Marcos-Pablos, S., García-Holgado, A., & García-Peñalvo, F. J. (2019). Modelling the business structure of a digital health ecosystem. In M. Á. Conde-González, F. J. Rodríguez-Sedano, C. Fernández-Llamas, & F. J. García-Peñalvo (Eds.), *TEEM'19 Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality (Leon, Spain, October 16th-18th, 2019)* (pp. 838-845). New York, NY, USA: ACM. doi:10.1145/3362789.3362949

Modelling the business structure of a digital health ecosystem

Samuel Marcos-Pablos
GRIAL Research Group,
Research Institute for Educational Sciences, University of Salamanca
37008 Salamanca, Spain
samuelmp@usal.es

Alicia García-Holgado
GRIAL Research Group,
Research Institute for Educational Sciences, University of Salamanca
37008 Salamanca, Spain
aliciagh@usal.es

Francisco José García-Peñalvo
GRIAL Research Group,
Research Institute for Educational Sciences, University of Salamanca
37008 Salamanca, Spain
fgarcia@usal.es

ABSTRACT

The current trend in digital solutions for the health sector is to move from fragmented services to progressively more integrated services provided by multiple stakeholders through technological ecosystem platforms. However, the business model is scarcely taken into account at the early stages of development of this type of ecosystems specially in the health sector. In the present paper a general approach towards the exploitation of a technological ecosystem focused on caregivers is presented. It follows the Business Process Model and Notation (BPMN) in order to develop different ecosystem's exploitation alternatives, taking into account the ecosystem stakeholders and their main value propositions. This serves as a starting data model in the software development process from which different business exploitation alternatives can be elaborated.

KEYWORDS

Technological ecosystems, software ecosystems, health sector, business modelling, health ecosystems, BPMN.

1 Introduction

During the last years technological or digital ecosystems, also called software ecosystems (SECOs) in the literature [1][2] have emerged as a solution to improve the knowledge management in heterogeneous contexts. They provide a general framework that allows defining and developing any type of technological solution in which data and information are the main objects of interest [3]. Technological ecosystems can be oriented to different domains depending on the problems they try to solve. In particular, there is a research area related to the use of this technological approach in the health sector [5]-[7]. However, from the authors understanding, to date none is focused on supporting the caregivers, despite the essential role they play in care provision. Caregiving activities have a high health and mental impact on caregivers: overload, depression, anxiety, etc. Thus, care related activities significantly reduce their quality of life and increases their social isolation and family stress. In this context, the current paper focuses on a technological ecosystem focused on caregivers, by developing the learning and knowledge management processes needed to enhance the caregiving competences of (in)formal caregivers, both at home and in care environments.

Furthermore, current proposed or developed technological health ecosystems tend to have problems when it comes to being deployed in the real world. This means that they are usually discontinued despite their great potential [4]. This may be because the vast majority of such proposals do not take into account the concept of value co-creation within the ecosystem, and lack from a business perspective when defining the relevant data to be exploited. They are usually focused on providing services for the patient end user but forget the rest of the stakeholders' when it comes to ecosystem exploitation.

Yet, before exploring the different ecosystem's exploitation alternatives, it turns out necessary to clearly define the ecosystem's business structure. Moreover, to obtain a successful business model that suits a software-based ecosystem, the business structure should

be included as an additional data model in the software development process [8][9]. To do so, the present paper employs the Business Process Model and Notation (BPMN), which is a standardized graphical representation for specifying business processes within a business process model. The use of this standard allows to include the business model in the definition of the ecosystem's data taxonomy during the initial steps of its development. This serves as a starting data model in the software development process from which different business exploitation alternatives can be elaborated.

The paper has been organized as follows. Section 2 provides an overview of the ecosystem. Section 3 describes the proposed model for the ecosystem's business structure. Section 4 presents the ecosystem's exploitation models extrapolated from the previous business model. Finally, section 5 summarizes the main conclusions of this work.

2 Ecosystem overview and structure

As stated in the previous section, the aim of the technological ecosystem is to provide a platform that allows (in)formal caregivers to develop and enhance their caregiving competences, as well as to mitigate the negative effects produced by caregiving activities such as physical and mental stress and social isolation.

As described in [10], a software ecosystem consists of three main structures, each including actors and software elements. First, software components build the software structure as the core of a software ecosystem. Second, the organizational structure governs the interaction and organization of actors and software, providing means to develop software-based services in the ecosystem. Finally, the business structure allows actors to create value within the ecosystem.

Taking the above description into account, the present ecosystem's software structure is based on the architecture proposal validated in previous works [11], and is organized into four layers as shown in Figure 1. The top layer is the representation layer, focused in ensuring the usability of the software components with focus on the user experience (UX) for unexperimented software users.

The second layer is the services layer, focused on three main components that offer a set of services to the users. First, an online tool (SocialNet) that provides a private social network composed of a set of private and safe areas called walls [12]. Walls are managed by (in)formal caregivers, care managers, but also the patients and their relatives may be granted access to the tool. Next, a learning platform (Discover) provides training support to cover different knowledge needs of the (in)formal caregivers, but also information, advice, and guidance, as well as access to a community of equals and experts [13]. Finally, the third component is a dashboard which provides tools based on visual analysis to support decision-making processes from the knowledge created within the ecosystem. The dashboard is based on Semiotic, a React-based data visualization framework.

The Static Data Management layer provides tools to centralize information needed by other components of the ecosystem. This layer has a database that stores data of different nature (e.g. information of ecosystem usage, provided treatments, caregivers visits, location, etc.).

Finally, the infrastructure layer provides a set of services that are used by the software components from other layers.

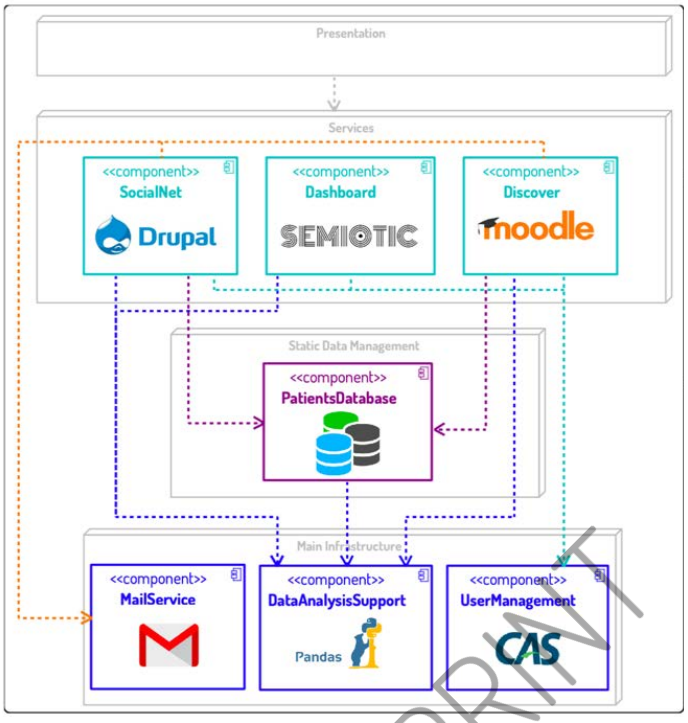

Figure 1. Ecosystem's software structure.

In terms of the organizational structure, the proposed ecosystem is based on a software platform that centralizes the actors' interaction. According to the ecosystem classification proposed in [14] the ecosystem lays in the province of Cornerstone Ecosystems: "where actors interact on top of a common software platform and usually extend the platform's functionality". This means that an ecosystem orchestrator that governs the interaction and organization of actors and software is needed, providing means to access the different services and data of the ecosystem. Furthermore, as sensible and medical data may be generated within the ecosystem components, the ecosystem orchestrator should take into account the ethics and data protection necessary to warranty a safe data governance.

As for the business structure, the following sections describe the taken procedure towards modelling the business component of the ecosystem which can lead to different exploitation models.

3 Modelling the business structure

Regarding the business structure, an initial approach to the ecosystem's business definition approach has been presented in [13], by the fulfilment of the Business Model Canvas (BMC) proposed by Osterwalder [15]. Osterwalder's approach has proven to be a valuable tool for describing not only commercial business models, but also in many other contexts including health-related ecosystems [16]. However, in order to successfully integrate the business and software structures, it turns out necessary that the software product requirements are aligned with the business needs, both in terms of business processes as in terms of the informational entities those processes deal with. As such, the platform specific model should be completed with the definition of the business structure modelled in such a way that the associated software and business processes can be easily integrated.

3.1 Business Process Model and Notation

The Business Process Model and Notation (BPMN) standard allows companies to graphically visualize their internal business procedures and provides a standard notation for process communication. The BPMN standard was originally developed by the Business Process Management Initiative (BPMI) but is nowadays maintained by the OMG (Object Management Group). It is a widespread standard that is actually used not only by organizations but also in academia [17].

BPMN defines three different types of diagrams: Process and Collaboration, Choreography, and in BPMN 2.0, Conversation diagrams were also introduced.

3.2 Process and Collaboration diagrams

Process and collaboration diagrams depict the interactions between two or more actors as a sequence of activities that produce the message exchange patterns between the entities involved. Each participant tasks are represented within a lane that contains tasks of the business process represented by interconnected boxes. Process and collaboration diagrams include events, subprocesses, flow objects, activities, gateways, etc.

Process and collaboration diagrams are used at a lower level and are the link between the business structure and the software structure. Process and collaboration diagrams are beyond the scope of the present paper, in which a high-level description of the ecosystem business processes is sought. In any case, the collaboration diagrams can be derived from both the choreography and conversation diagrams, which in turn are more useful for the current work in terms of establishing the business exploitation model as they provide an overall higher-level perspective of the business.

3.3 Users – DMS choreography diagrams

Choreography does not only describe what a business process does, but also define how individual process interact with each other. In short, it depicts all the processes and their required interactions in a business process diagram. However, unlike BPMN's process, it doesn't belong to any pool. The focus of a choreography diagram is the messages between the participant pools. A choreography diagram is populated with choreography tasks.

As an example, Figure 2 shows the interaction between the ecosystem users and the Data Management System. The DMS comprises both the Database Management System (DBMS) and the Decision Support System (DSS) (or Data Analysis Support in Figure 1). The DMS is the core of the ecosystem business, allowing the personalization of content for users and data extraction. The DMS will in turn be the source of added value to the ecosystem actors, as well as permitting new business paths to be opened within the ecosystem.

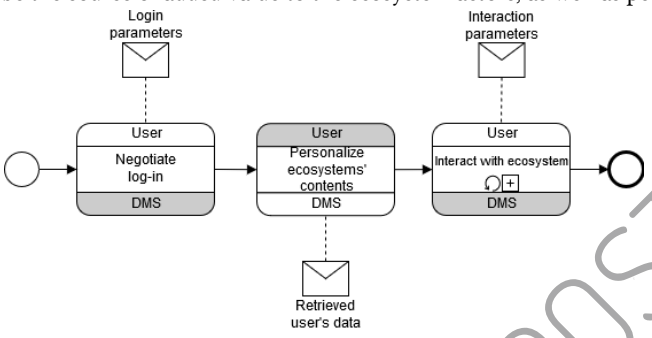

Figure 2. BPMN 2.0 Choreography diagram depicting the high-level interaction between ecosystem users and the DMS.

Unlike process and collaboration diagrams, choreography diagrams describe not only what a business process does, but also how individual processes interact with each other. They consist of at least two participants, an initiating and a non-initiating participant. As shown in Figure 2, tasks are defined as rounded boxes which include the participants involved. The task flow is represented with arrows connecting the tasks. The initiator of the interaction shares the same colour of the task, whereas the non-initiating participant is in grey. Choreography also defines the messages between the two participants in the task as message icons.

The main tasks involved in the user-DMS interaction include the log-in, the personalization of the contents accessible by a particular user and the interaction of the user with the ecosystem services. This last task is represented as a looped task which contains a set of subtasks (or subprocesses) which are modelled in figures Figure 3 andFigure 4 for primary users and care managers.

Figure 3 shows the choreography diagram for the “interaction with the ecosystem” task for primary users: patients and (in)formal caregivers. Primary users mainly interact with the ecosystem through its services. That is, patients and caregivers access the social network in order to share experiences or search for guidance and support, whereas caregivers also access the training program services to enhance their knowledge.

In terms of the business opportunities, Figure 3 model emphasizes the importance of registering all interactions within the ecosystem. Thus, users and the DMS will be interacting as business entities even when this communication is not the user goal. For example, and always taking into account the privacy and ethics, the DMS will register parameters such as search parameters, visited content, post content tags in the social network, usage time, devices employed for such usage, etc. All these parameters will serve for content personalization in future interactions, as well as for dashboard metrics.

Regarding the training activities followed by the (in)formal caregivers, the interaction with the DMS will allow to improve and adapt the training itinerary to the user training needs. This iterative process combines unassisted and assisted training. On the one hand, the user can employ tools to follow his own learning path without mentoring. In this case, users have at their disposal evaluation questionnaires (follow-up), personalized searches (to solve doubts or access specific contents) and content recommendation. Additionally, a Smart assistant nourished from the ecosystem interactions answers questions 24/7. On the other hand, the social network

allows for assisted training by experts in the mentoring program which support the caregivers in scheduled sessions or through other ecosystem tools (social network, email, etc.).

This assisted / unassisted support during the training program is reflected in Figures 3 and 4 through different tasks, but mainly in the "handle query task". It can be seen in Figure 3 that when a user has a query, it handles it to the DMS's smart assistant which will try to solve it. If it is unable to provide an answer, the DMS will handle the query to the care manager (Figure 4), which will provide feedback to the user and update the smart assistant parameters.

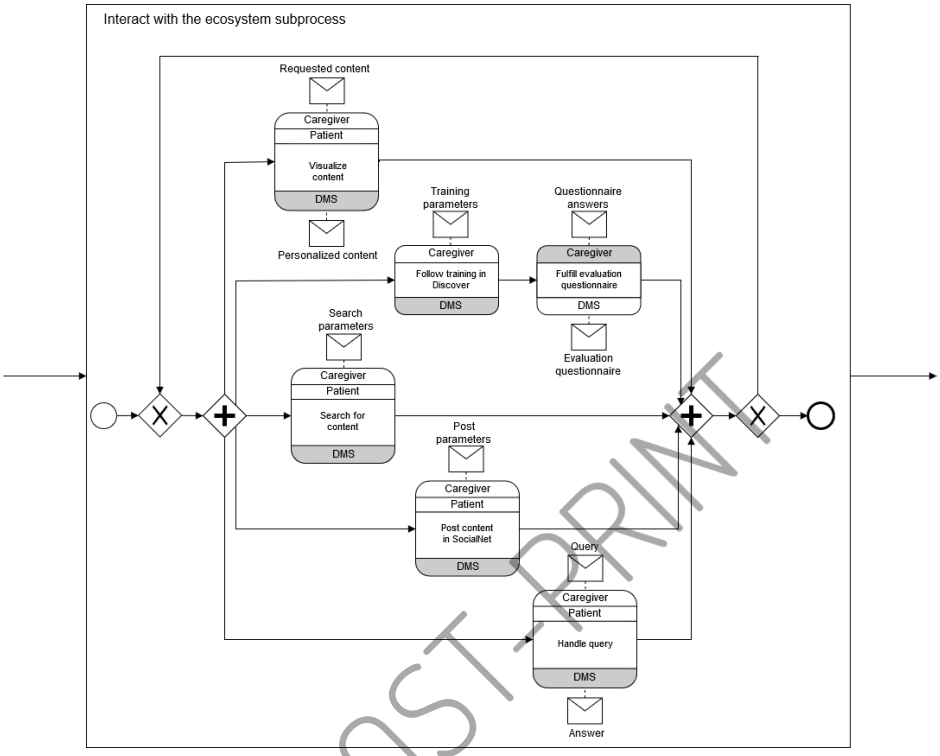

Figure 3. BPMN 2.0 choreography diagram depicting the "interaction with the ecosystem" looped subprocess for primary users (patients and caregivers).

The main tasks of the care manager are to manage and support the caregivers. By using the social network, the care manager could observe the patients' evolution through their posts, and may post comments, answer questions that cannot be solved automatically by the system as well as recommend changes in the contents of the training if necessary.

On the other hand, care managers will employ the dashboard parameters in order to organize the caregiving process. For example, if the care manager is in charge of a caregiving organization, he could use the dashboard parameters to supervise the patient evolution, the effectiveness of the training program, or assign caregivers to patients based on their care and training history. These tasks are reflected in the choreography diagram in figure 4.

In terms of this business process, that implies the data access and visualization in order to enhance decision making, the choreography diagram shown in figure 4 could be easily extrapolated for tertiary users, such as public administrators, health practitioners, pharma, etc. Next section will discuss the business model for these stakeholders in more detail.

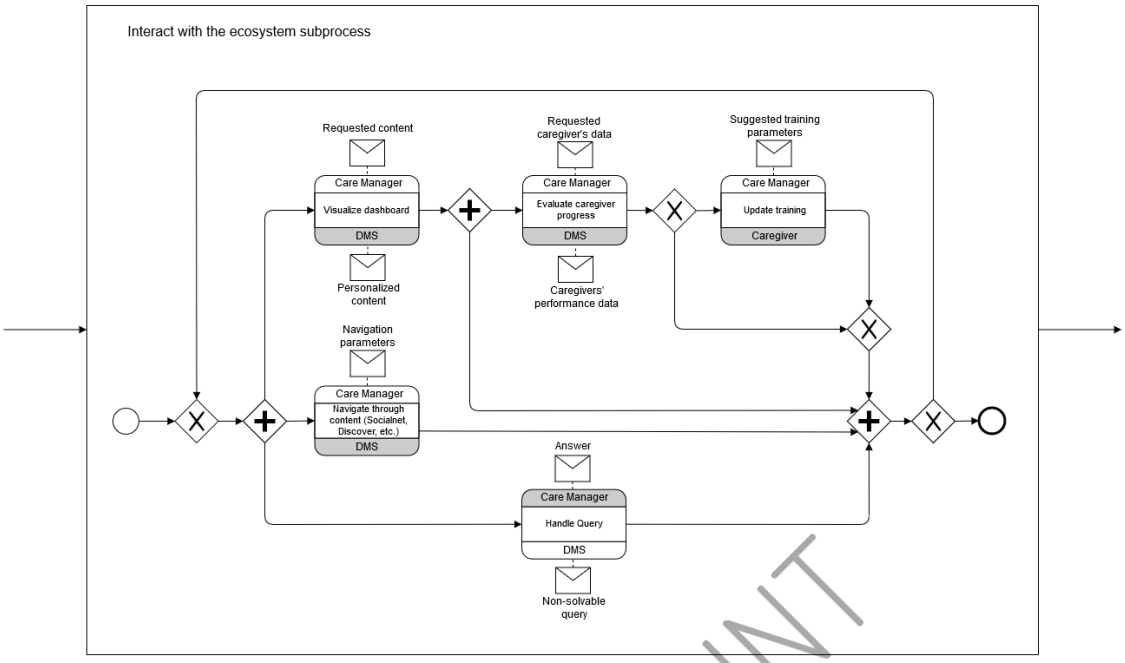

Figure 4. BPMN choreography diagram depicting the "interaction with the ecosystem" looped subprocess for Care Managers.

3.4 Between-actors conversation diagram

Inherent to the definition of technological ecosystems, it is the actors themselves who provide added value to the ecosystem beyond the platform over which they interact. In this sense, in terms of the business structure, the business model should focus on both the ability to extract data from the ecosystem software components usage as well as from the interaction between users itself.

Conversation diagrams are a BPMN 2.0 model type that take the concept of collaboration between users on a high level. The conversation model is a simplified view of a collaboration model but is helpful in order to analyse the communication between ecosystem actors, the possible data outcomes associated with such conversations and, in turn, the possible exploitation models that could arise based on the values the actors seek within them. The main benefit of the conversation diagram resides on its abstraction from the raw data interchange that occurs in pure software-based ecosystems, allowing to analyse more abstract value propositions susceptible of exploitation.

Figure 5. BPMN 2.0 Conversation diagram depicting the collaboration between ecosystem actors. shows the conversation diagram depicting the collaboration between the ecosystem actors. Conversation diagrams are based on three main types of elements only: participants, conversation nodes and conversation links. In BPMN 2.0 a participant is represented by a rectangle and is employed for people or organizations which are involved in a specific communication. In Figure 5, participants correspond to the different ecosystem actors. Participants are interrelated with conversation links represented with double lines. Finally, conversation nodes are represented with hexagons and describe the objective pursued by the communication between participants.

As stated before, these conversations are related to collaboration diagrams, as a conversation node can be expanded into a series of message flows between participants. Since participants in a conversation are actually BPMN pools, conversation diagrams can be directly linked to processes via conversation nodes.

Figure 5 includes the main actors considered for the ecosystem: primary (patients, relatives and caregivers), secondary (care managers and health practitioners), and tertiary (members of public administrations and research networks, platform suppliers and operators, pharmaceuticals, medical hardware and software providers, as well as the ecosystem orchestrator.

As an example, care managers (top left) are in charge of supporting caregivers in the learning process, as well as managing and scheduling the care provision to patients. In this sense, they will be also interested in reducing care costs and resource expenses. To do so, they will seek to acquire data that helps them to improve learning contents, for example by communicating with the public administration representatives and the health practitioners, or by requesting the ecosystem orchestrator access to specific data of the ecosystem services usage (e.g. the Churn rate, the number and type of questions raised during the training itinerary etc.). As Figure 5 shows, these interests are represented by conversation links and nodes with the corresponding actors.

Following the same approach, the rest of Figure 5 includes the conversation links and nodes for the rest of relevant participants. Briefly speaking, the ecosystem orchestrator (represented at the bottom of the figure) must manage the access to the different ecosystem

services for primary and secondary users, as well as the access to specific ecosystem data for secondary and tertiary actors. The access to a particular service/data will be granted once the user has logged into the system. However, each participant must negotiate their particular access privileges with the ecosystem orchestrator. For the above reasons, the orchestrator must maintain dialogs with all ecosystem actors.

Health practitioners' sought value is to improve health provision decision-making (represented by links with public administration, and research networks). They may combine data obtained from the medical records, with additional knowledge of ethnographical or population-based data obtained from the social network. Value offered includes providing care and treatment support by identifying better treatments and discard the least efficient ones (links with caregivers, pharma and medical solutions providers).

Public administration will seek for a better understanding of the health economic impact for example by disease category or patient sub-type, which would provide additional incentives to invest in treatments. As for research networks, their objective is to acquire new knowledge searching for new solutions to unresolved medical problems, investigating the interaction of different factors within the data in order to understand how they influence the risk for disease or disease expression. From the point of view of developers of medical hardware and software solutions, data on the evolution of patients as a result of the use of their devices which could be obtained from the social network for example. In terms of drug treatment, some diseases (e.g. dementia) are only susceptible of symptomatic treatment. In these cases, big data can provide a better understanding of how to best use the available therapies. Platform suppliers and operators will be interested in obtaining more relevant data on the use of the platform for monitoring system performance (e.g. time slots of maximum platform usage). Finally, the evolutive nature of the ecosystem and its services can lead to new business opportunities for other service providers.

All this information could be inferred from the data generated by the ecosystem but, as stated before, privacy and ethics must be assured within the data governance, so the access to all these data must be centralized. For that reason, all participants include a conversation link with the ecosystem orchestrator.

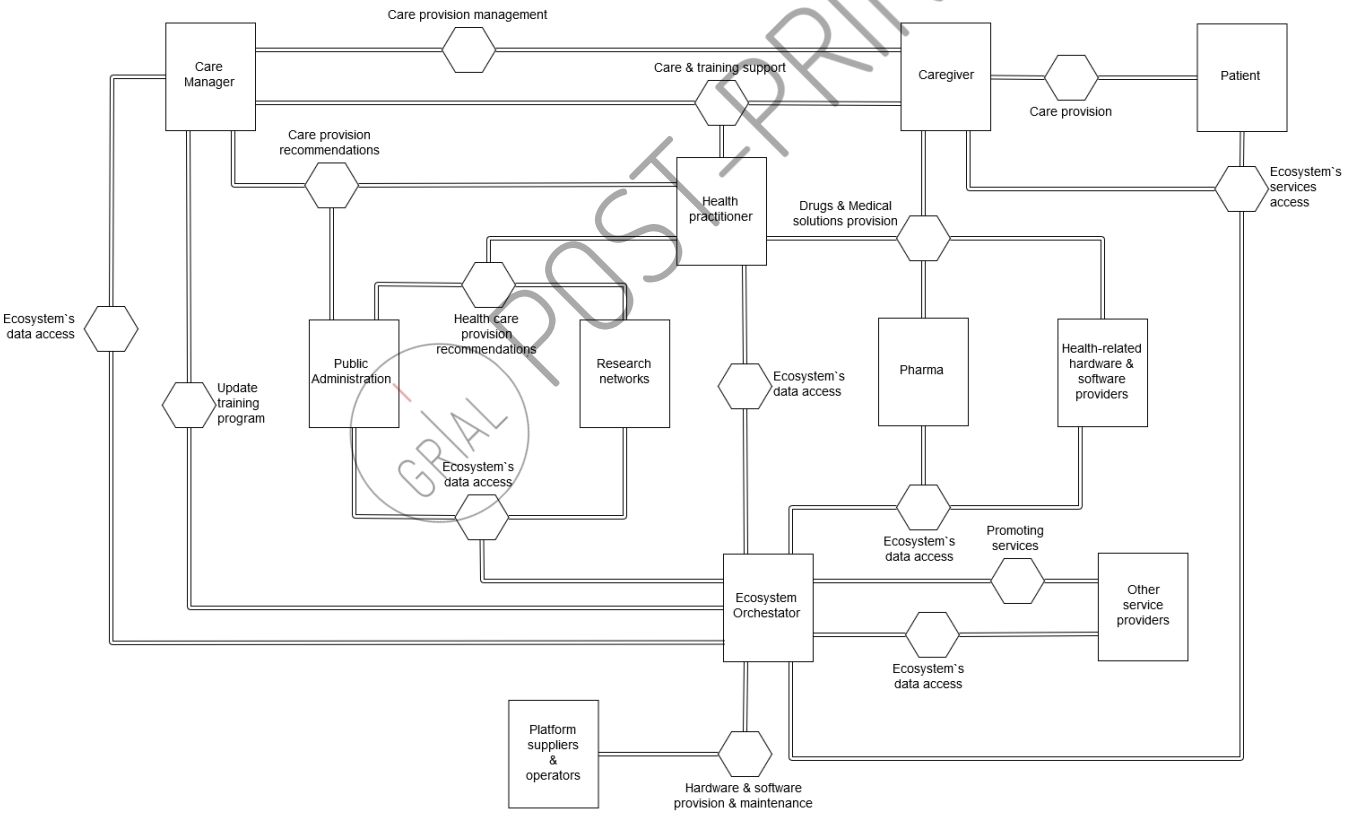

Figure 5. BPMN 2.0 Conversation diagram depicting the collaboration between ecosystem actors.

4 Business exploitation models

From the previous business models analysis, it can be concluded that, in order to exploit the data within the ecosystem, it is necessary to match the activities of the primary users with the value sought by the secondary and tertiary users and vice versa, and that the main business source resides in the exchanged data between the different users and between the users and the ecosystem.

Thus, the business relationships that generates revenue streams could involve four market segments and associated exploitation models: primary users (B2C), another company (B2B), health practitioners and public administration (B2P) and research networks (B2N):

- **B2C (business to consumer):** Due to the user-oriented approach of the business model, the business could be started with a freemium model (to obtain a large number of users) with basic functionalities and subject to advertisements. Different fees could then be applied for an improved service with more functionalities (i.e. greater or more diverse contents, direct contact with a private health professional, etc.).
- **B2B (business to business):** Fees can be applied for platform usage (with a fixed access fee plus another based on the number of users per organization); for the volume of requested data; by volume of data extracted from the use of the platform (traffic analysis, trend study); per functional module (if clients only want to obtain part of the available services); for integrations with internal information systems to exchange information; for advertising on the platform (e.g. through banners) or promoting third parties brands with dynamic activities such as training; etc.
- **B2P (business to Public administration):** The provision of data to public administrations can be focused on a pay per use model. However, payment offers or even a freemium model must be considered as the involvement of public administrations could affect the effective adoption and use of every digital solution through actions such as incentives, awareness campaigns or norms that influence the success of the activities of primary stakeholders. They provide a critical insight into the activities of a business, based on the benefits or risks of its processes on the community. Government entities can protect and promote the generated value.
- **B2N (business to health Networks):** The model can be similar to the previous case since the provision of big data to research networks provides visibility to the ecosystem, allowing the incorporation of new partners to it and influencing the development of new training activities with enhanced results.

5 Conclusions

The present paper has presented a general business model for the development of business exploitation of a health ecosystem even during its first stages of development. Taking into account this business model, the ecosystem developers could focus their efforts into the most important services and solutions that will provide added value to the ecosystem stakeholders, thus warrantying the ecosystem success after deployment.

Employing a standardized business notation as BPMN will permit to easily extrapolate this business model into concrete software solutions, which will in turn match to the ecosystem participants expectations.

Although it has been briefly mentioned through the paper, special care must be taken in terms of methods and tools for the automated but anonymized (or pseudo-anonymized) storage and analysis of the data during the business process. Future lines should put special emphasis on this respect, as it could difficult or even truncate some of the considered business processes.

ACKNOWLEDGMENTS

This work has been partially funded by the Spanish Government Ministry of Economy and Competitiveness throughout the DEFINES project (Ref. TIN2016-80172-R) and the Ministry of Education of the Junta de Castilla y León (Spain) throughout the T-CUIDA project (Ref. SA061P17).

REFERENCES

[1] D. G. Messerschmitt and C. Szyperski. 2005. Software ecosystem: understanding an indispensable technology and industry. MIT Press Books 1.
[2] K. Manikas and K. M. Hansen. 2013. Software ecosystems – A systematic literature review. *Journal of Systems and Software* 86, 5 (05/05/2013), 1294-1306. DOI:http://dx.doi.org/10.1016/j.jss.2012.12.026.
[3] F. J. García-Peñalvo. 2018. Technological ecosystems for enhancing the interoperability and data flows. *Journal of Information Technology Research* 11, 1, vi-x.
[4] Marcos-Pablos, S.; García-Peñalvo, F. J. 2019. Technological Ecosystems in Care and Assistance: A Systematic Literature Review. Sensors, vol. 19, art. 708, 2019. doi: 10.3390/s19030708.
[5] M. Mikalsen, S. Hanke, T. Fuxreiter, S. Walderhaug, L. W.M. Wienhofen, and N. Trondheim. 2009. Interoperability services in the MPOWER Ambient Assisted Living platform. *Studies in Health Technology and Informatics* 150, 366-370.
[6] Sten Hanke, Christopher Mayer, Oliver Hoeftberger, Henriette Boos, Reiner Wichert, Mohammed-R. Tazari, Peter Wolf, and Francesco Furfari. 2011. universAAL – An Open and Consolidated AAL Platform. In *Ambient Assisted Living*, R. Wichert and B. Eberhardt Eds. Springer, Berlin, Heidelberg, 127-140. DOI:http://dx.doi.org/10.1007/978-3-642-18167-2_10.
[7] L. M. Camarinha-Matos, J. Rosas, A. I. Oliveira, and F. Ferrada. 2013. Care services ecosystem for ambient assisted living. *Enterprise Information Systems* 9, 5-6, 607-633. DOI:http://dx.doi.org/10.1080/17517575.2013.852693.

[8] Leshob, A. Towards a business-pattern approach for UML models derivation from business process models. 13th IEEE InternationalConference on e-Business Engineering, ICEBE 2016, Macau, China,November 4-6, 2016(J. Guo, H. Cai, X. Fei, K. Chao, and J. Chung,eds.), pp. 244–249, IEEE Computer Society, 2016. doi: 10.1109/ICEBE.2016.049.
[9] Ferreira Cruz, E; Machado, R. J.; Yasmina Santos, M. From Business Process Modeling to Data Model: A Systematic Approach. 2012 Eighth International Conference on the Quality of Information and Communications Technology. doi: 10.1109/QUATIC.2012.31.
[10] Christensen, H.B.; Hansen, K.M.; Kyng, M.; Manikas, K. Analysis and design of software ecosystem architectures – Towards the 4S telemedicine ecosystem. Inf. Softw. Technol. 2014, 56, 1476–1492.
[11] García-Holgado, A.; García-Peñalvo, F.J. Architectural pattern to improve the definition and implementation of eLearning ecosystems. Science of Computer Programming 2016, 129, 20-34, doi:10.1016/j.scico.2016.03.010.
[12] Toribio-Guzmán, J.M.; García-Holgado, A.; Soto Pérez, F.; García-Peñalvo, F.J.; Franco Martín, M. Usability Evaluation of a Private Social Network on Mental Health for Relatives. J. Med. Syst. 2017, 41, 137, doi:10.1007/s10916-017-0780-x.
[13] García-Holgado, A.; Marcos-Pablos, S.; García-Peñalvo, F.J. A Model to Define an eHealth Technological Ecosystem for Caregivers. In New Knowledge in Information Systems and Technologies. WorldCIST'19 2019. Advances in Intelligent Systems and Computing, Rocha, Á., Adeli, H., Reis, L., Costanzo, S., Eds. Springer: Cham, 2019; Vol. 932, pp. 422-432
[14] Knodel, J.; Manikas, K. Towards a Typification of Software Ecosystems. In Software Business; Fernandes, J.M.; Machado, R.J.; Wnuk, K., Eds.; Springer International Publishing: Cham, Switzerland, 2015; pp. 60–65.
[15] Osterwalder, A., Pigneur, Y.: Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley, Hoboken (2010)
[16] León, M.C., Nieto-Hipólito, J.I., Garibaldi-Beltrán, J., Amaya-Parra, G., Luque-Morales, P., Magaña-Espinoza, P., Aguilar-Velazco, J. 2016.: Designing a model of a digital ecosystem for healthcare and wellness using the Business Model Canvas. J. Med. Syst. 40, 144 (2016)
[17] OMG, "Business process model and notation (bpmn), version 2.0," tech. rep., OMG, 2011.