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UNDERSTANDING THE CURRENT TRENDS IN MOBILE CROWDSENSING - A BUSINESS MODEL PERSPECTIVE

Case MyGeoTrust

Master's Thesis
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Abstract

Crowdsensing and personal data markets that have emerged around it have rapidly gained momentum in parallel with the appearance of mobile devices. Collecting information via mobile sensors and the applications relying on these, the privacy of mobile users can be threatened, especially in the case of location-related data. In 2015, a research project called MyGeoTrust was initiated to investigate this issue. One aim of the project was to study the potential business models for a trusted, open-source crowdsourcing platform. This study, carried within the MyGeoTrust project, reviews existing literature about business models, location-based services, and open-source software development. It then investigates the relationship between these topics and mobile crowdsensing. As a whole, this thesis provides an overview on the development of location-based services, as well as the current trends and business models in crowdsensing.

The empirical part of the thesis employs embedded case study methodology, acquiring empirical data from several sources. The analyzed case is the MyGeoTrust project itself, and other empirical data is collected via market analysis, interim reports, a user survey, and semi-structured interviews. This material forms the baseline for the empirical study and project-specific recommendations.

The findings suggest that creating a two- or multisided platform is the most robust business model for mobile crowdsensing. The identified benefits of platform-based business models include facilitating the value exchange between self-governing groups and possibilities to build positive network effects. This is especially the case with open-source software and open data since the key value for users - or "the crowd" in other terms - is created through network effects. In the context of open business models, strategic planning, principally licensing, plays a central role. Also, for a differentiated platform like MyGeoTrust finding the critical mass of users is crucial, in order to create an appealing alternative to current market leaders. Lastly, this study examines how transformational political or legal factors may shape the scene and create requirements for novel, privacy-perceiving solutions. In the present case study, the upcoming European Union (EU) General Data Protection Regulation (GDPR) legislation is a central example of such a factor.

Keywords business models, platform business, mobile crowdsensing, location-based services, open-source software, open data

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Tiivistelmä

Mobiili joukkoaistiminen (crowdsensing) ja sekä sen ympärille syntyneet henkilödatamarkkinat ovat kasvaneet huomattavasti matkapuhelinten ja vastaavien mobiililaitteiden yleistyessä. Tiedon kerääminen mobiililaitteiden sensoreiden välityksellä altistaa laitteiden käyttäjät yksityisyyden-suojan menettämiselle erityisesti paikkatietoa keräävien sovellusten kautta. Tämän maisterintutkielman kirjallisuuskatsauksessa käydään läpi keskeisimmät käsitteet ja tutkimussuuntaukset, joiden ymmärtäminen taustoittaa mobiilin joukkoaistimisen analysointia. Näitä ovat esimerkiksi liiketoimintamallit, paikkatieto ja siihen pohjatuvat palvelut sekä avoimen lähdekoodin sovellukset. Tutkielma on tehty toimeksiantona Maanmittauslaitoksen Paikkatietokeskuksen vetämälle MyGeoTrust-tutkimusprojektille.

Tämä tutkielma käyttää laadullista tapaustutkimus (embedded case study) -menetelmää, joka hyödyntää useasta lähteestä kerättyä empiiristä dataa, tässä tapauksessa tutkittavan tutkimusprojektin raportteja, puolistrukturoitujen asiantuntijahaastatteluiden materiaalia sekä jo aiemmin tehdyn käyttäjätutkimuksen tuloksia. Tapaustutkimuksen avulla on mahdollista tarkastella projektia tosielämän kontekstissa ja muodostaa suosituksia tulevaisuuden strategista kehitystä varten.

Tutkimuksen tulokset osoittavat, että alustaekosysteemin valitseminen liiketoimintamalliksi mahdollistaa mobiilin joukkoaistimisen sovelluksille laajimmat mahdollisuudet. Alustatalouden mahdollisuudet perustuvat ennen kaikkea verkostovaikutusten luomiseen sekä itsenäisesti toimivien arvon tuottajien ja käyttäjien osallistamiseen. Verkostovaikutukset ovat keskeisessä ase-massa erityisesti avoimen lähdekoodin sekä avoimen datan sovelluksissa, joissa arvonluonti ei tapahdu perinteisillä ansaintamalleilla. Avointen liiketoimintamallien tapauksessa kaupallistamisen strateginen suunnittelu on merkittävää sillä erityisesti julkaisulisenssin valinta vaikuttaa merkittävästi liiketoimintamahdollisuuksiin, ansaintalogiikkaan sekä alustan houkuttelevuuteen. Erilaistetuille alustoille, kuten MyGeoTrustille, on tärkeää aktivoida ja sitouttaa kriittinen käyttäjämassa jotta niiden on mahdollista kilpailla markkinajohtajia vastaan. Tuleva EU:n tietosuoja-asetus on esimerkki markkinaympäristöä uudistavista voimista, joka muuttaa nykyisen liiketoiminnan pelisääntöjä ja luo kysyntää uusille, mobiileita joukkoaistimispalveluita hyödyntävien käyttäjien ja heistä kerätyn datan, yksityisyydensuojaa kunnioittaville sovelluksille.

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Most important of all, I want to thank my loved ones. To my parents, Sinikka and Martti, I want to express my gratitude for always being there, supporting my studies and raising me curious. Markku, thank you for showing that studying does not have to be so serious. Niko, my soulmate. Thank you for your never-ending care and support, my life would be incomplete without you.

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List of abbreviations

API - Application Programming Interface

CAGR - Compound Annual Growth Rate

FGI - Finnish Geospatial Research Institute of the National Land Survey of Finland

FLOSS - Free/Libre and Open Source Software

FOSS - Free and Open Source Software

FSF - Free Software Foundation

GDPR - European Union's General Data Protection Regulation

GIS - Geographic Information System

GNSS - Global Navigation Satellite System, including Galileo, GLONASS, and GPS systems

GPL - GNU Public License

GPS - Global Positioning System, a GNSS which is owned by U.S. Government

ICT - Information and Communication Technologies

IS - Information Systems

LBS - Location-based Services

LBSN - Location-based Social Networks

OSGeo - The Open Source Geospatial Foundation

OSGIS - Open Source Software for Geographic Information Systems

OSI - Open Source Initiative

OSS - Open Source Software

PDS - Personal Data Storage

PIMS - Personal Information Management System

REST - Representational State Transfer

1 Introduction

Mobile devices have become an inseparable part of everyday life in the contemporary information society, and as recent success stories have demonstrated, the companies that manage to create a widely adopted and utilized platform are the ones generating huge revenues. Using certain platform-based services, which usually retrieve user data from mobile devices, has a prerequisite of accepting terms of service. These terms are usually composed in favor of company, offering no alternative settings for privacy perceiving users. Even though the data collected via sensors in mobile devices may be anonymized, the cumulative nature of the data tends to form user profiles. This action is called mobile crowdsensing and currently, the business models built around crowdsensing and crowdsensed data assume there's a tradeoff between privacy and the value of data. The motivation of this study is to identify and investigate alternative business model strategies that would help the data subject to have governance over their data collected via mobile sensors.

The aim of this thesis is to investigate business model options that could sustain the further development of the case, an academic research project called MyGeoTrust. Precisely, the development of location-based mobile services and crowdsensed mobile data collected via mobile device sensors are in the research focus. The research scope is defined by a real-life case and empirical study. Since location data is one of the most revealing data sets that can be collected and is widely crowdsensed from users mobile devices, geospatial information systems and location-based services (LBS) are analyzed in detail. The results of this study, for example a market analysis, open source[1] development, and recommendations of business models, can be further applied on several other data sets collected via mobile device sensors.

This introduction chapter will provide an overview on the subject by introducing the case project and relevant background data; presenting research questions, motivational factors and methodologies; and aligning what has been intentionally left out of the scope.

[1] In order to avert confusion with terminology, both *open source* and *operating system* are spelled as a whole and not abbreviated according to the usual practices.

1.1 Background

The evolution of LBS, especially location-based mobile services, has been rapid during the last 10 years, ever since mobile devices, mostly smartphones and other hand-held gadgets, started to appear in consumer markets. Even though the growth of device sales[2] has become steadier, the amount of mobile data generated by location-based services is continuing significant growth. For example, European Global Navigation Satellite System (GNSS) Agency (2017) forecasts that mobile applications relying on positioning information will be downloaded 7.5 billion times by 2019. Recent forecasts estimate that the global location-based services market will grow at a compound annual growth rate (CAGR) of close to 40% during the period of 2017-2021, summing up an incremental growth of $78 billion (Technavio, 2017). These numbers include a wide range of LBSs, ranging from the outdoor LBS segment to location-based navigation. The relevant scope for this study will be analyzed later on, but as the rough estimates display, the LBS market can be considered highly impactful in the future (Rao & Minakakis, 2003; Dhar & Varshney, 2011).

The case study researched in this thesis is MyGeoTrust, a joint research project between the Finnish Geospatial Research Institute of the National Land Survey of Finland (FGI) and the Faculty of Law at the University of Helsinki. The research project was initiated in March 2015, and the funded project phase is lasting until the summer of 2018. (Guinness et al. 2015) This strategic technology development project aims to create an open source platform that challenges the oligopoly of Google and Apple that are dominating the market of mobile location-based services with a market share of 96% (MyGeoTrust, 2017). The project and similar research initiatives are analyzed in more detail in Section 4.1.

According to Michael & Michael (2009), it is one thing to tag and quite another to track people based on their geolocation. The current trend has shifted from tagging to tracking, and therefore the questions related to data privacy and ownership are playing more significant role when designing new services. Furthermore, location privacy can be categorized based on its accuracy and timeliness. In line with the previous statement, Ardagna et al. (2008) identify and categorize different components of location privacy. The classification forms three main categories: identity privacy, position privacy, and path privacy, whereas location-tracking services as a means for path privacy has been found to cause higher privacy concerns than purely position-aware services (Coppens, Veeckman &

[2] according to Technavio (2017), the unit shipment of mobile computing devices totaled 2.12 billion units in 2016

Claeys, 2015). Remaining consistent with prior research literature, *privacy risks* are considered as a single-dimensional mechanism that evaluates the potential of losing control over ones' personal data (Xu, Teo, Tan & Agarwal, 2009).

Clarke and Wigan (2011, p. 140) go even further while stating that "you are where you've been", referring to the fact that depending on the terms of use and personal privacy settings of mobile phones, it is possible for service providers to track the exact path a single user is moving by plotting the trail or a series of locations over a period of time. They analyzed different risk factors of handheld devices, and found out that there is a strong emphasis on the privacy implications of location and tracking technologies that are widely exploited. There is a wide array of tools and processes that threaten to diminish the yet existing layers of the limited protections citizens still enjoy. (Clarke & Wigan, 2011.)

Mobile devices inherently disclose the location data of their users, bringing responsible data protection and usage the core of any service or application design. Combining the rapidly increasing amount of devices and the data these devices generate, varying motifs of service providers, heterogenic users and knowledge of data protection and upcoming legislation changes, the field of crowdsensed mobile data is in a focal point of research interest in the post-PC era.

1.1.1 Terminology

Shifting focus from the information economy to data privacy, law, and geospatial technologies, the terminology of this thesis varies a lot from chapter to chapter, depending on the subject. A special emphasis has been assigned on the glossary, providing an abbreviation list and also aiming to explain and rationalize key terms throughout the text.

Crowdsensing commonly refers to the method where data is collected via mobile sensors. In the context of this study, crowdsourcing and *crowdsourced mobile data* concerns data collection from smart devices via their sensors. Since smart devices contain several types of positioning solutions, for example sensors, satellites, and RF signals, geospatial data is among the most collected and used data sets from these devices (Pei et al., 2013; Lindquist & Galpern, 2016; Dong, 2017). *Mobile crowdsourcing* is a corresponding term to crowdsensing, but refers to process where Internet mediated tools are used as a platform for collecting information from indefinite sized group of citizens and organizations to gain new insights or feedback. This distributed problem-solving method is used, for example, for voting, fund-raising, and wisdom-of-the-crowd scenarios (Chatzimilioudis & Zeinalipour-Yazti, 2013). The emergence of crowdsensing has resulted from the growing usage of mobile devices and the term has gained foothold in academic research during the last ten years (Heiskala, Jokinen & Tinnilä, 2016) whereas mobile crowdsourcing often has connotations with the original usage of the term crowdsourcing. Therefore, the term crowdsensing is more adequate for this thesis and adopted unlike in the case project MyGeoTrust that utilizes the term mobile crowdsourcing.

In this study, the term *citizen* is used in parallel with individual person. Citizen expresses better the nature of a person who is entitled to privileges and rights of a freeman and who is entitled to protection provided by a government or state. This is mostly the case when discussing legal terms, rights and responsibilities. *Data subject* is a term referring to citizen who is subject of personal data, mainly used in legal and political matters. The term *user* is used when analyzing software and services, noting that users are mainly citizens but are freely downloading applications and buying products, thus being able to make the decisions by themselves.

1.2 Motivation

In the context of this study, the term *mobile crowdsensing* refers to data that has been collected from mobile device users and/or extracted from the sensors of individuals' mobile devices, usually through voluntary means (Hopkins, 2011; Ganti, Fan Ye & Hui Lei, 2011; Chatzimilioudis, 2012; Chatzimilioudis, 2013; Guinness et al., 2015; Dong, 2017). Crowdsensing can be divided into participatory sensing, where individuals are actively involved, and opportunistic sensing, where sensing is more autonomous (Ganti et al, 2011). According to Guinness et al. (2015), the largest players at the mobile business, such as Apple, Google, Microsoft, and Nokia, have employed crowdsensing from mobile users recently. As proposed in the article, the recent development has helped mobile devices and developers to better understand and predict users' preferences, generate common good and to improve services, but negative implications can also be found (Guinness et al., 2015). Nevertheless, the wider interplay of this multifaceted ecosystem of mobile crowdsensing platforms and long-term success factors have been scarcely studied even though it is agreed that the business models of platforms providers are known to be profitable in the long term (Heiskala et al., 2016). This thesis aims to create knowledge of these success factors as well as formulate business model suggestions for crowdsensing services. Heiskala et al. (2016) created a framework for their analysis of key factors of crowdsensing-based services. Even though the framework illustrated in Figure 1 was originally used to analyze crowdsensing-based services particularly in the fields of traffic and mobility, it forms a clear model of the key factors.

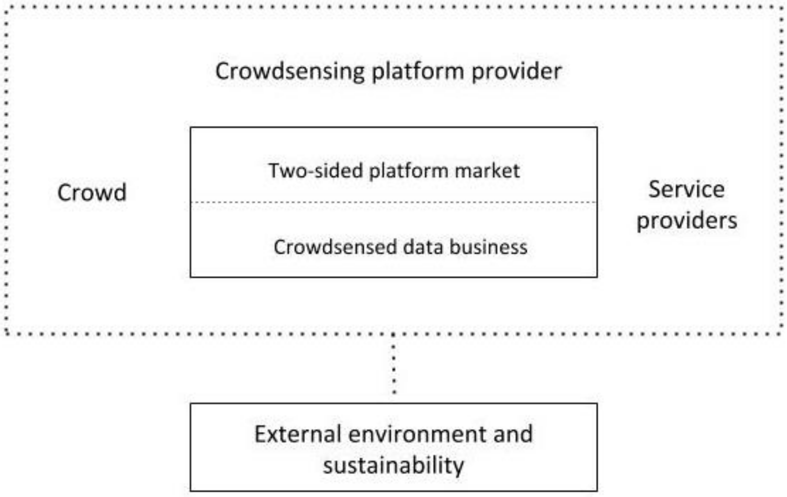

Figure 1. Framework for analyzing key viewpoints of crowdsensing-based service (Heiskala et al., 2016)

In mobile services, the value generated for the user is context dependent meaning that the value for users is created by merging, i.e. spatial factors with the overall service experience (Dhar & Varshney, 2011; Ryschka et al., 2016). Particularly, the customer's value creation perspective is often not recognized (Sandström, 2008). Context is a non-separable part of the user experience and therefore assumed to have an impact on the value of mobile services (Pura 2005; Gummerus & Pihlström, 2011). The value for location-based service users arises by integrating the location of the mobile device with other information, leading to knowledge-based personalization (Ryschka et al, 2016). From society's point of view, the availability of data offers multiple useful application areas, such as transportation and urban planning (Heiskala et al., 2016). Therefore, evaluating and understanding incentives for all stakeholders participating in figure actions lies in the core of this thesis.

Relating to the use-context and geospatial location, privacy is among the top concerns. In the worst case, the user may not even be aware that some third-party can access the data (Guinness et al., 2015). Furthermore, privacy risks, especially privacy connected to location, are seen as a key disincentive in crowdsensing participation (Heiskala et al., 2016). Understandable and transparent terms of service are playing a key role, and this question will be addressed in more detail in chapter 4 where alternative practices are suggested.

Multiple recent user surveys have shown that smart device users share a common and growing worry towards the privacy and portability of their personal data and are already discarding some unreliable applications (Welbourne, 2014; MEF 2017; MyGeoTrust user survey) Furthermore, citizens' privacy concerns over the security of their data have been increasing substantially during the last years, not least because of data breaches (Wicker, 2012; Spiekermann, Acquisti, Böhme & Hui, 2015; Greenberg, 2017; The Next Web, 2017). What is considered as a data breach can be questioned. For example, Spiekermann et al. (2015) point out that current commercial practices of personal data handling strongly undermine the principles how privacy is constructed in Western cultures. Personal data aggregation, secondary use, as well as identification are classified as data breaches according to this taxonomy (Spiekermann et al., 2015).

Nevertheless, leaks of crowdsensed mobile data make data subjects feel vulnerable, especially in cases where the data collector has not given clear terms of service for users in the first place. MEF's Global Consumer Trust Survey (2017) explores the attitudes and behaviors of smartphone users, especially towards services they use to gain insights about users' understandings of the nature of personal data and being a data subject. The survey also clarifies that the founding principles of privacy, security and identity are becoming recurrent topic in management meetings and boardrooms. New legislation, particularly the European general data protection regulation (GDPR), sets the stage so that consumers must give authorization before any data is collected. The MEF survey aims to create new knowledge for businesses about the opportunities and significance of shifting consumer trends (MEF, 2017).

The upcoming EU GDPR legislation creates both challenges and opportunities for companies, especially for those directly operating with smart devices and personal data. In parallel with the EU GDPR, The European Commission (Proposal for an ePrivacy Regulation, 2017) has proposed a Regulation on Privacy and Electronic Communications updates on the legal framework on ePrivacy. The proposal applies privacy rules for all electronic communications, including for example new players, such as WhatsApp and Facebook Messenger, unified and stronger level of privacy protection for both citizens and businesses, protection of metadata and simpler rules on cookies. These rules are applied in order to align the new GDPR regulation and the renewal is a part of major modernization process of the data protection framework. (Proposal for an ePrivacy Regulation, 2017) As a part of market analysis, a detailed review of EU GDPR is done in Section 4.2.1.

The MEF (2017) survey provides indicative numbers of user concerns, behavior and wishes towards service providers. For example, 43% of the respondents said they would be interested in a privacy-focused app that shows what data is being collected across all of the user's connected smart devices, and 53% claimed they know that they are not in control of the means their data is used for. To continue, users also value privacy protection and access to their data more than possible financial or other rewards. (MEF, 2017) All of these above mentioned matters are showcasing that there is an insistent need for privacy respecting applications that MyGeoTrust, among others, is aiming to solve.

1.3 Research question

In this research, the following research questions are aimed to be answered:

1. *What kind of business models are currently used in the context of mobile crowdsensing?*
2. *Based on the literature review and empirical study, which of these models are most suitable for mobile crowdsensing solutions?*

   -

In order to answer these research questions, we need to understand several key terms and theories, including free/libre and open-source software (FLOSS) and related business models, the current state of platform business, the evolution of geospatial information systems and location-based services as well as mobile data privacy and affiliated regulation. We will review these theories and concepts in the literature review and provide a synthesis of these findings.

Research questions have implications on both theoretical and empirical parts of the study. The first question requires a thorough literature review and framework creation whereas the latter one provides recommendations based on empirical analysis and findings.

1.4 Structure of the thesis

As the focus of the thesis is to create novel knowledge about the platform strategies, especially in the field of location-based services, this research paradigm is the common thread running through the study.

Chapter 2 provides a comprehensive literature review over the key themes: platform-based business models and the business development processes, location-based services and geographical information systems and, finally the fundamentals of free and open source software.

Chapter 3 introduces the methodology and theoretical frameworks of this study. Providing an overview of the embedded case study and the empirical data collection methods, the chapter provides background information for the analysis and synthesis part. Interview statistics are presented in detail.

The case and empirical evidence are showcased in more detail in Chapter 4. The case MyGeoTrust is explained against relevant characteristics, including the competitive landscape and PESTL model, design principles, and software architecture. Empirical data is reflected against the literature review and theoretical framework, and the synthesis aims to form business models for crowdsensed mobile data solutions. The suggestions are focused but not limited to crowdsensed mobile data. The PESTL analysis provides overall market examination of location-based services and discusses legal and political disruptions, such as the upcoming EU GDPR law and MyData movement.

Chapter 5 offers the key results and outcomes of this study by discussing theoretical implications and answers research questions. Finally, Chapter 6 provides summary of the study and managerial implications. Limitations of this research as well as further research questions are also presented.

2 Literature review

The literature review has a few key questions to answer: What kind of business models can be identified in the field of crowdsensing? What is the difference between open source and open data? How have the predecessors of the researched case, MyGeoTrust, evolved? What kind of open business models have been implemented in the field of geographic information systems (GIS) and LBS?

We will first answer the question: What are business models, and more specifically, what is the nature of open business models? The core theories behind the open business model theme are presented, and the differences between traditional, proprietary business models and open business models are shortly explained. After defining the context of business models in this research, we will discuss the key terms of open data and open source.

As a consequence of the highly technical nature of this study, the focus will be on explaining the details and evolution of both location-based services and open source software thoroughly. While both LBS and GIS rely on GNSS data, the nature and purpose of these services varies. Therefore, a special emphasis is dedicated on forming a clear understanding of the differences between LBS and GIS. Finally, we sill present the selected frameworks that are used when proceeding the case study.

2.1 Open business models

Despite the fact that academic world has adopted business model concept quite recently, it has gained steadily growing attention during the last 25 years (Zott, Amit & Massa, 2011). Open business models, deriving from the concept of *open innovation*, are even more recent, having been introduced by Chesbrough in 2006. Open business models add the innovation aspect into the core of business strategy. (Afuah, 2004; Chesbrough, 2006; Zott et al., 2011)

Even though the definitions of business models vary a lot, especially from one industry to another, an effort to define the concept of business model is made in this section. Furthermore, the purpose is to find suitable frameworks to be used in the case analysis later on. In this section, we will discuss business models in light of the economic literature, continuing with open source software paradigm in Section 2.2.

2.1.1 Defining business models

The earliest mentions of business models derive back to the 1970s, and they have been an integral part of economics ever since. According to various researchers (e.g. Amit & Zott, 2001; Hedman & Kalling, 2003; Afuah, 2004; Chesbrough, 2010; Lindman 2011; Zott et al., 2011) the concept of business models became pervasive with the emergence of the Internet in the mid-1990s, as the database analysis of the term usage shows (Zott et al., 2011).

As the literature review indicates, there is a plethora of meanings used for business model. The business model concept has been utilized to address a wide range of research questions in varying contexts and management areas. Given the interest towards the concept, the current business model literature does not offer clear meaning of the concept as a whole since the same term is used to describe, for example, e-business types, value creation, and value capturing strategies. (Zott et al., 2011) In addition, Chesbrough (2010) focuses on the relationship between business and innovation and has formed open business model theory from this point of view. According to Magretta (2002), business models are the managerial equivalent of the scientific method, usually based on hypotheses in the beginning and adjusted and revised when needed. Hedman and Kalling (2003) add that the business model concept has gained significant interest and foothold within the field of information systems. The concept is used for several research purposes, ranging from traditional strategy to e-business literature (Hedman & Kalling, 2003). Afuah (2004) defines business models as systems of connected activities, such as business systems, value chains, and vertical linkages.

Based on their structured literature review, Zott et al. (2011) compiled a list of widely-cited business model definitions. These definitions include, for example, views where business models are seen as an architecture of the product information; service flows; heuristic logic connecting technical potential with the realization of the economic value; or stories that explain how enterprises work. To sum it up, the logic of business models parallel around a company's costs, value proposition given to the customer, and the mechanisms used to capture value. Furthermore, the business model can be both a tool for innovation and a subject of innovation. (Zott et al., 2011)

The study conducted by Hedman and Kalling (2003) provides an overview of the conceptual business model literature and usage. One of the findings was that the empirical use of the concept has received critique for being fuzzy, but the business models could integrate different strategic perspectives. According to their literature review, e-business models are organized around two streams: one that aims to describe and define the components of an e-business model and another one that focuses on creating descriptions of specific e-business models. The most distinct difference between industrial age concepts and e-business models are the dissimilar rules and assumptions of how business actually is done. (Hedman & Kalling, 2003).

Economides and Katsamakas (2006) analyze operating systems as platforms. They reason this decision by saying that focusing on platforms is purposeful when studying two-sided markets and network effects. In a related vein, Choudary (2013) claim that platforms enable users to produce and consume value, for example enlarging the service at the technology level by using APIS. Heiskala et al. (2016) argue that two- and multi-sided markets differ from traditional offerings since costs and revenues may come from both/all sides of customers when traditional companies generate revenue from creating value for end-users. They have compiled a list of success factors related to two- or multi-sided platforms as listed in Table 1.

Table 1. Success factors of two- or multi-sided platforms (Heiskala et al., 2016)

1. Platform facilitates interaction between sides
2. Same-side network effects exist
3. Strong and positive cross-side network effects
4. Pricing strategy is designed to generate positive cross-side network effects
5. Adequate (low) multi-homing costs
6. Optimized switching costs
7. Finding niche users may provide success for smaller, differentiated platforms

These above mentioned factors reveal the multitude of components impacting the success of a certain platform. In addition to the simplicity of value creation in traditional business models, different costs related to selecting and staying with one platform are rather high in the platform industry and digital business overall. Winner-take-all competition is comparably distinguished for many digital services (Heiskala et al., 2016).

Zott et al. (2011) summarize the business model study they conducted that “In the technology and innovation management field, the business model is mainly seen as a mechanism that connects a firm’s (innovative) technology to customer needs and/or to other firm resources (e.g., technologies).” (p. 1035). On the contrary, Weber (2004) claims that the core issue of IP is that it aims to generate incentives for inventors and the companies employing them, therefore highly restricting the amount of potential users. Granting licenses based on IP rights are discussed under Section 2.2.1.

Besides the literature, there are also several tools and frameworks created for business model creation. Perhaps the best know is the “Business Model Canvas” created by Osterwalder and Pigneur (2010). The original canvas divides business operations into basic categories, including key partners, activities and resources, cost structure, revenue streams, value propositions, customer relationships, channels, and customer segments (Osterwalder & Pigneur, 2010). There can be found several iterations of the original business model canvas, targeted for example for startups, services, or lean project management.

For example, business model canvases are largely used already in the ideation stage when evaluating whether or not some business idea is profitable to be developed further. Related to the business model canvas, Osterwalder et al. (2013) suggest that the business model belongs to the strategic management terminology. Unlike the widely recognized Osterwalder’s model, Baden-Fuller and Haefliger (2013) claim that the business model is a stand-alone concept, justifying its own existence.

Despite the same term being used in different contexts to describe different phenomena, interpreting that the phrase *business model* is multifaceted and used to represent many concepts, some emerging themes can be commonly accepted (Zott et al., 2011, 1036). As a result of their examination of the business model literature, Zott et al. (2011) present four insights of what has been emerging in the business model scholastic: 1. the business model can be seen as a new factor of analysis, 2. business model scholars agree with a holistic and systemic approach in general, 3. activities performed either by the company or other stakeholders are included as a part of the conceptualization, and 4. business model researchers have altered prominence from value capture to value creation. The latter point is supported by the finding that the concept of value was evident in all of the areas of business model literature they reviewed. (Zott et al., 2011)

Hedman and Kalling (2003) state that improvements in value chain must become visible in an offering that will increase the experienced value, either in terms of quality and/or cost reduction. In mobile services and service business, the created value is proportionally hard to measure or even forecast when planning the service. As Gummerus and Pihlström (2011) have observed, conceptualizing the customer-perceived value is challenging in the world of often spontaneously used mobile services, but knowing the time and location of a mobile service user are thought to help users conquer geospatial and temporal restrictions (Pura, 2005; Gummerus & Pihlström, 2011).

In addition to the business model canvas, separated e-business models are one of the most recently adopted frameworks (Zott et al., 2011). Since the Internet is a chief driver of the striking growth trajectory in e-business, learning the best practices and components of successful e-business models may provide valuable insights also in the case of MyGeoTrust. One of the most simplistic schematics is the set of tools initiated by Weill and Vitale (2001). Their model is based on three categories of objects: 1. participants, standing for customers, suppliers and stakeholders; 2. relationships; and 3. flows, such as money, data, product, or service (Weill & Vitale, 2001; Zott et al., 2011).

2.1.2 Open business model patterns

The term *open business model* was coined by Chesbrough (2006) in his book "'Open Business Models" which is heavily based on the open innovation theory, brought in the academic consciousness also by Chesbrough. Dissociating open business models from "closed" business models, it is mentioned that the open business models are opened up so that it allows external ideas and technologies to flow in from outside and vice versa. This shift in mentality also requires some changes in how the value creation is seen and therefore, this section focuses on examining and explaining different types of open business model strategies. Open source software is presented as an example where openness and overcoming traditional borders has been creating significant value. (Chesbrough, 2006)

On the other hand, *open business* is seen to stand for many different meanings, such as open source, open data, open cloud, open standards, open business and so on (Chesbrough, 2006; Chesbrough, 2011, Parker & Van Alstyne, 2013). Overall, the open approach values transparency and accountability between the actors in value chain. Additionally, even though some ideas are shared between open innovation and open source software development, open innovation scholars subsume both value creation and value capture are sourced from business models. Open source advocates incorporate the value creation phase but dismiss the significance of value capture (Chesbrough, 2011, p. 211).

Placing copyrights and patents are forms of intellectual property (IP) protection that enables proprietary distributors to set specific limitations on how their licensed software may be used (Harison & Koski, 2010; Hall, 2017). Chesbrough (2006) claims that selling or acquiring IP rights as a part of business model is connected with open innovation principles. SMEs that usually have less IP than large corporations need more often to co-operate and share both IP and technology with external stakeholders/other parties (Chesbrough, 2006). Nevertheless, open source companies are able to change licensing models only if they have full ownership of the IP (Onetti, 2009). Boudreau (2010) states that it is a wider debate, whether opening up a technology by granting access for third parties would be the best way for development and commercialization. Opening has the ability to enlarge the potential beyond the possibilities of original project, but can also its developer with very little or no control. Typically choosing open approach reduces the innovator's divide of profits by allowing the competition on a certain platform. (Boudreau, 2010)

As stated in the previous section, business models heavily rely on defining the value. Von Hippel and von Krogh (2003) state that the most typical models of innovation are *private investment* and *collective action*. The *private investment* model has a built-in assumption that the returns of innovation run for the inventor and result accumulation of private goods whereas the *collective action* presumes that in the case of market failure, innovations should be obtained in collaboration for the public good (von Hippel & von Krogh, 2003). In this vein, the core value is seen very differently depending on the model. Therefore, von Hippel and von Krogh (2003) coined a novel *private-collective* innovation model that combines the best parts of both approaches in a flexible way.

The rise of platform based economy has led to the emergence of more open and collaborative business models. Since collaboration has become more and more Internet mediated, the solutions can be sought from wider audience. Usually, platform based business is considered as two or multi-sided business (see Shapiro & Varian, 1998; Rochet & Tirole, 2003; Parker & Van Alstyne, 2013). As pointed out by Economides and Katsamakas (2006), two-sided pricing strategy cannot be adopted by open source platforms since the offering is provided by free at least to some side (end-users, other organizations, or companies). Switching costs that users face when considering another platform or service are common for both proprietary and open source platforms (Economides & Katsamakas, 2006). While the upcoming EU GDPR and changing design principles are guiding software companies towards interoperability and portability, and therefore remarkably lowering these switching costs, the toll of implementation and adaption will stay.

Weber (2004) defends free and open source software by saying that in the proprietary software product, the innovator benefits from "renting" the product, rather that improving it, and distributing the updates for users for free. Proprietary model makes innovators lazy since they are already profiting from their creation (Weber, 2004). On the contrary, Chesbrough (2006, 42-43) claims that freeing the latent value from technological innovations requires business models.

Bonaccorsi et al. (2006) state that in the open source industry, the traditional variation between process, product, and organizational innovation fade. Instead, innovation includes additional dimension of business model since open source also disrupts the former model of raising money by selling software through licenses. (Bonaccorsi et al., 2006) Nevertheless, Onetti (2009) argues that open source software are licensed and usually the business model choices are fitted accordingly to the license. Sometimes the original license turned out to be an improper choice in terms of business and thus needed to be changed (Onetti, 2009). This research suggests that business model choices are strategic decisions also for open source software providers. The openness of a company's business strategy is found to be negatively related to the switching costs on the supply side (Bonaccorsi et al., 2006).

By the time Chesbrough wrote his book, the open source software was lacking clear and well defined business models, or more specifically, *open source business models* (Chesbrough, 2006, 42-43). However, few business models formed to profit from OSS can be found. Chesbrough (2006, 45) categorizes them based on the added value, ranging from the lowest to the highest respectively: 1. selling installation, service, and support in addition to the software; 2. versioning the software, i.e. providing free entry-level version; 3. software integration with other IT infrastructure in use; 4. offering commercial complements to OSS. The classification of open-source business models is discussed in more detail in Section 2.2.3.

2.2 Free/Libre and Open Source Software

Free and open source software (FOSS) and Free/Libre and open source software (FLOSS) stand for a software or application released under a license that authorizes the assessment, use, moderation, and redistribution of the source code (Crowston, 2012). The term open-source software and it's foundations as we understand it nowadays was coined around 1999 by Eric Raymod in his book *The Cathedral and The Bazaar* (Chesbrough, 2006; Lindman, 2011). The term FLOSS covers all versions Free/Libre/Open source Software whereas term *open-source software* (OSS) is most widely used among proprietary actors (Lindman, 2011). Fitzgerald (2006) claims that the term OSS was coined to correct the misperceptions that *free software* was not business friendly or meant for making money.

These development activities are carried out by Internet-based online communities where software developers voluntarily collaborate to create needed software or applications (von Hippel & von Krogh, 2003). The term "free" does not solely mean the price tag of the software would be zero, rather than the code is open, public, and non-proprietary. The point is, no licensing fees or royalties go for to the creator but some cost will emerge, for instance costs of training sessions and hardware investments. (Weber, 2004)

According to the literature review by Crowston (2012), the amount of FLOSS literature has surged since 2006, even though the academic research is relatively young. Depending on the exact background of the researcher and the topic, the form of publication (journal article or conference paper) varies a lot and therefore FLOSS review aims to have a selection of both types (see Crowston, 2012).

2.2.1 Defining Free and Open Source Software

Albeit the foundations of FLOSS were laid by actions of major computer manufacturers in the 1960s, the movement has been strongly led by hackers and developers. Back then, software products were designed only to run particular hardware and thus were not portable or interoperable. The major technological advancement leading towards the emergence of FLOSS was the release of IBM System/360 computer architecture and the promotion made by opening up the source code. Furthermore, IBM actually encouraged users and software developers to form communities on their own. (Schoonmaker, 2007) Distributing open-source software may be profitable strategic decision for large companies, if the certain technology forms a de facto standard for the industry, and the company can profit from compatible products (Harison & Koski, 2010). Later on, when IBM moved its software products under strict licenses and proprietary model, the development was at first driven by the launch of ARPAnet, the first continental and high-speed computer network, and further by FLOSS products built on the top of the UNIX system (von Hippel & von Krogh, 2003). As an example of highly successful FOSS project, Linux was a huge, common effort by the developer community, started by Linus Torvalds and coordinated via Internet (von Hippel & von Krogh, 2003; Schoonmaker, 2007; Harison & Koski, 2010). The overall practices of Internet-based communities and fragmented work are still thriving in the FLOSS field.

Even though FLOSS ecosystem is organized in community form and driven by voluntarily participating people, there can be found few different schools inside the community. According to von Hippel and von Krogh (2003), being a logical continuum for Free Software Foundation (FSF), the open-source software movement was established in the late 1990s. While both FSF and the open-source movement agreed on the same licensing practices, the open source movement focused on emphasizing the practical benefits of this kind of development, rather than being powered by philosophical principles. It was not until the turn of the millennium when open-source software gained its foothold as a considerable economic, cultural, and academic phenomenon, instead of being classified as a marginal movement (von Hippel & von Krogh, 2003; Crowston, 2012).

In a similar vein Crowston (2012) and Hall (2017) claim there's a difference between *free software* and *open-source software.* Hall (2017) states that both are licensed according to the criteria set forth by the FSF and Open Source Initiative (OSI) and admits that the above mentioned types are not coextensive but fill many of the same requirements and are often intertwined to concepts of FOSS or FLOSS. Despite this imperfect correlation, the terms can be meaningfully analyzed in the sense of commercial use analysis. Some researchers are using the open-source software (OSS), without committing the definitions of free or libre - whenever this is the case, the abbreviation OSS is used. The diagram below shows the relation between free, open-source, and public source software licenses. (Crowston, 2012; Hall, 2017)

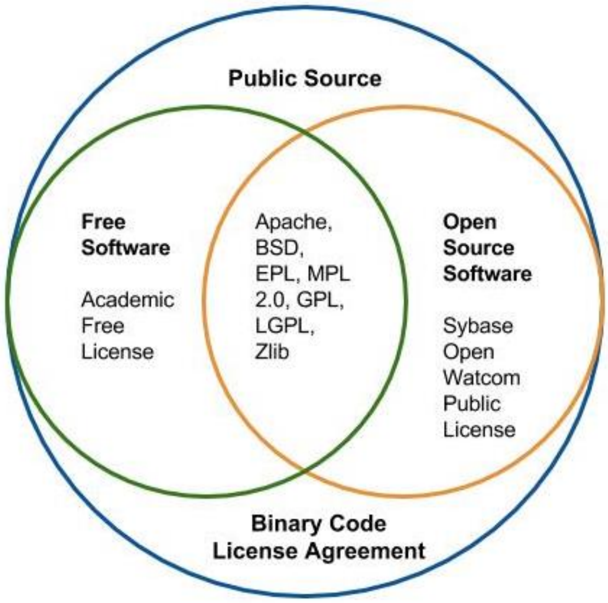

Figure 2. Categorization of free, open-source, and public source software licenses. (Hall, 2017)

As the figure shows, there are certain licenses falling into each category. In the context of this study, the term OSS provides definition that is both exact enough and does not exclude relevant references outside the scope.

The open-source movement can be defined as a global promoting effort of open style of software development that is more aligned with the scientific ethics than proprietary models of invention distribution (Deek and McHugh, 2007, as cited in Donnelly, 2010). Schoonmaker (2007) analyzes three distinct approaches to FLOSS, each having a divergent relationship to the software business. These approaches include IBMs dual licensing model, Free Software Foundations freedom and ethics highlighting approach, and open-source model.

According to Weber (2004), one distinction between proprietary and FLOSS is that while the source code is written in a human-readable programming language, commercial software is usually released in binaries (machine-readable) that cannot be read, interpreted or edited by humans. Therefore, the source code is always released with the software so it is available for anyone who so wishes (von Hippel & von Krogh, 2003; Weber, 2004).

The immense number of different FLOSS licenses is a problem noted by several researchers and authorities. For example, Hall (2017) states that despite the efforts to restrict the emergence of new FLOSS licenses, there are hundreds of different licenses. OSI (2017) recognized the problem in 2004 and after launching a campaign targeted to slow down the growing number of open-source licenses, they launched a License Proliferation report in 2006. Still, in 2009 the amount of OSI approved licenses was 72 (Onetti, 2009). The report provided a categorization of the licenses into groupings based on both content and usage (OSI, 2017). For these reasons, it is not meaningful nor possible to evaluate these licenses one-by-one. Therefore, I'm using yet existing high-level classifications in order to compare different FLOSS license types.

Hall (2017) divides FLOSS licenses into three main categories: strong copyleft, weak copyleft, and permissive based on the scope of the license's copyleft effect. These run from the most strict to the least restrictive, the first being the tightest, respectively. Copyleft is a licensing practice, denoting that subsequent programs based on some software program must be licensed similarly as the original software (Mustonen, 2003). This policy positions FLOSS users in guardianship since they have to make sure that the used software as well as all of the software upon which the used one is built has to meet the license requirements.

GNU General public License (GPL) constrains that distributors of GPL-licensed software provide royalty-free, redistribution and copy allowing access to the source code for both GPL software and any creation based on the GPL software. This procedure refers to the criticism the use of copyrights and patents used to limit the free copying, modifying, or distribution of certain software (see von Hippel & von Krogh, 2003; Hall, 2017). Currently, GPL is the most used strong copyleft license (Widenius & Nyman, 2014). The GPL license is usually chosen by person who prioritize using Linux, over the Berkley Software Distribution (BSD) combined with BSD Unix (Onetti, 2009). Furthermore, GNU GPL itself was created under a copyright law, in order to combat with the proprietary software and enable FLOSS model to coexist with commercial software (Schoonmaker, 2007). As the creator of GNU Project and a founder of Free Software Foundation, Richard Stallman has said, free software is a question of liberty, not price (von Hippel & von Krogh, 2003; Stallman, 2010).

When comparing GPL rules to other types of FLOSS licenses, few key differences can be found. For example, GPL software cannot be combined with proprietary software programs as products published under permissive and weak copyleft licenses can (Widenius & Nyman, 2014). Therefore, some companies opt-out using GPL since the software code they would be producing on the top of GPL licensed software cannot be published, either due to privacy or business reasons. Permissive license goes even further than weak copyleft license (LGPL) or GPL by allowing the license to be changed to a proprietary license and not giving a full guarantee to access to the source code. The Mozilla Public License is one widely used example of weak copyleft licenses. (Widenius & Nyman, 2014)

From the business perspective, an open-source project may have both a corporate company and an open-source community working together in a same project (Lindman & Nyman, 2014). Some FLOSS licensed software applications may be even produced in a similar manner than proprietary software, as has been the case with MySQL (Crowston, 2012). When for profit companies are collaborating with an open-source project and choosing the license, it is worth to bear in mind that any proprietary program that is connecting and open-sourced to a GPL-licensed program must also be (re)licensed under GPL (Widenius & Nyman, 2014). According to Lindman (2011), the open-source revolution never came in such a volume as predicted and hoped for. Nevertheless, especially the industrial use of OSSes has grown steadily and gained foothold in parallel with proprietary software (Lindman, 2011).

The variety of open-source applications is vast: there are thousands of projects, ranging from office suites to databases to marginal utensils (see von Hippel & von Krogh, 2003; Weber, 2004). According to Economides and Katsamakas (2006), who compared the two-sided competition of proprietary and open-source platforms, the selection of applications is wider on the open-source platforms. In addition to the selected license (proprietary or open-source), the revenue generating possibilities are depending on various other factors, such as the business model, end users and their willingness to pay, overall competition, and the level of the service and support. What needs to be recognized is that the selection of a certain license is unconditionally also a business model selection (Onetti, 2009). To be more exact, Onetti (2009) claims that the license choice defines the possibilities to apply funding, investors, customers, and even the environment where the business "may grow and compete".

Fitzgerald (2006) states that FLOSS products are primarily targeted at horizontal infrastructure whereas most commercially focused, open-source based software is built in vertical domains, often having paid developers working on the assigned coding tasks. OSS 2.0 (analogous with Web 2.0) approach defines open-source products as platforms on top of which a company builds its own value-adding solutions. Gradually, platform and added software solutions form an ecosystem.

2.2.2 Difference between open-source and open data

There are distinctive differences between open-source and open data. Lindman and Nyman (2014) state that one of the significant differences is that open-source refers to application and code whereas open data can be numbers, names, or locations. Furthermore, open-source code, as well as application, is something that produces or deploys data (Lindman & Nyman, 2014, 13). Both open-source and open data have their own licenses that are based on the copyright protections, providing different levels of protection according to the owners or creators choosing. Free and open-source software is implying that the code basically a list of instructions, organized as a form of a recipe, but missing the extra layers of copyright, licenses, patents and other legal protection tools that proprietary software deploys (Weber, 2004).

Table 2. Examples of key value sources in open-source vs open data. (Lindman & Nyman, 2014)

	Actor	Economic value	Other value
Open-source	Companies	Dual licensing, support and services	Product innovation, platform innovation
	Customers	Cost savings	Evade vendor lock-in
	Actor	**Economic value**	**Other value**
Open Data	Data owner	Sales of premium access	Public service, receive additional developmental resources
	3rd party	Sell applications	Increased transparency, novel services

Table 2 shows the scarce classification between open-source and open data. As a result of comparing the commercial aspects of open data and open-source, Lindman and Nyman (2014) found out that the open-source income flows from various origins, the main categories being support & services and dual licensing. The open data business is a relatively novel field and therefore, no fixed business models have yet emerged. Usually, these services are free for customer when the data publisher or application owner pays the costs. (Lindman & Nyman, 2014)

Open Source Initiative (OSI) is an international, non-profit organization that protects and promotes open-source software, development, and communities. The initiative is playing a key role in stewarding the definition and guidelines of open source:

> "Open-source software is software that can be freely used, changed, and shared (in modified or unmodified form) by anyone. Open-source software is made by many people, and distributed under licenses that comply with the Open Source Definition." (Open Source Initiative, 2017.)

According to OSI, the history of sharing and collaborative development of code is as long as software development itself, having been powered with the rise of Linux in the late 1990s (Open Source Initiative, 2017). The open-source as a concept was coined in 1998, in Palo Alto, California, briefly after the Netscape source code was announced to be released (OSI, 2017). At that time, Netscape was a giant player in internet browsers with a dominant market share and the release of its source code was an advent for the creation of Mozilla Organization (Bicknell, 1998). The foundation of OSI and the Open Source Definition (OSD) marked new era while launching first formal list of approved licenses and clauses, that have been later categorized and labeled further to meet the demand created by growing usage. Still, OSI has the position of being the standards body trusted by both the developer community and business and government. (OSI, 2017)

One key distinctions between open-source and open data projects is that according to Lindman and Nyman (2014), developers can participate with altering motivations whereas the publisher of open data is normally taking care of the costs of data processing, storing, and correction. Therefore, open-source processes tend to be more unlocked as the prerequisites are not that binding (Lindman & Nyman, 2014).

Making a difference between open-source software business models (FLOSS) and MyData based services, MyData can be described as a human-centered personal data, where data is not just open but also designed in a certain way. The roots of this approach lie on the ground of Nordic welfare societies but the model has gained foothold internationally during the recent years, merging themes like MyData, Self Data, PIMS (Personal Information

Management Services) etc. MyData approach intrinsically adopts human-centric perspective whereas FLOSS only refers to certain classifications of freely licensed software. MyData is discussed in more detail in Section 4.2.1.

Based on the literature review done by Economides and Katsamakas (2006), open-source literature can be divided into four scarce categories: individual incentives on participating the open-source activities, companies' incentives to adopt open-source initiatives, business models of open-source adopters, and the competitive consequences of open-source.

2.2.3 Business of open-source and open data

Watson et al. (2008) recognize five different business models of software production: proprietary, open community, corporate distribution, sponsored OSS, and second-generation OSS. Proprietary and open community are representing the opposite ends of the scale whereas the latter three can be classified as hybrid models. They claim that the proprietary model has been a market dominator throughout the decades. Nevertheless, proprietary software can be leveraged as a freeware or with freemium models, the distinction being that user is unable to modify the source code. (Watson et al, 2008) On the contrary, Schoonmaker (2007) lists only three major models for software business: proprietary, free and open-source model, and dual business model, combining both proprietary and open-source software. Bonaccorsi et al. (2006) conducted a study of Italian open-source providers and found out that few companies chose a business model offering only open-source solutions while the vast majority offered both open-source and proprietary products. This hybrid business model raises revenues from traditional license fees and opens-source -related products (Bonaccorsi et al., 2006).

According to Lindman and Nyman (2014), openness means that a software, an application, or dataset can be obtained free, intending that the provider does not earn anything from sharing these or letting others to build novel services on top of their releases. It is assumed that in the current market situation, generating revenues on open data is pretty hard and usually data releasers get funding and/or help for maintenance and data collection from public sources. (Lindman & Nyman, 2014) However, as recent examples have shown, corporations have opened up both open-source codes and data sets for developers to build on. For example, Movesense, consisting of a set of APIs, developer tools, sensors and support is an open development environment created by a sports manufacturer Suunto (Movesense, 2017). In order to gain more rapid development cycle in the motion sensing scene, the company has outsourced a part of potential innovations according to the open innovation procedures, utilizing both open-source and open data. To sum it up, open-source software is also in the interests of corporations, not just hackers and developers intrigued by freedom.

Harison and Koski (2010) examined of 170 Finnish software companies. Factors were absorptive capacity, intellectual capital, and the education level of employees. *Absorptive capacity* refers to the ability parallels with open innovation since its ability to absorb, apply, and generate commercial benefits from information or innovation external to the organization. *Intellectual capital* are especially in demand in OSS projects where knowledge about OSS specific legal and business practices is needed, in addition to the required technical skills. *The education level of employees* usually indicates the human capital of the organization and the advanced level education can possibly be affecting to the likelihood of implementing OSS strategies. (Harison & Koski, 2010)

When looking at the results of open-sourced projects, the open-source code and/or application is developed and improved in the process whereas the open data usually remains the same, results being external (Lindman & Nyman, 2014). If the platform or data provider wants to utilize these outputs further, it is in theory possible with FLOSS products but seemingly harder with refined data.

Lindman (2011) examined in his doctoral dissertation different OSS strategies and divided into two distinct categories: inbound (software is developed for company’s internal use) and outbound (OSS is leveraged outside) OSSes. Lindman (2011, 19) also classified the main OSS research themes and found the following contexts: 1. OSS as a part of organizational change 2. collective efforts in understanding OSS adoption 3. legitimization of organizational OSS adoption, and 4. communal discourse related to OSS as a driver of change. What is remarkable in this OSS theory review is the emphasis of organizational research.

Economides and Katsamakas (2006) define software and operating systems as platforms. From this point of view, the technology and development platforms are understood as “hubs of technology industries” (Economides & Katsamakas, 2006). What needs to be always considered when evaluating the effectiveness of selected business model is the amount of stakeholders on that certain field. The lure and wider societal benefits of open-sourced software is also based on the network effects, i.e. amount of users on that field. The term network effects is inextricably related with platform economics and two- or multi-sided markets. When evaluating the usefulness of open-source, the number of other organizations adapting open business models plays a vital role. If the key players are still trusting on internal innovating and usage of proprietary software, open-source provider may have hard times to find potential and powerful stakeholders outside the developer community. Nevertheless, the recent trends are showing that the rapid disruption of the business logic of the industrial age has led to increasing need of collaboration.

One example of the recent developments is the hackathon culture, where computer programmers and other enthusiasts collaborate on software project in sprint-like, intense events, usually organized by or after the order of larger corporations. Hackathons typically produce massive amounts of code and service ideas, based on open APIs, software development kits (SDK), and existing open-source code provided by corporations.

Offering APIs can be seen as a form of open business, naturally depending on the type of the API. Boyd (2015) classifies API strategies under three main categories: private, public, and partner. Private APIs are for internal use and can serve as a first point of exploiting APIs in an organization and work as a testbed. Partner APIs are used for integration between a company and its stakeholders whereas public APIs are also offered for third parties. (Boyd, 2015) Public APIs are most useful in creating business strategies and monetizing assets since they serve as a platform for third party application development.

2.2.4 Success factors of FLOSS initiatives

Proponents of open-source software, for example Weber (2004) claim that collaborative FLOSS projects have demonstrated that “a large and complex system of software code can be built, maintained, developed, and extended in a nonproprietary setting in which many developers work in a highly parallel, relatively unstructured way” (p. 2). Examples of this kind of success stories include Linux, an open-source operating system, and Apache, cross-platform web server software (Crowston, 2012). GNU, standing behind the already mentioned GPL licensing model, was developed as a free software system compatible with UNIX. The purpose of the GNU Project was to create a *copyleft* license that required users to participate promoting the freedom of use and development of the source code (Schoonmaker, 2007).

One key factor to discuss when inspecting FLOSS success factors are the motivational drivers. Donnelly (2010) suggests that developers are contributing to programming activities for variety of reasons, for instance gaining recognition, promoting FLOSS movement, improving their personal skills, or just developing the software faster for their own purposes. The latter point may be one of the key drivers behind FLOSS success, endowing more agile bug-fixing and software development. Accordingly, endogenous and motivational drivers of developers are not to be underestimated since the internal motivation is arguably the most important force when there is no remuneration (Mustonen, 2003; Crowston, 2012).

Few other suggestions have been linked to the enhanced level of creativity, that proprietary software product don’t support. For example, Nyman and Widenius (2014, 4), suggest that the adoption of open-source code empowers organizations to harness the creativity and labor both their employers and customers in new ways. The success of Linux is often analyzed by comparing Linux and Microsoft (Mustonen, 2003; Economides & Katsamakas, 2006; Harison & Koski, 2010) or finding patterns of open-source development. Linux is even called a paragon of an OSS product, merely associated with the large developer community it has been able to adapt (Harison & Koski, 2010).

As Simoes-Brown and Harwood (Sloane, 2011) sum it up, we need to focus more on access and less on ownership. They explain that the traditional motif of supply and demand economics the consumption is achieved via ownership of scarce products and services. Nowadays, there’s no lack of source code or data in the sense of digital service production, rather capabilities and understanding how to use it to benefit us all the most. Furthermore, Weber (2004) states that the open-source development process can also produce new perspectives and understanding on central problems of social cooperation.

In their article Economides and Katsamakas (2006) compare the pricing strategies of proprietary and open-source technologies and suggest a framework for optimizing the pricing strategy for a platform company. One of their findings is that the variety of proprietary applications is larger and usually more profitable when the chosen industry platform is open-source (Economides & Katsamakas, 2006). Additionally, a key motivation to run open-source projects are cost savings due to the higher amount of relevant feedback and bug reports, as Widenius and Nyman (2014) have found on their literature review.

When it comes to successful pricing strategy, Mustonen (2003) found out that when competing against proprietary software or application, the lower implementation price of an open-source product is critical. Economides and Katsamakas (2006) claim, based on their economic framework, that it is crucial to evaluate competition on all levels: on both platform and application levels as well as combined action across both.

If the success is analyzed from financial perspective, not just how widely the software is adopted and used, the ones who have gained most sponsors and investments include RedHat, MySQL, Astaro, Compiere, and Funambol (Onetti, 2009). On the other hand, commercial companies like Sun Microsystems and IBM have been launching some of their previously proprietary products as open-source and have acquired OSS startups to build up open-source product portfolio (Onetti, 2009). For example, MySQL was acquired by Sun Microsystems in 2008 for $1 billion (Arrington, 2008).

2.3 Location-based Services and Geographic Information Systems

Navigation solutions, geographic information systems (GIS) and location-based data gathering are core expertise areas of Finnish Geospatial Research Institute whose research group of Intelligent Mobility and Geospatial Computing is primarily responding of running MyGeoTrust project. Therefore, positioning MyGeoTrust adequately between the traditional GIS services and recently developed and more commercially used location-based services is an important part of forming the clear picture of the market possibilities for the service.

In this study the interest is in crowdsensed mobile data, including geospatial data collected via GNSS sensors. Because the research focuses on service level applications and the usage of personal data, the technical specification of sensors is not examined in detail. Furthermore, all data, whether they have been extracted from stand-alone GPS-only sensors, multi-GNSS, cellular networks, or Inertial Measurement Units (IMU), are seen equal.

2.3.1 Location-based Services

Location-based services (LBS) are a group of services that are supplemented by and depend on the location information of a mobile device (Rao & Minakakis, 2003; Hirsh et al., 2006; Dhar & Varshney, 2011; Ryschka et al., 2016). Küpper (2005) states that understanding the meaning of the term *location* is principal for defining LBS in detail. On the most basic level, location refers to a certain place in the world. Locations can be either physical locations, such as a particular place of an object of the real world, or virtual location that can be associated with a location or a meeting place in cyberspace. (Küpper, 2005) This recitation is important since most location-based services are mobile device applications operating in a cyberspace, but using the physical location as coordinating system. To sum it up, LBS predominantly are associated with physical locations and usually operate on portable/mobile devices (Küpper, 2005; McArdle, Ballatore, Tahir & Bertolotto, 2010; Ruiz Vicente, 2011).

Dhar and Varshney (2011) claim that even though the emergence of LBSs has been forecasted and waited for since the early 2000s, the market entry has been impeded by the challenges in technological development and streamlined business models between service providers, mobile device manufacturers, and telecommunication carriers. Rao and

Minakakis (2003) characterized the early development of location-based services by stating that the degree of fit between the system's technical viability and the marketing strategy will be the key driver in LBS evolution. These observations disclose that the business environment where LBS operates is very complex one, dealing with multiple stakeholders at a time. Nevertheless, since the location-based emergency services were launched in the mid-1990s as a first LBSs, a wide range of applications have been released (Ryschka et al., 2016).

Physical locations can be further divided into three subcategories: descriptive locations, spatial locations, and network locations. *Descriptive location* always refers to natural geographic object and therefore it is a fundamental part of our everyday life. *Spatial location* can be seen as a synonym for position, pointing to a single location in the Euclidean space. *Network location*s are composed of many local networks, where the location of a single user is identified based on the IP address or a base station in the case of mobile networks. (Küpper, 2005) A single LBS may be utilizing all three categories, as is the case in MyGeoTrust. The application is currently collecting both Wi-Fi signals as network location data and the spatial location signals are combined with descriptive locations on the UI level.

Dhar and Varshney (2011) suggest that the quality of service of LBS should be measured as a combined result of required locational accuracy, response time, and reliability of operation. As one LBS design principle they suggest that the application middleware should be planned to involve the main characteristics of the end product (Hirsch et al. 2006; Dhar & Varshney, 2011). However, designing inexpensive, high-quality, and reliable LBS systems from a fragmented puzzle of dissimilar software, hardware, and connectivity has remained a challenge (Rao & Minakakis, 2003).

Due to the rapidly increased usage and interested towards LBS, some research openings have focused on the privacy aspects and concerns. According to Xu et al. (2009), the privacy calculus, i.e. the level of compensation vs. shared privacy, depends on the information extraction method (push or pull). These conclusions were gained as a result of a quasi-experimental survey where individual privacy decision making was compared with information gathering methods (push or pull), and privacy intervention approximates (Xu et al., 2009). Even though most of the LBSes are analyzed from the users' point of view, cultural aspects are usually not taken into account (Xu et al., 2009; Ryschka et al., 2016). These are addressed in more detail as a part of the PEST-analysis in Section 4.

Location-based services can also refer to the subcategory of location-based social networks (LBSN), which are social networking platforms and services where the core is based on geospatial data. Examples of this kind of services are Foursquare, Flickr or Strava, where the dimension of location bridges the gap between the physical world and online social networking services (Xu et al., 2009; McArdle et al., 2010; Zheng, 2011). The geolocation is one of the most important components of user context and it also reveals an extensive amount of knowledge about person's behavior and interests. Furthermore, location-based social networking does not only stand for actual shared location but also the generated knowledge inferred from a person's location-trajectory and location-tagged data (Zheng, 2011).

Location-based social networking can further be categorized into three groups: *geo-tagged media based*, where location is only used to feature and enrich media contents*; point-location-driven*, the current and shared location is the main element of connecting users; *trajectory-centric*, where both location points and the detailed route description with additional tags and tips (Zheng, 2011). Likewise, Ruiz Vicente (2011) states that location-related data can either be analogous with location, known as *geotagging*, and with users, known as *user-tagging*.

Typically, LBs operating environment set particular limitations for design. At first, the processing power and screen size of mobile devices is restricted which can be resolved by reducing the information provided on the user interface (McArdle et al., 2010). Furthermore, there are great variety of operating systems and development platforms used, making the creation of interoperable LBS even harder (McArdle et al., 2010).

One the key concerns of location privacy derives from the terms of service offered by LBSN service providers. Usually, the user needs to accept unilaterally composed stipulations to be part of the certain community. There are no alternatives for either accepting or declining the terms: the opportunity costs are whether or not to use the certain application.

2.3.2 Geographic Information Systems

The mapping in location-based service is accomplished by spatial databases and GIS in the most cases (Küpper, 2005). In addition to GIS, *spatial databases* that are designed to efficiently store, run queries, and optimize spatial data serve as a data base for GIS. In the context of LBSs, GISs are paramount for indicating the positions of particular objects and used for mapping geospatial location onto understandable descriptive location. (Küpper,

2005) The term geographic information system was used the first time publicly in 1968 (ESRI, 2012).

According to Donnelly (2010), GIS has developed from custom-build programs generated by government agencies in the 1960s to personal computer based applications in the 1980s to integrated web-based solutions in the 2000s. According to McArdle et al. (2010), the emergence of the internet and World Wide Web has provided a great benefits for the whole GIS industry since early 1990s. Ever since, the use of standalone GIS has declined and webGIS emerged (McArdle et al., 2010).

The previous example of the shift from standalone to web-based platforms is one specimen of the changes how GIS has been gaining momentum and survived all recent technological shifts, for example moving from paper to computer aided mapping and real time locating systems. GPS and laser scanning for 3D modeling are examples of the most recent and remarkable advances in GIS development (Zhang et al., 2013).

Today, there is a rapidly growing amount of GIS applications established on the web (McArdle et al., 2010). GIS market is dominated by handful of companies: Intergraph, MapInfo, and ESRI being the largest one. These particular companies are producing desktop GISs, the most typical software category of GIS applications. The FLOSS culture has always been strong among the field of GIS, even though the Open Source Geospatial Foundation (OSGeo) was founded in 2006.

Donnelly (2010) admits that the adoption of FLOSS for GIS has been increasing during the last decades. One example of the recent developments is the automation of map-based information, where GIS technologies have been quickly stabilized and upgraded (Zhang et al., 2013). According to Zhang et al. (2013), the width of GIS implementation is extensive and is becoming a crucial framework for understanding this dynamic world. The problem with skyrocketing augmentation are the costs and vendor lock-ins of commercial distributors. This supports evidence from FLOSS world, that open-source GIS (OSGIS) are dismantling the restrictions of interoperability, portability and sharing of data. Besides the openness and public data providers, economic factors are pushing the transference towards open-source technologies and therefore, numerous GIS applications have been published under GNU Public License (GPL) (McArdle et al., 2010). Market trends and participation in OSS development projects are main factors affecting the license selection of individual software products (Harison & Koski, 2010).

2.3.3 Difference between LBS and GIS

When compared to location-based services, GIS services are much older, having been evolving from the geographic data generated by earth orbiting satellites whereas LBSs have grown in number since the advent of mobile devices.

As Küpper (2005) explains, GISs cover a variety of services, being used for example in the fields of mapping, transportation, and surveying and are carrying out the mapping between different types of location information. Rigaux, Scholl and Voisard (2002) define key functions of GISs to be storing geographic data and retrieving and combining this data. If LBSs use geospatial data to provide information or services for mobile device users, according to Wade and Sommer (2006) GISs are used to visualize and categorize place-related data in order to perform geographic analyses and create maps. Zhang et al. (2013) add that GIS provide map and routing service, computing, analysis and geocoding for location-based services.

Understanding the basics of GIS and the database management systems these applications use is crucial premiere for designing location-related services. The problem of this intertwist has led to few drawbacks in LBS adoption and development. Zhang et al. (2013) state that GIS-supported LBSs often face high entry barriers since expertise to handle and maintain the GIS infrastructure is scarce. The high clock speed of technology shifts and lacking standards in the industry have been causing numeral false starts and wasted attempts (Zhang et al., 2013).

One way to evaluate the differences between GIS and LBS is to look closer how location-based services can be characterized. According to Dhar and Varshney (2011), LBS form four main categories: information and directory services, tracking and navigation services, emergency services, and location-based advertising. Information and directory services provide data about the nearest interest points, i.e. services located near the users. This application category is closest to the GIS approach yet providing an additional layer of information on the top of the geospatial data level.

Lack of adequate skills in GIS management and adaption may affect the erratic level of LBS applications. When there are restricted amount of resources in use, the main focus is usually getting the minimum viable product in action and prune the extensive services, i.e. additional security layers. If maintaining wide code library and building trustfully working data bases is a great challenge for big companies, it is even more challenging for SMEs. Applications that utilize geospatial data and location information need to be coded flawlessly not to mention the privacy aspects. Besides the vast array of different technical decisions, for example choosing the right data base model or query language, utilizing a GIS is a complex project. Zhang et al. (2013) claim that LBS system development is usually depending on GIS standardization, especially the spatial data modeling and processing standards coined by OpenGIS Consortium.

Mapping and geographical modeling being widely run by public or governmental organizations has led to that open-source GIS software has a relatively long history. The Open Source Geospatial Foundation (OSGeo) has adopted Open Source Initiative’s protocols of certified open-source licensing so that all projects of the foundation are available freely (OSGeo, 2017). For example, the foundation is providing a wide project library of different types of software and source codes, including content management systems, desktop applications, geospatial libraries, metadata catalogs, and web mapping (OSGeo, 2017).

2.3.4 Open-source business models in LBS

As discussed in the previous section, in the GIS world OSGeo and other open-source initiatives have been sustaining transparency and free movement of data and software. The situation is not as clear in the field of location-based services since most operators and service providers are private companies rather than public or governmental institutions. Naturally, proprietary companies usually try to protect their IP rights in order to gain competitive advantage over others. In this section, I will examine further if open-source business models can be found among LBSs and how the service providers could open up their businesses.

In the context of this study, the main motivation is to find solutions for establishing and sustaining location-based services that are designed to protect data subject’s privacy. As it was investigated in Section 2.3.2, open-source GIS software has long traditions and therefore MyGeoTrust can be seen as a clear continuum of these traditions.

Few studies have been conducted over the open-source software based LBSs. McArdle et al. (2010) argue that utilizing web-based open-source technologies to build LBSs could be one option. This is justified by the reason that web-based technologies are ubiquitous, requiring only suitable web-browsers to enable cross-platform data flows and improving access. Nevertheless, most LBS compatible open-source software packages were GPL-licensed (McArdle et al., 2010).

One example of open-source standards created for LBSs is the OpenLS Services by Open Geospatial Consortium (OGC). According to Dhar and Varshney (2011), key functionalities provided by OpenLS platform include open interfaces for LBS core functionalities like route estimation, directory, geolocation utility, location data and map visualization, and gateways.

It has been claimed that there are several challenges slowing down the development, offering and wider adoption of LBSs. One of these challenges is the lack of suitable business models, in addition to the emergence of technologies and the selection of suitable applications (Dhar & Varshney, 2011). The article by Dhar and Varshney is written from the advertising industry's context, but the analysis addresses some universal challenges shared with plethora of location-based services, including some study about the open-source players in the field of LBS.

Open Mobile Alliance (OMA) and Open Geospatial Consortium (OGC) are among the key influencers providing components of the LBS standards infrastructure (Dhar & Varshney, 2011). OGC differs from OSGeo since its role as a consortium is to develop open geospatial interfaces and standards for technology developers whereas the latter ones mission is to sustain and promote collaborative enhancement of open-source geospatial technologies and data (OGC White Paper, 2011). One example of these standardization tools is the Mobile Location Protocol (MLP) created by OMA. This particular protocol provides specifications for location information exchange between geolocation servers and the LBS application Furthermore, the protocol supports users' privacy by granting access to location information only for authorized users. (Dhar & Varshney, 2011)

One business model logics in LBS sector is that original equipment manufacturers (OEM) are creating and opening development platforms. According to Dhar and Varshney (2011), this business model is gaining reputation and has few alterations: revenue sharing, hosting and advertisement. In the revenue sharing model, every contributing party is allocated for receiving a part of the service fee. In the hosting model, the LBS operator pays a fee that can be either a fixed monthly sum or usage based, for the hosting service provider. Advertising revenues are generated from the ads seen on mobile applications or sites. (Dhar & Varshney, 2011)

There has been particular patents filed for location-based service architecture. For example, Alan, Schroth & Palmer (2012) have claimed a patent called "Location-based services" (patent number US2012129553 A1) that provides methods and systems related to LBSs like geo-fencing, outputting location-based data on a mobile device, varying transmissions to and from a mobile device, and delivering location-based alerts. The patent consists of technical drawings for the software architecture and data storing, modules of service etc. Despite the fact that the patent file mentions privacy and an option provided for the user to choose if the location or direction for the device is recorded to which database, the architecture can by no means be described privacy enhancing. The principle of *privacy by design* is not used, nevertheless the privacy aspects are not fully excluded either. This patent example underlines the core difference between privacy promoting MyGeoTrust architecture and traditional LBS architectures and also explains the aim to provide similar privacy enhancing services via open-source communities for other organizations as well. (Alan, P. 2012).

One of the key challenges of mobile applications overall remains also with location-based services: how to retain users after they have adopted a certain application? Zhou (2016) studied the continuance factors behind LBS usage and conquered an information system success model. The key factors for continuance were trust, flow, and privacy concern, usually addressed more thoroughly in open-source software development than in proprietary models.

2.4 Conclusions from the literature

The business model literature offers plenty of possibilities for strategic planning and decision-making but leaves framework creation open-ended. The literature review showcased that the concept is lacking clarity, which is due to the rather recently aroused academic interest towards the business model discipline. *Business model* is an umbrella term for several concepts, not just one mutually agreed one. In addition to being a tool for value creation and capture, business models are also used as weapons against competitors. Therefore, business models are potential sources of competitive advantage. (Zott et al., 2011) Success and performance of a company can be explained via adopted business models, and as Afuah (2004) suggests, the profitability can be determined from the corresponding means of business model components. In open business models, innovation is added as a key component.

Among the key factors of the future adoption rate of LBSs are the emerging technologies and decreasing prices of mobile devices, service applications, and data transfer. LBS acquisition is strongly dependent on the prices that network operators charge for value-added mobile data services. Furthermore, the equation between price, privacy and usefulness is extremely volatile, mirroring personal preferences, especially with the “nice-to-have” rather than “must-have” LBS applications (Dhar & Varshney, 2011). Nevertheless, new technologies alone are not guaranteeing commercial success and novel approaches to business models are required (Heiskala et al., 2016).

In the field of open data and open-source, major developments have happened during recent years. Open-source software has already been tested, and a variety of business models have emerged. The open data business, however, is still in its infancy (Lindman & Nyman, 2014). The overall OSS adoption has mainly been driven by market entrants (Harison & Koski, 2010). As is the case with the MyGeoTrust project, the source code and part of the data are planned to be opened. Therefore, the literature review over the best FLOSS practices and licenses is further discussed in the empirical study chapter.

As Lindman (2011) points out, selecting one best OSS solution for a company or a project is challenging. Whether concerning business models or licenses, the research on OSS technologies and frameworks may help the company, but it needs to be backed up by empirical analysis and proof (Lindman, 2011). While the principles of open-source software development and projects are widely agreed, the selection of license, legal status, and business models are complex questions (see Chesbrough, 2006).

Even though companies tend to have control over open-source platforms (Economides & Katsamakas, 2006), open-source can become a standard, as the example of Linux shows. For example, Google’s Android operating system uses a kernel which is based on the Linux kernel. Furthermore, Android’s source code is also available as open-source, and its software development kit (SDK) offers further possibilities for open-source development (Schoonmaker, 2007; Guinness et al., 2015; Lindquist & Galpern, 2016).

3 Methodology

A case study is one variety of qualitative, social science research methods. Yin (2014) defines case study to be the most appropriate and preferred when the research questions are either *how* or *why* questions; investigator does not have control over the nature of the events; and when the focus is rather in researching a contemporary than historical matters. Therefore, case studies are conducted in real-life environment with contemporary matters and research data collection is planned accordingly (Yin, 2014, p. 2).

According to Yin (2014, p. 4) case study methodology has been widely used in several fields, including sociology, business, political science, and anthropology, just to name a few. It is adequate method to gain knowledge of individual, group, organizational, political and social phenomenon. To sum it up, case study research allows maintaining a holistic and authentic approach. (Yin, 2014, p. 4-5)

3.1 The case study protocol

Yin (2014, p. 3) suggests that proceeding a case study should start with an in-depth literature review and research question formulation. Thorough outlining is highly useful when taming the complexity of the social phenomena researched. Intricate social structures in case studies try to illuminate a decision or a series of decisions, for example *how* business models should be structured or *why* some licensing model should be selected (see Yin, 2014, p. 15). Therefore, Yin (2014, p. 16-17) has formulated a twofold definition of case study, where the first half defines *the scope of the study* and the second one *the features of a case study*. Formulating this study has been outlined following the previously suggested case study principles.

According to Yin (2014, p. 29), designing a case study research design includes five distinct and important steps: 1. forming case study questions; 2. evaluating possible propositions; 3. deciding units of analysis; 4. designing the logic that links the data to the propositions; and 5. forming the criteria for evaluations of the findings. Characterizing the unit of analysis is a crucial step and has to follow the design challenges of construct, internal, and external validity as well as reliability (Yin, 2014, p. 29).

Case study evidence can be collected and/or retrieved from plentiful sources. Yin (2014, p. 103) classifies six sources of evidence: documentation, archival records, interviews, direct observation, participant-observation, and physical artifacts. In order to maintain a high quality, one case study principle is to use multiple origins of evidence (Yin, 2014, p. 102). In this study, documentary information, interviews, and archival records are utilized. Documentary information covers all internal records, written reports and papers as well as interim and process updates produced during the MyGeoTrust project. Interview data was specifically collected during and for this study by interviewing members of the project steering group. Archival records include MyGeoTrust user survey conducted in the beginning of the project and Wi-Fi and location data collected with MyGeoTrust software.

Data collection principles depend on the type of the evidence. (Yin, 2014 p. 105-113). For example, documentation and archival records are usually stable so it can be retrieved easily, ranging over a long period of time, and contain specific data with rich details. Weaknesses of these evidences usually occur with restricted access or either biased selectivity or reporting. (Yin, 2014, p. 106). These risks can be mitigated with source criticism and diligent background checks of documents and other sources used.

Perks of collecting evidence via interviews are related to insightful and highly targeted data, but the common pitfalls mainly derive from poor interviews design and reflexivity (Yin, 2014, p. 106). Wengraf (2001) explains that unlike other forms of research activity, interviews are planned and prepared half- or quarter-scripted, leaving possibilities for improvisation and co-production. Semi-structured interview method were partially selected as it is less prone to reflexivity and poorly articulated questions than surveys and other structured forms of interviews where the investigator is not making the questions in person.

3.1.1 Embedded case study

An embedded case study is a variation of single-case study, where two or more sub-units are selected and analyzed instead of one, holistic case (Yin, 2014, p. 55). The embedded case study methodology avoids some pitfalls of holistic study, for example mitigating the risk of having one, strictly focused research question, having flexibility to address additional research questions than the original setup, and providing more concrete data. Nevertheless, the possible shortcomings of the embedded case study include focusing too much on the subunit level analysis, unsuccessfully delivering the big picture or even failing to meet the study framework. (Yin, 2014, p. 55) These pitfalls can be avoided with thorough case design and being careful that the collected subunit data is not too detailed.

In his book, Yin (2014, p. 133-150) explains the need for analytic strategy and illustrates case analysis procedures. According to him, analyzing case study evidence is seemingly challenging since the exact techniques are not adequately defined, unlike in the case of statistical analysis. Nevertheless, data analysis can consist of examining, categorizing, tabulating, testing or recombining collected evidence (Yin, 2014, p. 132).

3.2 Interviews

Interviews are powerful tool in case study because they are able to produce exactly targeted data, benefiting directly case study topics (Yin, 2014, p. 106). Interviews can provide essential evidence for case studies since the majority of case studies are related to human affairs or actions and are usually divided into prolonged case study interviews, shorter case study interviews, and surveys (Yin 2014, p. 110-113). Even though this particular study is about open-source software and business models, the end users deciding whether or not to use some product are after all humans making the decisions. This point of view should be emphasized especially in the context of data privacy, freedom, and control.

Overall, interviews can be divided in open, semi-structured, and structured interviews. Open interviews are guided by research themes and respondents usually are experts of a certain area whereas structured interviews are based on hypotheses and answer options are defined by interviewer or researcher. (Järvinen & Järvinen, 2004; Yin, 2014) In this study, interviews were organized as semi-structured interviews, which was chosen as a most suitable way to gather qualitative and descriptive insights. Semi-structured interview is a combination of these two, providing more freedom for the responder to express her/his own insights and possibilities for interviewer to delineate and sharpen questions if they are not understood correctly (Järvinen & Järvinen, 2004). On the contrary, conducting surveys is less time consuming method to collect data but contains risks that can be eliminated in semi-structured interviews, i.e. misunderstanding of the context and questions or missing possible new avenues of discussion.

Although semi-structured interviews may be identified easier to design, including open-ended questions and lots of freedom, improvising during the interview needs careful mental preparation. Furthermore, analyzing data collected via semi-structured interviews requires usually much more time for interpretation and analysis of the results. (Wengraf, 2001.)

In general, face-to-face interviews are perceived as the most productive way of conducting interviews in social sciences (Holt, 2010) but new telecommunication tools have challenged this mode of data production (Hanna, 2012). This is especially the case when producing narrative data but also a common reasoning for semi-structured interview arrangements (Holt, 2010). From the point of view of this particular study, the contextual data and background where interviewees came from was known in advance, making it more efficient to manage semi-structured interviews and reducing risks related to unknown circumstances. Perhaps the most remarkable factor for the success of telephone or Skype interview is how used both the interviewer and participant are in communicating with such tools (Holt, 2010).

Hanna (2012) conducted PhD study interviews using face-to-face, phone and Skype interview techniques and found out that Skype with added visual interaction comes closer to the original in-person meeting than phone and can be used to provide more freedom for both interviewer and respondents. Knowing that all steering group members requested to be interviewed were very busy and some living outside the Helsinki area, Skype interview was offered as a possibility already on the invitation email. The interview request letter as a whole is documented in Appendix A.

3.2.1 Interview preparation

The interviewee group was chosen from members of MyGeoTrust steering group, e.g. representatives of companies and public organizations that belong to the group. The steering group has representatives from several organizations and companies, including Here, Microsoft Mobile, Grundium, Sports Tracking Technologies at Amer Sports, IndoorAtlas, Shoplitics, KONE, Ekahau, Sanoma Media Finland, and SSH Communications, as well as the Ministry of Transport and Communications. All organizations are participating voluntarily and in a personal capacity[3], and none granted money for the research project. Their activity level has varied throughout the project, the requisites for steering group members being only participation to the official meetings and milestone evaluations.

The motivation to interview only stakeholders having inside knowledge about MyGeoTrust was to gain deeper insights than it would be with interviewees not familiar with the project. Due to the highly technical and complex nature, it was practical that interviewees can evaluate the project goals and process over a longer time period and also evaluate how their own expectations have changed or how the markets have developed during the past years. Another motivation was to gain insights to the open-source development motifs of the steering group members, in order to fit MyGeoTrust business opportunities better to the current market situation.

[3] For example, one steering group member changed companies during the project. This person continued as a member under the new company.

The interview requests were sent a few weeks before the first interview, and all were carried out within the timespan of three weeks. The invitation email provided basic information about this particular study and its aims, and it highlighted few key themes where the interview questions would be centered on. The interview questions were not handed out prior to the interviews in order to maintain adaptability, such as the possibility to open new avenues of discussion. Forming the final set of questions required a few iterations, and questions were also reviewed and revised by a few senior researchers at FGI.

3.2.2 Interview statistics

Semi-structured interviews are usually conducted as individual or group interviews, and usually group interviews are not seen as biased if the participant selection is done carefully. In this study, two interviews were carried as individual interviews and two interviews as group interviews of two people. Each of the respondents was invited to be interviewed in person. Both of these group/pair interviews were suggested by respondents and accepted by the interviewer, due to the limited time and strict schedule. When comparing the different forms of the interviews, the insights from pair interviews were seemingly deeper since in both cases the participants knew each other and were able to complement or argue one another's comments. As seen from Table 3, the length of the interviews varied from 26 to 65 minutes, where the longest one was a joint meeting with two interviewees.

Table 3. Interview statistics.

Title	Interview duration	Date
Director, Business unit	26 minutes	22.1.2018
Senior Adviser	58 minutes	29.1.2018
Senior Adviser	58 minutes	29.1.2018
Director	65 minutes	6.2.2018
Director, Business unit	65 minutes	6.2.2018
Technical Advisor	27 minutes	9.2.2018

The interviews were conducted at respondents' premises, as this happened to be the most flexible way for each interviewee. The permission to record was mentioned in the invitation letter and asked in the beginning of every interview situation, just to make sure that the recording of information was transparent. The interviewer started the discussion by introducing herself and the topic and purpose of thesis, and it continued with a few demographic questions.

The questions were classified into three main categories: the current knowledge of MyGeoTrust and participation to the project; experiences of open-source software and open data; and the future expectations of the MyGeoTrust outcomes, as well as the overall development of open-source. The questions started with most concrete and experience based ones and moved on to more abstract, future-oriented, and complex ones.

3.3 Evaluation criteria of the method

Case study as a methodology is widely recognized among open-source software researchers. According to Crowston (2012), case study was the most common research method when studying FLOSS development literature, consisting of 135 empirical studies. This particular methodology was found in 43% of the evaluated papers, whereas surveys appeared in 25% of sampled papers and interviews in 10% (Crowston, 2012).

Since the purpose of this study has been to find purposeful business models for research project outcomes and further development, the embedded case study method felt like a natural choice. Also, the findings and experiences from previous usage of case study methodology in similar cases supported this choice. The case study has been in the center of the study, and the framework has been constructed around it. As the semi-structured interviews were conducted in order to deepen the understanding of the competitive landscape and to gain insights from external stakeholders, the amount of interviews was rather low. If the interview would have been main source of empirical data, the researcher would have used interview results more thoroughly in the case analysis part. Finally, we chose the semi-structured interview method for this study, as it gives an adequate amount of freedom to elaborate questions *ad hoc*.

4 Empirical study

This chapter provides a deeper understanding of the case MyGeoTrust, starting with an in-depth case presentation and continuing with the overall market environment analysis conducted using the PESTL framework. We analyze the design and technological principles behind the MyGeoTrust application and compare them with similar research projects and endeavors.

The model was first presented as the ETPS model by Francis J. Aguilar in 1967 (Frue, 2017). The original model included economic (E), technological (T), political (P) and socio-cultural (S) factors. The model was later been widened with environmental (E) and legal factors (L), and rebranded as PESTEL. In the current study, political and legal factors are combined under the same title, whereas the environmental factor is left out, as it is deemed irrelevant for this kind of research project. (Frue, 2017) We compare the PESTL model and other well-known strategic planning frameworks in the next chapter.

4.1 Case MyGeoTrust

MyGeoTrust has been designed according to three major principles, which have been guiding the further development and selection of technologies. As a human-centric approach, the MyData Alliance and its principles have been one of the major influencers, and therefore these are discussed in parallel with the detailed case analysis.

4.1.1 MyData approach

The MyData Alliance, internationally known as MyData Global Network, is an open community, whose members share a common urge to create interoperable and human-centric models for personal data management. Originally, the Alliance was spun off from a report that the Ministry of Transport and Communications commissioned from the Open Knowledge Finland association. It is currently managed by Open Knowledge Finland and Aalto University. The MyData Global Network has been built in order to unify wide range of actors from fragmented communities together.

Recent steps have included publishing of the *MyData Declaration* (MyData Declaration, 2017), which came to the light after the meetings of the “European PIMS Community”. Two major goals were stated during the meetings: the first one is to establish a MyData Global Network as a legal entity, and the second is to start by developing a common set of principles for human-centric personal data. The above-mentioned MyData

Declaration answers to the second goal, creating a thorough set of principles for restoring the balance of data ownership and moving towards a human-centric vision of personal data. (MyData Declaration, 2017.)

MyData shares certain principles with open-source code. For example, MyData infrastructure has to be decentralized and data has to be machine-readable. Some relevant standards include: REpresentational State Transfer (REST) for interfaces; RDF, XDI, and W3C as data formats, Oauth for access delegation, Creative Commons and Open Notice for data licensing and rights, as well as different cryptographic methods like blockchain. According to the MyData Alliance, personal information is created especially within banking and insurance, transport, communications, media, retail, energy, and education sectors. This personal data becomes “MyData” when a data subject has right to access and control it. (MyData Declaration, 2017) The movement towards MyData has been recognized lately, and for example Heiskala et al. (2016) propose that the development of personal data markets may affect also crowdsensing-based (transportation) services, adding new requirements for individual data control.

There are several alternative ways to organize personal information. These are API ecosystem without any infrastructure boundaries, organization-centric aggregate model, open MyData service infrastructure, and/or national systems (MyData, 2017). MyGeoTrust aims for the open API ecosystem, where the third-party can directly retrieve open data via queries. This is made possible by anonymizing data and creating an extra layer between raw data storage and API queries. In other words, anonymization is a built-in character.

4.1.2 Design principles

MyGeoTrust has been developed with three core principles in mind (Guinness et al., 2015). The monikers are stated as follows: *Privacy by Design*, *User Decides*, and *Trust Trough Transparency*. These are further explained in this section.

First, privacy by design implies that privacy should be ensured by the design of the system as far as technology allows. In addition to architecture design, the technology is complemented by user and third-party agreements. Secondly, user decides refers to the principle that whenever possible, the decisions of how the platform operates are left to the user. For example, the privacy profile chosen by the user controls the behavior of mobile applications using this platform. Finally, trust through transparency is emphasized by designing and operating the software with the maximum possible level of transparency (Guinness et al., 2015).

One method of securing the privacy of personal data is anonymization. Shehu et al. (2013) used an alternative term, *depersonalization*, and tried to form a concept that could sufficiently address privacy concerns left outside appropriate legal protection. The key principle behind Shehu's depersonalization framework is the assumption that researchers or analysts do not automatically need the personal identifiers of data subjects in order to achieve valuable insights (Shehu et al., 2013). From a technical perspective, there are multiple ways to perform depersonalization, for example, cryptographic keys, step-by-step pseudonymization, temporal cloaking, and K-anonymity (see Gkoulalas-Divanis, 2011). Wider analysis of anonymization techniques is left outside the research scope. These frameworks offer privacy improvements for the data subject by anonymizing the information, but unlike the MyGeoTrust architecture, they do not offer freedom to choose the privacy level case-by-case. Nevertheless, as was pointed out during the steering group interviews, it is a relevant question to think how anonymized the data is if several anonymized data sources can be combined. Merging multiple anonymized data sets can pretty easily lead to de-anonymization, as is especially the case with location data. Especially anonymized location data can still be used to deduce individuals' frequently used locations and reveal their personal information that way whereas cryptographic keys are challenging to scale (Ganti et al., 2011).

As stated in the previous chapter, most conventional techniques are based on the fact that there is enough crowdsensed data available for training purposes, even on the initial stage of application development (Dong, 2017). This challenge has been applicable with MyGeoTrust as well and the initial versions have been tested with a limited number of test users and refined based on feedback (Guinness et al., 2015).

4.1.3 Technical solution

The technical solution behind MyGeoTrust has been touched on throughout the study, but this section now aims to draw a concise picture of the whole software architecture and source code produced as a result of the research.

Since location data and geospatial analysis are in the core of activities of FGI, location data was a natural choice for what type of data would be collected during the research project. In addition to location and Wi-Fi data, the architecture is being developed towards a more holistic service architecture that can gather, process, and support data of other types as well. In addition to the sensors collecting location data Wi-Fi data can also be used when estimating locations. For example, in dense areas Wi-Fi hotspots may provide more exact data than data collected via different sensors.

Currently, the data collection process is conducted via the MyGeoTrust client, which is the application installed by the device owner. The MyGeoTrust client performs two separate functions. First, it provides certain data, depending on the privacy settings, to third-party applications on the mobile device. Secondly, it stores anonymized data on the MyGeoTrust servers, again according to the user's privacy settings. This software architecture is shown in Figure 3.

The MyGeoTrust servers also provide data to third-parties via REST APIs. Currently, data are only available via these APIs under two scenarios: (1) The data have been designated as "public" by the data owners, and (2) the data owners can access their own data after authenticating using a username and password. In the future, the REST APIs will also allow third-party organizations to access data via a so-called "trust third-party" route. This route is for accessing data which the data owner has granted access to specific organizations. The idea is that the user trusts these organizations to use their data for specific purposes, such as improving the organization's services using crowdsensed data. This exemplifies the principle of "user decides," explained above. This is just one of many examples where the MyGeoTrust design principles can be seen as fundamental to the whole infrastructure of the system. In general, the design principles have a huge impact on technological decisions during the course of the MyGeoTrust development.

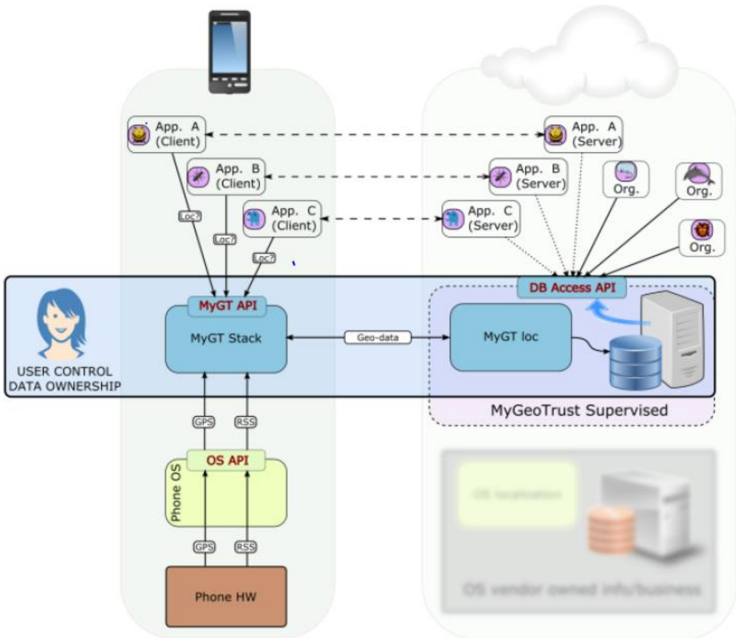

Figure 3. MyGeoTrust software architecture. (Guinness et al., 2015)

The illustration of software architecture shows how MyGeoTrust forms an additional, user controllable, layer between the API of operating systems and application clients and servers. As stated in the literature review, the key concerns of location privacy derive from the terms of service offered by service providers: usually, there are no alternatives for either accepting or declining the term and the decision is whether or not to use the certain application. One of the key principles behind MyGeoTrust software design has been the goal to create a model that is rather providing a grayscale of different privacy levels, than being a purely black-or-white decision of participation.

The lack of alternatives is distinct with big players, such as Google, Apple, Facebook, and Amazon (GAFA), since their business models are built on platforms and data ownership whereas MyData movement aims to bring data subject back to the center. Even though companies like Google or Apple are not selling the user data they have collected, the platform ownership and business models have affected user behavior and biased competition because it is difficult for smaller companies to compete against these namely free services.

4.2 Current competitive landscape

The LBS market in total has boomed during the recent years, hand-in-hand with the growing amount of location-tracking mobile devices. One recent report classifies that the global LBS market consists of several different actors, such as location, digital map, navigation, platform, mobile search and social media marketing providers as well as of location technology and application developers (Wireless News, 26.5.2017). This multitude of different application areas explains why platform-based companies have gained massive market shares.

PESTL-framework is adopted due to its appropriateness for higher level strategic planning and forecasting. This particular framework was chosen over other widely used strategic management tools, such as Porters' five forces model and SWOT analysis, since the nature of the case study is disruptive and interdisciplinary, benefiting most from the macro environmental analysis PESTL can provide. Grundy (2006) claims that when comparing to Porter's five forces, PESTL provides an overall picture of the competitive climate, moving on a higher level than growth drivers or five competitive forces analyses. Grundy continues that while PESTL factors are generally hospitable and applicable, Porter's five force model draws more detailed picture of competition dynamics. (Grundy 2006, 216) In this thesis, the main purpose is to evaluate possible business models to sustain the future developments and when the front-end is still fuzzy, five forces analysis of micro-level competitive environment would be too detailed. In the future, best results are most probably gained by combining different levels of strategic planning tools.

4.2.1 Political and legal factors

Political and legal factors are inseparable parts of any research dealing with personal data and therefore addressed here together. Due to the upcoming changes in legislation, political and legal factors are intertwined in this sense. As Xu et al. (2009) found out while building a framework for a privacy calculus model, government regulation, in parallel with compensation and industry self-regulation, was recognized as a highly effectual variable in privacy intervention approach. Therefore, governmental actions, especially data protection, highly impact on the usage of LBSs.

Nevertheless, both data protection and the technical solutions behind GDPR and the discussion going on about MyData movement are excluded from this study in a broader sense. Both have significant effect on location data, but since MyGeoTrust has been built to fulfill privacy and interoperability requirements, among others, and therefore these changes don't have effect on MyGeoTrust basic functions or software architecture. The upcoming legislation of course highly affects market dynamics, citizens' rights, and knowledge about data privacy as well as creates new business and partnership possibilities for players whose services meet the requirements.

What makes these factors even more topical is the upcoming European General Data Protection Regulation (GDPR) that will be affecting every single actor gathering, processing and storing data. As European Commission's info site clarifies, the EU GDPR will be the most important update in data privacy regulation in 20 years (EU GDPR, 2017). The GDPR is set to come into effect on May 25th 2018, so all organizations handling either EU citizens personal data or operating in EU have to find solutions to be GDPR compliant or they shall be assigned fines up to €20 Million or up to 4% of the annual worldwide turnover of the preceding financial year in case of an enterprise at the highest. (Official Journal of the European Union, 2016) Currently, privacy regulations around the globe are among the least harmonized fields of law, creating uncertainty for companies and organizations. Different countries are applying divergent rules for data collection and therefore, digital business that does not recognize traditional country borders, is exposed to legal and enforcement risks. (Spiekermann, 2015)

The main purpose of the law is to harmonize data privacy laws across Europe, to protect and empower all EU citizens' data privacy and to revise the way organizations approach and conform data privacy (Official Journal of the European Union, 2016). From the viewpoint of a citizen, the key factors are updated data subject rights that are expanding current rights in many ways. These rights include concepts of breach notification, right to access, right to be forgotten, data portability, privacy by design, and data protection officers. One thing already build in the FLOSS applications will be pushed to proprietary software world with the help of GDPR: data portability.

Patenting and formal IP rights do not affect organization only when it is planning to apply a patent for some practiced technology. Instead, if some other company already holds a valid patent, it may obstruct others from using that particular technology for the same purposes, at least without paying fees.

4.2.2 Economic factors

From a business perspective, mobile devices are powerful data collection tools since one device contains multiple sensors for crowdsensing purposes (Dong, 2017). In this sub-chapter, crowdsensed mobile data is examined from the platform owner’s perspective, emphasizing the business possibilities this data offers and also the challenges the upcoming GDPR legislation brings along. The viewpoint is turned around in the next sub-chapter 4.1.3 where user’s perspective is analyzed, building on the top of the context pyramid showcased next.

Economic and social factors are overlapping in platform based business since the success of a certain platform depends on the amount of users it can adopt and engage and users’ willingness to participate depend on the quality of the service. Therefore, privacy aspects are crucial for both social adoption and successful business. Data leakages and other factors have remarkable effect on the reputation of the platform and service providers. The Next Web’s (2017) article revealed that Android phones had leaked user’s locations for Google, even though users had been disabling location services. There are a vast amount of similar news about data leaks and even the sensitive location data these services can reveal legally, as has been the case in US military areas, made public by Strava heat maps (Liptak, 2018). Therefore, a need for independent layer that is fully under user’s control and provides protection and data anonymization can be well understood.

As mentioned in the introduction chapter, MyGeoTrust is built on the top of crowdsensed mobile data and currently the majority of the data collected is location data. Mobile device based positioning can be divided into three families: satellite-based, such as GNSS; sensors-based, such as accelerometers, gyroscopes, and cameras; and networks-based, such as Bluetooth, WLAN, and RFID (Pei et al., 2013). These various sources of raw data make it possible for crowdsensing to build complex, data-rich overall pictures of mobile device users. Moreover, applications using this kind of data can make decisions and give suggestions based on limited observations of the surroundings (Dong, 2017). Pei et al. (2013) created a context pyramid, shown in Figure 4, as a part of research project modeling human behavior for new mobile application software architecture.

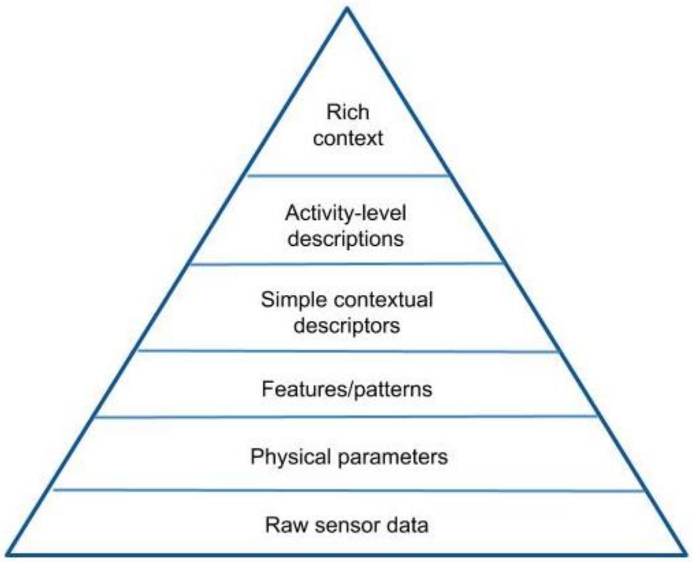

Figure 4. Context Pyramid. (Pei et al., 2013)

As seen from the picture, it is possible to create behavioral models based on the raw data extracted from mobile devices. Pei et al. (2013) claim that combining locating and motion recognizing sensors in mobile devices enable the cognitive ability of interpreting human behavior. Based on the raw sensor data, it is possible to extract more granular parameters, for example geospatial coordinates, acceleration, or velocity and create a profile about physical parameters. The higher the ladder of the context pyramid is, the finer the pattern recognition is. Rich context includes abundant social and psychological contexts that can be portrayed in natural, descriptive language. (Pei et al., 2013) For example, rich context can built images as specific as "Meeting on Monday morning at FGI in room 309 with Jack and Jane. Meeting has been going on for 30 minutes. Jack is standing and giving a presentation. Jane and I are sitting and listening with interests." (Pei et al., 2013, 1406).

The previous example illustrates the possibilities of crowdsensed mobile data collected and combined from embedded sensors. The ability to combine raw data from several sources discloses whether, where, and with whom the tracked user is, including also co-location privacy (Ruiz Vicente, 2011). According to Dong (2017, 10), the free movement of mobile devices enable collecting “high-quality and large-scale sensor data on the fly”.

The more raw data is crowdsensed, the more precise data mining and behavior modeling it can be done with the rich information. This far, mobile applications, or at least the freemium versions, have merely been free for users since users have been indirectly changing their personal information for free services. According to Dong (2017), mobile users are attracted by services that can create additional value and are willing to contribute their data by joining the system. Mobile crowdsensing systems also rely on users who are constantly willing to allow such applications to gather data (Heiskala et al., 2016). As GDPR legislation transforms the revenue logic of platform providers, some applications may change their business models and start to monetize things they have been providing freely. This is one possible scenario for the future developments.

One key driver for the wider adoption of location-based services is the price of several technologies (Dhar & Varshney, 2011). Location tracking via mobile networks requires a lot of bandwidth and works most efficiently when the data rate is high and the latency is low. More specifically, the data creation requires money and when comparing the prices of the mobile data packages in Finland and in the U.S., for example, the distinction is clear. While we have used to comparably low prices regulated by the EU it is worth to notice that globally much higher prices and scattered Wi-Fi connections are hindering the development of the whole LBS ecosystem. While supporting a higher density of mobile broadband users, the upcoming 5G mobile network system (see Osseiran, 2014) likely provides assets for LBS development as well.

Economic analysis covers also the overall competitive situation, including possibilities for economic growth and profitability. There has been few initiatives conducting similar research than MyGeoTrust, but no actual products could have been found. The aim of the Zone-it project was to create an online notice board for matching offers and requests with exact coordinates. Accordingly, the parameters for fully functional LBS were defined to be ephemeral, anonymous, trusted and support goal-oriented communication, without being interrupted by proprietary operators (Stroeken, 2015) Another research project called Locaccino aimed to be a location-centered social application, granting user a precision control over their location sharing. The project was conducted by the Mobile Commerce Lab at Carnegie Mellon University during the years 2008-2013 and the architecture was quite similar to MyGeoTrust, providing secure access to third party APIs and user control over API access rights. (Toch, 2010)

4.2.3 Social factors

The social factors of location-based services and crowdsensed mobile data cover several topics: user privacy, experienced value, inclusiveness, and human behavior. One specific subcategory of location-based services, location-based social networks (LSBN), is discussed in more detail.

According to Dhar and Varshney (2011), one key reason for the slow adoption of LBSs are the privacy issues. This is the main driver especially within location-based advertising and mobile marketing and can be easily considered intrusive. There’s a fine line between adequate personalization and raising privacy concerns. (Dhar & Varshney, 2011) Xu et al. (2009) created a *privacy calculus* framework for analyzing the privacy aspects of data exchange in the context of LBSs. The calculus in here refers to revealing personal information in order to getting some benefits in exchange and theoretical frame is consistent with the common theory of markets as an exchange. According to several studies of consumer privacy concerns and buying behavior, consumers conduct risk-benefit analysis of factors related to particular personal data revelation in contemplation of assessing privacy concerns. As a result, the use of LBS often requires that individuals are continuously weighing their decisions to engage with such services in terms of the privacy of their own data and the data of their social network. (Xu et al., 2009) The perceived value from the service affects consequentially to the user acceptance of LBS (Zhou, 2016).

Partially a social factor and partially a choice of design, incentive mechanisms are central issues for the success of crowdsensing. Jaimes, Vergara-Laurens, and Raij (2015) state that based on an extensive literature review, the following characteristics are obligatory for the success of crowdsensing: 1. economic feasibility, 2. data quality, 3. area coverage, 4. fairness, 5. adequate number of participants, 6. adaptable to increased demands and 7. independent/human controlled. Heiskala et al. (2016) classify the incentives of mobile crowdsensing participants in to following categories: access to the service, monetary incentives, social and collective incentives, and intrinsic incentives. Above mentioned personalization is one of the key benefits that companies and service providers using crowdsensed mobile data are targeting to. According to Dong (2017), a mobile device user can benefit from the participation in mobile crowdsensing by receiving improved and more tailored services. Implementing the definition of personalization to the context of LBS, the location-based applications can be easily customized, based on the users’ activity, preferences, and geolocation. Since MyGeoTrust works as a middleware layer between the applications and hardware of mobile device, users can remain their control over the privacy and define which applications are trustworthy enough to be granted the access to personal data (Guinness et al., 2015).

As Xu et al. (2009) sum it up, “Individuals are likely to give up degree of privacy in return for potential benefits related to locatability and personalization”. In the beginning of the MyGeoTrust project a user survey was conducted. The survey gained 191 individual respondents (149 were completely and 42 partially filled) from several countries around the globe. The biggest amount of respondents were located in Finland (44.6%), India (15.3%), and the U.S. (9.6%), respectively. The background (age, sex, field of employment, education) of the respondents varied widely, so answers cannot be explained by demographic factors. Significant number (90.7%) were smartphone users, the other categories being tablets, feature phones, or mobile phones without internet connection. (MyGeoTrust user survey, Appendix C.) Therefore, it is assumed that the respondents were informed enough to answer questions about the usage of localization and crowdsensed mobile data. The most relevant findings were related to users’ habits to use or restrict location services, relationship towards user agreements, understanding the principles of crowdsensed location data, and privacy concerns. These all were asked individually.

If users have to pay for certain services, it is more certain that their buying behavior changes. For example, according to MyGeoTrust user survey (Appendix C), 83% of the participants in a multiple response question impressed that they want to know what kind of personal data is collected and 78% want to know for what purposes or applications their data is being used. Willingness to know whether the data can be associated to them personally, which companies have access to their data, and who else has access to their data also gained a response rate over 70%. These answer rates show that even though mobile device users have been willing to share their data in order to be able to use certain services, awareness of data collection is high and may change when user agreements are revised. Since the survey was conducted in 2015, current concerns may be even higher due to the recent data breaches.

Recognizing and creating appropriate incentives for mobile crowdsensing participants is important, especially during the bootstrapping phase of the platform (Dong, 2017). Beyond the obvious motivation of using geolocation services, strong social aspects can be identified. Heiskala et al. (2016) divide these social incentives to collective, social self-interest, and social interaction. Many LBSs have features that enable sharing one’s current status, activity, or mood. The motivation to share current location, sports routines, or to geotag pictures, deals with the need to socialize with other users (*social self-interest*) and be an active content creator in online communities (possibility *for social interaction*). As the context pyramid in Figure 4 showed, creating this kind of contents provide very rich context information that usually is widely available for other users. Since the social aspect is strong in this kind of activities, privacy aspects are usually secondary for the user.

4.2.4 Technological factors

Some of the major technological attributes, including the evolution and future usage of mobile devices, the growth of LBS and GIS sectors, and the future development of OSS vs. proprietary software business models are discussed elsewhere in this study and therefore only listed in here.

The future development of mobile device sensors, especially those implemented in smartphones, will have a powerful effect on mobile crowdsensing. The biggest predictions consider 5G technology, improved sensors such as Bluetooth low energy (BLE), sensors with cameras, different immersive user interfaces as well as improvements in GNSS technologies, regarding especially Galileo satellite constellation (see Gartner, 2018).

Technological challenges and uncertainties are widely acknowledged in both hardware and software development of mobile devices. Ganti et al. (2011) state that resource limitations have been well studied traditional sensor networks. Mobile devices that are utilizing vast amount of sensors are also highly dynamic in availability and capabilities. This means that predicting the energy consumption and bandwidth needs are challenging to forecast precisely. Furthermore, different types of sensory data may be interdependent, leading to special requirements for trade-offs. (Ganti et al, 2011)

Another challenge Ganti et al. (2011) mention is the low duty cycling in existing solutions. Applications are mainly designed for particular context and scale inefficiently when several applications coexist (Ganti et al., 2011). Despite the recent developments, Dong (2017) states that efficient bootstrapping and continuous improvement still are commonly faced performance challenges in mobile crowdsensing systems. During his doctoral dissertation studies, Dong (2017) examined these technical challenges and found out that during the initial stage of application development there is usually not enough crowdsourced data available. Another challenge considers careful design of crowdsensing algorithms, important part of being able to collect sufficient data.

Technological advancements are constantly monitored also by private users. For example, new Apple products cause rumors of new features months in advance and the actual launch events gain vast audiences. In a similar vein, Google does not usually document specific details of their operating system or announce their development plans regarding Android updates. Developers and researchers relying on the data collected via Android must be inclined with unforeseeable changes. (Lindquist & Galpern, 2016)

4.3 Conclusions from the empirical study

MyGeoTrust project has been created around three principles *Privacy by Design*, *User Decides*, and *Trust Trough Transparency* which have been guiding the development work from the beginning. The purpose of these principles was to emphasize the focus and values of the project, as well as create distinction with the status quo. The MyData movement and ideal of individual data governance have significantly affected the principles of MyGeoTrust user approach. The results from the initial user survey conducted in the very beginning of the project were analyzed to form a wholesome understanding of user motivations and behavior of mobile device, and more specifically, smartphone users. These results formed one empirical source of evidence, among the interviews designed for and conducted with the members of the project steering group.

PESTL-framework was used to analyze how the current market environment is structured and what kind of changes are expected to happen in the future. Political (P) and legal (L) factors are playing crucial role in formatting the future rules and legal environment for mobile crowdsensing services. Especially the challenges of the upcoming EU GDPR law enforcement were emphasized. At the moment, organizations can only prepare to the regulation but comprehensive effects and changes for business operations are realized after the law enforcement has been functioning some time. The analysis of economic (E) factors revealed that the recent developments of mobile device sensors have provided a myriad of possibilities for companies to build businesses, either on the top of different platforms or based on the crowdsensed mobile data.

Social (S) factors are overlapping with economic ones, especially in platform-based business, since the platform and service providers are depending on users' willingness to participate in crowdsensing actions. Currently, companies have been creating their businesses in the belief that if the service is good enough, it will lure enough users. The upcoming changes in data protection regulation may have an effect on users' behavior when granting data governance for citizens over organizations. Technological (T) development has assisted economic development by providing more accurate data collection methods and cheaper mobile technologies that are basically available for everyone. The future development of mobile device sensors are dealing with 5G, BLE, and GNSS improvements.

To sum, mobile crowdsensing is multidisciplinary operating environment where the possible success is dependable on multiple factors.

5 Discussion

In this section, the findings from empirical study part are compared with the theories introduced in the literature review. The motive of this chapter is to analyze whether this study agrees or disagrees with the existing theories and literature, or if any new findings have emerged. This case study was limited to a certain scientific project and therefore, the results can be generalized to similar cases, where the continuation plan of a scientific software project is planned. When conducting the empirical study, especially the insights revealed during the steering group interviews, it was realized that forming unified business models or strategy is not possible within the limitations of this study. Nevertheless, it is possible to indicate key factors affecting the future development, especially in commercial environment, and craft recommendations based on the real life observations. These findings are reflected against the research questions, divided under theoretical and empirical implications.

Several sources of evidences were collected and used during this study. Starting with theory formation via thorough literature review of the most central topics, conducting a case study and analyzing case related materials, and creating a case specific empirical data via semi-structured interviews, this study has constructed a multitude of findings that are analyzed in the following chapter.

5.1 Key findings

This study extended the previous crowdsensing literature by analyzing development processes of crowdsensing solutions in the context of a privacy perceiving user rights. The motivation of this thesis was to understand what are the current trends in mobile crowdsensing and what kind of business models have emerged around the industry.

The most comprehensive results can be achieved when approaching MyGeoTrust as a platform and analyzing both development and business possibilities against platform strategies. For a platform provider, the created value can be multitude (Heiskala et al., 2016). In the case of MyGeoTrust, both open data and open-source software can be treated as individual cases, having different users, costs, and value propositions.

According to literature review, success factors of platform strategy are widely agreed. Bonchek and Choudary (2013) offer one example when nominating three factors: connection as the easiness of plugging into the platform, gravity for attraction, and co-creation of value. As Choudary (2013) stated, platforms don’t usually have any value when the first users come in. The critical mass is needed that the platform turns out to be successful and starts to attract an exponential amount of users. The acquisition of users is crucial for gaining the network effect where a platform turns out to be self-sufficient, attracting the critical mass of users. One illustrating example comes from the world of smartphones. According to Bonchek and Choudary (2013), Nokia and Blackberry became “shadow of their former glory” since their products could not respond to the competitive advantage Android and Apple received with the help of their platform ecosystem. As found in the literature review, the network effects are powerful also in the case of open-source platforms. The number of other organizations adapting open business models plays a crucial role whether or not a certain open-source platform gains foothold and becomes actively used.

Platforms have different challenges than traditional pipe or funnel like business models. Choudary (2013) defines the key challenges to be “chicken-and-egg” problem of attracting both producers and users on the newly established platform and making sure that producers create value by producing contents. Neither is the monetization as straightforward as is the case when selling products via sales pipe (Choudary, 2013). Defining where the value comes from and who should pay for it and how much is also a future challenge for MyGeoTrust. If publishing both source code and data under certain open-source licenses, the usage itself cannot be charged as proprietary business but operating costs should be covered.

According to Hedman and Kalling (2003), causal relations exist between different business model components. First of all, the offering must be in equilibrium with the quality/price market position. As the empirical data from interviews proves, companies consider that it is possible for them to pay for open-source developers and open data with some limitations: it should help them to solve certain problems, it should be guaranteed that the data is flawless and validated, and the price should be reasonable.

The role of financial planning and pricing strategy will be emphasized when GDPR law enforcement changes the market dynamics so that data subjects become also data governors and can start to sell their data for companies that currently have been crowdsensing it for free. This change will add complexity to the platform business and monetary streams. As one of the interviewees pointed out, GDPR is good for data subjects but a challenge for companies. Challenge refers, for example, to the rights to be forgotten and data portability. From the viewpoint of the interviewed company, it is sometimes easier to take in the whole data chunk, anonymize data, and store it securely on appropriate servers so it can be retrieved and deleted whenever needed. Another interview respondent said that open data can also be used as a training data for the software development phase. This kind of usage gives more flexibility since the data is not part of the final, commercial software solution rather than part of internal development.

The platform business model has to be managed and revised continuously as a part of the process management. When evaluating most centric business model factors in IS investments, the resource/system, the activation of the resource (activities), and the quality and price need to be managed. Despite creating almost limitless amount of business possibilities, e-business models have several shortcomings, for example, lacking the causality analysis of business models components and longitudinal management processes. (Hedman & Kalling, 2003)

5.1.1 Theoretical implications

The research questions this study aimed to answer were disassembled into several subareas and are answered on this section. The research questions addressed in this study were:

1. *What kind of business models are currently used in the context of mobile crowdsensing*?
2. *Based on the literature review and the empirical study, which of these models are most suitable for mobile crowdsensing solutions?*

Among the key factors of the future adoption rate of LBSs are the emerging technologies and the questions of data privacy and security. The situation before GDPR legislation is unclear also for established players and bulletproof estimations about the future developments cannot be made. The current platform business models are built on the assumption that users do grant their data for free and the terms of service are also binding from users' point of view (see Pei et al., 2013; Lindquist & Galpern, 2016; Dong, 2017). The empirical study, especially the analysis of user survey results and market environment, indicates that there is a growing demand for crowdsensing solutions that are built according to MyData principles and would guide the data governance practices towards more privacy respecting ones.

Currently, personal data markets are still taking shape and crowdsensing practices are strongly promoted by the companies benefiting from these data collection methods (Spiekermann et al., 2015). The winner-take-all strategy is thriving among two- and multisided platform markets (Heiskala et al., 2016), leading to the almost monopolistic dominance by certain players, as the example of GAFA shows. Therefore, open-source platforms have not achieved such foothold as they could have.

The definition of business models and open business models, deriving from the open innovation paradigm, offers plenty of possibilities for strategic planning and decision making but leaves framework creation open-ended. Business models are potential sources of competitive advantage. (Zott et al., 2011) Success and performance of a company can be explained via adopted business models and the profitability can be determined from the corresponding means of business model components (Afuah, 2004). Instead of forming a single business model framework, this thesis created knowledge about how to build continuum for mobile crowdsensing software after the initial research phase. Relevant factors for planning successful continuum towards the future were found among the business model and open innovation literature, as well as from the open source software cases. This study also creates understanding about the complex set of decisions that are needed when planning to operate in legally and politically changing landscape, by proposing that even the selection of software license requires thorough market analysis.

The second research question was focused on case study analysis and empirical findings. Platform pricing strategies of proprietary and open-source technologies were found to be integral part of the pricing strategy optimization for a platform company. One of the key findings was that the variety of proprietary applications is larger and usually more profitable when the chosen industry platform is open-source (Economides & Katsamakas, 2006). Based on the literature review and empirical study, it can be agreed that certain key factors exist mutually in crowdsensing-based services. The framework created by Heiskala et al. (2016), illustrated in Figure 1, describes the very nature of location-based crowdsensing overall. This study agrees that crowdsensing platform providers need to engage with both users and service providers, creating a two- or multisided platform markets and business avenues for crowdsensed data. External environment, for example legal and political matters, are inseparable part of the crowdsensing business as was found in the empirical study.

Nevertheless, new privacy improvements will probably change user behavior and service adaptation, an issue that has widely remained untouched in crowdsensing literature. Regarding the case study, it is also crucial to understand how the potential users of the open-source software as well as the end products would be using and developing it further. As was found in the literature review, the markets of personal data are just gaining momentum (Spiekermann et al., 2015), and this assumption can be agreed based on the empirical study on GDPR legislation and market environment. In the current theorems, lack of privacy and individual data governance was seen as a common weakness in current crowdsensing business models, but no further empirical studies were conducted. The MyGeoTrust user survey, analyzed as a part of this study, confirmed the lack of privacy and need for stronger personal data protection as well as revealed that users are willing to create alternative privacy profiles for different services. This far, the user agreements of common crowdsensing applications and LBSs have not provided possibilities to specify personal privacy settings.

Furthermore, generating revenues from open data is hard (Lindman & Nyman, 2014) so the logical focus is creating the business model around the platform rather than based on specific applications and collected data. This momentum creates possibilities for new platforms to arise, especially if they manage to fulfill one or more of the success factors found to be crucial for two- or multi-sided platforms listed in Table 1 (Heiskala et al., 2016). For example, finding niche users is one success factor for a differentiated platform. The literature review and empirical study showed that the current practices of personal information collection are far from transparent and we have found in the study, MyGeoTrust could be released as a differentiated platform, creating new avenues for privacy enhancing crowdsensing applications. The focus of the crowd/user perspective should be emphasized to ensure the relevance of MyGeoTrust project.

To sum, in previous research and literature crowdsensing has been studied from specific angles, addressing for example technical requirements, privacy issues, business models or personal data business but a thorough study of the history and current developments in crowdsensing has been missing. Even though the privacy aspect have been emphasized, end-user perspective has not been researched. End-users should be involved also in the development of user agreements, not just the progress of new widgets and visual layouts. This study aimed to form an overview of the complex subject and to provide recommendations for future development.

5.2 Analysis of the steering group interviews

All of the motivational drivers mentioned in the previous section are valuable touchpoints when evaluating the benefits of community efforts in open-source projects. In the case of MyGeoTrust, some extrinsic drivers are probably related to increased level of users' own privacy and control over their personal data. Incentives and compensations of user participation were discussed earlier.

Second part of the steering group interviews focused on finding out their motivation of participating in open-source development projects and former experiences working with open-source projects. The interviewees were mainly positive about granting support, but the ways varied greatly as did the type of the organizations. One interviewed steering group member claimed that the usefulness of OSS depends on the community developing it: "Open-source code that is also used commercially is usually the most updated and developed, and therefore, requires least modification". According to Fitzgerald (2006), OSS is labeled reliable and cost effective also by several market-leading companies, i.e. Amazon and Google that have adopted open-source platforms on which it is possible to offer their own services. Since they do not have the need to redistribute software, OSSes can be modified for their internal needs without facing compliance issues with licenses (Fitzgerald, 2006).

As stated in the OSS literature review, using OSS is not costless, even though the code itself would not cost. Three interviewees stated that using OSS creates several sources of indirect costs: legal costs, internal development and programming costs, and requires planning and training. Furthermore, even though the core code can be free, usually it needs to be specified and packaged in a certain way which causes service fees. According to one respondent, it is sometimes impossible to know whether adopting OSS is reasonable or not, when comparing to in-house software development. This, of course, depends on the size and resources a company has and purposes it is using the code. Relying mostly on open-source can be meaningful choice for a small company that does not have adequate skills and when the software created does not deal with personal information, i.e. does not cause crucial security risks.

Third set of interview questions dealt with future expectations. The key findings from interviews concerned the usability of the source code and open data created during the MyGeoTrust project, expectations towards the project results, and overall experiences from using OSS in proprietary means. One finding was that using open data created during the project has its limitations since companies are responsible for the validity of the data and if requested by the data subject, forced to delete certain data. This finding is supported by theoretical evidence that at the same time, personal data can be an asset as much as a burden for companies, mainly due to the legal uncertainties (Spiekermann, 2015). The value of the project was mostly seen in creating a new software paradigm of crowdsensed mobile data and generating research reports. It was disagreed, that this particular project should produce any market ready outputs or business value as it was seen to be a responsibility of commercial operators. Therefore, the role of applications created under the MyGeoTrust has mostly benefitted in providing an initial testbed for the platform.

5.3 Managing the future development

The business model categorization for open-source software discussed in the literature review is also applicable in the case of MyGeoTrust and provides an approximate framework for future planning. Question about the true relevance of MyGeoTrust outcomes and further development plans arose in the steering group interviews. It was disputed, if this sort of publicly funded project should in the first place aim to generate software products or should it focus on the research solely. It is true that companies have competitive advantage and market understanding as well as resources to create market-ready products, but on the contrary, lack courage or possibilities to devote massive resources on new research openings. Usually, the best results are gained from the interplay between companies and academia. The aim of the project has been to generate new knowledge, preferably for public good and open up research outcomes according the FLOSS principles. Therefore, the business possibilities are evaluated only in the purpose of sustaining the further development of the project, not to create revenue.

The development phases of FLOSS are configured differently than in conventional software development. Fitzgerald (2006) states that after the need identification, an initial prototype is constructed. Usually the requirement analysis and design decisions are made before the larger community of developers starts to operate. High degree of modularization is integral to allow distribution of work. These above mentioned stages form the first step of the process, called *development life cycle*. By far, operations of MyGeoTrust have been focusing on this stage and the next steps of *product domains*, including the construction of horizontal infrastructure, are planned. Only after these stages come *primary business strategies, product support* and *licensing*. (Fitzgerald, 2006) Based on the earlier findings concerning the remarkable nature of licensing, it is recommended that business strategy is defined in parallel with license selection.

Critical mass of developers is as crucial for open-source development projects as users are for platforms. Lakhani and Wolf (2005) have studied the motivational drivers of individuals who are contributing to the development and creation of free and/or open-source projects. Their study revealed that motivational factors can be divided into two main categories: intrinsic and extrinsic motivation. Intrinsic motivation, where the action is valued for its own sake, consists of two distinct sub-categories: 1) enjoyment based, and 2) obligation/community based. Enjoyment based refers to activity where the part-taking itself works as a motivation whereas community based motivation is created from strong collective identities and minimized personal gain seeking. Extrinsic motivation, where indirect gains can be gained when completing the task, drives individuals' behavior. They define immediate payoffs being related to either the possibility to be hired or paid by the taken actions or to the users' own need for particular software. Extrinsic motivation also contains some delayed benefits, such as overall career development or improved programming skills (Lakhani & Wolf, 2005).

According to Lindman and Nyman (2014), maintaining a community creates similar costs and issues for both open data and open-source participation. Coordinating FLOSS communities is an acknowledged challenge. Crowston (2012) states that even though several studies have been conducted on FLOSS, coherent knowledge composition or systematic literature review have not been made. Therefore, management of community efforts remain as a challenge and has to be tailor-made for every software project.

6 Conclusions

This chapter provides a summary of the thesis by looking back on the case study and the empirical findings. Implications for practice are presented and lastly, limitations of the study and possibilities for future research are reviewed.

6.1 Managerial implications

Implications for practice are presented to sum up the key findings and what should be taken into account when planning the future development of crowdsensing services. The empirical study showed that conducting macro-level analysis of the competitive environment is a crucial predecessor for binding strategic decisions. For example, selecting the best OSS solution for a company or a project is challenging. The research on OSS technologies and frameworks may help the company but needs to be backed up by empirical analysis and proof (Lindman, 2011). The next phases of software development are strictly intertwined with strategic level decisions, like business strategy, and as it was observed in this case study, analyzing several different theoretical frameworks and empirical data sets is very demanding.

The study found that three guiding principles around which MyGeoTrust has been created are differentiating it distinctively from other initiatives utilizing crowdsensed mobile data. Especially the requirement for transparency creates new ethos of data subjects’ rights. The significant trailblazing role should be emphasized more as it has chances to raise the awareness of the current prevalence. When planning the development phases of the MyGeoTrust project, it is recommended to form transparent and well-rounded use cases. This is essential especially when communicating the project results for possible research consortium and/or commercial partners.

One thing to consider when planning open-source business models are the IP rights. In the case of OSS, the logic is not as straightforward and has to be carefully evaluated when choosing the open-source license and evaluating IP rights arrangements. The open-source movement is strongly associated being against patents (Harison & Koski, 2010) but there are also several reasons why to obtain a patent on a software invention distributed under the open-source license (Majerus, 2006). In the case of MyGeoTrust, the decision whether or not to use licenses outside open-source community depends on the selected business strategy and also on possible stakeholders, especially companies and furthermore, affects the future business model.

Now, when actual applications have been developed and have demonstrated that it is possible to create privacy perceiving LBSs, it is recommended to conduct a user study how applications designed after MyGeoTrust principles would change behavior and especially long-term behavior in the context of adapting new applications. Renewing the user survey could reveal previously unforeseen patterns in user behavior. This research provides some implications of platform business realms and, as discussed in the empirical part of the study, software business that is launched as a platform confronts different challenges than software released as a package. Based on this, further analysis could reveal significant links between platform strategies and user adaptation of crowdsensed mobile data services.

The empirical research indicated that it is important to involve steering group members, or other closely related stakeholders, as project partners. It is extremely vital to gain insights from a group of experts coming from different industries. Without this involvement, many business related questions would remain untouched. Depending on the background of the involved steering group members, the key findings from interviews varied little, but each contribution provided something new, either about how value of the project was seen or where the outcomes of the project could be used.

Applying user-centric MyData approach (MyData, 2017) as a basic principle caused additional challenges for finding exact literature to rely on. The MyData approach is relatively young and relevant academic studies analyzing the software design or commercialization to support this study could not be found. Lack of unified theoretical context proved out to be a demanding framework to work with.

As happens with scientific research projects, MyGeoTrust has evolved significantly during its lifespan. Therefore, some of the used technologies and data architecture analyzed in this study may already be replaced when the official funding of the project ends. There are some major development steps happening currently and the vision has become clearer as the knowledge and understanding of the external developments and environment has cumulated. Empirical study turned out to be the most important part of this study, enabling the formation of certain future recommendations for the project.

6.2 Limitations of the study

Some very closely related research paradigms have been left out of the scope, in order to maintain consistence. Data privacy and MyData approach are at the core of the MyGeoTrust case study, but are only covered as a part of PESTL-analysis in Chapter 4. Also the legal and political aspect, such as EU GDPR legislation, are only analyzed as a macroeconomic determinants and further analysis is left outside the scope. This study focuses on the business possibilities at the business level of the applications, denoting that the in detail description and comparison of all protocols and architectures of geospatial technologies has been excluded.

This research was conducted as an assignment for Finnish Geospatial Research Institute of National Land Survey of Finland. Therefore, some case materials concerning MyGeoTrust research project are not questioned since the practices are already evaluated and approved by international scientific community. The interviewees were also selected from yet existing steering group, instead of having an open call. The selected interview method has several acknowledged shortcomings, such as the dependability on interviewees and their decision of sharing or not sharing certain insights. In order to tackle biased interests, various sources of evidence has been used. The study was carried out by single researcher, which may leave research findings receptive to unilateral interpretation.

Qualitative studies have typical limitations and some of these are also applicable with this particular study. For example, repeatability is quite challenging with qualitative studies as well as is the generalization of results in case studies. Therefore, research findings from this study are most useful in the sense of this particular case which was studied and other, juxtaposed cases. Novel insights were created concerning the data protection and privacy methods in location-based services and new knowledge was created regarding the existing business models in crowdsensed mobile data.

Since the studied case was highly scientific and technical research project, it was much more challenging to form unified business models than it would be for yet existing company or product. Therefore, the open business models are recommendations and provided as a starting point for the actual product development phase. Furthermore, the case organization is publicly funded research institution that is focused on doing groundbreaking science rather that creating market ready products. The smartphone applications created during the project were developed purely for testing the software architecture and source code, not to be commercialized as is.

6.3 Further research

The interdisciplinary nature of this study created diverse possibilities for further research. Firstly, when evaluating the future development possibilities, strong emphasis was put on the upcoming political and legal changes. In the future, the effects of EU GDPR law enforcement could be studied form software developers point of view. Another aspect that is most probably going to change is the business logic of platform-based services.

Secondly, the key findings concern the behavior of mobile users, proposing several ways how changes in the participation drivers could be examined to gain better understanding of user behavior. The effects of user-centric, privacy enhancing, platform design on the willingness to participate in mobile crowdsensing activities could be researched. In a related vein, how to assemble data and user privacy as a built-in feature for mobile applications could be analyzed.

Thirdly, the academic research field of mobile crowdsourcing and crowdsensing is still pretty much non-existent. The sensors in mobile devices are widely utilized in several business environments, for example in location-based services, but wider understanding of the ecosystem is underdeveloped. Long-term success factors and the most user-centric business models could be extended to an independent study.

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Appendix A: Interview request message sent to interviewees

Dear Mr. / Ms.,

I am working as an Assistant Research Scientist at Finnish Geospatial Research Institute, and currently conducting a M.Sc. Thesis research of open business models for the MyGeoTrust project. As a part of the study, I'm conducting interviews with the members of the MyGeoTrust steering group and hope you would have the possibility to participate. Your insights as a steering group member would be very valuable for both the research project and for my thesis work. The thesis is supervised by Project Manager Mr. Robert Guinness (cc:d in here) and the aim is to find open business models to sustain MyGeoTrust project outcomes also in the future.

Interviews can be held in Finnish or in English, according to your preference. The most valuable way would be to have a meeting in person, but if that's not possible, Skype interview will work as well. The interview will last around 60 minutes and I hope the interview could be conducted by early February. The date will depend, of course, on your availability. I'm asking a permission to record the interviews in order to be able to analyze them later on. All interview data will be anonymized and your name or organization won't be revealed.

The interview questions will be centered on your organizations use of crowdsourced mobile data, need for location-based services and the knowledge and usage of open source software and open data.

I look forward to hearing from you soon and appreciate your time and consideration.

Kind regards,
Laura Leppälä

Appendix B: Interview questions

Basics:

i. Education and years of work experience?

ii. What is your current position or job title?

iii. Earlier work experience?

1. Involvement in the project & other prior knowledge:

1.1 What is you involvement in this project?

- What was the original motivation behind joining the steering group?

1.2 Have you been following MyGeoTrust news or results?

- If yes, via which forum?
- How actively?

1.3 What kind of expectations you have/and about the project outcomes?

- Have these expectations changed over the project timeline? How?

2. Open source and open data:

2.1 What kind of experience do you personally have with open source projects or open data?

2.2 Would you benefit more from open source (code) or open data? Why?

- If you're not using open source already, what hurdles there are preventing you to take action?
- What benefits you've experienced from open-source projects or open data?

2.3 Can you imagine that you would somehow contribute to the efforts? (more specific form)

2.4 Which of the following ways of supporting further open source development of MyGeoTrust would you consider possible?

- Supporting open source dev by paying a developing group or foundation
- Assigning your own developers to an open source project?
- Collaborating with the open source/data community?
- Collaborating with other companies? How about competitors?

2.5 Have you supported other open-source projects in these ways?

3. Future expectations:

3.1 MyGeoTrust is currently collecting Wi-Fi and positioning data. What other datasets would be interesting for your company to use? Why?

- MyGeoTrust implements "privacy by design" principles, is your company benefiting from anonymized user data?

3.2 Can you think, what other types of actions should be implemented to build on top of MyGeoTrust (or other similar projects)?

3.3 What major changes do you perceive in the usage of open source applications?

Appendix C: MyGeoTrust user survey

Response counts		
	Count	Percentage
Complete	149	78 %
Partial	42	22%
Total	191	

Age		
	Count	Percentage
under 18	25	14.2%
18-24	20	11.4%
25-34	70	39.8%
35-54	45	25.6%
55+	6	9.1%

Gender		
	Count	Percentage
Female	55	31.1%
Male	121	68.4%
Prefer not to answer	1	0.6%

Country of residence		
	Count	Percentage
Finland	79	44.6%
India	27	15.3%
United States	17	9.6%
Bangladesh	7	4.0%
Germany	6	3.4%
All others	41	23.4%

How would you describe your expertise in the use of mobile phones in general?		
	Count	Percentage
Basic: I know little or close to nothing, I am a basic user	16	10.0%
Intermediate: I know a bit, and I like to customize and play with the services offered	57	35.6%
Expert: I am an expert user and want to know how things work inside my phone	87	54.4%

Which of the following mobile devices do you use? (check all that apply)		
	Count	Percentage
Smartphone	147	90.7%
Feature phone	14	8.6%
Mobile phone without internet/data connection	11	6.8%
I use a mobile phone, but I don't know how to describe it	2	1.2%
Tablet	81	50.0%
Other	3	1.9%

Which of the following mobile operating systems do you use? (check all that apply)		
	Count	Percentage
Android	100	62.5%

iOS	66	41.3%
Windows	38	23.8%
Symbian	11	6.9%
Sailfish	1	0.6%
Something else	4	2.5%
I don't know	6	3.8%

How frequently do you use Internet on your mobile device?		
	Count	Percentage
Regurlarly	143	89.9%
Occasionally	12	7.5%
Never	4	2.5%

In your mobile device settings, how often do you have location services (e.g. GPS) turned on?		
	Count	Percentage
All the time	36	22.9%
Often	39	24.8%
Sometimes	44	28 %
Rarely	27	27 %
Not at all	6	3.8%
I don't know	5	3.2%

If a specific app asks to use your location, how often do you allow it?		
	Count	Percentage
Always	19	12.3%
Usually	40	26 %
Sometimes	35	22.7%
Rarely	20	13 %
Never	5	3.2%
It depends on the app	35	22.7%

Do you tag locations in social posts (Do you include your location in e.g. Facebook posts)? (check all that apply)		
	Count	Percentage
Always	14	9.1%
Sometimes	79	51.3%
Never	52	33.8%
I don't post to social media	16	10.4%

On a scale from 1 to 4 how concerned are you about the privacy of your mobile phone data, such as location tracking data? (1 = least concerned, 4 = most concerned)		
	Count	Percentage
4 most concerned	42	35 %
3	44	36.7%
2	27	22.5%
1 Least concerned	7	5.8%

Do you read the user agreements for apps that utilize your location?		
	Count	Percentage
I always read the agreements	12	8.2%
I usually read the agreements	18	12.2%

I occasionally read the agreements	56	38.1%
I never read the agreements.	56	38.1%
I don't accept user agreements that require me to share my location	5	3.4%

Which of the following best describes you regarding your location data?		
	Count	Percentage
I'm willing to share all my location data, even if it can be associated to me personally	20	13.6%
I'm willing to share anonymized location data if I know what it will be used for	58	39.5%
I don't want to share location data that can be associated to me personally, but I'm willing to share anonymized location data	40	32.7%
I don't want to share my location data at all	21	14.3%

Are you aware that smartphone operating systems (Android, iOS/iPhone,…) may be collecting location data from their users?		
	Count	Percentage
Yes	141	97.2%
No	4	2.8%

Concerning the privacy of your mobile data, which of the following statements apply to you? (check all that apply)		
	Count	Percentage
I want to know what data is being collected from me	117	83 %
I want to know for what purposes/applications my data is being used	110	78 %
I want to know if the data can be associated to me personally	106	75.2%
I want to know what companies have access to my data	101	71.6%
I want to know who else has access to my data	101	71.6%
Other	6	4.3%

Which of the following would help you trust a location-based app more? (check all that apply)		
	Count	Percentage
A simple and understandable privacy policy	97	66.4%
Transparent practices concerning the use of personal information	96	65.8%
Transparent practices concerning how personal information is secured	82	56.2%
Ensuring privacy by design e.g. minimizing the collection of personal information	85	58.2%
An user interface that explains clearly what effect a certain privacy setting has	80	54.8%
Reputation of the company or organization behind the app	51	34.9%
Other	5	3.4%