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A model to define an eHealth technological ecosystem for caregivers

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Abstract. The ageing of world population has a direct impact on the health and care systems, as it means an increase in the number of people needing care which leads to higher care costs and the need for more resources. In this context, informal caregivers play an important role as they enable dependent persons to stay at home and thus reduce care costs. However, long-term continuous care provision has also an impact in the physical and mental health of the caregivers. Moreover, geographical barriers make it difficult for caregivers to accessing psychoeducation as a way to alleviate their problems. To support caregivers in their needs and provide specialized training, technology plays a fundamental role. The present work provides the theoretical basis for the development of a technological ecosystem focused on learning and knowledge management processes to develop and enhance the caregiving competences of formal and informal caregivers, both at home and in care environments. In particular, a platform-specific model to support the definition of the ecosystem based on Open Source software components is presented, along with a Business Model Canvas to define the business structure as part of the human elements of the technological ecosystem.

Keywords: Model Driven Development, eHealth, software ecosystems, technological systems, Software engineering, Business Model Canvas.

1 Introduction

It is a fact that world population is aging. According to the United Nations world population prospects, the number of older persons — those aged 60 years or over — is expected to be more than double by 2050 than it is today, and growing faster than all younger age groups [1]. A common characteristic of the elderly is the frequent occurrence of both cognitive and physical impairments, which results in an increase in the cost of care and resources needed for this population.

In this sense, informal care plays a very important role within the care systems of many countries [2], as it prevents the institutionalisation of the dependent persons enabling them to stay at home and thus reducing care costs. However, the average age of

the caregivers is also rising, and providing long-term continuous care entails a high physical and mental health impact for the caregivers [3], who suffer problems such as work overload, depression or anxiety, significantly reducing their quality of life and increasing their social isolation.

The caregivers need, therefore, a way to obtain answers to the questions that daily arise during their care duties, psychological support to help fulfil their tasks, information, advice and guidance, as well as an access to a community of equals and experts that can help them. But only when they can all get it easily, in low cost formats and when the information is adapted for them and easy to understand.

Psychoeducation [4] can be an alternative solution to alleviate the aforementioned. Psychoeducation involves providing information in a coherent, simple, accurate and objective way, both for the dependent people and their caregivers. However, access to psychoeducation, which is mostly performed through face-to-face interventions, is usually difficult for caregivers as they cannot leave alone the person they are attending, or because of geographical barriers especially for those who live in the rural environment.

In this sense, IT solutions can allow (in)formal caregivers and dependent persons to receive support in their needs. These technological solutions can make it possible to design and develop personalized attention services, provide remote teaching-learning environments as well as social networks for social inclusion and contact with experts regardless of their situation and context.

The present paper aims to providing a technological ecosystem [5, 6] that allows the caregivers to develop and enhance their caregiving competences both at home and in care environments, and also to share that knowledge with the persons they take care of. In order to support the definition of this ecosystem, a platform-specific model and a Business Model Canvas were developed.

The rest of the paper is organized as follows. Section 2 describes the methodology used to define the technological ecosystem. Section 3 presents the model to define eHealth ecosystems for caregivers. Section 4 depicts the business structure using a Business Model Canvas. Finally, Section 5 summarizes the main conclusions of this work.

2 Methodology

The definition and development of technological ecosystems has greater complexity than traditional information systems. The problems inherent to software engineering, such as the interoperability between components or the evolution of the ecosystem, are combined with the difficulty of managing complex knowledge and the diversity of people involved [7]. In order to improve the definition and development of this kind of technological solutions, two metamodels were defined and validated in previous works [8-10]. First, a platform-independent metamodel (PIM) that identifies the main concepts of a technological ecosystem and the relations among them (https://doi.org/10.5281/zenodo.1066369). On the other hand, a platform-specific metamodel (PSM) to define ecosystems based on Open Source software (http://doi.org/10.5281/zenodo.1284567). Both metamodels are instances of Ecore

[11], a simple meta-metamodel based on Meta Object Facility (MOF), the standard provided by the Object Management Group (OMG) to support Model-Driven Architecture (MDA).

In order to provide a technological ecosystem for formal and informal caregivers, the ecosystem metamodels were used as a starting point. Fig. 1 shows the different models and transformations in the four–layer metamodel architecture of MDA. First, the eHealth ecosystem model was instantiated from the platform-independent ecosystem metamodel. Later, the model was transformed in a platform-specific metamodel using a set of rules defined with ATL [12].

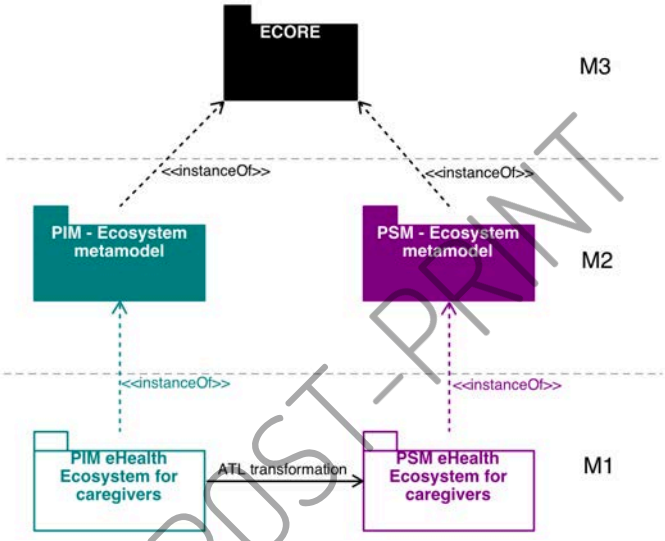

Fig. 1. Models and transformation to get the platform-specific model of the eHealth ecosystem for formal and informal caregivers

To complete the definition of the eHealth ecosystem for caregivers, the platform-specific model is completed with the definition of the business structure through the Business Model Canvas (BMC) [13]. This structure is part of the human components of the ecosystem. One of the main differences between technological ecosystems and other approaches such as software ecosystems (SECO) [14], is the human factor, although it has presence in any kind of technological solution, in the case of technological ecosystems the human factor has the same relevance than the software components. People are not only end-users but also an important component of a technological ecosystem [15].

The BMC is a template that depicts a methodology to design and describe a business model. Business models are defined by [13] as a description of how an organization creates, delivers, and captures value, where 'value' is the benefit an actor gets from the ecosystem in the form of need satisfaction or problem solution [16]. The BMC consists in nine different blocks that describe the business infrastructure, value propositions, customers and finances.

The obtained platform-specific model and the Business Model Canvas serve as a guide to later develop the corresponding eHealth technological ecosystem.

3 eHealth ecosystem for caregivers

The platform-independent ecosystem metamodel provides the basis to define different kinds of technological ecosystems focused on knowledge management, consisting of a set of software components, human elements and the relationships between them, without a core software system that provides the basic functionality. Regarding the platform-specific ecosystem metamodel, it provides the basis to get the guidelines to define those technological ecosystems using Open Source software components.

The aim of the eHealth technological ecosystem for caregivers is to support the learning and knowledge management processes to develop and enhance the caregiving competences both at home and in care environments of formal and informal caregivers.

As we described in the methodology section, the model of the eHealth technological ecosystem was instantiated from the ecosystem metamodel [10]. The instance is a PIM to define eHealth technological ecosystems for caregivers. Fig. 2 shows this process on the right column.

This PIM provides the concepts and the relations between them in order to support the definition of different real ecosystems. To get a model with details about the software used to implement the ecosystem, a set of ATL rules was applied. These rules transform each element in the PIM to an instance of the platform-specific ecosystem metamodel. Fig. 2 shows the results of this transformation on the left column.

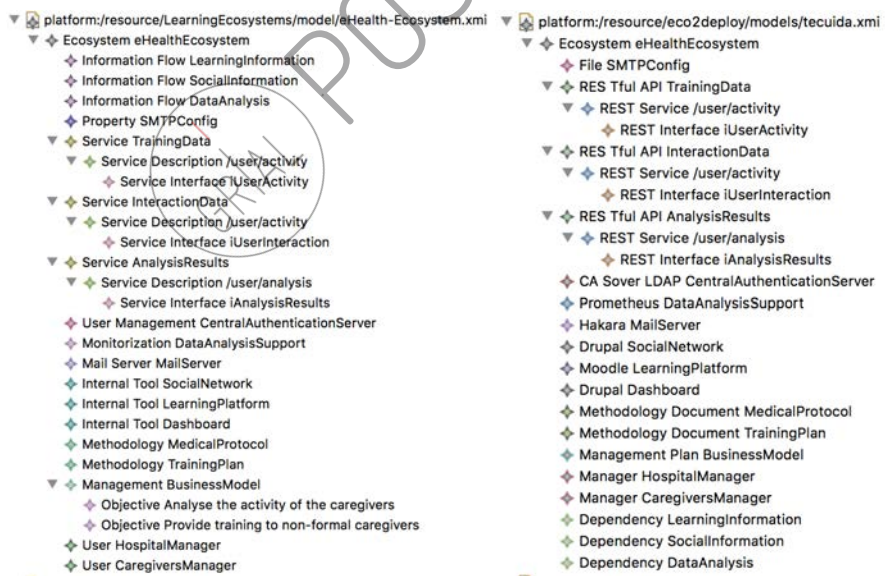

Fig. 2. Instances of the ecosystem metamodel, both platform-independent and platform-specific metamodels

The platform-specific metamodel has no visual editor associated, the result of the transformation is an XMI file with the description of the model. In order to complete this information, the model was represented using a CASE tool. In particular, the model was represented by three views or packages. The views correspond to the three main parts identified in a technological ecosystem: software components, human elements and the relationship among each other. These views show the elements from the model in black and the elements from which they are instantiated in grey.

First, Fig. 3 shows the view of software components that compose the eHealth technological ecosystem for caregivers. There are two main types of components: infrastructure and tools. The *eHealthEcosystem* represents the ecosystem, it is the main element that contains the other model elements. It is instantiated from the *Ecosystem* class of the metamodel.

The infrastructure is composed of: *MailServer*, to send emails from the different software components, it provides the *SMTPConfig*; *DataAnalysisSupport*, to monitor the activity of the users and their interactions; and a *CentralAuthenticationServer* to centralize the user management, both data and login to the ecosystem.

The tools that provide the user-level services are instances of different Open Source tools represented in the metamodel: *SocialNetwork*, *LearningPlatform* and *Dashboard*. The *SocialNetwork* represents a private social network for patients, caregivers and relatives. The *LearningPlatform* is focused on providing psychoeducation support for formal and informal caregivers. Finally, the Dashboard is focused on decision makers and caregivers' managers in order to support the decision-making processes.

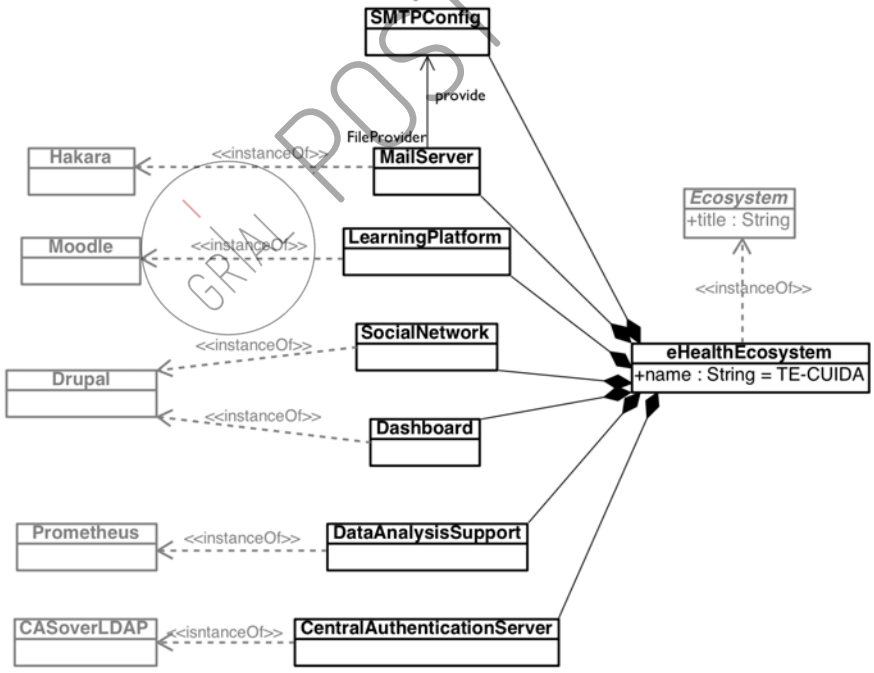

Fig. 3. View of software components of the eHealth ecosystem for caregivers

Fig. 4 is focused on the human factor as a key element of the eHealth technological ecosystem. The main users are represented as instances of *Manager*, *Methodology* and *Management* classes of the platform-specific ecosystem metamodel. In particular, the manager of the hospital or care center is represented by *HospitalManager*, and the manager of the caregivers as *CaregiversManager*. These users establish a set of methodologies (*TrainingPlan* and *MedicalProtocol*) and perform the business model (*BusinessModel*) which is described in detail in the Section 4.

Finally, Fig. 5 shows the view of the services which implement the information flows between the different software components of the eHealth technological ecosystem. There are three main services that are instances of *RESTfulAPI*: *InteractionData* to get the information of the users in the social network; *TrainingData*, to get information about the activity of the caregivers in the learning platform; and *AnalysisResults*, that provides the data analysis layer to support the information shown in the Dashboard.

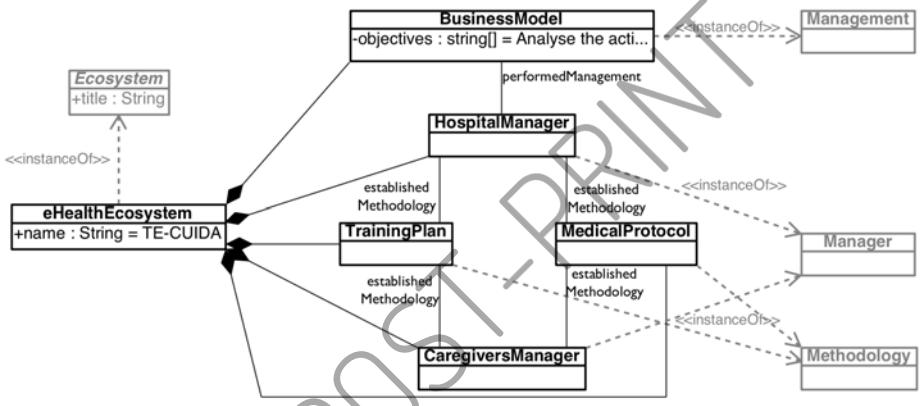

Fig. 4. View of human factor of the eHealth ecosystem for caregivers

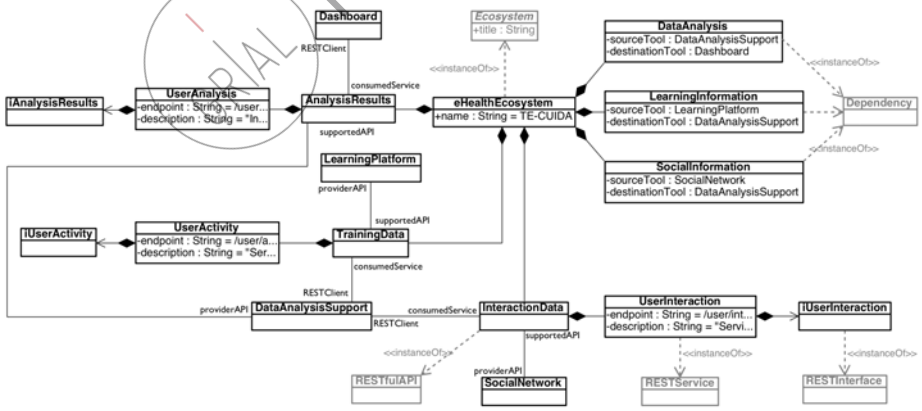

Fig. 5. View of services of the eHealth ecosystem for caregivers

4 Business structure

In order to design the business structure, we use the BMC approach developed by Osterwalder and Pigneur [13]. 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 [16-18]. From a business perspective, one of the main distinctions of technological ecosystems when compared to other types of business models resides in the involvement of the different ecosystem actors in value co-creation. As stated in [19]: "the motivation of actors to participate and engage within a medical ecosystem arises from the reciprocal benefits, namely the value propositions that variant types of actors within the ecosystem offer and seek". As such, value in ecosystems also emerges through interactions and collaboration between the different ecosystem actors [20], and this collaboration should be fostered by the ecosystem business design. These values are not independent from the other parts of the business model as they influence all other elements and building blocks.

In order to apply Osterwalder's model to our ecosystem proposal, we based the design in a literature review aimed to identify how technological ecosystem proposals address the business component, along with a systematic mapping study of the most relevant EU funded projects related to the health domain [21]. As a result, we obtained an insight of the main trends, lacks and opportunities, involved actors (stakeholders, end users, etc.), employed technologies, projects' investment, etc. related to the development of ecosystems in the health sector.

The BMC is available on http://doi.org/10.5281/zenodo.2273646.The outcomes of these reviews were applied to define the different blocks of the BMC as follows:

- In terms of the **Key Partners**, health and care authorities are needed as main information providers regarding the care delivery models and legal and privacy requirements that may vary across different regions, as well as being potential ecosystem investors and provide access to other stakeholders.

Hospitals and care institutions partnership offers real scenarios and personnel involved in the provision of professional care. They also act as providers of the knowledge and expertise in care giving and psychoeducation, helping to build a trusted environment for the informal caregivers, the dependent persons and their relatives.

Research institutions are needed in order to maintain the state of the art of the ecosystem's technological components, as well as for providing the latest trends in eLearning methodologies and psychoeducation protocols.

Platform suppliers and operators will guarantee the good functioning of the ecosystem's underlying technologies, as well as provide means for the incorporation of new components and services.

- The **Key Activities** to be carried out in order to provide the considered services and generate value for the ecosystem stakeholders include: the design, development, operation and maintenance of the technological platform components and ontologies; the development of the psychoeducation eLearning contents; the identification of the most relevant data from the application of care and psychological activities within

the ecosystem that could be relevant for the health and care stakeholders; and the identification of the platform's key performance indicators (KPIs) that allow monitoring its performance and the extraction and analysis of data (usage, trends, most demanded services) that could be valuable for current or potential involved ecosystem actors.

- The **Key Resources** needed in order to develop the proposed business model are the ecosystem components: social network, eLearning platform, mailing system and dashboard (which could evolve based on the observed ecosystem activity and actor needs); the platform hosting infrastructure; the technological expertise required to develop the platform components and ontologies, data mining, analysis and visualization; and finally the medical and educational expertise for providing adequate online psychoeducation contents.
- From a global perspective, the three main benefits that the ecosystem offers to its community of users are: the improvement of the quality of life of patients and (in)formal caregivers, a better quality of care and, as a consequence, a reduction of care provision costs. **Value propositions** include and are built around these three main values, based on the other model blocks (partners, resources, activities, etc) to translate these benefits into concrete services. As stated before, these values greatly depend on achieving the involvement of the different ecosystem actors and not just the key partners (patients, relatives, third party care organizations and providers, etc.).

It has to be noted that value propositions are interrelated as, for example, the access to the social network or the psychoeducation learning program enhances the quality of care, but also improves the quality of life of patients and carers (better care planning that results in more spare time, contact with other users with the same needs and specialized personnel that provides support, advice and guidance etc.), and all these values will, in turn, result in a reduction of care costs. Also, it has to be taken into account that value propositions in an ecosystem are also subject (and meant) to evolution as the ecosystem itself evolves, since the incorporation of new actors or services can cause new functionalities to appear.

Thus, value propositions include a personalized learning itinerary for (in)formal caregivers by accessible psychosocial programs; a network that includes care professionals for social communication and support; valuable data for: the analysis of the different care and psychological action protocols, monitoring of the psychological disorder evolution and trends analysis (personal, geographical, etc.), analysis of ecosystem usage, user needs and trends; and the possibility of promoting third parties care solutions, incorporate new services and/or modify existing ones.

- The first of the **Customer Segments** refers to the patients and relatives as informal carers, as they are the main target consumers of the ecosystem. On the other hand, health and care providers shall be considered either as direct customers or act as solution intermediaries providing the proposed services to their carers in a business-to-business-to-consumer (B2B2C) approach. Also, health and care related service providers could act as ecosystem complementors or third-party providers who could be interested in promoting their services through the platform (e.g., care institutions,

travel agencies, pharmaceutics, etc.), employing the platform available channels (social networks, mail), and using the trends data obtained from the ecosystem usage. Public health authorities are also a potential customer segment because they can act as funders (especially in countries with public health systems). In addition, they may be interested in making use of the ecosystem valuable data for the analysis of health evolution trends to enhance the health provision system.

- The **Customer Relationships** that must be maintained with each customer segment are the psychoeducation training program, the provision of professional medical and care contacts, training on platform usage, allow updates of platform contents and services and the promotion of third-parties care-related services.
- Considered **Channels** to reach the customer segments include the different direct contacts attained through the key partners that would include other regional / national health authorities and care related networks, and the promotion through social networks and web marketing.
- The **Cost Structure** that determines the costs of the business model is directly related to the tasks of development and deployment of the ecosystem, and includes: the platform development and maintenance, it's hosting, the communications infrastructure, and the IT and health personnel needed to develop and provide the considered services and functionalities.

In terms of the **Revenue Streams**, proposed values to the customer segments may generate different revenues at different levels. The considered revenue streams include: customers using ecosystem services; providing training to clients for the usage of the ecosystem; the IT support and maintenance; the ecosystem related data and its analysis tools; and the publishing of third parties care-related services.

5 Conclusions

The ecosystem metamodel allows to define models to support learning and knowledge management processes in heterogeneous contexts. The platform-independent and the platform-specific ecosystem metamodels were validated in our previous work, and their quality was also validated using the metamodel quality framework proposed by López-Fernández, Guerra and de Lara [22].

The platform-specific metamodel to define an eHealth technological for caregivers is based on a robust Model-Driven Development (MDD) solution. This model provides a guide to develop a real ecosystem to support learning and knowledge management processes to develop and enhance the caregiving competences of formal and informal caregivers, both at home and in care environments.

Taking into account the business structure is a fundamental aspect in the design and development of technological ecosystems, as it allows to reduce the gap between the technological structure and the actors' real interactions after ecosystem deployment. If these characteristics are omitted from the ecosystem design, they will surely affect the ecosystem health and performance once it has been deployed in real world scenarios. However, taking into account the business structure during the technological platform conception is not an easy task. To ease this process, we have modelled the business

structure following the Business Model Canvas (BMC). On this respect, the research contributions have been within the identification, from the existing literature and EU funded developed projects, of the care ecosystem human components and their interactions, their value propositions and needs, and the key resources, costs and revenue streams associated with the care-related services provision chain.

The results of this work, both the platform-specific model and the BMC, have a number of important implications for future studies. In particular, it would be interesting to develop several case studies in order to test the proposal in the eHealth context.

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