Design rules for the healthcare platform ecosystem – Parkinson disease case

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ABSTRACT

This study investigates how a pilot healthcare platform ecosystem was designed and piloted for Parkinson disease patients. This study depicts an interaction model between the technology, platform ecosystem studies, funding and research institutes, industry partners, and individuals with their visions for health care platform ecosystem. This platform ecosystem, based on distributed and virtual computing technology, provides a possibility to introduce specialized global players in health care. The keystones for the design rules consist of four elements (1) the architecture model to attract third parties involvement, (2) business constraints and health care issues solved by the technology and architecture, (3) cooperation model to build a pilot system, and (4) employing science community to deploy the results. The study uses inductive research approach with case study methodology.

Keywords: platform ecosystems, virtual computing, scalable business models, healthcare

1. Introduction

Hanh et al. (2016) define platform ecosystems as follows: it combines the streams of product families, e.g., modularization and architecture, and market intermediaries, e.g., multi-sided markets. Attour et al. (2016) discuss that platform ecosystems are modular structures where several components, formerly independent, are interconnected through a key asset: a technological platform. This platform can take the form of a product, a service, a system, or technology. Tiwana et al. (2010) state, that software platform ecosystems connect specific platform module developer with the end customer or other developers in the Business-to-Business market. This approach creates two side-sided markets.

According to Van der Meulen (2017), digital platform ecosystems are one of the most critical concepts affecting digital business. Scholars highlight that software platform ecosystems shift the competition and innovations toward platform ecosystems (e.g., Yoo et al., 2010). Taylor (2017) says that the large, varied, and relatively uncoordinated participants can contribute to the evolution of the platform ecosystem by producing unprompted innovation and change. Platform ecosystem contexts can produce strong sociotechnical ties among participants, including strong social bonds with the hub company. These ecosystems, platform ecosystems, and open innovations will change postindustrial mantras such as cost-conscious, effectiveness, productiveness, and customer-centric values to be more capability and community-centric (Letaifa, 2014; Pitelis, 2009). Aligned with this thinking, Latour states non-human can also have agency (see, e.g., Barron, 2003).

The scholars state that there are significant gaps in platform ecosystem studies. For example, Hanh et al. (2016) state that there exist relatively few studies within this discipline of inquiry. Taylor (2017) states that platform ecosystems are unique and less understood contexts in comparison to more traditional, tightly coupled alliances and supply chain networks. The technologies concerning the platform ecosystems develop fast, and new concepts are introduced continuously. This fast development of the concepts changes enterprises and societies. Therefore, it is essential for research to be able to anticipate the progress of this development and effect of it on the businesses and the societies in general.

This study increases the current pool of knowledge as it plans to fulfill some of the key research gaps discussed by the Hanh (2016) and Taylor (2017) above. This study contributes to the research of the platform ecosystem and current knowledge by studying how the business concepts can be created for a platform ecosystem within one industry. This study increases the understanding of the platform ecosystem, especially in the setting of new businesses in the context of the business to business networks. This study executes constructive qualitative case studies in the selected technology industry, namely health care. Majority of studies have been done in the software platform ecosystems in the digital industry.

The remainder of this paper is organized as follows. First, in the literature review, we study the knowledge of how to create a platform ecosystem. Based on the review, we propose a tentative model. Second, we describe the constructive research methodology used in this study among patients with Parkinson's disease. Third, we introduce the framework built based on the design project that was executed to form a new ecosystem based on the technologies available and the industry needs. Finally, we discuss and identify further research avenues.

2. Literature review – theory background

In this study, we employ Teece's concept of complementary assets (Teece, 1986). The idea of Teece's paper is that innovation usually requires complementary assets for generating profit.

Complementary assets can be, for example, another innovation needed by this new innovative design such as a memory card. Complementary assets can also be aftersales service, marketing, or production capability. Nowadays, the Platform as a Service (PaaS) system provides many of the complementary assets for constructing new systems, usually including lucrative scalable business models. For example, Heroku PaaS provides most of the databases and development tools, but also delivery platforms and tools to follow-up the quality of the software service. PaaS forms scalable platform ecosystems, in which users can generate products for wide audience worldwide, but also tools that can be employed others this platform ecosystems' developers or users.

In this world of the ecosystems platforms, it might be difficult to distinguish what the complementary asset is and what the product is. Many of the products can be complementary assets and vice versa. Service-Oriented Architecture (SOA) proposes that each of the product provides a service interface for other application to employ (Newcomer & Lomov, 2005). The standard way to provide it is to use digital RESTful API interfaces for delivering data in JSON or YAML format. The Swagger tool is employed to create standard YAML interface to ease the software development.

Nerland (2017) writes that engineering effort like programming is heavily commodified and objectified in terms of standards, software, and platforms that are defined and materialized as artifacts. Technology and computing practices are continuously changing. Complex technological objects and practices resist this commodification (Mackenzie, 2005; Bowker & Star, 200). This contradiction brings a creative dimension to work, which may serve as a primary driving force for platform ecosystems (Jensen, 2007).

In an ecosystem platform, each actor provides or employs standards or platform ecosystem's specific resources, among other artifacts, throughout various kinds of interfaces. The standard supply concept with specific product set-up in this business context is extended to be both supplier and customer in the specific platform ecosystem. Knorr Cetina (2007) states that artifacts are not passive products but rather active partners in knowledge practice: they have powers to produce effects and internal structures. The primary job of the artifacts in a platform ecosystem is dissociative that helps to stand apart from the real world or knowledge object through modes that characterized it by disruption, reflection, and abstraction. Knorr Cetina (2007) states this standing apart permits the object to "speak back" and reveal untapped opportunities. From this perspective, it is possible to create the forms of active, reflexive, and experientially-based relations in which the interplay between the real world and knowledge objects and an actor can occur. Therefore, the platform ecosystem that consists of multiple artifacts is needed to be designed well to make them a full member in actor-networks.

The suppliers provide a continuum of various kinds of platform ecosystems that are employed by the same suppliers and consumers. This statement is also supported by Bianco et al. (2014), who state that many time software platforms can be used as a stand-alone product, but at the same time it allows integration with other applications and tools, e.g., Google maps. In order to create a new platform ecosystem for a particular market, the specific market's desires that are many times latent cannot be identified only by the platform ecosystem owner. A vital platform ecosystem's community can address these desires

The classification of software ecosystems functionality is discussed relatively scantly in the literature. Dal Bianco (2014) et al. classifies the resources of the ecosystems in three categories that are Application Boundary Resources, Development Boundary Resources, and Social Boundary Resources. Fotrousi et al. (2014) classify the ecosystems platforms by their business areas, e.g., Software Development, Telecom, Business Management, Logistics, Transportation, Healthcare, Consumer, or Unspecified. They also classify the ecosystem platforms to be either digital or software ecosystems. Lee et al. (2015) compare two platform ecosystems, namely Google's and Apple's ones. They refer to earlier studies in which Apple's iOS platform is defined to be an integrator platform with Apple's control over both assets and customers. It differs from Google's Android as it opens the content selection process. In addition, Da Silva et al. (2014) classifies the ecosystem platforms based on their capability to scale. They have several categories for it: Load, Space, Space-Time; Structural, Distance, and Speed Distance scalabilities. Also, they discuss artifact scalability as all the organizations bring in their complexities and people scalability that references instability of the system in front of the increasing number of users unpredictable behavior.

Based on this brief literature discussion, our standpoint is that the creation of a platform ecosystem is a project that combines various kinds of the ecosystem for complementary assets and thus forming a new ecosystem that can be employed to meet specific markets' latent and non-latent market desires.

3. Data collection methods

Several meetings with individual stakeholders were organized to discuss the details of the platform ecosystem framework. The stakeholders included clinicians working in the area, sensor manufacturers, expert from the medication company, patients, and researchers specialized in the area. The outcome of the meetings was presented in the various project leadership meetings. The overall implementation guidelines were discussed and agreed upon in several meetings. The data were mainly extracted from various meetings and review meetings that were arranged on a monthly bases. The meetings typically lasted from one to two hours. Many other meetings were conducted from 2016 to 2018 – some of them weekly. The meeting attendees were from various companies and other project partners, including members of the hospital, companies involved, government agency, leadership team, top management, and individual employees. The stakeholders' interviews were recorded manually as well as the related emails and the minutes of the meetings were archived to support the creation of the innovation management framework for this study purpose. The construction itself was tested tentatively by several test users prior to Parkinson's patients' tests.

4. Results with analysis

4.1 A case study in the Health Care business

A research project was set-up with academics, industry, and Satakunta Hospital District. The Tampere University of Technology applied the project funding for the consortium from the government agency with aiming to study Parkinsons' patients' gait outside the hospital automatically and remotely. For monitoring of the gait, several different sensors and applications from different manufacturers were utilized including, for example, acceleration sensors, force sensors, and an application that was used to register the medication intake. Together these sensors and apps from different manufacturers were used for demonstrating an ecosystem platform to collect and analyze the data and to meet the needs of the use case of home monitoring of chronic diseases. Satakunta Central Hospital co-operated providing academic knowledge of Medical Science, Parkinsons' patients' medical treatment, and study design. Orionpharma is one of the major manufacturers of Parkinson patients' drugs for Parkinson's disease. Suunto Oy provided electronic sports devices such as smartwatches and bands for various sports activities with good matching as in this case, the patient movements were planned to be monitored. Forciot is a Finnish start-up that designs smart insoles, for example, for sports activities to get also the gait information. The role of the Tampere University of Technology also was to be responsible for developing signal processing solutions for the analysis of the gait patterns and other sensor data collected. It also had a role to lead the project and to investigate how to build a platform ecosystem based on the inputs from the project members, market and general and commercial technology platform ecosystem providers for desired complementary assets or as an opensource.

4.2 Market desires

The aim of constructing the system is to make it attractive to use and thus supporting the creation of the ecosystem. Therefore, the consortium decided to provide the project development results based on the open source principle to make third parties to easy to contribute. The other decision was to apply Service Oriented Architecture in order to let the third parties design their solutions on the base of the others' solutions. Each user provides their solution with REST API and employing JSON with Swagger (YAML) approach, which is a standard to document the application interfaces. The REST API interface works on the top of Internet Protocol leading to distributed solutions with which to the whole globe can be targeted as a market. Each instant of the various applications can be run independently in many parts of the globe where the data can be delivered on IP networks. This means that a patient can be in Thailand, and the doctor monitoring the status of the patient could be in another country. This technology approach can lead to, for example, certain hospitals specializing in treating specific diseases even globally.

From the technical aspects and implementation's point of view, the desire was to simplify access to patients. Companies' ITs tend to be bureaucratic, and that often leads to the major delays in the implementation (e.g., Hickson et al., 2009). The hospitals are very careful with patients' data security. According to them, it was important to ensure that there is no violation of data security, and all the regulation are followed. They are reluctant in allowing the data to be followed in the countries in which they do not have juristic legislation power to protect patient data. Based on the interviews and various discussions, data security was one of the major issues to meet in designing the ecosystem.

4.3 Building analysis framework of the platform ecosystem

The ecosystem platform provides various tools for further developing an analysis of data provided the patients. So far, we employed various Python's machine learning libraries and Matlab's analysis tools. In this study, we have concentrated on analyzing Parkinson patients' gait. For Parkinson disease, we extracted those features that are meaningful for studying this disease. In addition, human gait can be employed to analyze also various other diseases, such as MS, Alzheimer, and other neurological diseases. For these diseases, the analysis software developers need to build relevant machine learning system trained particularly for these diseases. Tentatively we have built tools to support the starting the analysis of the gait data on the top of the raw data that we are collecting form mobile microservices. This includes, for example, the synchronization of the data from various sensors, harmonization of the sensor data presentation format, and concatenation of the from brief data intervals to continuous data. Thus, we have created an interface that codes the knowledge related to the raw data readily available for those who employ machine learning systems for patient analysis.

We have also tested other types of sensors for real-time remote collection. For example, the use of Suunto's Movesense to provide heart rate and heart rate variability. Sichiray's Mindwave EEG has also been tested. This might lead to the same platform system being employed to analyze other potential patients and their diseases. From platform ecosystem designed and constructing a point of view, we need to propose tentative Service Oriented hierarchy how the data can be stored to be available other new analysists and end users and how they should store the data to enable data to further refined. Figure 1 proposes the Service Oriented Architecture hierarchy.

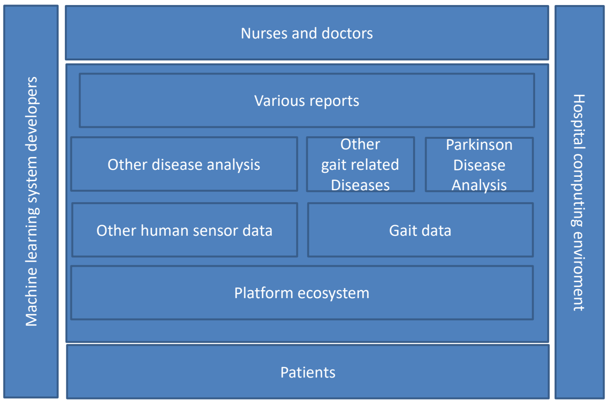

Figure 1: Data analysis framework of the platform ecosystem

4.4 Platform ecosystem analysis

Two of the industrial partners provided their own platform ecosystem. The Suunto's Movesense system was based on the smart wrist or chest band type of device for collecting information such as acceleration, gyroscopic, and heart rate of the targets' movements. Suunto Oy provided various tools and open APIs for outside developers to build their own solution. Forciot Oy provided smart insoles with standard Bluetooth LE interface that helps the integration to a platform ecosystem. On top of that, it was decided to employ Google's Android phones for data collection and transfer. Android and its development environment with third-party tools form its own ecosystem. Other platforms to be employed were Linux based machines for the data collection and the analysis. The platform ecosystem to be employed for movement or gait analysis was an opensource Python based analysis libraries. The data was collected from the various platform ecosystem, and these platforms were integrated by employing standard REST APIs interfaces in which data was formatted to be compatible with the JSON standard (see Figure 2).

The project's platform ecosystem consisted of various other ecosystems, as described above. These various ecosystems were integrated together by employing RESTful APIs with sensors' specific mobile micro-services (Ruokolainen et al., 2018). Various business actors that can contribute to the ecosystem platform development can be pointed out: (1) Hospital clinics and various instates can provide the market desires e.g. what they would like to have, (2) analysis software developer might have their knowledge what can be done and how to meet these desires, (3) devices manufactures can provide new hardware and related ecosystems and (4) these expressed elements can be integrated and maintained by platform ecosystem developers. The platform ecosystem forms a structure and codes the information between various actors. The messages inside the platform ecosystem are exchanged in structured and agreed formats. As stated by Knorr Cetina (2007), artifacts are not passive members in the active partner in knowledge practice as this case proves.

Figure 2 describes the architecture of the system with the related actors.

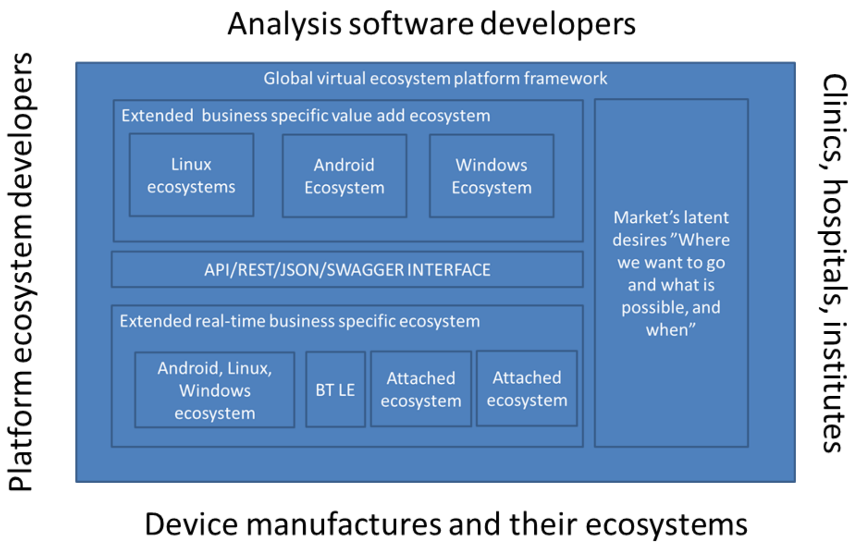

Figure 2: Platform ecosystem's high-level architecture

5. Conclusion

The gaps mentioned by the literature related to the platform ecosystems have earlier been only scarcely studied, and their developments are less understood than the R&Ds' traditional product developments (e.g., Hanh, 2016; Taylor, 2017). This study increased the understanding by demonstrating the development of the system for health care, although it still needs further development.

This studies' health care platform ecosystem was constructed from the complementary assets of the related platform ecosystems and those value-add services produced by the platform ecosystem's users. This platform ecosystem is not a well-defined set-up but rather lives from ideas and innovations that can be implemented on the top of the other value-add services. In order to be a member of the ecosystem, value-add services, and other elements in the ecosystems need to follow the ecosystem rules not to jeopardize other value-add services. The contributors to the ecosystem need to share some common understanding and rules to keep the ecosystem up and to run.

The rules for building an ecosystem to meet specific business needs are as follows:

1. The platform ecosystem value-add services meet the specific market desires, e.g., in this study, they are related to Parkinson disease, patients,
2. A platform ecosystem brings together various other platforms ecosystems under the common topic as in this case health care, and they provide complementary assets.
3. Platform ecosystems meet development users' desires for constructing value-added solutions.
4. The desires need to be strong enough to create social bond keeping the ecosystem and sub-ecosystem and value-adding developers together.

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