Smart Industry Systems

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IoT platform for Agriculture Rural Smartness

Group 9

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Abstract

The Internet of Things could be a significant point in smart agriculture as it allows farmers to gain more information about their crops. HabibiGarden as a platform has the ability to transfer data that is generated from the tools like sensors over the network and provide insightful information. The collected data is integrated into the Rural Smartness platform which is service-oriented architecture (SOA). By the Habibi Controller, the sensed data gets sent to the Habibi cloud. The Enterprise Service Bus (ESB) gateway has the capability to uniform the data. All the agriculture rural business units in RSP are using the Habibi Garden IoT solution to optimize the agriculture products and demand fulfilment. Provided data is used into the marketplace platform which is associated with the Rural Smartness Application. At last, FAIR principles were addressed as they facilitate management of data in order for farmers to make conscious and better-informed decisions about crops and profit.

Introduction

This report presents the architecture for the integration of the Rural Smartness Platform (RSP) with the products from Habibi Garden, a company that develops IoT devices and services in the agricultural sector. After analyzing the RSP proposed by the case and the solutions offered by Habibi Garden an integrated solution was proposed by designing Archimate models and using the TOGAF framework.

Case Analysis

The case presented the architecture in figure 1 for the RSP, which we took into consideration for proposing an integration with the Habibi Garden solutions.

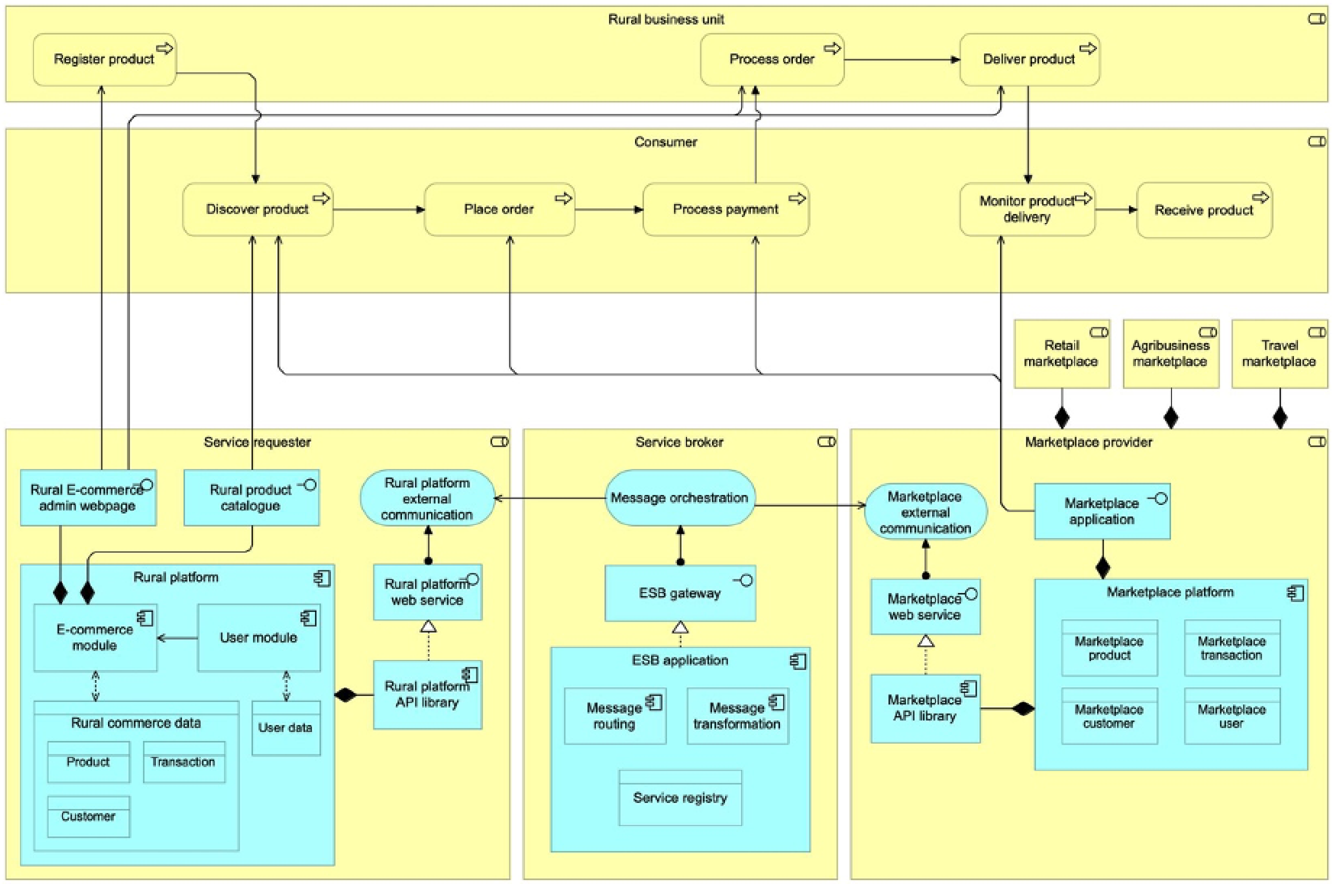

Figure 1: Archimate model of the Rural Smartness Platform (RSP) (Source: Case description provided on Canvas)

Problem statements

In order to start this case some problems from the case description were taken into consideration. First, it is required that an IT infrastructure is created in order to improve the economic welfare of citizens from Indonesia. Moreover, different IoT sensors and components are going to be integrated in the solution, some examples of those are: real-time sensor data, weather forecast, planting calendar and harvest schedule, crops pricing information, expected yield of the crops, and the kind of crops best suited to be planted in a certain farm field.

Regarding the commands from Rural Smartness and the use of data that are produced by the IoT platform, the integrated platform can address some issues:

- Most suitable crops for planting and at which quantity
- The main criterias for suitable farmlands
- The resources and required investment for planting these crops

- The estimated profit by planting these crops

Objective of the solution

The solution consists of various, smaller solutions and separate goals. Below, each will be explained in combination with the stakeholders of each part of the solution. First, an Agriculture Rural Business Unit is introduced. Their goal is to have demand fulfillment in time, as well as accurate product offerings so the consumers are well informed. Secondly, the provincial government of the area involved who are interested in new policies to have a way of intervening accurately when something goes awry. HabibiGarden is a third stakeholder who is interested in improving data usability to find more information on benefits of their IoT system to attract more future customers. Lastly, the marketplace service provider who is interested in accurate inventory of the products sold in the market.

Motivation Viewpoint

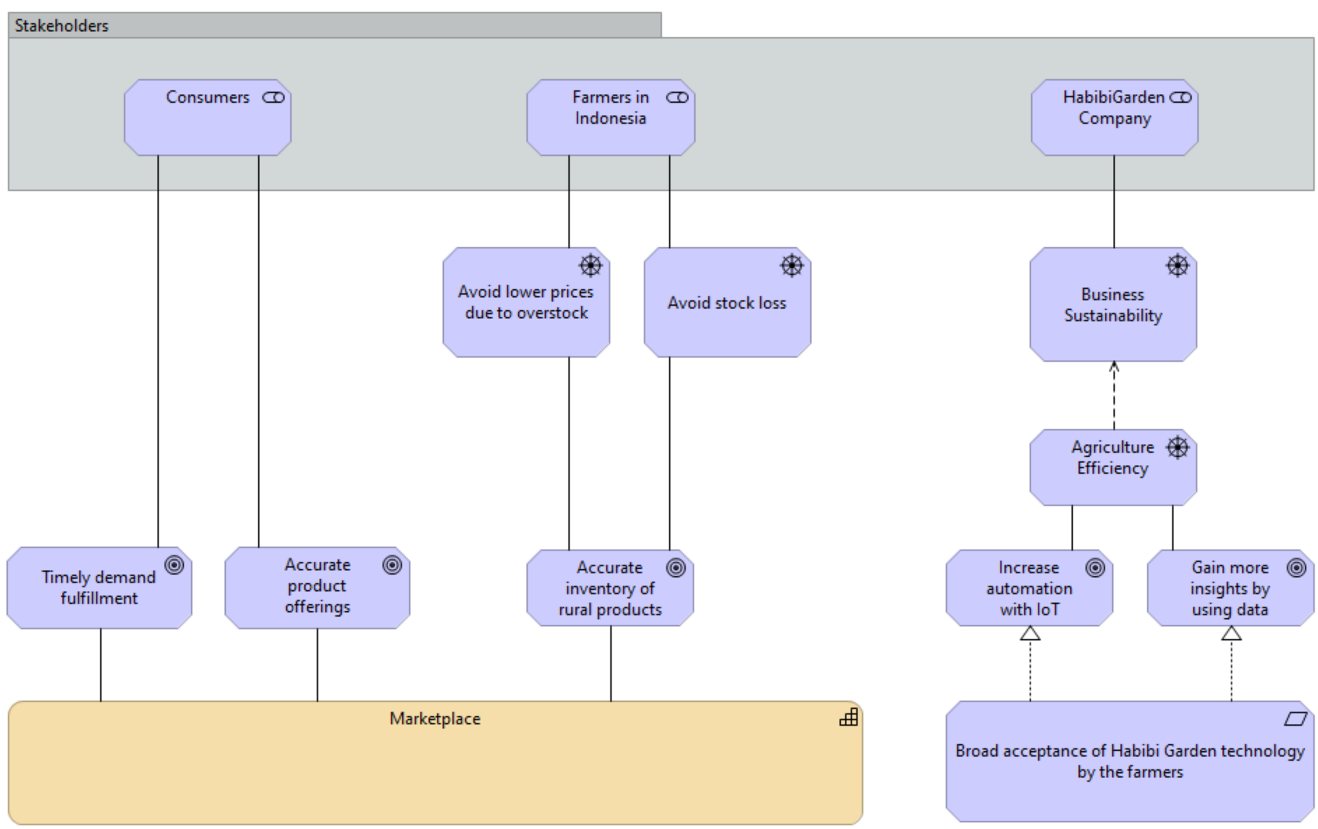

Figure 2: Archimate model of the case study

The figure above shows the motivation viewpoint of the project. As can be seen, there are 3 main stakeholders, being the consumers who interact with the marketplace, the farmers in the rural area, and the company HabibiGarden. All of these stakeholders have different goals. The consumers want accurate product offerings and timely fulfillment of demand as that makes the use of the marketplace more enjoyable and they can count on the accuracy of the availability of the products they intend to buy. The farmers have completely different goals, as they would like to have an accurate inventory of their products to prevent stock loss and avoid making less profit when the prices go down due to increasing supplies. HabibGarden, the company who provides the rural smartness IoT platform, would like to have their product be widely accepted by farmers. This will give the company the chance to increase the automation done by implementing IoT infrastructures and will make them gain insights by using the data, both leading to increased agriculture efficiency.

Assumptions being made

The basis of the project is the Rural Smartness Platform (RSP). It is an IT service platform that is based on the service-oriented architecture (SOA). The goal of the RSP is to make it easier for rural communities to enter into the digital business ecosystem (DBE). These communities participating in this ecosystem is likely to result in them increasing their profit and therefore improving the economic climate in these rural areas.

The data on the crops collected by the HabibiGarden platform could be integrated into the Rural Smartness platform to allow for increased interoperability. The architecture of this system will have to adhere to the following specifications. The three most important layers (technology, application and business) should be represented clearly as this is the base of the project. Secondly, it is important to adhere to the FAIR data principles and the Rural Smartness characteristics. And lastly, it is important to stay close to the use case and provide answers that address the questions mentioned there.

Habibi Garden products

Some of the products and services offered by Habibi Garden were taken into consideration when creating the final solution to the case, some of those products are presented below:

- HabibiGrow - Main brain in carrying out plant maintenance activities such as watering plants and cooling the Greenhouse automatically.
- HabibiCooling - Integrated with Habibi Grow and Habibi Climate as a control system

- HabibiClimate Pro - Has three sensor readings that can display nutrient value (ppm), RH, and soil temperature.
- HabibiClimate Station - Helps in monitoring the actual weather conditions of your garden automatically for the next few days via a smartphone
- HabibiCam - Monitor the Physical Growth of Plants and Security and Gardens using internet connectivity

Current architecture

Designing the current architecture is important to help understand the present state of the project, the decision was made to make three separate models that highlight the most important parts of the architecture. Below, there are models of the technology layer, the application layer, and the business layer with information about design decisions made during the modeling.

Business layer

The business process starts with product registration, where the information of the product from the rural business unit is recorded by the e-commerce module of the rural platform managed by the service requester. After the product is registered, consumers can discover the product through two interfaces:

- The rural product catalog provided by the service requester
- The marketplace application provided by the marketplace provider

Subsequent to this product synchronization that made the products discoverable either in the Rural Platform or in the Marketplace, buyers are now able to purchase the product and settle the payment for their transaction. Due to the synchronization, the transaction can now be performed on the marketplace platform side and the transaction data will be relayed to the rural platform for the rural business unit to process and fulfill.

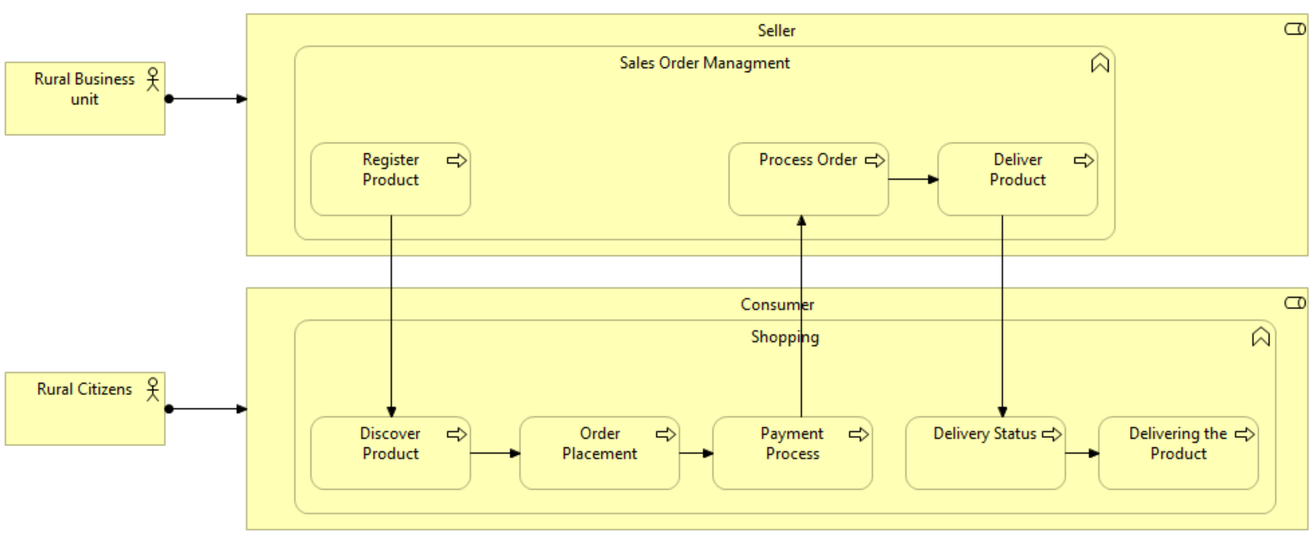

Figure 3: Archimate model of the Business Layer

Application layer

The application layer, demonstrated in figure 4, is composed by the applications artifacts and its interaction with the technology artifacts. There are two main services, represented in the figure, that are of interest for the project. Those are the Crop Monitoring, realized by the Rural Smartness Application, and the Software as a Service (SaaS) from Habibi Garden solutions, realized by the IoT platform. Though they are not yet integrated, that will come at a future step.

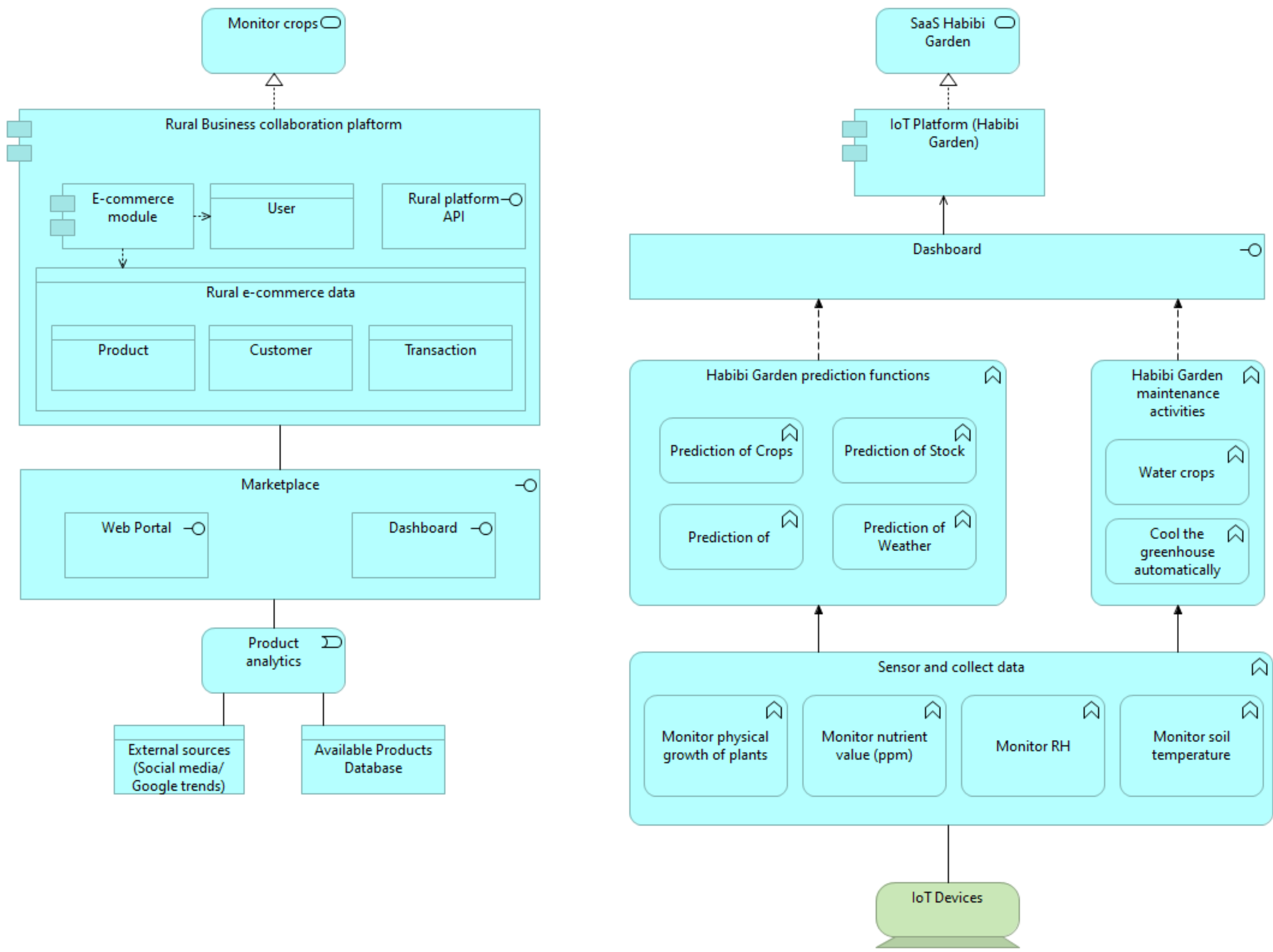

Figure 4: Archimate model of the Application Layer

In the case of the Rural Smartness Application, there are two main data sources, which are external sources and a database with the available products, which does not have automation, therefore has to be managed manually by each farmer. The next step is the analytics of the gathered data. At last, the data will be consumed by the Marketplace, which is separated into Web Portal, Dashboard and API Management artifacts. The Marketplace is associated with the Rural Smartness Application.

The process for the IoT platform happens in a different way. The IoT devices will collect the data, this is represented by different application functions, which are Sensor and collect data, Habibi Garden prediction functions and Habibi Garden maintenance activities. Then the data will flow to the Dashboard that will serve the IoT Platform.

Technology layer

In figure 5, the model of the technology layer of the project can be found. The technology layer consists of two different parts: the marketplace and the HabibiGarden IoT. The marketplace consists of a cloud infrastructure that involves commerce data and a web application for the Rural platform. Through a service broker, this rural platform is connected to the marketplace web service. In this web service, customers can order goods and pay for them using the financial transaction manager.

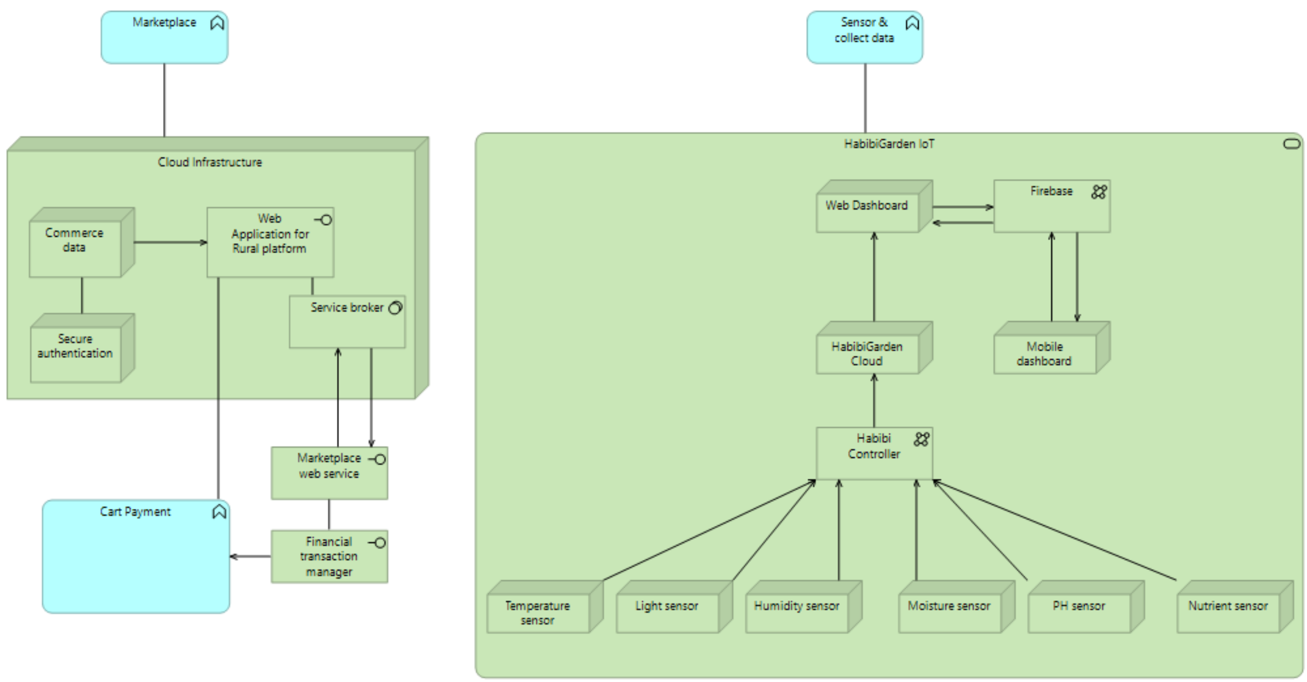

Figure 5: Archimate model of the Technology Layer

The second part consists of several sensors for light, water, and soil PH as well as humidity sensors and nutrient sensors in the soil. Through the Habibi Controller, the sensed data gets sent to the Habibi cloud, using the internet. The cloud is connected to the Web Dashboard that can also be accessed on mobile devices through the use of Firebase. The dashboard allows users to keep track of their crops and might even be able to use it to see what their crops need. As can be seen in the figure above, the two main parts of this system are not connected to one another and it could be more efficient to find a way to integrate the two. When the two are connected, there is a chance for interoperability as well as improvement of the economic welfare of the farmers as they can create more profit with the newly gained knowledge.

Target architecture

The target architecture shows the models that are necessary for presenting the integration solution of this case. Below we start by creation the Implementation and Migration viewpoint, followed by the target business, application and technology viewpoints.

Implementation and Migration viewpoint

The implementation and migration viewpoint, presented in figure 6, shows the steps needed in order to have the integration between the RSP and IoT platform. Moreover, it is also shown the deliverables and the motivation goals that the project would address. In this model, the main aim is to demonstrate the phases needed to achieve the project's goals. In this case, it will be done by, first, adding FAIR data principles and, second, deploying a new integrated platform that will allow farmers to make more conscious and better-informed decisions regarding their crops and profit. All of the goals set by the project are addressed in this solution, as can be seen in the implementation and migration architecture.

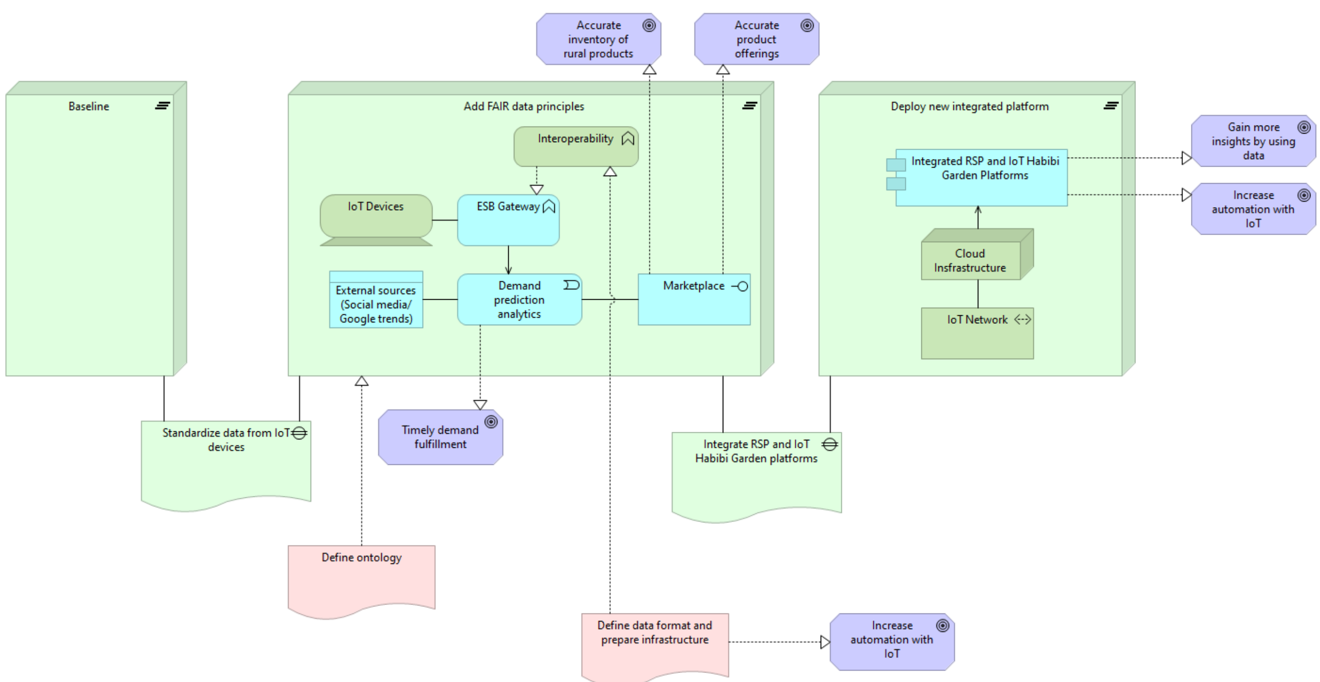

Figure 6: Implementation and migration viewpoint

In the first plateau the goal is to add the FAIR data principles in the solution, they will be further explained, though we consider that having a standard ontology would make the project more complete and would facilitate the integration of both solutions. The same is valid for the standardization of the data format.

Then, when the infrastructure is ready and the integrated network is set up, it would be possible to deploy the new integrated solution. Which would facilitate the achievement of the two last motivation goals of the project.

Future Business viewpoint

The target business viewpoint shows after the customer settled for the payment of the product in one of these marketplaces, the order transaction data will be passed on to the ESB to be transformed and routed to the Rural Platform. As the Rural Platform receives the 'paid' transaction order from the marketplace platforms and assumed order processing, the changes in the stock amount of the product being purchased will be broadcasted to the synchronized marketplaces by the ESB. Integrated data with Marketplace Platforms are data which is related to Rural E-Commerce that can be information of registered products, orders, and the customer.

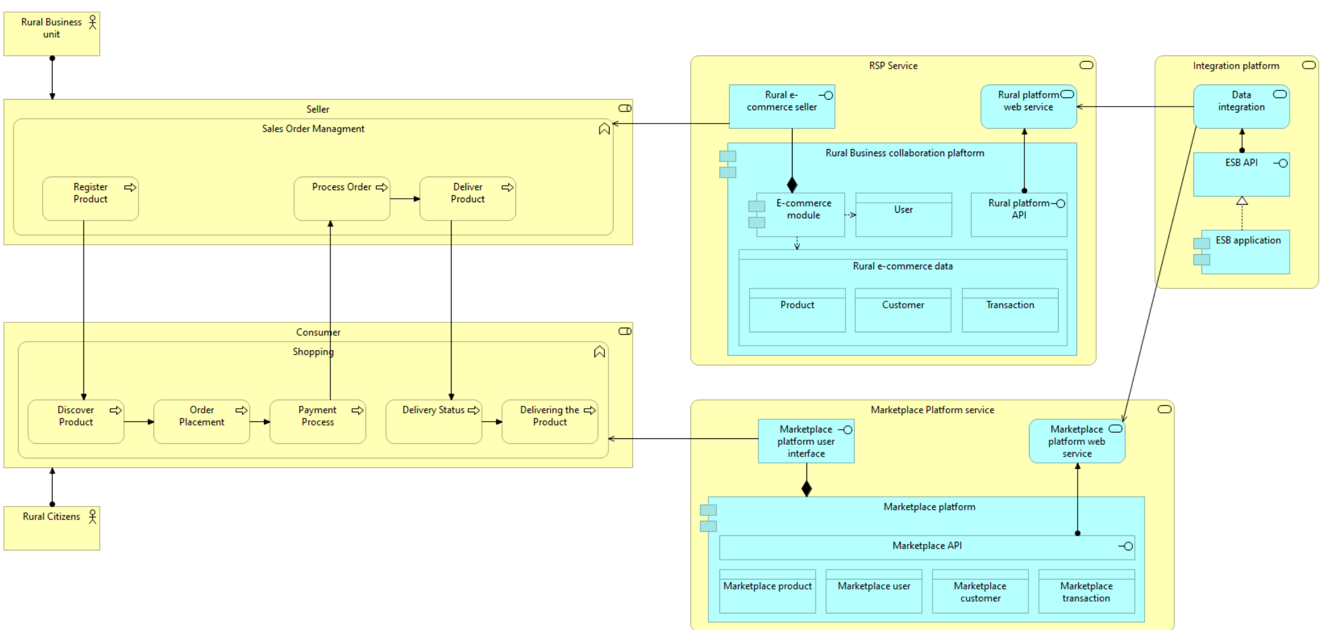

Figure 7: Future Archimate model of the Business Layer

Future Application viewpoint

The future application viewpoint shows how the interaction between the RSP and IoT platform would be done. For that, the communication layer was added.

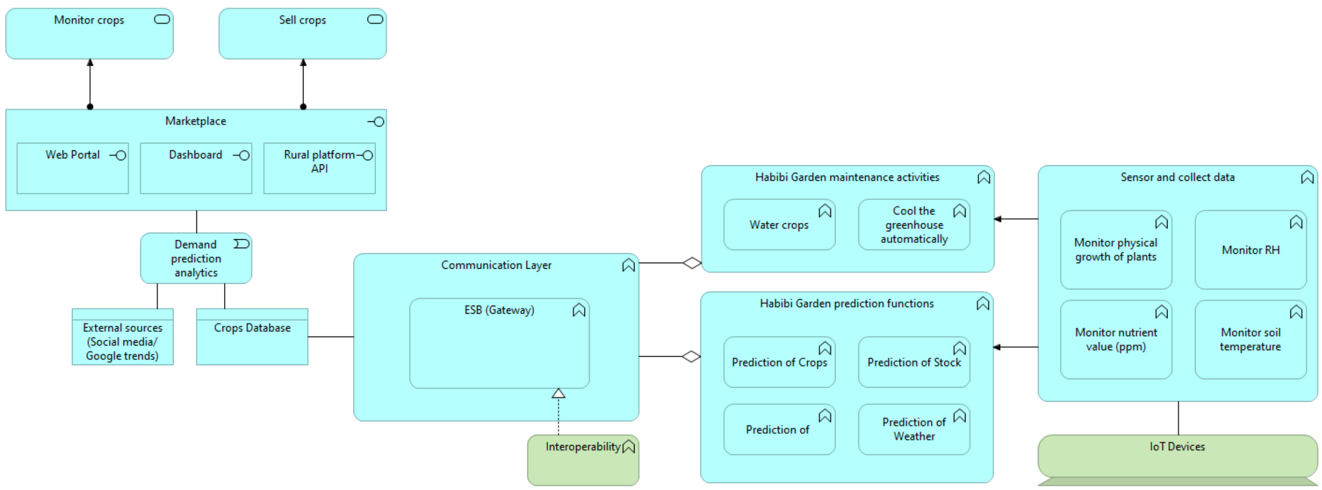

Figure 8: Future application viewpoint

Since it is important to secure interoperability for the project, the data will be collected and the Enterprise Service Bus (ESB) gateway will provide uniformization of the data that will be collected from multiple solutions from the Habibi Garden company. In figure 8, it is possible to see how the products and services of Habibi Garden will interact with each other and, then, transfer its data to the RSP application.

Future Technology viewpoint

The goal architecture for the technology layer can be seen in figure 9. As opposed to the model in figure 5, the two main parts (marketplace and HabibiGarden IoT) are now connected with one another through a network that uses message-based communication.

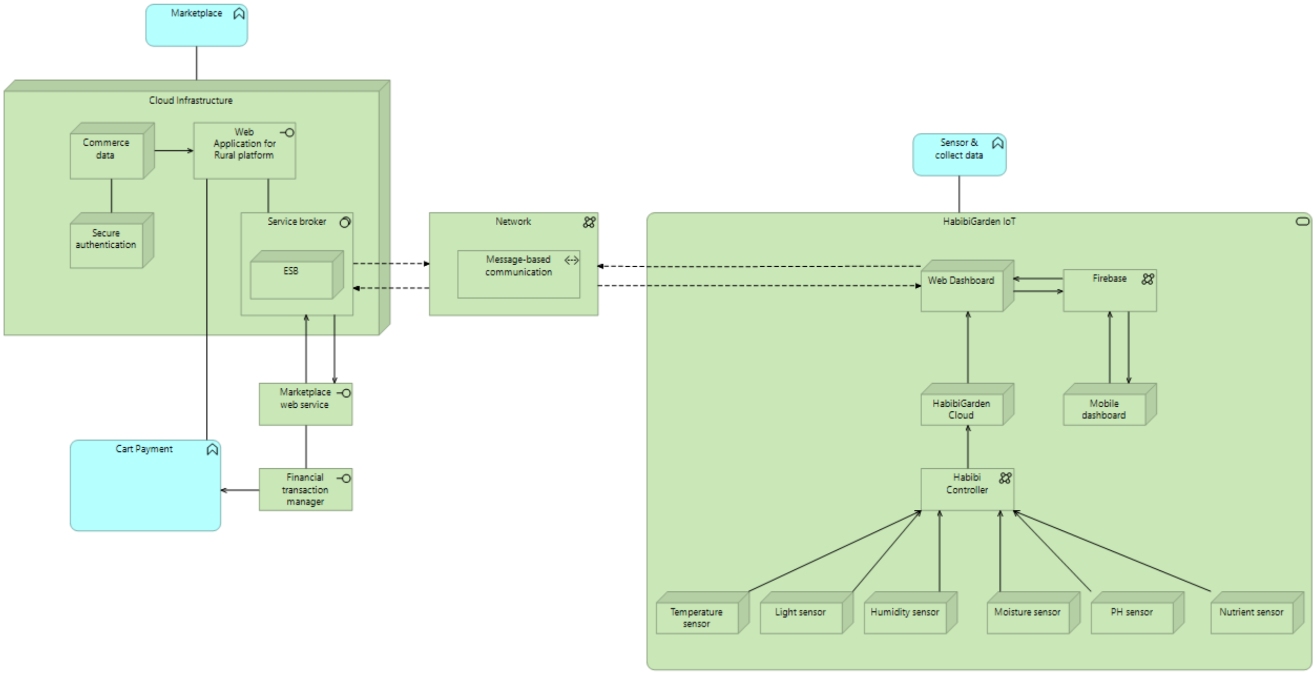

Figure 9: Future technology viewpoint

A publish-subscribe pattern is the selected solution in this case, to avoid the verbosity problem that occurs when too much data is sent across a network. With this integration, the two systems will be much more interoperable than the current situation in which there are two loose systems.

Combine all the layers in only one viewpoint

To be able to show the architecture in a more complete way, a viewpoint that combines artifacts from the business, application and technology layers was created.

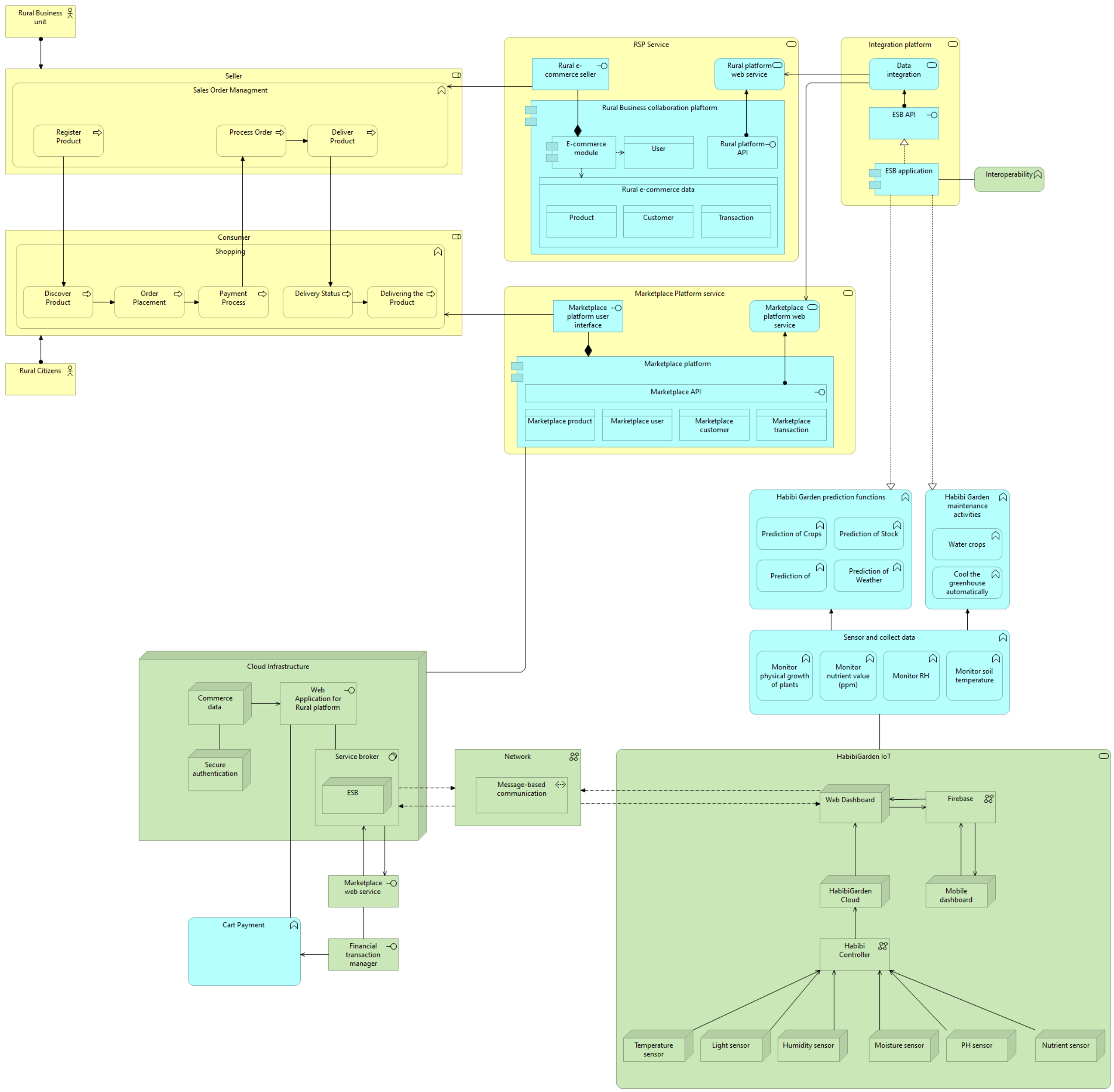

Figure 10: Viewpoint with business, application and technology layer artifacts

Figure 10 demonstrates the integration between the RSP and IoT platforms in a complete approach, that way it is possible to see how the technology artifacts communicate between each other and are associated to the application layer. At last, the business layer gives evidence of how the business artifacts interact with the application layer artifacts, giving an ample view of the architecture of the entire project.

FAIR principles

The FAIR principles are essential to make this project efficient. The FAIR principles are about helping in the management of data in order to bring more value to the whole process, therefore ensuring transparency, reproducibility, and reusability (Wilkinson et. al., 2016). FAIR stands for Findable, Accessible, Interoperable and Reusable, those principles will be further explained and applied to the case below.

Findability

This principle is important to make the project consistent and to assure that data and metadata about the crops and customers will be handled correctly. Therefore, it is important that each (meta)data receives an unique identifier and that they are indexed in a searchable resource. Besides, data should have rich metadata, which should contain the identifier of the data they refer to. That way, when two different people working on the project need to find some data about a specific crop, they will be able to find it and get to the same conclusion. Marketplace service providers can fulfill it. This principle is related to the Crops database artifact from the application layer in the future architecture presented.

Accessibility

Regarding accessibility, security is an important factor to take into account. It is important that the data is easy to access, but only by those who actually need to. There is a difference between being accessible and openly available, and that difference needs to be acknowledged. The data can be accessible yet secure if a system of authentication and authorisation is put in place, for this case it relates to the secure authenticator node presented in the technology layer from the architecture. How this can be achieved will depend on the type of service the final product works. If customers pay one price for the whole service, then the authentication can be done before users access the cloud, as they then have access to all of the data that is available in the cloud. However, if they pay for parts of the system, then the authentication should be done at a different time as the user might not have access to the whole service but just a part of it. Either way, login with the use of a username and a password is a viable option for the authentication and authorisation process as it is easy to use and no additional security measures such as separate codes that get sent to the user by email are necessary. Here the dashboard (Described earlier) allows users to have access to all necessary information.

Interoperability

With the use of the enterprise service bus (ESB), interoperability gets easier. This is due to the fact that the ESB realizes a communication system between the applications that have interactions (both demonstrated in the application layer architecture), which relates to FAIRness principle I2 presented by Wilkinson et. al. (2016), which states that "(Meta)data should use vocabularies that follow FAIR principles". By ESB, facilitated data integration and service orchestration between SOA-based platforms and the marketplace platform, the users' data and registered products can be forwarded and offered to a bigger market customer with a faster-paced market. Then, the buyers may be able to discover the local rural products from the marketplace platform or from the rural business platform itself, so Habibi Garden can have this capability to provide all these.

Moreover, we also recommend that a common ontology is used by the stakeholders of this project. This would facilitate the integration and would ensure that (meta)data corresponds to the expected artifact from the architecture.

Reusability

Due to the possibility of having different data formats, structures, and integration patterns, it might be difficult for other people/projects to reuse the data that has been created. Therefore, it is essential that data is richly described and correctly labeled. The use of a well documented API can provide clear data usage instructions as well as ensure that the data is up to standard, following the principle R1.2. which propose that "(Meta)data are associated with detailed provenance" (Wilkinson et. al., 2016). When the (meta)data used in the system follows certain standards, it will be easier for others to reuse that data for their own purposes. In this way, the data collected by the sensors, for instance, can be used by many other people as well.

Rural Smartness Principles

Rural smartness can best be described as the situation in which the economic welfare of citizens in rural areas improves after investments in human capital IT infrastructure and services. There are 4 important principles to keep in mind when discussing this topic, being: connectedness, participatory governance, digitally empowered citizens, and coherence of IT service provision. The following definitions are taken from Mukti et. al. (2021).

Connectedness

According to Mukti et. al. (2021) the best way to describe connectedness is the following: the connectivity enabled by the IT infrastructures and services between the different stakeholders in the rural business ecosystem. A simple explanation of this would be: if the implemented infrastructure works well, the stakeholders will be more connected to one another. In this project, this can be seen in the marketplace, where the different stakeholders can get more information about the products. The ties between the farmers and third party buyers are closer than ever, making them more connected, but also allowing all the parties to gain benefits from that connection.

Participatory governance

This principle can be defined as: stakeholders in the government participating to improve the economic status of rural communities through the availability of IT services. In this case, this would mean that the governmental programs also use the IoT platform to undertake action regarding improvements of welfare. The way this comes back in the project is the implementation of the Rural Smartness Platform. The government is responsible for implementing this so the community can use it.

Digitally empowered citizens

Citizens will be empowered by the implementation of IT infrastructures to enhance their creative and innovative capabilities. This comes back very strongly in the project as the IoT platform will allow these farmers to keep better track of their crops. Through the use of sensors by HabibiGarden, the farmers will be able to have more information about their produce than ever. The system will be linked to a database containing information about different crops that might be able to teach them how to farm more effectively, which hopefully leads to improved harvests. This in turn will improve their economic welfare, as these farmers will be able to maximize their profits and lower their losses. When the farmers are better informed about their crops, they can make more conscious decisions which will hopefully lead to increased yields and profits. The extra money could enable the citizens to innovate more or improve their business in other ways.

Moreover, farmers would be directly connected to their buyers, therefore they would be able to collect more information and improve the products and services they provide.

The rural areas to which the project applies, are often not fully developed yet. This might mean that many people will lack knowledge and skills in the technology department. This part of the Rural Smartness Principles addresses this gap and aims to close it.

Coherence of IT service provision

This principle is best defined as: the alignment of IT service provisioning in rural areas. The IT service delivery should be aligned strategically so that the implementation goes smoothly. This principle is really about efficiently implementing the IT infrastructure. Since logistics in general are challenging in underdeveloped areas, this can cause problems in installing the technology in the area. Not only can the physical roads be an obstacle, the digital roads can be too. It is likely that, compared to developed countries, the existing internet infrastructure is not as well-developed and can therefore cause challenges along the way. Therefore, it is important that those challenges are not reflected with extra costs for the farmers.

Risk analysis & difficulties

The project contains quite a lot of risks and difficulties that should be addressed. Only the most obvious ones will be discussed here. First, the risks spread out across the entire project and cover many different parts of the architecture. An example of a risk is the integration of the two pillars (RSP & HabibiGarden IoT) as the first one is covered by the government while the IoT platform is provided by a third party company. If the integration is not smooth or does not work well, the entire system will not work so this is a significant risk. This is where a consultant can come in to ensure the project is implemented smoothly and all stakeholders are content with the architecture.

Next to this, a risk is that the HabibiGarden products, such as the sensors, break. If these sensors stop working, new ones need to be installed to ensure that the service works correctly. This means that either the local farmers would have to know how to replace these sensors, or HabibiGarden needs to have employees near these communities to fix hardware problems when they occur. This is not merely a technological problem, it is also a logistical issue.

A significant difficulty to mention is that the prediction of crop yield and demand is hard as many different factors come into play here. How will the prediction deal with natural disasters? What if a pest reaches the rural area and the entire fields get infected? These are important questions to take into consideration as they affect the crop yield greatly. According to Van Klompenburg, Kassahun & Catal (2020) a lot of research is being done on how to use machine learning to predict crops more efficiently. This makes it possible in the future to have a more accurate idea of what the prediction will be to assist the farmers in their work.

A second obstacle would be the logistics of the products. Indonesia is built up of many different islands making transportation more challenging. Overcoming this obstacle is not part of the scope of this project, but it could be considered as part of future work, as it affects the overall business ecosystem greatly.

Conclusion

Looking at the architectures, the integration of the Rural Smartness Platform and the HabibiGarden IoT service is definitely possible. Introducing these technologies to farmers in rural areas is likely to help them gain more profit as they have more knowledge on their crops. The combination of the sensors from HabibiGarden and the data from the marketplace will give these people more insight in their product as well as their business in terms of demand, even though the latter may be difficult. The gained knowledge will allow the farmers to adapt their ways of working to better suit the environment, which will lead to increased profits as they now produce crops that fit well with the climate.

The implementation of the architecture will face obstacles, such as: different stakeholder goals, logistical difficulties, and uncertainty in expected crop yields, but once these are overcome it enables the farmers to secure better income and reinvest this money to innovate more.

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