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DEVELOPMENT OF E-SERVICES WITH THE IMPLEMENTATION OF MICROSERVICE ARCHITECTURE – RESULTS OF RESEARCH IN AMM SYSTEMS*

ROZWÓJ E-USŁUG Z IMPLEMENTACJĄ ARCHITEKTURY MIKROSERWISÓW – WYNIKI PRAC BADAWCZYCH W AMM SYSTEMS

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Abstract: The purpose of this article is to identify the management practices of the research and development project (R&D) in the field of e-services for residents, created by the IT company AMM Systems LTD – grantee of the RPOWD Programme 2014-2020, Measure 1.2.A. The article presents a preliminary pilot study, followed by an in-depth study among enterprises that have benefited from subsidies for the development of R&D activities. Manifold research questions were defined, i.e.: For what purpose did AMM undertake the development of research and development activities based on the selected research and development department? Were the products (i.e. e-services) carried out according to the plan? Do the developed e-services enhance the competitive advantage for AMM? The audited entity was AMM Systems LTD (formerly SISMS LTD). The subject of the research was the activity of the company and the activity of the R&D department implementing a R&D project co-financed by the EU.

Keywords: e-services, microservice, mobile application, R&D, AMM Systems.

Streszczenie: Celem niniejszego artykułu jest identyfikacja sposobu zarządzania projektem badawczo-rozwojowym (B+R) w obszarze e-usług dla mieszkańców, wytworzonych przez przedsiębiorstwo informatyczne AMM Systems Sp. z o.o. – grantobiorcę programu RPOWD 2014-2020, działanie 1.2.A. W artykule przedstawiono badanie wstępne o charakterze pilotażowym, po którym planuje się badanie pogłębione w przedsiębiorstwach, które skorzystały z dotacji na rozwój działalności B+R. Zdefiniowano pytania badawcze, m.in.: w jakim celu AMM podjął się rozwoju działalności badawczo-rozwojowej, opierając się na powołanym dziale badawczo-rozwojowym? Czy zaplanowane do wytworzenia produkty (e-usługi) zostały wykonane zgodnie z planem? Czy wytworzone e-usługi wykreowały przewagę konkurencyjną dla przedsiębiorstwa AMM? Podmiotem badanym był AMM Systems sp. z o.o. (wcześniej SISMS sp. z o.o.). Przedmiotem badań zaś – działalność spółki oraz działalność działu badawczo-rozwojowego, realizującego projekt badawczo-rozwojowy współfinansowany z UE.

Słowa kluczowe: aplikacja mobilna, B+R, e-usługa, mikroservis, AMM Systems.

1. Introduction

Multiple e-services have been introduced to the Polish e-services market in recent years. The coronavirus pandemic forced the acceleration of the use of e-services by citizens who have been ‘grounded’ by Covid-19 in their homes. The specificity of the pandemic has forced citizens, local governments and the national government to make further attempts to handle these official matters remotely.

The aim of this article is to identify the management practices of the research and development (R&D) project in the area of e-services for residents carried out by the IT company AMM Systems LTD (AMM), which were the subject of a 24-month grant co-financed by the European Union under the RPOWD Programme 2014-2020, Measure 1.2.A. This is a preliminary pilot study followed by in-depth research in enterprises that have benefited from subsidies for the development of R&D activities. The following research questions were defined for the purpose of theoretical and explicative research:

- for what purpose did AMM undertake the development of R&D activities based on the selected R&D department?
- were the products (i.e. e-services) planned for production carried out according to the plan?
- which of the services produced turned out to be the most attractive and which were not in terms of business (revenue/income) in line with the development barriers model?
- was the number of e-services planned to be created optimal?
- did the created e-services enhance the competitive advantage for AMM?
- without the co-financing from the European Union, would the scope of work in the research and development project be the same as in the case of financing R&D from own funds?
- was there a business synergy in the product portfolio i.e. the e-services owned by AMM?
- do customers and end users use the created e-services within R&D?

Several methods and research tools were used in the pilot research. First, the research was dynamic, as it was carried out four times during the R&D projects (35 months from the beginning of the project), participant observation, a direct interview with the company's Management Board and the analysis of the source documentation of the project were used. The audited entity was AMM Systems LTD (formerly SISMS LTD). The subject of the research was the activity of the company and the activity of the research and development department implementing the R&D project co-financed by the EU.

2. Characteristics of the examined entity

AMM Systems LTD (formerly SISMS LTD) belongs to the small business sector and provides e-services (available on: www.sisms.pl) as part of its operational activities. The company has been operating since 2009 in the e-services sector for local government, being a leader in Poland and having a 16% share in this sector in 2019. The company employed personnel for 17.7 projects in 2019. The revenue was approximately PLN 3.5 million and came mainly from the e-service of the automatic public transport system SISMS for residents of 512 municipalities in the field of information services important for the residents, e.g. on dangerous weather conditions, crisis situations, and important information for local communities. The company carries out this service using the nationwide mobile application called Blisko (which means 'nearby' in Polish), SMS communication, the resident zone portal and e-service cards. The company's customers are mainly municipal and city offices and municipal communes in Poland. The management board of AMM decided to establish a research and development department in 2015, which is headed by a manager reporting directly to the company's management board. AMM (2016 and

2018) benefited twice from EU subsidies for the development of R&D activities from Measure 1.2.A. under the Regional Operational Program of the Lower Silesian Voivodeship for 2014-2020, Priority Axis 1. Enterprises and innovations, Measure 1.2 Innovative enterprises.

The narrow specialization in the local government industry allowed the company to diagnose the problems and needs of the offices and their applicants. The company's services differ in terms of graphical interfaces, UI (user interface; the way the user interacts with the system) and UX (user experience using the user interface), i.e. each is operated in a different way and requires the user's familiarity with a new tool. Access to e-services is unstructured and dispersed in various places of the web portals. Most often they require the registration of a separate user account and duplication of the same data. The experience and knowledge gained during the provision of services by AMM show the need to centralize the e-services provided by local government units (LGUs) in one graphical interface. An important aspect of the system will be its availability from the level of various mobile and stationary devices, a web and mobile application for Android and iOS platforms will be created, and the requirements of the WCAG 2.0 standard in terms of the guidelines indicated in the KRI will be met.

2.1. Main assumptions of the R&D project (2018-2020)

The project entitled "Construction and development of SISMS 3.0 e-services with the implementation of microservice architecture for residents and local governments as a further development of R&D activities of SISMS LTD" is based on the development of the services offered in a model that will allow to centralize the so-far dispersed e-services provided for residents, entrepreneurs and investors as well as local governments. The customers will decide what functionalities and what communication channels they want to use, and they will be able to define how they are to be implemented in their own infrastructure and with which systems it is to be integrated. Customers will be able to decide whether they want to use all the functionalities within the Resident's Account, or whether to use them as separate services. The project's budget was originally PLN 3.045 million PLN, of which the subsidy from the EU amounted to PLN 1.775 million. As a result of the project, at the end of the project the budget was reduced to PLN 2.471 million, of which PLN 1.47 million came from the EU. The project implementation period was from 2 January 2018 to 27 January 2020. A complete change of the architecture of SISMS and Resident's Accounts was planned as well as the transition from the monolithic applications to functionalities based on microservices. Microservices will constitute the 'foundation' with which the sets of functionalities used by clients will be created (microservices as a private cloud).

2.2. Functional assumptions of the architecture of the research and development project (2018-2020)

The aim of the project is to create the SISMS 3.0 system, which consists of several modules – microservices and functionalities as well as a modular graphic interface of the Resident's Account.

Microservices:

- Microservice SMS sending,
- E-mail microservice,
- Microservice notifications,
- Record microservice,
- Internationalization microservice,
- Geolocation microservice,
- Beacon microservice,
- API (application programming interface).

Functionalities:

- Operator Panel functionality,
- Online service cards and forms functionality,
- Municipal economy functionality,
- Civic budget functionality,
- Consultation Platform functionality,
- Report a bug functionality,
- Publishing real estate advertisements functionality – investor's portal.

Information subscription management functionality:

- Creating dedicated modules functionality,
- Mobile Resident Card functionality.

Modular Graphical Interface – Resident Account

By default, customers do not have access to microservices but only to functionalities, which then use the services offered by microservices internally. The functionalities will be flexibly adjusted by connecting or disconnecting microservices adapted to the customer's requirements. The functionalities provide dedicated graphical user interfaces (GUI) to minimize the effort needed to learn how to use them and to ensure the appropriate comfort and ergonomics of the client's work.

3. Microservice architecture

The functional division of the system into independent modules would deliver specific business values to the company. This division will enable:

- reusing ready modules in other projects,
- combination of services in order to obtain new business values,

- ease to modify, without having to stop the entire system,
- replacing modules with other modules (prepared by third companies or purchased in the SaaS model).

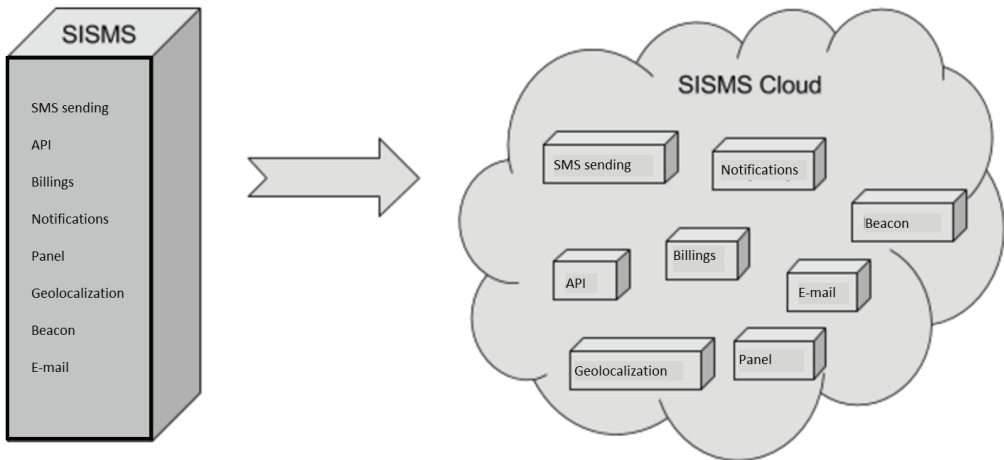


Fig. 1. Flexible microservice architecture

Source: own elaboration based on documentation from AMM Systems LTD.

The goal of this activity is to move from monolithic architecture to microservices. Then it becomes possible to build a private cloud with flexible components that can be easily modified, extended and multiplied. The inspiration for such architecture is the ‘reactive manifesto’, which concerns:

- responsiveness – the system responds as quickly as possible, without waiting for additional resources,
- resilience – the system as a whole works despite the unavailability of individual elements, maintaining coherence of operation,
- flexibility – the changing load (more users, more tasks) does not hinder the service,
- messaging as communication between services.

Another microservice is SMS sending as a separate microservice based on:

- standardized API,
- the possibility of integration with new (e.g. cheaper) providers of the SMS sending service,
- shipping data separate from system data,
- a separate infrastructure optimized to deliver messages to users effectively.

This solution will reduce the cost of handling the sending SMSs. It will allow for much more flexible cost management and enable the easier expansion of other company’s projects, thus increasing its competitiveness.

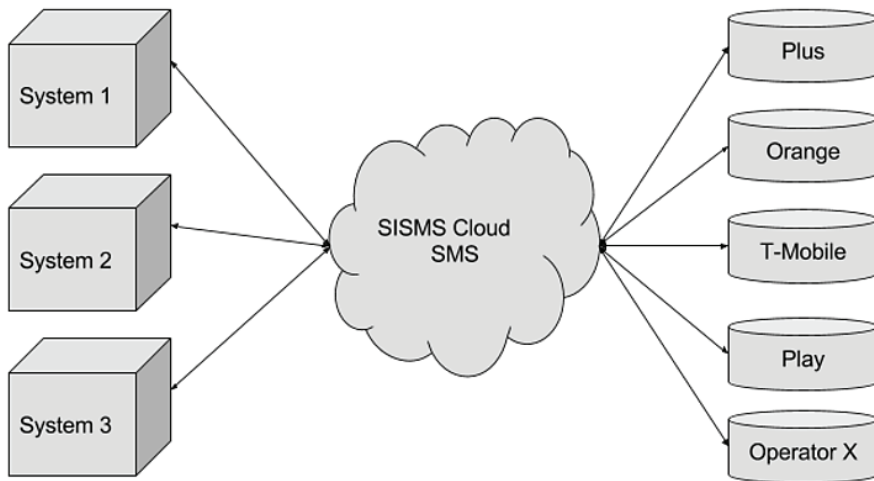


Fig. 2. Architecture of the SMS sending microservice

Source: own elaboration based on documentation from AMM Systems LTD.

3.1. E-mail delivery microservice

E-mail sending is closely related to the system, so that every minor change forces the system to be temporarily unavailable for its customers. There is no possibility of flexible traffic management. Shipping handling data is closely related to other data in the system.

Sending an e-mail as a separate microservice from:

- standardized API,
- the possibility of integration with its own infrastructure for sending e-mails, as well as the use of external suppliers,
- e-mail sending data separate from system data,
- a separate infrastructure optimized for effective delivery of messages to servers intermediating in sending e-mail messages.

3.2. API

Internal rebuilding of the API according to the ‘event-streaking’ approach (processing based on events)

The solution is to:

- build a separate message log for individual applications,
- record a log of sent messages,
- record notifications,
- each application downloads a log fragment limited by the ‘from’ and ‘to’ dates, and a timestamp of the last download.

This innovative ‘time window’ solution will increase the flexibility of the system, thus allowing to increase the number of simultaneous queries, increasing the responsiveness and overall user experience. The log (commonly referred to as the ‘log’) will allow the users to shorten the time and cost of individual system queries. By specifying the time interval it will be possible to download events that took place just in the specified range. In extreme cases, it will allow to recreate the full history of communication with a given client.

3.3. Notifications microservice

This microservice of notification dispatch constitutes a separate microservice which will be able to send appropriate notifications to Android and iOS systems. There exists a separate infrastructure with the necessary databases appropriate for handling notifications.

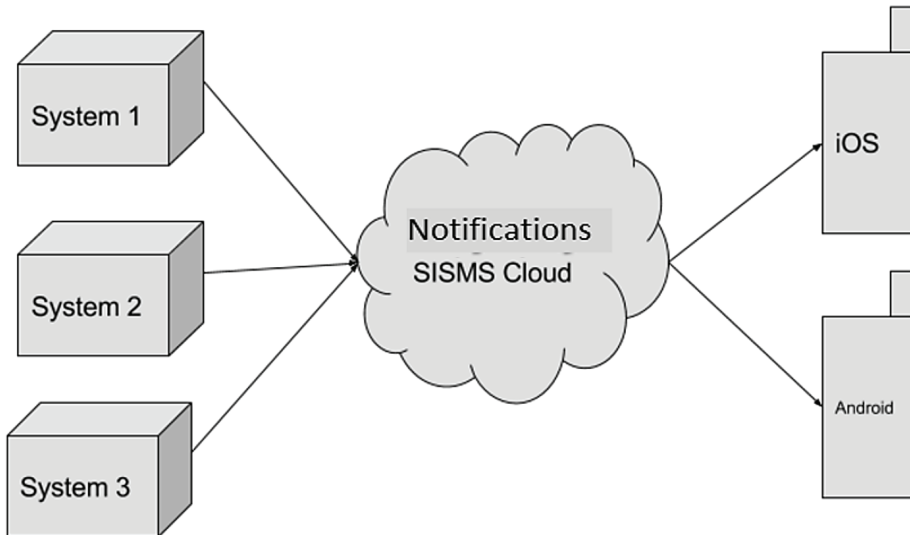


Fig. 3. Architecture of notifications microservice

Source: own elaboration based on documentation from AMM Systems LTD.

The main elements of the solution are:

- preparation of a unified API to connect to the website,
- preparation of database that stores the data necessary to send notifications,
- sending to iOS,
- sending to Android,
- building a key management panel and configuration necessary for the implementation of notifications.

3.4. Billing microservice

Separating the billing and similar mechanisms into a separate service (microservice) and transferring them to other servers will increase the efficiency of billing management.

The solution is based on:

- cyclical conversion of amounts due, packages, packages and individual contract properties,
- possibility to download generated statements and reports.

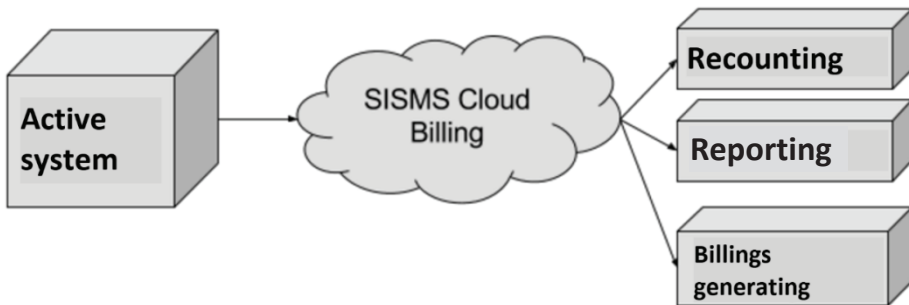


Fig. 4. Billings microservice

Source: own elaboration based on documentation from AMM Systems LTD.

3.5. Functionality Operator Panel

It is planned to prepare a new graphic design taking into account the current standards in the UI (user interface, the way the user interacts with the system)/UX (user experience using the user interface) category. There is planned an implementation of a new look with the necessary changes in the system to enable using the infrastructure based on microservice.

The solution assumes:

- preparation of an innovative appearance adapted to users,
- use of the new cloud architecture,
- preparing optimal practices of implementing functional changes faster.

3.6. Internationalization microservice

The current system is not adapted to support languages other than Polish and currencies other than PLN. After changing and modernizing the Operator Panel described in the previous point, it will also be possible to reconstruct the system by implementing translation services and other European currencies. The prepared files with translations will be uploaded to the system and then displayed in a unified form to users from other countries.

3.7. Geolocation microservice

Contextual communication enables the transfer of information in the context of place and time (geolocation). The microservice will make it possible to reach the recipients of the message, saving time and not imposing content that they do not need. In some cases, the system should only send messages to users located in a specific area.

The solution is to handle and use geolocation – thanks to this innovation, the system will know where a given user is located and will be able to take appropriate action.

The system will automatically track the user's location and send messages appropriate to his/her current location.

3.8. Beacon microservice and developing beacon tool

The project involves adding to the mobile application the ability to support Bluetooth Low Energy (BLE) communication and creating a Beacon BLE device that will meet the requirements of local government units. The mobile application should receive a notification with information when it is in the vicinity (up to a few dozen meters) of a specific object or objects (BLE beacon). There is planned a separation of the implementation-specific protocol into a separate handler to enable communication adaptation to cooperate with the produced BLE Beacons.

3.9. Resident accounts – Modular Graphical Interface

The planned transition from monolithic architecture to architecture based on microservices and functionalities will allow for the construction of a private cloud with flexible components that can be easily modified, extended and multiplied, thus enabling the creation of any set of functionalities. Each set selected by the customer may be different, therefore an important element of the system is a flexible modular graphic interface that will facilitate visualization of selected functionalities.

The clients will also be able to choose the information distribution channel through which they will send messages to residents: notifications to mobile devices, e-mails or SMSs. They will also decide whether their 'resident account' is to be an information portal, a platform for two-way communication or also an individual account with personal data and on-line payments.

3.10. The functionality of online service cards and forms

Online Service Cards and e-forms for e-PUAP (Electronic Platform of Public Administration Services) are functionalities that will enable the creation of online forms and information documents for matters handled by online means of communication in local government units.

3.11. Municipal economy functionality

This functionality is designed for municipal economy enterprises, the main goal of which is to make it easier for residents to access information about the waste collection schedule and to expand the scope of knowledge in the area of waste segregation. The client will receive a comprehensive tool supporting information management and communication with residents along with the functionality of creating, managing and editing waste collection schedules. The application possesses information about the current waste collection schedule, types of waste, the location of waste containers on a map base and contact details. It will enable the user to send messages quickly. The application will inform the user about the waste collection and allow residents to send notifications concerning illegal landfills.

3.12. Civic budget functionality

The civic budget module will allow residents to participate in the design of local spending. The authorities allocate a certain part of the budget and put it at the disposal of the residents who will decide what to spend the money on. The module will have flexibility and functionality so that it can be easily adapted to the requirements of the regulations and resolutions of the civic budget, and the graphic design includes the visual identification of local government units.

3.13. Functionality of the consultation platform

The consultation platform is an excellent tool supporting social dialogue. It gives great opportunities to identify the needs of the residents, who can submit their comments and ideas and obtain information about the currently conducted consultations.

Thus it will be possible to consult each project or investment with the residents, listen to their needs more closely and involve them in the development of local government units.

3.14. Report a Bug functionality

This will enable easy and quick reporting of any irregularities in the functioning of the local government unit infrastructure to the relevant services. Report a Bug simplifies communication by allowing to collect queries and manage workflow in one place. Better communication increases engagement, maximizes efficiency and improves service quality at a lower cost.

3.15. Functionality of publishing real estate advertisements – investor’s portal

The functionality is mainly aimed at supporting the process of finding a buyer, tenant or tenant for a local government property and will allow the presentation of information on commercial premises and land intended for investments. It will enable quick and effective management of local government units’ resources and provide comprehensive support for providing public information in this regard. The tool is also intended to allow local government units to promote real estate and investment areas among entrepreneurs and encourage them to greater economic activity.

3.16. The functionality of managing information subscription for a specific location

It will enable the transmission of information based on the declared location data. Each user will be able to add a location (address) for which he/she would like to receive information. This will allow the office to send information specifying precisely the address/shipping area, and the user will receive information closely related to the indicated address, e.g. about disconnecting services (water, electricity, gas, Internet), about dangerous situations related to the indicated location.

3.17. Automatic sending of messages

The module can function as a separate product or as part of the Resident’s Account. The module will allow to inform about the amount of liabilities to local government units, charging interest, upcoming payment dates, initiated enforcement proceedings, as well as sending a reminder about the lack of payment or thanks for the payment made. The implemented system will contribute to improving contacts with taxpayers and increasing the availability of information on the status of individual taxpayers’ affairs.

3.18. The functionality of creating dedicated modules

The goal is to create tools for the rapid creation and configuration of modules, flexible enough to be able to meet the client’s requirements as much as possible.

Hence the system will not have static modules imposed in advance, nor will there be two-way communication. The modules will be built from available, configurable components.

3.19. The functionality of the mobile Resident Card

The Resident Card is a modern and multifunctional carrier of online services and products in the format of a payment card and a mobile application. The Resident Card is also a loyalty program under which the resident can receive it free of charge,

and after registration entitles them to earn and spend points under the system. The equivalent of the card will be a mobile application, thanks to which residents participating in the loyalty program will have access to a map with marked enterprises participating in the initiative. The application will also inform residents about the number of points accumulated and the bonuses they are entitled to.

Loyalty points are calculated and used to obtain a discount through wireless data transmission between the partner's mobile device or beacon and the resident's card also in the mobile application version. Under the agreement with the local government, the partner will receive a device to operate the system.

4. Conclusion

Research based on of AMM Systems LTD is rather in its initial stages and does not constitute a normative basis for the formulation of final conclusions and recommendations verified on an appropriate research sample. These studies, due to their preliminary nature (stage I of the research), made it possible to obtain answers to the research questions formulated in the introduction, aimed to improve the quality of in-depth research (stage II). Below there are listed the answers to research questions and the obtained research results.

The answer to the first question concerns the objectives and reasons for submitting the research and development grant. According to the Management Board of AMM Systems, the decision was based on the desire to:

- create and introduce new services for the company,
- create strategic competitive advantages based on innovation,
- gain the position of a technological leader in the communication sector between residents and local government units in 2020,
- create new competences in a team of programmers creating solutions in new technologies and a new model of service provision (SaaS),
- increase the profitability of operations.

From the perspective of the end of 2020, the company managed to achieve all of the above-mentioned goals, except for gaining the leading position and increasing the profitability of the activity. Currently, it is difficult to assess whether the company has maintained its leading position, as contact with the authorities is difficult. The company is generating operating losses, largely due to the difficult economic and pandemic situation in local governments. Municipalities are currently spending their funds mainly on protecting residents and local government institutions against coronavirus.

The products (e-services) planned for production as described in this article, were made according to the plan. However, the priority in the schedule was given to two services, i.e. waste management and the functionality of online service cards and forms. There were two main causes:

- legislative changes regarding the harmonization of Polish law with the EU law in the field of municipal waste segregation – the need to segregate garbage and impose charges on residents for improper segregation,
- the emergence of the coronavirus pandemic, which has changed the way of dealing with official matters towards e-services.

The results of the conducted research indicate that two of the most attractive services in terms of business are:

- waste management,
- functionality of online service cards and forms.

These services overcame the following development obstacles: the barrier of product manufacturing, the first revenue barrier, the revenue repeatability barrier. The so-called first income in 2020 constitutes another hindrance, but the Management Board plans to generate income in 2021.

The results of the conducted research also indicate that too many e-services and functionalities have been planned. From the perspective of the 24-month duration of the project, the Management Board of the company would have taken slightly different decisions. If they had had the opportunity to plan the tasks again, they would have abandoned several of them (namely the publication of real estate advertisements – investor’s portal, consulting platform and internationalization microservice). Thus the number of planned e-services was not optimal.

Another answer concerns the question of whether the developed e-services have created a competitive advantage for the AMM company. From the business perspective, the Management Board’s response is positive, as the company gained an advantage over its competitors (the first service on the market and comprehensive solution) in terms of two key e-services: waste management and online service cards and forms. Currently, in the pandemic situation, the main services that the company sells in the SaaS model are a system for waste segregation and online service cards and forms with a search engine.

The answer to the question of whether without the co-financing from the European Union, the scope of works in the research and development project would be the same as in the case of financing R&D from own funds, was a clear “no” on the part of the Management Board of AMM. The company treated non-returnable subsidies as a source of financing for additional innovations and a tool to reduce business risk in the case of new e-services. In the event that there were no EU subsidies, the company’s Management Board would have implemented a much smaller scope of the project, which would minimize the risk of a potential business failure.

Another issue concerned the potential business synergy in the product portfolio i.e. e-services produced by AMM. As a result of the research and development project, in the opinion of the Management Board there was a synergy between individual microservices, in particular microservices for flexible SMS sending, notifications and e-mails with specialized services such as ‘municipal waste management’, ‘automated cards and forms’, and ‘Report a Bug’ microservice.

The last research issue was an attempt to determine whether customers and end-users use the created e-services under R&D. The data provided by the company showed that the main services that the inhabitants of municipalities are eager to use are active service cards and the “Segrego” waste management system.

Service cards is a system for organizing information and integrating e-services in local government units using service cards and a search engine. Service cards are a new way to systematize public information at the level of local government unit in such a way that it is easily accessible to residents. There are currently four active customers in the service card system (as of 20 Nov 2020). The total number of service cards entered into the system is 1396. On average, as many as 349 service cards of the type ‘deal with it’ or e-services in the commune are defined. Comparing the types of card, there are more e-services available in the system – 869. There are 527 cards of the ‘deal with it’ type. It follows that the type of card most frequently used by residents are e-services.

Currently in the service card system there have been already 2708 successful searches. During one search, there were situations in which the user clicked on the link many times. The total number is 3008. This shows that most of the searches were successful at the first attempt. The average number of searches in one commune is 752. The position of the links clicked by residents varies, and the average position is 4. The total number of sessions (visits) of service cards is 4919, where there were 3369 unique users. This means that over 30% of users are ‘returning users’. The record number of searches by one resident is 254. Over 30% of users searched successfully for information more than once. The number of ‘returning users’ (more than 10 times) is just over 2%.

On the other hand, the second system i.e. the “Segrego” waste management microservice, which is already used by customers and users, consists in the following functionalities:

- waste collection areas and waste collection schedules,
- e-mail/mobile app reminders on waste disposal,
- collection points and containers for bulky waste,
- search engine “how to segregate waste”,
- educational tab of the “Good to know” type presenting interesting facts,
- notifications of residents (e.g. illegal dumping or unclaimed waste),
- waste payment deadlines,
- companies exporting waste along with assessments,
- e-mail messages/in the mobile app addressed either to all users or to specific areas only.

The number of active local government customers of the Waste Management System as on 24 November 2020 was 47. The total number of export areas in the system is equal to 860, which gives the average number of export areas in the commune at the level of about 18. The total number of collection points entered into the system was 1376, which gives an average of 29 additional specific waste

collection points in municipalities. The total number of companies that export waste within examined system w 57. This means that on average every fifth commune is served by more than one waste-export company. In the Waste Management System, the company has a search engine with a default database of over 750 kinds of garbage, along with the information as to which container it should be put in. More than 12% of customers made changes to the search engine available to their residents. The total number of residents registered in the system is 94 280, including 93 058 mobile application users and 1 222 people using the e-mail notifications option. In November 2020 there were 37 842 messages received in the form of notifications and 934 received in the form of e-mail. In turn, the residents sent 1 410 reports to municipalities regarding irregularities and problems in waste segregation.

The authors of this article are aware that the research is not fully representative as it concerns only one company, namely AMM Systems LTD. However, continuing the studies will show further directions for in-depth research to be conducted in order to improve the quality of the research in the second stage.

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