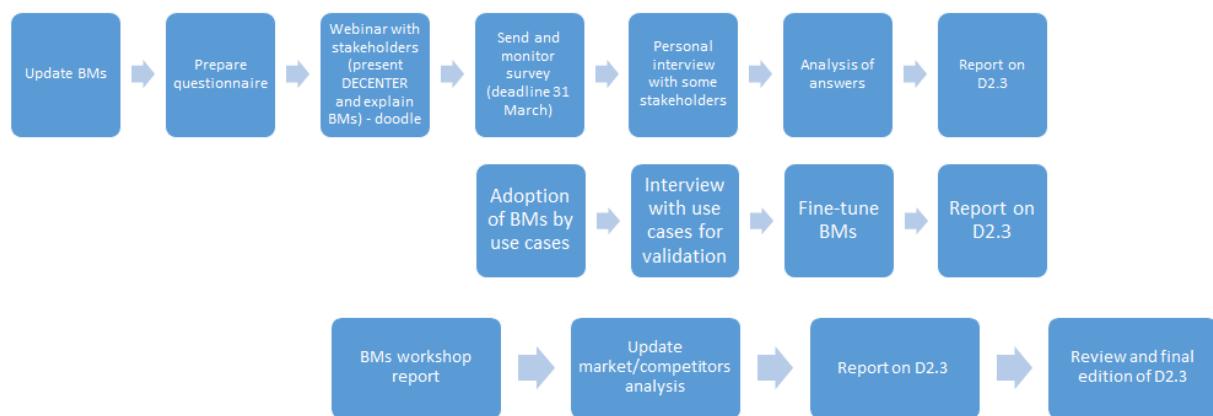


Figure 2. Activity work plan Y3

The activity work plan above just put in a sequenced timeline the steps identified in the roadmap. It was executed according to the plan. All the phases are reported in the different sections of this document.

4. Market Context

In previous deliverable D2.2, a preliminary market analysis was conducted with the focus on edge computing and IoT market. At that time, more than one year ago, the DECENTER results were keen on the edge orchestrator and IoT platforms and add-on services were not sufficiently developed and exploited. Thus, the analysis put the focus on the edge/IoT market segment, and the considered competitors were the traditional cloud/IT vendors and emerging edge/IoT providers.

During last year of the project, the architecture was further evolved to provide more relevance to on top services and then project results were classified as platform oriented results (fog, IoT and brokerage platforms) and add-on services (digital twin, AI, security and data management). This updated view also changed the market segment where the project results were fitting. Now, we have realised that the AI at the edge segment is closer to the project than pure edge/IoT segment, as the ultimate goal of DECENTER is to facilitate the development of AI applications leveraging on edge/IoT infrastructures by allowing AI developers of abstracting from hardware management. AI at the edge is understood here in two senses: allowing AI apps using effectively edge devices; and using AI to improve efficiency in edge devices.

For the competitors' analysis in the market segment, we refer to deliverable D3.4 where it has been included some similar solutions to DECENTER in the AI at the edge domain. ARM, EuroTech, NVIDIA and Microsoft Azure were described and analysed in comparison to DECENTER features. As it was stated in such deliverable as result of the analysis, DECENTER is the only complete offering which provide high value for money since it requires few investments for adoption and then higher percentage of revenue. Despite of DECENTER allows to avoid the vendor lock-in, other comparable solutions have a stronger ecosystem and more solid commercially as they have been in the market for longer time.

Some market insights which reinforce the relevance of DECENTER solution.

Following Gartner hype-cycle of edge computing in 2020¹, *Edge AI software refers to the use of systems for orchestrating, integrating, deploying and monitoring ML models across edge and IoT environments*. According to Gartner, the maturity of this market is still emerging and only represents between 1%-5% of penetration, while the benefit rating is high.

According to IDC², *the AI component of the Edge will become increasingly important, driving 10% of the market and doubling its market share by 2024*. Currently the process of data in real time is becoming a critical mission for many companies and technologies like AI by providing models to analyse and make predictions based on that data are crucial for the fulfilling the mission. So far, the computation of these models was mainly done in cloud or datacenters, but due to *the advancements in the silicon industry and the ability to run increasingly efficiently AI models on small footprint devices*, *Edge is becoming the preferred environment*. The use of edge devices for computing AI models allows a better time-to-value and cost effectiveness. Now, cloud is more used for the AI model training, while edge is used mainly for AI inferencing.

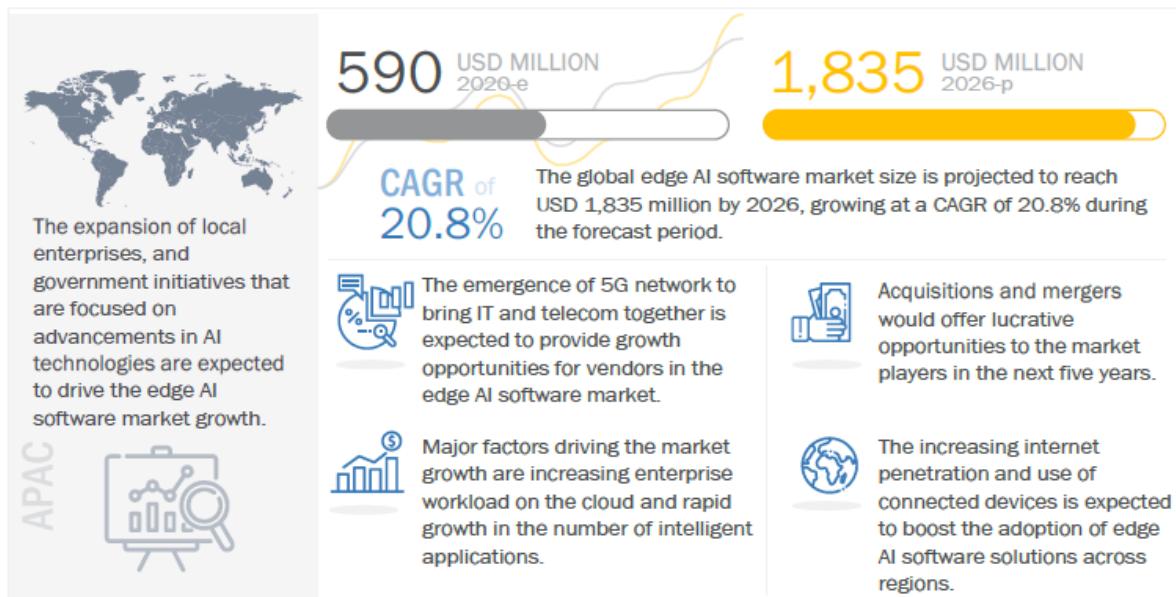
¹ <https://www.gartner.com/en/documents/3989981/summary-translation-hype-cycle-for-edge-computing-2020>

² <https://blog-idceurope.com/5-areas-where-edge-computing-will-be-key-for-developing-innovative-technologies/>

By teknowlogy.com, *while edge-based AI is faster, offline-compatible, less resource-intensive and more respectful of privacy, it has also major drawbacks as:*

- Deploying a model on many types of devices is not trivial as today's technologies.
- Updating the model used for inference in the edge is more difficult than updating a central model in a private or public cloud, as edge devices are distributed in several locations.
- It may difficult the AI model training as it is not learning from the inference process in the edge.

In order to understand better the Edge AI market, a report from MarketsAndMarkets³ explains which are the main forecasts, dynamics and drivers of this market. According to them, the global edge AI software is projected to reach up to 1.835 USD millions by 2026, that is three times more than in 2020. This represents a Compound annual growth rate (CAGR) of almost 21% in this period.



e: estimated; p: projected

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

This analyst shows as main drivers for the market the rapid growth in number of intelligent applications and the increasing enterprise workloads in the cloud which are impacting in the need of having more computation in the edge. However, privacy and security are still concerning in edge AI applications. The emergence of 5G network is seen as an opportunity to bring the IT and telecom markets together and will foster definitively the plethora of solutions at the edge in many sectors. In the numerous interviews the analyst did, low interoperability and optimization of standards were the identified challenges for the upcoming future.

³ <https://www.marketsandmarkets.com/Market-Reports/edge-ai-software-market-70030817.html>

The edge AI market is divided into several segments which are represented in the picture below. The red arrows mark those segments which DECENTER is also addressing, so it shows the mapping of DECENTER into the market and how is present in all the segments.



According to MarketAndMarkets, the video surveillance segment (video and image recognition), the Energy and Utilities vertical and North America region are expected to hold the largest market size, but Asia Pacific in growth.

5. Novel business models for DECENTER results

There have been two iterations in the definition of DECENTER business models. In a first stage, there was considered as a result of DECENTER the overall DECENTER platform as a monolithic element was taken into account, so the elaborated business models were oriented to explore the way to make it profitable the platform itself. This was the work reported in D2.2 and the seed for the internal remote workshop which is described below in section 5.1. In part, thanks to this workshop, but also to the evolution of the technical developments in the use cases, it has been realized that the project results were indeed of two types (as described in section 5.2): a core platform which provides the baseline functionality for doing AI at the edge; and a set of surrounding services which provide specific functionalities for advanced features. Thus, the business approach was revisited, and new business models were elaborated as described in section 5.3.

5.1 Initial business models workshop

Once a preliminary business model was depicted (included in D2.2), DECENTER partners were invited to an internal remote workshop carried out by T2.3 team to discuss on the initial business models for DECENTER results and how to exploit them by the use case partners, considering the different partners' profiles.

The workshop was carried out on April 21, 2020 (M22) and was attended by seven participants from some DECENTER partners: Orlando Avila (ATOS), Soonho Lee (Daliworks), Janez Breznik (UL), Domenico Siracusa (FBK), Levent Gürgen (Kentyou), Andrea Leveghi (TN) and Ángel Soriano (ROB).

The workshop was split into three parts:

1. Firstly, as most partners were not familiar with the business model concept and the Business Model Canvas (BMC) technique, the first part of the workshop was to present the concepts and all the elements of the BMC tool.
2. Then, an initial version of the BM for DECENTER results was presented. At this stage of the project, the main result was only the DECENTER platform, so services around the platform were not yet depicted by the partners, that is why they are not mentioned in the business models you will see below. All partners discussed it and refined the initial proposal for the DECENTER business model in a general way.
3. Once the business model for the DECENTER platform was discussed, the partners were asked for filling all the BMC features (Customer Segment, Cost Structure, Revenue Streams, and Key partners, among others) in case they were the commercial providers of the DECENTER platform, and leverage the DECENTER platform for their businesses.

An online presentation was used to carry out the remote workshop and BMCs templates. Partners who did not attend the event were sent the workshop presentation and a BMC template to collect their specific contributions to their use cases offline.

During the plenary discussion, DECENTER partners highlighted that at that stage of the project they did not know yet which services/solutions specifically DECENTER platform could

provide since the final definition of the use cases components was still ongoing. So, they discussed the BMs considering their general knowledge of the platform as a whole at that moment. An initial draft of the BMC for DECENTER platform was presented by the task team, which was refined by the discussion outcomes.

The outcomes of the workshop were a more refined business model of the DECENTER platform and an initial analysis of the business models for the different use cases. The BMCs resulting from the partners discussion can be found as reference in Annex I, thus they can be compared with the updated ones in sections 5.3 and 7.

Some of the points discussed in the workshop were:

- Partners noted the importance of a joint exploitation agreement in case of an exploitation of DECENTER platform by the partners, which includes partners' roles, obligations, responsibilities, etc. taking into account that may some partners are not interested in participating as an active partner in the joint exploitation due to its organization profiles, but instead as a key partner.
- The BM needs to specify whether the Cloud Services are going to be offered along with the DECENTER Platform or not, as well as the IoT infrastructure
- In this BM are included all the potential customers for DECENTER Platform regardless of the project use case.
- During the workshop, several concerns arose regarding the revenue stream. Some partners highlighted that the revenue stream and customer segment will also depend on the profile of the company/partner who will run the business and their commercialization strategy or interests. This point will be addressed by the following BMs personalized by use case partners, which provide initial BMs that may be adopted by DECENTER use case partners.

- **UC1: Smart City Crossing Safety Business Model**

The Municipality of Trento remarked that they could exploit the platform to provide services to their citizens or provide DECENTER user case result to SMEs working in Smart City domain.

- **UC2: Robotics Logistics Business Model**

Robotnik will leverage the DECENTER project results to include some project features and software developments into its manufactured robots. Robotnik's customers are mainly Warehouses.

- **UC3: Smart and Safe Construction App Business Model**

The University of Ljubljana is interested in providing Consultancy services to construction companies as advisors on the use of AI in construction.

- **UC4: Ambience Intelligence for Safety at Home and Around Business Model**

KETI's main customers could be innovative companies developing Cloud/Fog/IoT applications or services targeted to smart office/house and they think they could provide DECENTER platform solutions through subscription fees. Pay-per-use for AI solutions or customized pricing based on specific projects. They also would like to provide consultancy services.

More details about the partners' individual and collective exploitation plans and mapping of these business models in their plans can be observed in D6.5.

5.2 Updated description of DECENTER outcomes

The business models depicted in the workshop reported in the previous section were produced taking as project outcome the existing platform at M22, April 2020, as described in deliverable D2.2, putting the emphasis in the exploitation of the platform itself as a whole. During the workshop, and in further discussion within the consortium, both the architecture and the exploitation mindset were progressing more towards a service-based concept and business models. Then, the identified business models so far, had to be revisited again according to the latest version of the architecture, which high level view can be seen in the figure below.

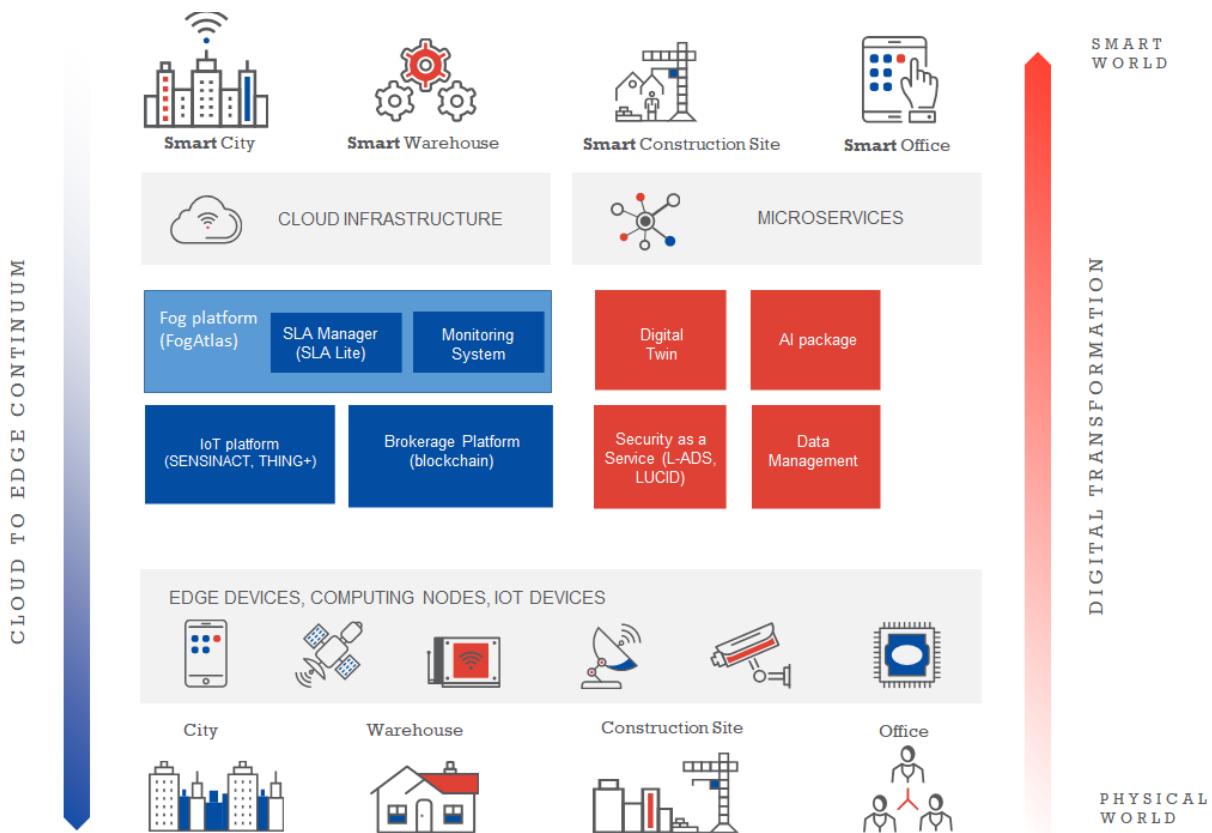


Figure 3. DECENTER high level architecture

The blue and red colours in the picture represent the available set of platforms (in blue) and services and tools (in red). The table below shows the provided functionality for each of the three platforms (including the sub-components) and the four core services. It also indicates the components that have been used by the four use cases in their pilots, according to the interviews held with all of them to review their business models and discuss the adoption roadmap (see section 7 for more details). Further details on the components can be consulted

in the technical deliverables of the project. This section only recaps the list to provide the context for the current deliverable.

DECENTER component	Provided functionality	UC1 (TN)	UC2 (ROB)	UC3 (UL)	UC4 (KETI)
Fog platform (FogAtlas)	Resource orchestration, infrastructure Management, dashboard	O	O	O	O
SLA Manager (SLALite)	Smart Contracts, assessment of violation of contracts between services		O	O	
Monitoring System	Monitoring of edge/cloud infrastructure, collects metrics and store them	O		O	O
Brokerage platform	Selection, selling and exchange of resources (using blockchain)	O		O	
IoT platform (Sensinact or Things)	Capturing of data from physical world and providing analytics				O
AI package	Data compression, interfaces to AI microservices, model management	O	O	O	O
Data Management	Model repository, Access verification to models, data privacy	O	O	O	O
Digital Twin (Sensinact)	Representation of real world by modelling how would be and using real data	O	O	O	O
Security as a Service (L-ADS, LUCID)	Security (by anomaly detection) and Robustness		O		

Table 1. Mapping of DECENTER components into use cases implementations

5.3 Final business models of DECENTER results

Based on the final architecture and expected outcomes of the project in terms of functional blocks, the initial business models were reviewed and produced again. It was also considered the adjustment made in the target market, moving from edge/IoT platforms in general to solutions more focused on AI at the edge. These elements conducted to redefine the value proposition of the overall solution and to consider not only the global solution as the unique exploitable asset, but also the modular set of services as an alternative choice for future profitability.

Therefore, four types of business models were analysed:

- Full Solution (platform + services) BM: where all components were in place. It is the less probable, but applicable to many cases. Figure below presents the elaborated BM for this case.
- Minimal Viable Product (MVP) BM: for generic scenarios which use essential functionality of DECENTER (mix of platform and services). The exploitable assets would be a subset from full solution. Looking at the used components by the use cases, the MVP should be formed by: **Fog Platform, AI Package, Digital Twin and Data Management**, as these elements are present in the four use cases. Conceptually, the BM would be quite similar to the Full Solution BM. This is the MVP of the demand, that is, of the DECENTER users, which represents what the users need from DECENTER solution mainly. In the context of D6.5⁴, a different MVP has been identified focusing on the maturity level (TRL >= 6) and integration (IRL >= 4). In that case, the components of MVP would be the **FogAtlas, Monitoring System, IoT platform, SLA manager and AI package**. By comparison of both MVP sides, it is easy to identify the gaps covered by DECENTER and future challenges still in the roadmap.
- Some examples of applicable scenarios beyond the project use cases. In order to demonstrate the validity of DECENTER beyond the project use cases, a realistic scenario was defined to show how DECENTER would be deployed in such case and which will be the corresponding BM, as described below.
- Use cases BMs for the specific pilots in project. Section 7 is fully devoted to the final business models of the use cases.

The **full solution business model** is showed in the figure below. The identified customers for DECENTER as a whole were the cloud/fog/IoT providers and the innovative SMEs and companies which develop AI based applications. DECENTER may offer them (value proposition) to close the gap between AI developers and infrastructure operators and to facilitate for them the creation and operation of AI-based cloud native applications. The partners could engage customers in different ways such as webinars and training courses, doing innovation workshops with them, offering them pilots to demonstrate DECENTER benefits or taking advantage of partners' strategic partnerships with service providers. The engagement can be done by several channels like the project web site, the social networks, conferences, industrial events, etc. Some key activities are needed to be able to provide the value proposition stated above: maintenance and evolution of components and services; and promotion of the results to engage customers. To perform such activities, some resources will be needed as for example: the DECENTER components themselves, the knowledge of the partners to provide services and they effort in time and cost that they will need to maintain and promote the components and services. Project partners can provide the DECENTER solution alone or in partnership with others like service providers, OS communities, startups or future research projects working on similar or complementary areas. In relation to the cost-revenue streams, the cost is mainly related to the personnel cost required to maintain the components and promote them; while the revenue could come from the license of some of the components, pay per use model in case of platform as a service, fix price for a project or pilot execution or new public funding in case of future awarded research projects.

⁴ Refer to D6.5 for more information about these metrics and their evaluation

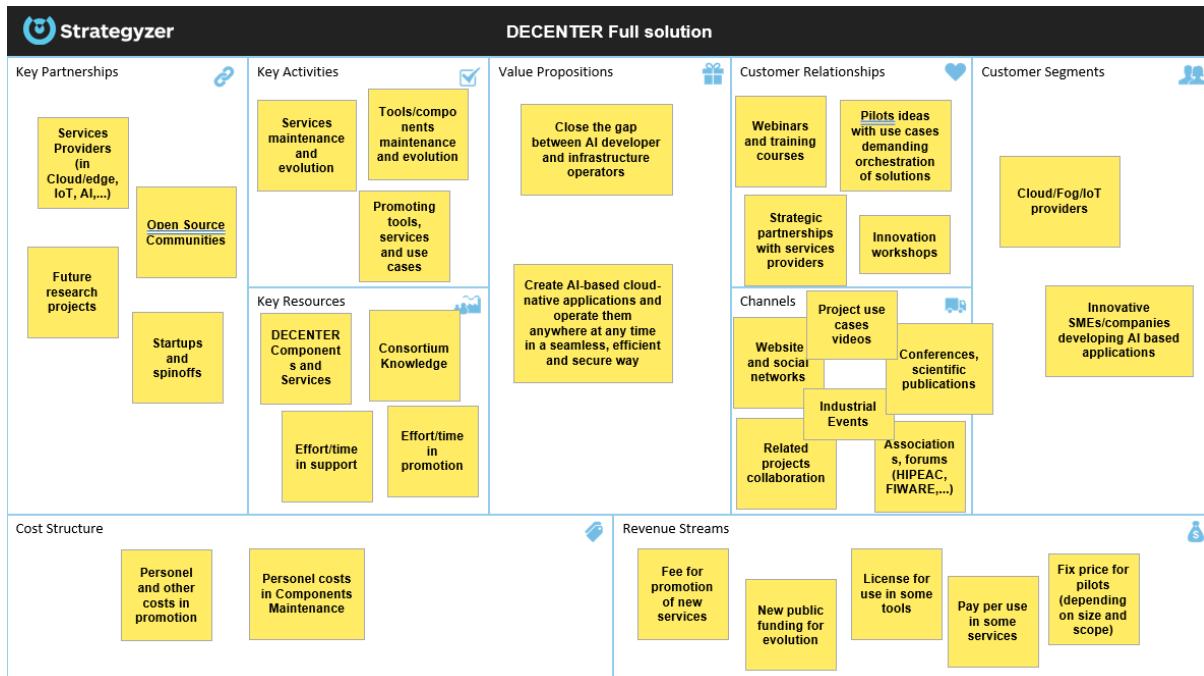


Figure 4. DECENTER full solution BM

Bearing in mind that DECENTER architecture can be consumed in a modular way, and observing that the use cases did not need all the components to run their scenarios, the idea of having alternative DECENTER deployments with a sub-set of platforms and services was reinforced. These different deployments were also conducting to more focused business models of smaller scope. Following, an example of DECENTER deployment in the optimization of winery production is described.

Let's imagine a wine producer who has some IoT sensors in the cultivation for measuring humidity and temperature connected to an **IoT Platform hosted in the local edge**. He has also running a **local AI service** for the prediction of the best time for the vintage based on data from sensors and drones running in a **local Edge device**. In last modernization of the winery, he also counts on some drones' observation provided by a **third-party** provider through an **AI service** embedded for the detection of grapes colour in vines and running in a **remote Edge**. Figure below show graphically the scenario.

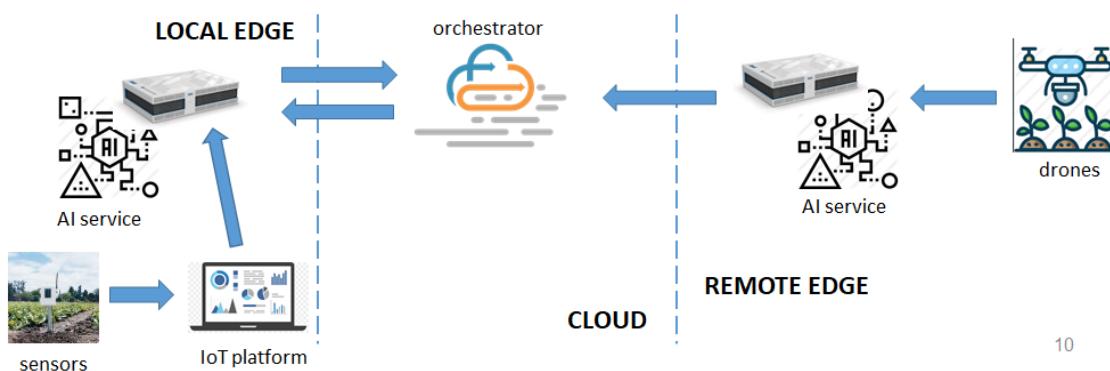


Figure 5. Example of DECENTER deployment – description

The DECENTER components that would be required to implement this scenario would be the following:

- **IoT Platform** to collect the data from the sensors
- **Digital Twin** for representation of the real world and simulation
- **AI package** to manage the local AI service
- **Model optimization** to prepare and optimize the local AI service
- **FogAtlas** service orchestration platform to smartly deploy the services in local Edge, remote Edge and cloud infrastructure
- **Monitoring System** to monitor de availability of all deployed services
- **SLA Lite** to establish the contract between local AI service and remote AI service provided by drones third party
- **L-ADS** to monitor and detect anomalies (security issues) in incoming network traffic to FogAtlas

By mapping the DECENTER components needed in the concrete scenario, the actual deployment could be similar to this:

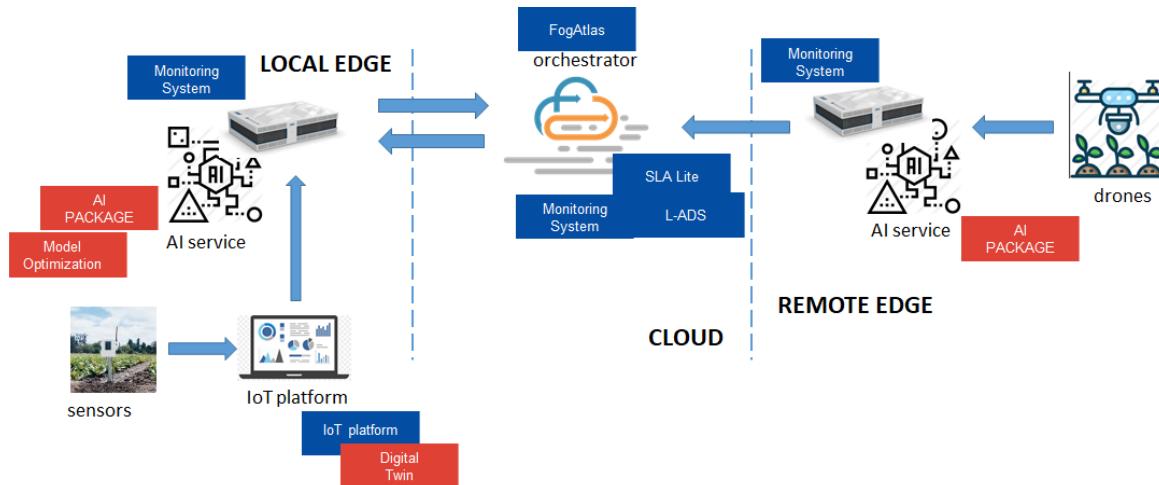


Figure 6. Example of DECENTER deployment – mapping

DECENTER partners (owners of the required components to build the solution) are curious to see how they could get some benefits from the customers involved in this scenario, so they can check the proposed business model below. In order to facilitate the reading of the business model canvas, different colours have been used to identify the flows for the three types of customers in the example: the wine producer as final user, the IT company which is developing the solution for the wine producer and the AI service provider which is providing her service through the DECENTER platform.

The wine producer (in blue) will be interested in monitoring and predicting when his grapes will be in the right time for the vintage. Thus, he will not be the direct customer for DECENTER

but for the IT company which is developing them the solution. It has been put here to clarify his value proposition.

The IT company will use DECENTER to easily create the application that the wine producer needs. They probably knew about DECENTER through our web site, social networks or some event and they will learn from DECENTER by some webinars and courses. The key activities for them will be to deploy the DECENTER components, develop the specific applications, acquire the sensors and edge devices were required by the wine producer and hire the drones service. The IT company then, will require a kind of partnership with several providers. The company will have to invest in the application development and providers' services costs, while DECENTER partners will have to invest in maintaining (and maybe support) the IT company for the components it will use. On the other side, the partners could get some revenue by licensing the components or charging for the provided support to the IT company.

Finally, an AI service provider could be interested in providing its service through DECENTER catalogue of services and use DECENTER components for focusing on the AI service development, abstracting from the deployment. In this case, the AI service provider could pay per use of the DECENTER components required to develop its service.

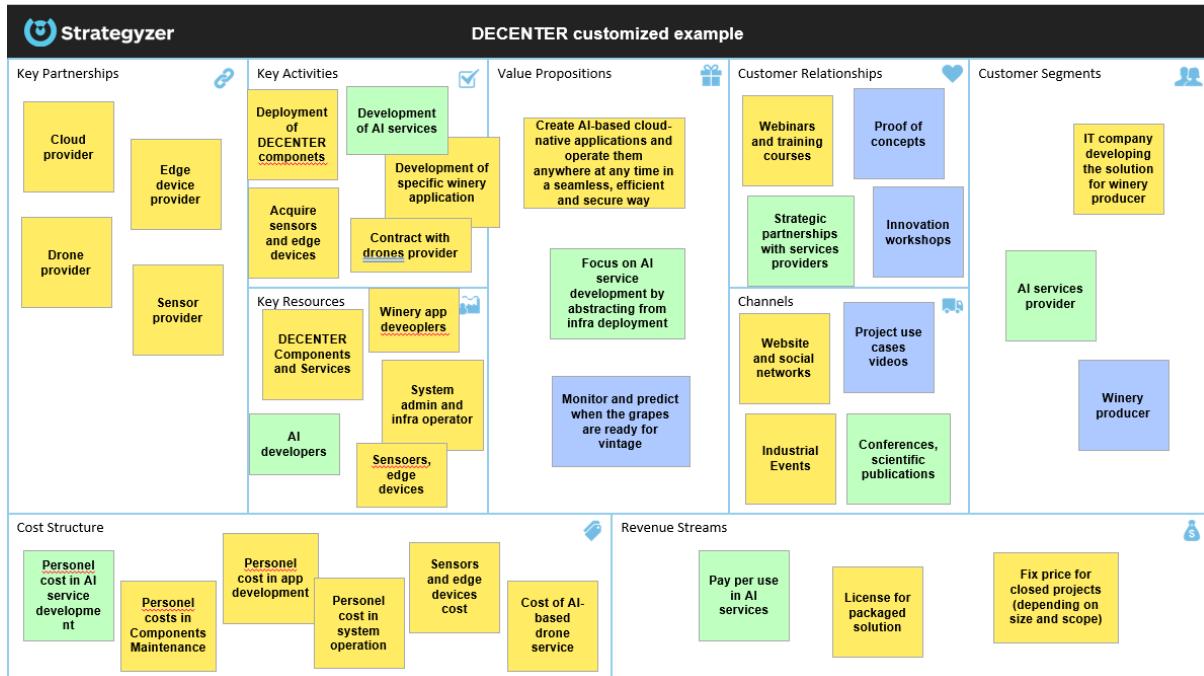


Figure 7. DECENTER winery example BM

6. Market validation of DECENTER business models

After the theoretical analysis about potential Business models for DECENTER solution, a validation in the real world with external stakeholders and use cases was required. This section details how it was conducted and the obtained results.

6.1 Method of work

Figures 1 and 2 of this document show the different steps have been followed in this activity. The approach has been working first internally in the project by analysing the potential market, the exploitable results, the possible ways to do business around the results and then assess the theoretical work, first internally with existing use cases in the project, and secondly with some external stakeholders, to avoid any bias that project partners may have.

For the internal part of the process:

- market analysis reports have been consulted;
- some workshops have been organized to discuss about the business models;
- analysis of competitors was conducted to identify the differentiation points and value proposition of DECENTER;
- and finally utilization of a known tool like Business Model Canvas to model the possible business models by experts in business development.

This first internal part was complemented with interviews with the use cases partners to depict their adoption roadmap as can be read in section 7.

The external action was the presentation of DECENTER to a group of 20 stakeholders outside of the project and the request to fill a survey with their feedback about project results and potential business models. The details about the conducted work and results of the survey can be seen in following sections.

The list of stakeholders was selected by all partners from their network of partners or customers. It was intended to include all the geographies across Europe and Korea and all types of profiles (academia, industry, final users) in order to get a more complete and holistic feedback.

In order to get more accurate answers from the selected stakeholders, two online workshops were organized (on 26th February and 4th of March) with them to explain them in advance the project, the results and the proposed business models. Not all the stakeholders attended the offered workshops, but the presentation was available for all of them. They had till 30th April to provide their answers before analysis. All partners supported in pushing their contacts to fill the questionnaire.

6.2 Validation criteria

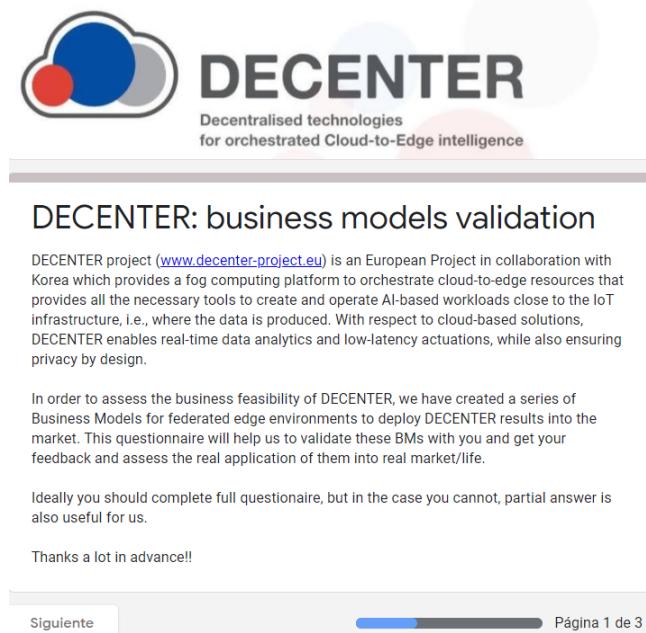
The survey was elaborated with the purpose to assess the validity of DECENTER in relation to the potential impact the project may have and how easy the adoption of results could be. Thus, beforehand thinking on the survey questions, the WP2 team worked on the criteria that the survey should ask about to measure the level of impact and adoption of the project.

The table below shows the criteria chosen and the concept that stakeholders must value from lower to higher with five possible choices.

	Criterion	Value [0 - 1] lower, [1 - 2] low, [2 - 3] medium, [3 - 4] high, [4 - 5] higher
IMPACT	Revenue stream potential	Value the revenue stream proposed by the BM
	Customers' acceptance	Value the customers' acceptance of the product or service
	Differentiation	Value the novelty on the market comparing with other existing solutions
	Visibility	Value the potential to raise attention without dedicated marketing campaigns
	Customers' need assessment	Value how important for the customer is the need met by the solution proposed
	Impact on the customers' business	Value how the solution impact on the customers' business in terms of benefits
EASE OF IMPLEMENTATION	Criterion	Value
	Investment costs/customers	Value investment costs for customers
	Learning Curve	Value the time invested in learning how the solution works
	Integration	Value the integration effort to use the solution together with customers' existing infrastructures and providers services
	Transparency	Value how detailed is the info provided to the customers

6.3 Stakeholders survey

The survey sent to stakeholder after the two explanatory workshops was available almost one month for them to be filled at <https://forms.gle/4c3FYTAZkExaGHhA8> in Google Forms. After an introductory text, it had 6 questions about impact assessment and 6 for adoption feasibility, so it can be filled in about 10 minutes.



DECENTER: business models validation

DECENTER project (www.decenter-project.eu) is an European Project in collaboration with Korea which provides a fog computing platform to orchestrate cloud-to-edge resources that provides all the necessary tools to create and operate AI-based workloads close to the IoT infrastructure, i.e., where the data is produced. With respect to cloud-based solutions, DECENTER enables real-time data analytics and low-latency actuations, while also ensuring privacy by design.

In order to assess the business feasibility of DECENTER, we have created a series of Business Models for federated edge environments to deploy DECENTER results into the market. This questionnaire will help us to validate these BMs with you and get your feedback and assess the real application of them into real market/life.

Ideally you should complete full questionnaire, but in the case you cannot, partial answer is also useful for us.

Thanks a lot in advance!!

Siguiente Página 1 de 3

Here below, the list of stakeholders that were contacted in the process can be seen. We have not specified the concrete persons for data protection rules, but the name of participating organizations and the type of entity is listed here. In case of organizations that are also project partners, the contacted people were not involved in the project but belonging to other departments and with no previous knowledge about DECENTER. Some of the organizations played a double role as they could answer from diverse angles.

TYPE	SELECTED STAKEHOLDER
Infrastructure (cloud) providers	Atos, Gluesys
Technology Innovators (universities)	Aalto University, Sejong University, University of Lancaster, Ajou University, Postech, Hanyang University
Technology Innovators (companies)	U-HOPPER, Innogrid, OzLife, Intellicode
System Integrators	Deimos, Daliworks, Atos, Konika
End Users	Konika, Comune di Trento, Robotnik, CGP
Market researcher	IDATE

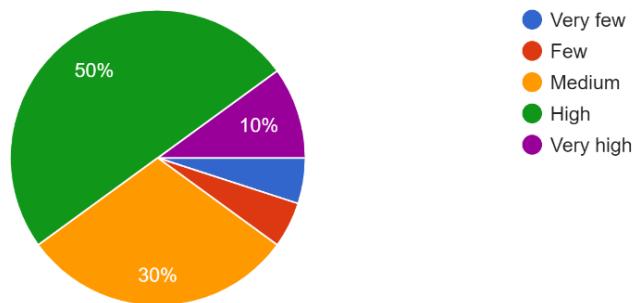
6.4 Analysis and results

Once collected the inputs, this section shows and interprets the obtained results. Each question is addressing some of the validation criteria above mentioned.

Impact assessment analysis

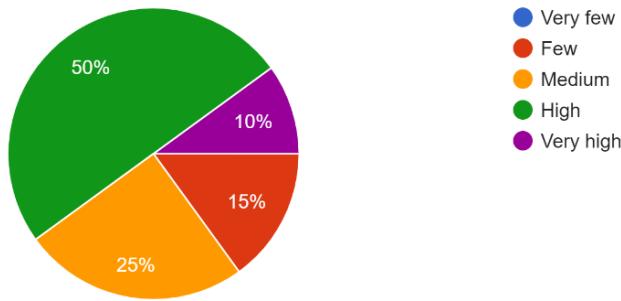
The first question was addressing the *Customer's need assessment* criteria and clearly the 60% of stakeholders considered that DECENTER is high or very highly a solution for them, plus a 30% more who are thinking could partially cover their needs.

How much is DECENTER proposing a solution that could be useful to solve any of your needs?
20 respuestas



The second question was asking about *Differentiation* of DECENTER from other existing solutions in the market. Again, here only the 15% of interviewed considered that DECENTER is few different from what exists. The remaining 85% in high, very high or medium term consider that results are promising in the market.

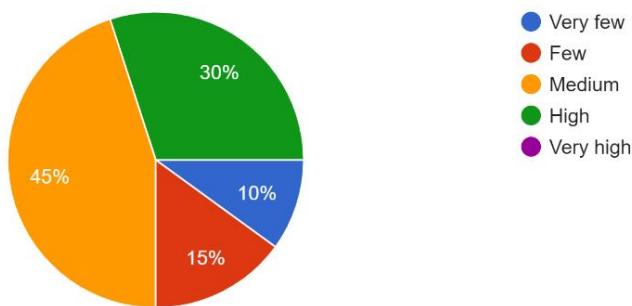
How much novel is DECENTER on the market comparing with other existing solutions under your knowledge?
20 respuestas



The third question was addressing the *Visibility* level of the project. The 25% of stakeholders were not almost aware of DECENTER before our contact, while 45% of them listened to talk about it and 30% were quite informed about what going on.

How much are you aware of DECENTER project and results?

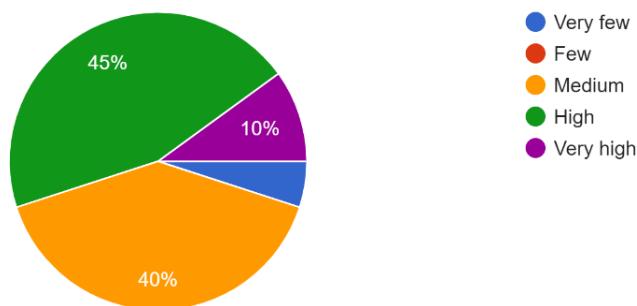
20 respuestas



Question below was intended to detect the *Impact on customer's business*, which benefit they would expect in terms of business. Practically all the stakeholders think that DECENTER may bring any kind of benefit to their business, being distributed mostly between high and medium expectation.

Which would be the degree of benefit in your business if you used DECENTER solution?

20 respuestas



Finally, people were asked to comment on the most valuable feature of DECENTER for your business/organization and they appreciated mainly: the orchestration of distributed edge/cloud resources; allowing saving time in developing applications; applicability in different domains; containerization of components and use of blockchain for smart contracts.

Complementary, they had also to express the most desirable feature which DECENTER should have for your business/organization. They provided various ideas that may also be considered for future enhancements:

- A security layer between Cloud and remote site probably based on vRAN technology. DECENTER already provides security mechanisms but not explored yet in the vRAN context (outside the scope of the project).

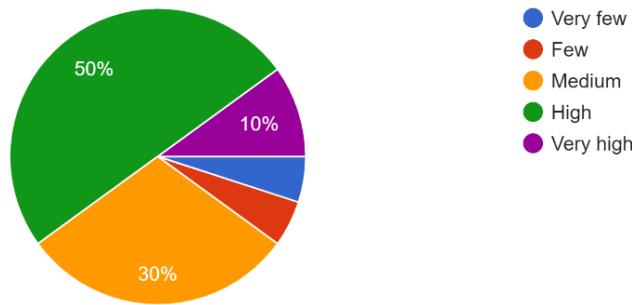
- Pre-packaged and validated software packages that could be demonstrated and shorten time to market for customers, ideally with the ability to implement a proof of value in weeks. DECENTER provides a repository with the ability to perform the pre-packaged AI applications to be immediately deployed. It shall be noted that the logic for each application is left to the application developer.
- AI platforms for small computing footprint used in edges. DECENTER provides AI models optimization to get the maximum efficiency in executing workloads in resource-constrained devices.
- Cloud-based fleet management systems. In DECENTER this is really possible, but it has not been investigated as it would be for a project more deeply focused on cloud infrastructure management rather than AI and cloud/IoT technologies.
- Integration of AI and IoT systems with resource orchestration. This feature is already provided by DECENTER.

Adoption feasibility analysis

The first question of this block was to check the *Customer's acceptance* of the solution in their businesses. The majority of stakeholders (90%) will accept it in very high, high or medium degree. Only 10% will not see the possibility to adopt it.

Would you accept the adoption of DECENTER in your business?

20 respuestas

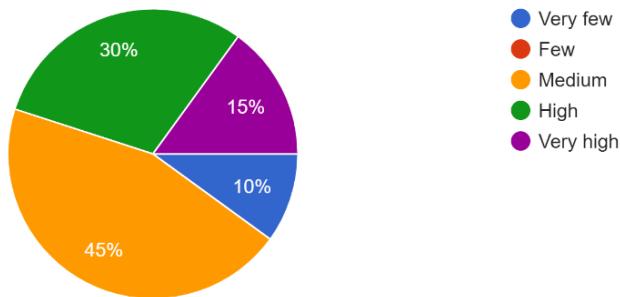


Then, next question was about *Learning Curve* how long it takes to learn about the solution. The stakeholders think that the solution is quite complex, and they would have to invest a lot of time to make solution works by themselves. Only 10% of them think is feasible to learn it in short time frame.



How do you perceive the time is needed to invest for learning how the solution works?

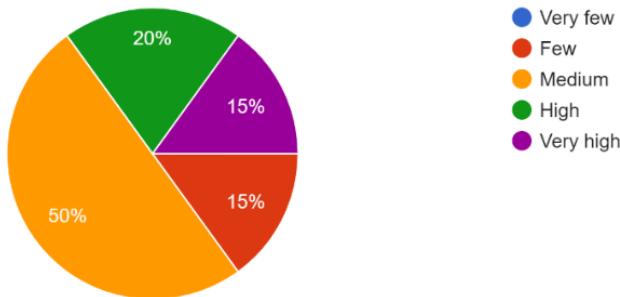
20 respuestas



They think also that the *Integration* effort will be considerable to integrate DECENTER into their own systems. This can represent a business opportunity for partners as they can support stakeholders and similar companies in the integration process of DECENTER in their ecosystems.

How much could be the integration effort to use the solution together with your existing infrastructures and systems?

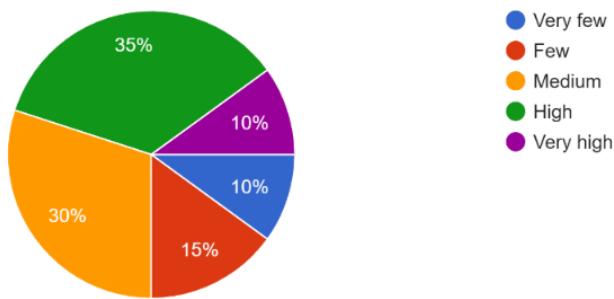
20 respuestas



Next question is about *Transparency* of the consortium towards the customers, users and research community, how much information they facilitate outside the project. In some cases the perception is that the project provides few or very few information, 25% in total, which is significant. More insights should be known to establish a diagnosis about that, but as an improvement to mitigate this feedback, the project is publishing more details in the project web site about the results.

How much detailed is the info provided by the consortium to the users?

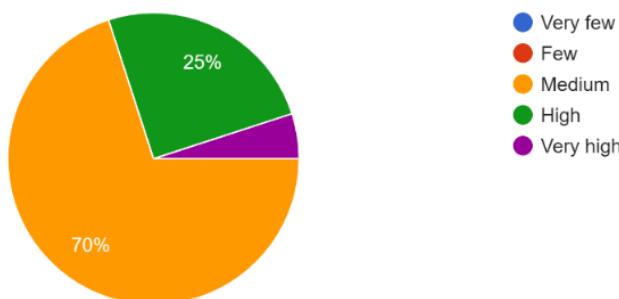
20 respuestas



Next question is addressing the *Investment cost* which would be required to adopt DECENTER in a business. The perception of the majority is that it would be needed to invest roughly in order to adopt DECENTER results, probably in learning the system as it was highlighted before, or maybe in equipment (edge or cloud) or in buying AI apps and services. The relevant take away is that none stakeholder think that is no need of investment to adopt DECENTER.

How would you assess the required investment and cost that would be required for adopting DECENTER solution?

20 respuestas

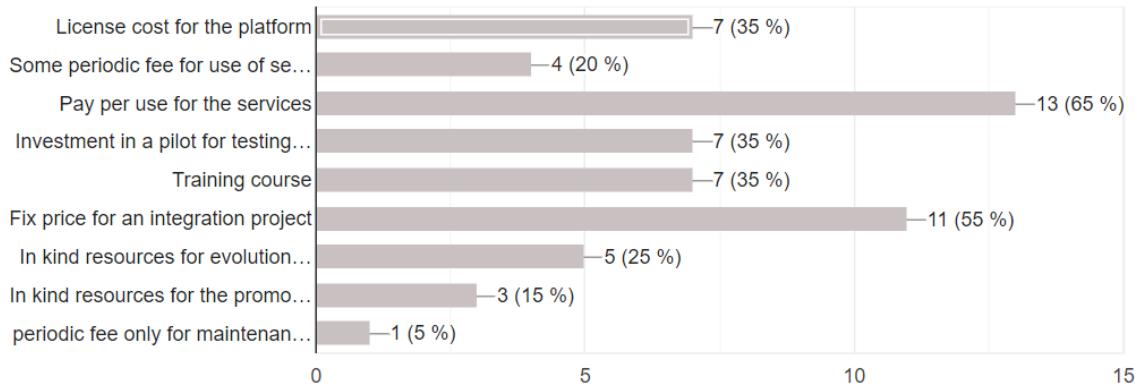


Finally, the stakeholders were asked about their preferences as customers to acquire DECENTER outcomes. They had to indicate what they would prefer to pay for. Big preference to pay per use of offered services (AI service, cloud/edge service) or for a close project at fix price to integrate DECENTER into the customer's system. This is quite coherent with the analysed answers previously and also with the proposed business model in section 5. Other revenue streams for partners could be according to the stakeholder's preferences: provide a training course, run a pilot to demonstrate the value and even pay a licence if the solution was offered as a platform.

D2.3: DECENTER Business Models

What would you be willing to pay for of DECENTER?

20 respuestas



The survey has been a very useful instrument to assess the assumptions about possible impact and adoption of DECENTER in potential customers. It has showed the relevance of DECENTER results in the market, the value it brings to the business and the requirements are needed to set up DECENTER in a real scenario. Thanks to the obtained feedback, some improvements have been achieved during the remaining project and others are identified for the next future.

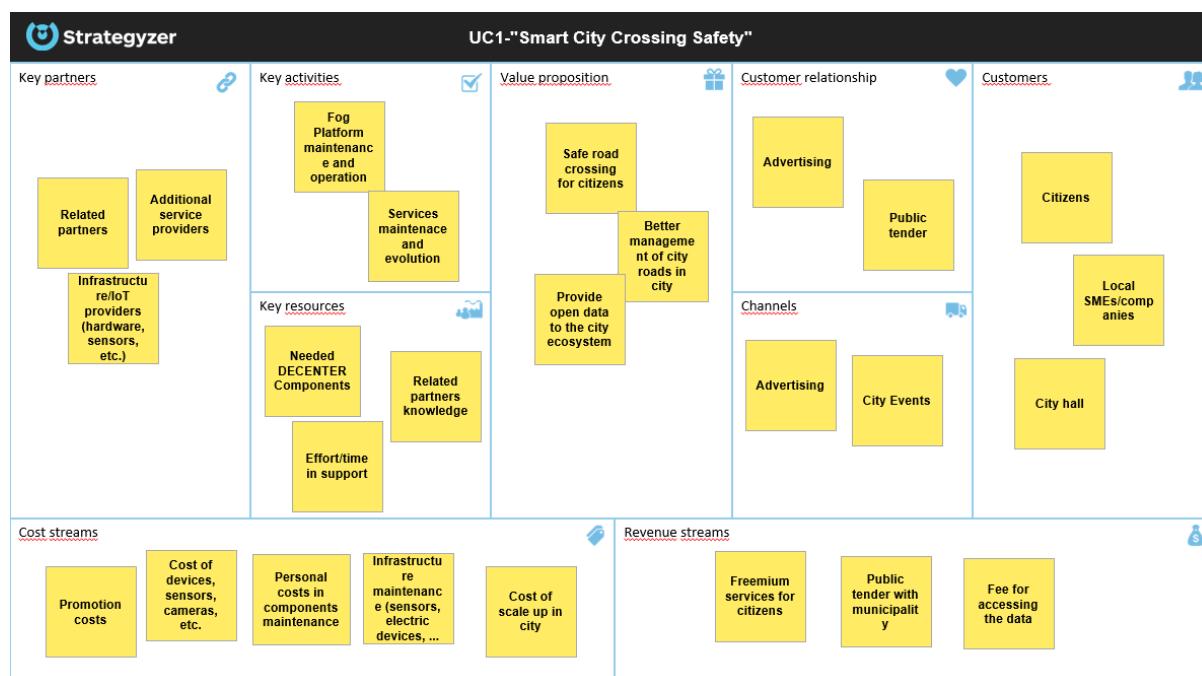
7. Adoption roadmap in DECENTER use cases

In parallel to the survey for external stakeholders, personal interviews with the project use cases' owners were conducted by the business models team. The goal of these interviews was to discuss about the preliminary business model Canvas which was elaborated in the business model workshop organized in 2020 and updated in case of need and define the realistic adoption path that each use case owner expected to apply. Their adoption roadmap must be aligned with their individual exploitation plans depicted in deliverable D6.5, therefore this section has been elaborated by checking the use cases exploitation plans at D6.5 and assessing their alignment with the feedback obtained across all interviews.

The interviews took place during April 2021 and this section describes the updated business models according to the insights from the interviews and a feasible adoption plan for each case.

- **UC1: Smart City Crossing Safety Adoption Roadmap**

During the interview, the Comune di Trento explained that all assets are already in place in the road and in systema, but there were still some technical issues, so results about validation were not available yet at that time. The proposed solution answers to a need for the city as the population demands to increase road safety. The Comune di Trento considers the solution very innovative and presented it at the Smart City world congress. They perceive the innovation in the technology behind the solution as useful for processing the data on the edge and, based on that, provide a quick response time. Their plan for the future is to keep the devices in the city and test them with several solutions, in collaboration with the other initiatives carried out in the Trento smart city lab. They see value in taking control of cameras within city possibly avoiding direct human intervention.



They already have a formal partnership in place with FBK to generally collaborate on many projects for the city, so there will be easy to enhance the current pilot although it is not expecting any investment in the short term. Any public tender has been discussed yet. They

are also commitment in promoting the project results and their pilot in events they were attending.

With the information obtained in the interview and pre-analysis of their business model, here below the resulting new business model for the UC1. It represents all potential customers, value propositions and cost/revenue streams that a use case like the one represented by Trento may exploit. Not all choices must be adopted in case of Trento, for example, only citizens and city hall will be actual customers for the moment (no local SMEs are expected) and public tender is not expected to be published for now, but would be a typical contract mechanisms for other similar use cases in other cities.

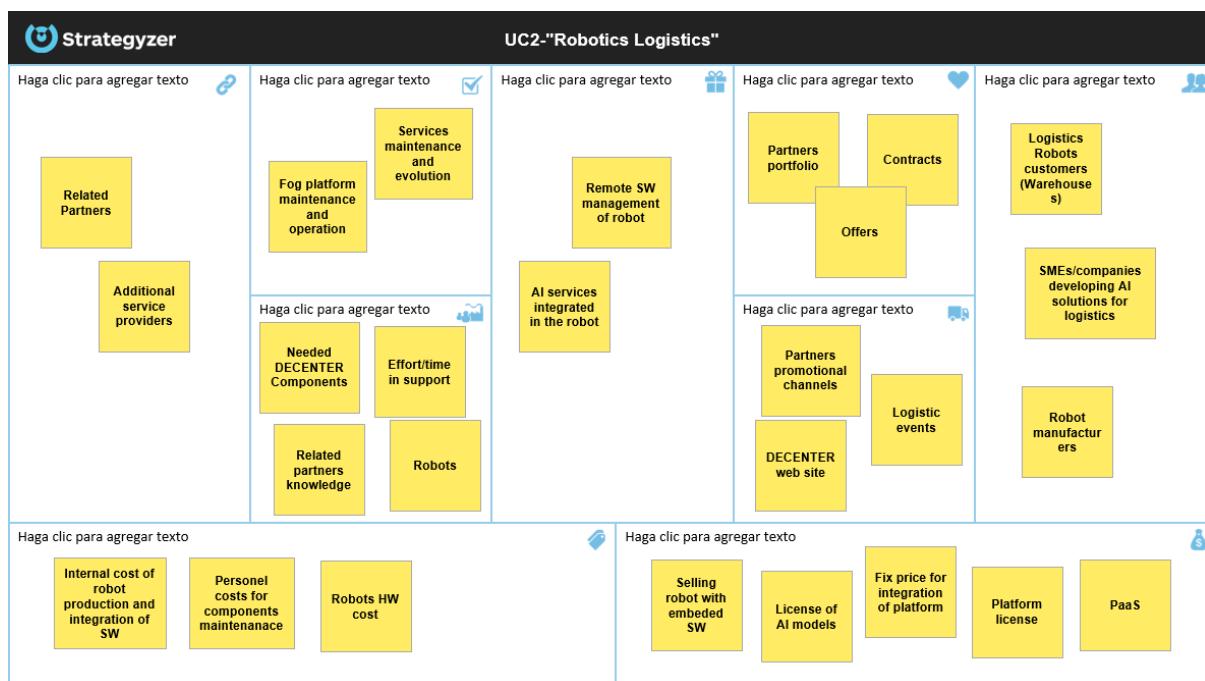
- **UC2: Robotics Logistics Adoption Roadmap**

Robotnik expressed in their interview that DECENTER has been useful for them to validate the edge concept in robots. They found several added value as relevant:

- Cost reduction in robot management
- Remote SW installation in the robot once it is in production
- Easier remote maintenance of robot
- New business model: robot plus services, not only the robot

However, they are aware of still lacking performance and robustness of the solution to work in production environments. Intensive test is required to be able to adopt it. Technically speaking, they found a stability issue with the use of Kubernetes as it is not working well yet with ROS, the operating systems of robots.

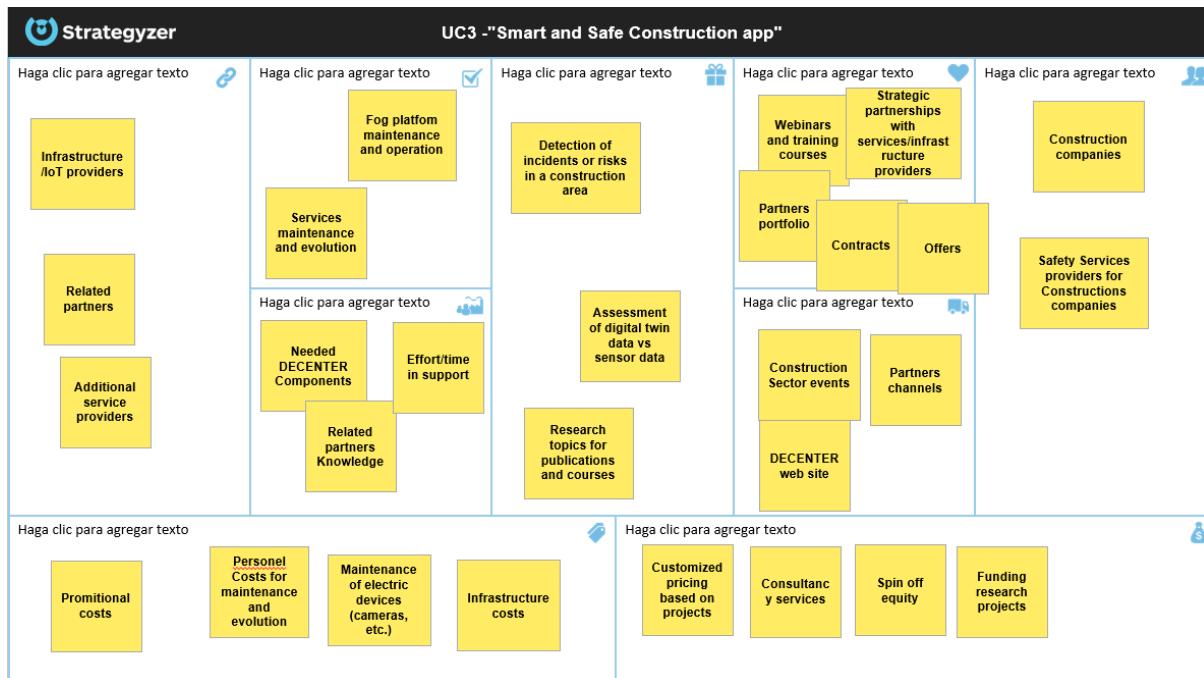
In near future, their plan is to go further with test of DECENTER solution in experimental environment, but 3-years far still to make any test in production. They would explore some partnership with FBK and Atos in future research projects to enhance the existing solution to an upper level of maturity.



- **UC3: Secure and Safe Construction Adoption Roadmap**

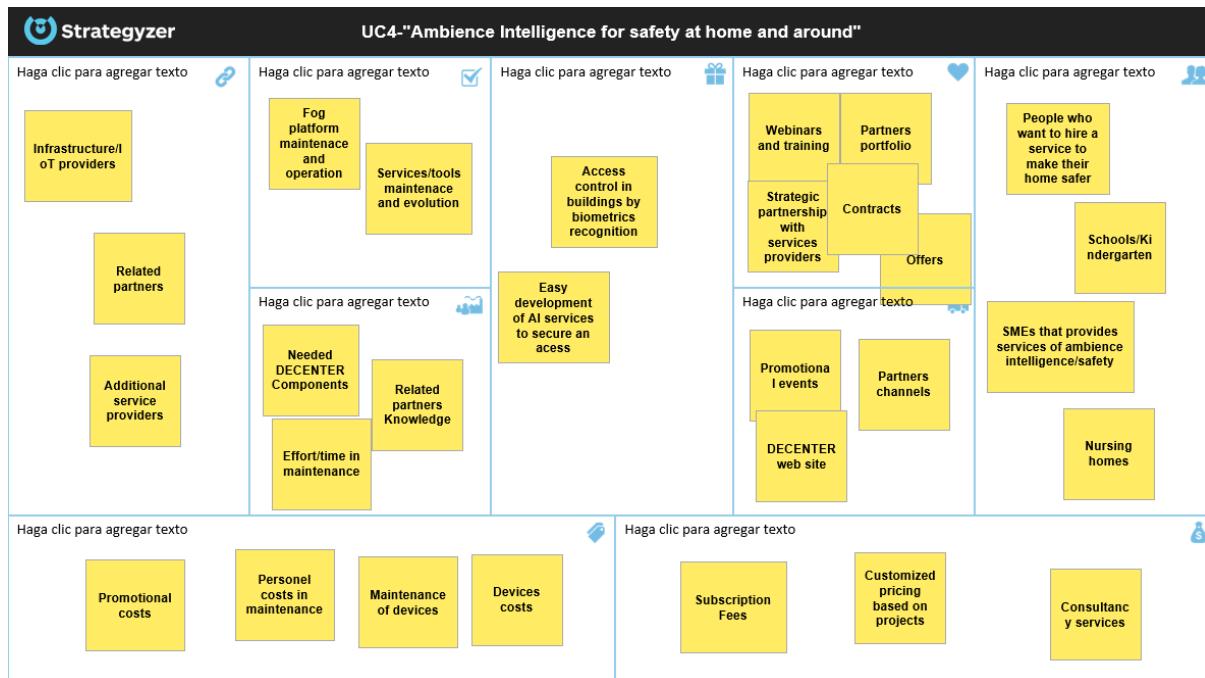
Ljubljana University is the owner of this use case for CGP construction company as final user. Their main interest in DECENTER is about AI in video streaming as it is a very dynamic scenario which requires of edge benefits and very useful for creating a safe construction space. They plan to create a repository of AI containers for users of IoT platforms that was able to matchmake the sensor data and twin data.

From project's results, they have submitted a publication and creating a teaching course. They are also planning to use the results and do further research in the Ontochain project. The setup of a dedicated spin off company from the University is also considered as an option.



- **UC4: Ambient Intelligence for Safety Office**

In case of KETI, as a research organization, they receive a lot of visitors and they need an accurate system to verify the access of people (visitors and employees) to the buildings. They are then using DECENTER technology for controlling the access. DECENTER pilot has been installed in their building and for now it is providing good results. They plan to use it for themselves but also selling it to other companies or organizations with a license. Potential customers will be small size companies which buy innovative solutions. The value for them resides in the combination of edge and cloud resources, taking advantage of agile processing on the edge and privacy/security on the cloud. They plan partnership with Kentyou for Digital Twin, Daliworks for the IoT platform and FBK for FogAtlas.



8. Conclusions

This deliverable collects the resulting work of Task 2.3 which goal was to create a portfolio of application, service and infrastructure deployment scenarios in which DECENTER fits for real world business models and goals.

A roadmap was defined to accomplish the work properly and it covered the initial market analysis based on the DECENTER results domain, the business models identified in collaboration with partners (workshop) and validated with external stakeholders through surveys and interviews to finally produce a final validated version of the business models and an adoption roadmap of them in the use cases.

Considering the final architecture of DECENTER, we have realised that the AI at the edge segment is closer to the project than pure edge/IoT segment, as the ultimate goal of DECENTER is to facilitate the development of AI applications leveraging on edge/IoT infrastructures by allowing AI developers of abstracting from hardware management. AI at the edge is understood here in two senses: allowing AI apps using effectively edge devices; and using AI to make more efficient the edge devices. Thus, the market segment to contextualize the project was shifted from “edge” to “edge AI”.

With regards to similar solutions in edge AI market, DECENTER is the only complete offering which provide high value for money since it requires few investments for adoption and then higher percentage of revenue. Despite of DECENTER allows to avoid the vendor lock-in, other comparable solutions have a stronger ecosystem and more solid commercially as they have been in the market for longer time-

Market forecasting is really promising for edge AI, expecting 1.835 USD millions of incomes, up to 10% of market penetration and around 21% of CAGR by 2026. DECENTER is fitting significantly in most of the segments in which edge AI market is divided.

In this context, the task 2.3 was in charge of defining the possible business models for DECENTER solution based on a modular set of platforms and services. The process was carried out in two iterations, thus the first version of business models was reported in D2.2 and reviewed in an internal workshop organized on April 2020 while the final one with the validation and adoption roadmaps is reported in this document.

Business models for full solution, minimal viable product (MVP), use cases and customized example were created. They show different value propositions depending on the customer nature and required components from DECENTER to cope with the needs. Business Model Canvas was the tool used to represent the business models. They give also some insights about cost and revenue streams associated to each case. Looking at the used components by the use cases, the MVP should be formed by: Fog Platform, AI Package, Digital Twin and Data Management, as these elements are present in the four use cases.

The theoretical business models were then validated with 20 external stakeholders through a survey that provided a valuable feedback about the strong and improvement points of DECENTER. Internally, the models were also assessed with use cases owners by adapting them to the particular use cases adoption roadmaps.

The results of the validations show that DECENTER is a relevant solution to solve some of the market needs and there are not so complete solutions in the market which provide a modular and customizable approach like DECENTER. The possibilities are very wide but also the future challenges are ambitious and require further research and innovation.

Annex I: Initial DECENTER business models (as reference)

- **BM for DECENTER platform**

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
			Channels	
Services Providers (Cloud Providers, IoT providers, Infrastructure providers, etc.) Technical Partners	Operation of DECENTER platform Support Services	An open, secure and robust Fog Computing Platform to orchestrate cloud-to-edge resources Platform based on existing open-source frameworks working in Fog domain	Webinars and training courses Incorporation of new use cases demanding orchestrate of resources Strategic partnerships with services providers	Innovative SMEs developing Cloud/Fog/IoT solutions or services Innovative SMEs and companies working in AI Companies and SMEs working in vertical sectors with real time constraints
	Key Resources DECENTER components Consortium Knowledge	Blockchain-based framework to allow cross-border dynamic binding of resources AI models for cloud-to-edge computation	DECENTER project Website and online channels Project Dissemination (Conferences, events, scientific publications) Another related projects collaboration Industrial events	Services Providers Software Developers Municipalities Robotics manufacturers Construction companies Home-services providers
Cost Structure Marketing Maintenance of the platform Personal costs Services providers costs (Cloud providers, Blockchain costs)			Revenue Streams Platform-as-a-Service Customized Revenue model based on projects	

Figure 8. Initial DECENTER Platform BM

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Technical Partners (FBK) Infrastructure providers (hardware, sensors, etc.)	Operation of DECENTER platform Support Services	An open, secure and robust Fog Computing Platform to orchestrate cloud-to-edge resources Platform based on existing open-	Advertising	Citizens SMEs working in

	Key Resources DECENTER components Consortium Knowledge	source frameworks working in Fog domain Blockchain-based framework to allow cross-border dynamic binding of resources AI models for cloud-to-edge computation	Channels Advertising City events	
Cost Structure Marketing Initial cost of devices, sensors, cameras, etc. Maintenance of DECENTER platform (personal costs) Maintenance of infrastructure (sensors, electric devices, electrical power, etc.)			Revenue Streams Freemium services for citizens Subscription fees for SMEs/companies	

Figure 9. Initial Smart City Crossing Safety Business Model

Key Partners	Key Activities	Value Proposition An open, secure and robust Fog Computing Platform to orchestrate cloud-to-edge resources Platform based on existing open-source frameworks working in Fog domain AI models for cloud-to-edge computation	Customer Relationships	Customer Segments
			Key Resources DECENTER components	Channels Same sales channels as used for other products (robots, etc.)
Cost Structure Marketing Personal Costs (Software developers, hardware technicians) Others TBD			Revenue Streams Software development included in the robots. Cost added to Robots' prices	

Figure 10. Initial Robotics Logistics Business Model

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Infrastructure providers Technical Partners	Operation of DECENTER platform	An open, secure and robust Fog Computing Platform to orchestrate cloud-to-edge resources	Webinars and training courses	Construction companies
	Support Services	Platform based on existing open-source frameworks working in Fog domain	Strategic partnerships with services providers	Safety Services providers for Construction companies
Key Resources		Channels		
DECENTER components Consortium Knowledge		Blockchain-based framework to allow cross-border dynamic binding of resources QoS models for AI applications deployed across the cloud-to-edge computing continuum	Promotional events in Construction sector	
Cost Structure			Revenue Streams	
Marketing Maintenance of the platform Maintenance of the electric devices (cameras, etc.) Personal costs			Customized pricing based on project Consultancy services (in case of UL)	

Figure 11. Initial Smart and Safe Construction app Business Model

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
IoT providers Infrastructure providers Technical Partners	Operation of DECENTER platform Support Services	An open, secure and robust Fog Computing Platform to orchestrate cloud-to-edge resources	Webinars and training courses Strategic partnerships with services providers	People who want to rent a service to make their home safer

	Key Resources DECENTER components Consortium Knowledge	Platform based on existing open-source frameworks working in Fog domain Blockchain-based framework to allow cross-border dynamic binding of resources AI models for cloud-to-edge computation	Channels Promotional events	Schools/kindergartens Nursing homes SMEs that provides services of ambience intelligence/safety at home
Cost Structure Marketing Maintenance of the platform Maintenance of the electric devices (cameras, etc.) Personal costs			Revenue Streams Subscription Fees Customized pricing based on project Consultancy services Pay-per-use	

Figure 12. Initial Ambience Intelligence for Safety at Home and Around Business Model