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Analysis and Utilization of Online Community Information for Technology Planning

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Abstract

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In the era of disruptive innovation, a core facet of technology planning entails exploring and analyzing information from a variety of external sources. With the development of information and communication technology, we now have means to both access and analyze a very effective source of such kind: online communities. The massive amount of information generated in online communities, where a diverse group of individuals voluntarily share opinions, ideas, and data, patently carries powerful potential in aiding technology planning. Despite their conceptual utility, previous studies have lacked empirical engagement on the role of online communities and leveraging of online community information into technology planning processes. The question, then, is how to distill the helpful information from swaths of data.

Within this context, this thesis explores how to analyze and utilize the online community information to help in technology planning. It begins by distinguishing two types of online communities relevant for our purpose: tech-discourse community and tech-foresight community. First, the tech-discourse community, where tangible and foreseeable future is discussed among user innovators, can be a source for identifying potential needs and user ideas; as a

representative case of tech-discourse community, the thesis discusses mobile App Store community. Second, the tech-foresight community, where conceptual and distant future is explored among large number of participants, can be a source for exploring potential disruptive signals and scenarios of future technology. This study especially coins the information from tech-foresight communities as 'futuristic data'.

The thesis consists of three research themes and six corresponding modules. The first theme aims to analyze the characteristics in tech-discourse and tech-foresight communities. Research module #1 analyzes the patterns of innovation in tech-discourse communities, choosing mobile application services from App Store as a representative case. In consequence, the module finds that innovations in tech-discourse communities are often based on divergence and convergence of existing products. Research module #2 analyzes the potential of futuristic data in tech-foresight communities. Since the concept of futuristic data is new in technology planning, futuristic data is defined and analyzed in terms of its utility in technology foresight. By comparing it to patent data in terms of future-orientation, information scope, and perspective, the module identifies futuristic data in tech-foresight communities as a potent source of foresight.

The second theme aims to identify and take advantage of opportunities of innovation from tech-discourse communities. Research module #3 scans potential user needs from tech-discourse communities. To this end, the module introduces 'user-centric service map' to discover new product opportunities in service vacuums, and makes suggestions toward those opportunities by using adjacent reference services. Research module #4 implements on user ideas based on existing products. The module focuses on more active and enthusiastic user innovators' ideas, converting them into new product opportunities that are further developed by using reference services. To this end, text mining-based case-based reasoning approach is suggested.

The last theme aims to take advantage of information from tech-foresight communities into technology planning. Research module #5 visually scans potential disruptive signals from futuristic data for technology roadmapping. In this module, potential disruptive signals are narrowed down through three successive keyword maps: self-organizing feature map-based keyword cluster map, treemap-based keyword intensity map, and network-based keyword relationship map. Research module #6 extracts rules to build scenarios from futuristic data. This module focuses on fuzzy cognitive map-based scenario building, and the modeling elements such as concept nodes and their causal edges are identified by text mining and fuzzy association rule mining.

In whole, this thesis can help to provide concrete and systematic tools that facilitate technology planning by considering both user innovation and disruptive innovation. Ultimately, the tools can serve technology planners to proactively investigate innovation opportunities and drivers and candidates of future technology by tapping into the massive and ever-growing collective knowledge from a large number of voluntary participants.

Keywords: Online community information, Technology planning, User innovation, Disruptive innovation, App Store, Futuristic data
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Chapter 1. Introduction

1.1 Background and motivation

Recent patterns of technology innovation have been described as discontinuous or disruptive rather than continuous or sustaining. They, in fact, hold a high level of uncertainty for the success of innovation, despite a substantial investment for developing new disruptive products or services (Christensen et al., 2006; Kohli et al., 1999) (i.e., in this thesis, "products" is general term that includes both goods and services). In this context, the importance of foresight into possible future paths of technology and innovation and their accompanying uncertainties has been significantly increased (Carlson, 2004). Because technology foresight explores, detects, and predicts the future changes and developments in various industries, markets, and technologies, it is a crucial aid in future technology innovation. Numerous research emphasized that one of the core capabilities of technology foresight for dealing with disruptive innovation is in the generation of creative thinking, which can be obtained by absorbing knowledge from various sources (Christensen et al., 2006; Drew, 2006).

As a source of technology planning, online community has become one of the most effective sources. Advances in information and communication technologies (ICTs) such as web 2.0 and collective intelligence have not only facilitated users to organize and share innovations through online communities (Kozinets et al., 2008; Rayna & Striukova, 2015), but also experts and general public to discuss and combine foresights of the shape of future technology (Cachia et al., 2007; Haegeman et al., 2013; Schatzmann et al., 2013). Accordingly massive information is generated as a diverse group of individuals voluntarily share opinions, ideas, and data, etc. in online communities (Dahlander et al., 2008; Füller et al., 2006; Gangi et al., 2010). These are suggested as the basis for a bigger, more creative brainstorming in which future concepts, ideas or scenarios can be tested and refined (Haavisto, 2014; Schatzmann et al., 2013). Thus, the effective leverage of online community information is becoming a core competence for technology planning. The online communities related to technology innovation, along with the activities of participants, are categorized into two types: tech-discourse community and tech-foresight community, as described in Table 1.1.

Table 1.1 Two online communities related to technology innovation

	Tech-discourse community	Tech-foresight community
Definition	Online community that mainly includes histories of use and discourses on solving a general problem and/or developing a new solution for technology innovation	Online community that mainly foresights the future of technologies by sharing trends, predictions, perspectives, and insights among stakeholders
Nature of information	Tangible future Foreseeable future Specific, micro	Conceptual future Distant future Unspecified, macro

Providers of information	Active users of product who offer their sentiment or behavior Enthusiastic users of product who offer new problems or ideas	Experts who share and generate futures knowledge General public who share and generate futures knowledge
Similar previous terms	User innovation community (Dahl et al., 2011; Dahlander & Wallin, 2006)	Future-oriented community (Gheorghiu, 2009; Schatzmann et al., 2013)
Examples	App store as open source software community	Database and wikis, trend news and blogs, social rating systems, collaborative scenarios, prediction markets
Role in technology planning	Source of identifying potential user needs and user ideas Source of community-based innovation	Source of exploring potential disruptive signals and scenarios of future technology; Source of community-based foresight
Related innovation	User innovation and continuous innovation	Disruptive innovation and discontinuous innovation
Information of our interest	Information related to use context and use behavior Information of user requirements, feedback, and ideas for product features, and functions	Information of technical, social, economic, political, and/or environmental issues related to future technologies

Tech-discourse community is where the participants share the problems and solutions regarding of tangible innovation. It is related to 'user innovation community' (Dahl et al., 2011; Dahlander & Wallin, 2006), the collection of user innovations where user role as both consumer and innovator. A representative example is open source software such as App Store. The information appeared in such communities can be sentiment or usage patterns, new problems or ideas of products, and descriptions of resulting user innovations such as mobile app services. Leveraging such information into internal innovation can be a great contribution to identify potential user needs and new product opportunities. Thus, tech-discourse community is regarded as a source of community-based innovation.

On the other hands, *tech-foresight community* is where the participants share conceptual insights or predictions on future of technology. It is related to 'future-oriented community' (Gheorghiu, 2009; Schatzmann et al., 2013), where large participants generate, interact and exchange the knowledge of future technology. This type of community leads to open and collaborative technology foresight, which are not possible before. The previous methods for technology foresight have been largely dependent on expert-based subjective approaches (Bishop et al., 2007; Derbyshire & Wright, 2014), which are evolved into quantitative data-based approach and the integration of both (Georghiou, 2008; Haegeman et al., 2013; Popper, 2008), typically using science and technology data such as patent and bibliometric information. However, thanks to the emergence of tech-foresight communities, the discourse on future technology has expanded from an expert-dominated domain to a more public one that includes a diverse group of interested individuals as well as enterprises.

Discussion, predictions, and information about future technologies can now be found in tech-foresight communities as diverse as database and wikis, trend news and blogs, social rating systems, collaborative scenarios, prediction markets. This thesis coins these data as *futuristic data*, a collection of online extracted documents about the future of technology that incorporate large participations of the experts and the public. Many recent studies referred to the impact of futuristic data on the technology foresight in terms of collective intelligence, creativity, and/or interdisciplinary expertise (Cachia et al., 2007; Haegeman et al., 2013; Schatzmann et al., 2013). Thus, compared to previous source, leveraging technology-foresight community information can be advantageous to exploring potential disruptive signals and scenarios of future technology.

Although tech-discourse and foresight communities entail the 'future' of technology, they are different in terms of tangibility, distance, and scope of future. Since in tech-discourse communities, user innovators gather for common interests for a certain brand or product, the information from their sharing can be tangible, foreseeable, specific, and micro future. The examples can be user ideas for a certain product's functions. On the contrary, participants and stakeholders in tech-foresight communities share conceptual, distant, unspecified, and macro discussions on future technology. Even though they also congregate for similar concerns on technology fields such as artificial intelligence, the scope of discussion can be far various; including technical, social, economic, political, and/or environmental issues. This comparison can be understood in line with that technology foresight is the prerequisite and antecedents to technology innovation.

Citing evidence of the contributions from individual users and user communities in new product development (Franke & Shah, 2003; Von Hippel, 2005), previous literatures explored various characteristics of users in tech-discourse communities. Among the notable questions addressed were the following: what are specific characteristics that distinguish innovating and non-innovating users?; do community users collaborate with and/or assist one another?; why do community users participate in innovation?; and how does the company motivate the users? (Franke & Shah, 2003; Füller et al., 2008; Lakhani & Hippel, 2003; Lüthje, 2004; Ogawa & Pongtanalert, 2013). Most of these explorations, however, were based on case studies or small-sample studies (Bogers et al., 2010). Furthermore, attempts to devise general methods for collaboration with user communities (Ebner et al., 2009; Füller et al., 2008; Ogawa & Pongtanalert, 2013) focused only on company-led approaches that push users to goal-oriented innovation activities, such as idea competition (Ebner et al., 2009), integration of virtual interaction platform to community (Füller et al., 2006), and community-based toolkit (Jeppesen & Molin, 2003) 2003). There is a distinct lack of user-led approaches that leverage independent user ideas into company's innovation process (e.g. extracting ideas from user-generated online postings or feedback). Without discrediting the value of company-led approaches, it is obvious that scanning from millions of freely-generated public ideas carries massive potential benefit (Haavisto, 2014); this module will attempt to fill the lack by pursuing this avenue.

Prior attempts for tech-foresight communities, meanwhile, are far behind; because they are an initial stage emerged in 2010s. As the role and impact of ICT in technology foresight is intensified, previous research mentioned various concepts relevant to futuristic data but in different terminologies, such as futures 2.0 (Pang, 2010, 2011), foresight 2.0 (Nelson, 2010; Schatzmann et al., 2013), future oriented communities (Gheorghiu, 2009), collaborative foresight (Markmann et al., 2012; Weigand et al., 2014), online foresight platform (Raford, 2015), foresight support system (Keller & von der Gracht, 2014; von der Gracht et al., 2015; Walden et al., 2000) etc. They, however, seldom attempted to investigate the characteristics of futuristic data in an empirical way (Raford, 2015); moreover, they did not meaningfully address quantitative data-handling methods and supporting tools for futuristic data, the needs for which have rapidly increased (Keller & von der Gracht, 2014; Woo et al., 2015).

1.2 Purpose

The overall purpose of this thesis is to analyze and utilize online community information in order to introduce open, collaborative, and collective intelligence in technology planning. The detailed purposes are suggested as three folds:

(1) Research theme 1: to analyze the characteristics of information in tech-discourse and tech-foresight communities
(2) Research theme 2: to identify and conceptualize opportunities of technology innovation using tech-discourse community information
(3) Research theme 3: to identify and model drivers and alternatives of technology foresight using tech-foresight community information

Thus, this thesis is composed of these three research themes; they encompass two sub-modules according to type of community and approach. Therefore, six modules to analyze implications and provide concrete methodology for online community information-based technology planning are included in this thesis, as shown in Figure 1.1. Research theme 1 is divided according to type of communities. Module #1 aims to analyze the patterns of innovation within tech-discourse communities. Module #2 aims to analyze the potential of futuristic data in tech-foresight communities.

The rest of themes are divided according to the approaches of utilization: visualization and reasoning. Responding to research theme 2, module #3 aims to scan potential user needs. Based on the theories that potential user needs can be identified from user contexts, the information related to use context and use behavior in tech-discourse communities is the focus of this module. In turn, product vacuums – unsatisfied and undeveloped potential needs and user contexts – are regarded as the candidates of new product opportunities.

Module #4 aims to implement user ideas based on existing products in tech-discourse communities. Specifically, this module focuses on the information of user requirements, feedback, and ideas for product features, and functions in tech-discourse communities. In this setting, the user idea themselves can be new product opportunities; however, they can still overlap with existing products. Thus, undeveloped user ideas are regarded as the candidates of new product opportunities.

Lastly, for research theme 3, module #5 aims to scan potential disruptive signals. The futuristic data in tech-foresight communities contain the information of technical, social, economic, political, and/or environmental issues related to future technologies. Thus, topics and keywords from these futuristic data can be candidates of disruptive signals and discontinuities. Module #6 aims to extract rules to build scenarios in tech-foresight communities. Likewise in previous module, the effective summarization of futuristic data can be scenario models. Since one of effective knowledge summarization method is investigating causal relationship, the module build scenarios based on causal relationships.

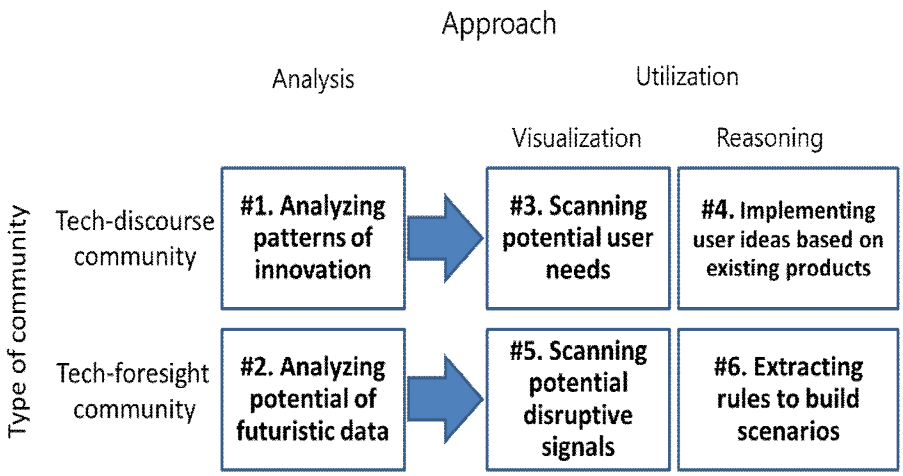


Figure 1.1 The structure of this thesis

1.3 Scope and framework

The challenge for leveraging online community information into technology planning can be related to nature of online communities (Cachia et al., 2007): An information complexity issue. As the number of information is too much, the valuable information and knowledge are buried deep within the data, and it is thus a challenging task to find them with manual analysis. Moreover, most of online community information can be disorganized and unstructured in raw textual formats and void of machine-readable attributes.

In response, the systematic ways to uncover, interpret and digest knowledge over large numbers of online community information should be explored. To this ends, this thesis develops and elaborates the approaches of data mining and analytics algorithms. As depicted in Figure 1.2, three main key categories of methodologies are 'text mining', 'visualization', and 'reasoning'. First, text mining is utilized to pre-process and structure the unstructured texts. Second, visualization methods are utilized to explore, scan, and detect interesting topics such as potential user needs and potential disruptive areas in visual and interactive manner. Third, reasoning methods extract the cases and rules which are latent in large data, thus are utilized to deriving solution cases for problem and the rules for modeling.

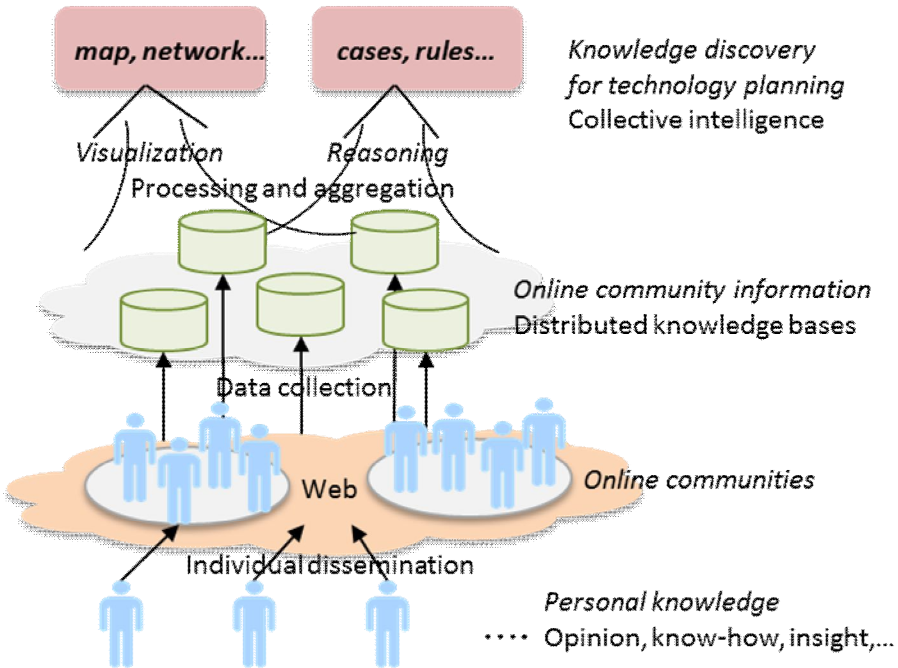


Figure 1.2 Approaches to utilize online communities

Table 1.2 Specific approaches of utilization modules

Modules	Approach	Major method
#3. Scanning potential user needs	▪ Mapping context information with existing products ▪ Conceptualizing new product opportunities by benchmarking reference products	▪ User-centric service map
#4. Implementing user ideas based on existing products	▪ Checking overlap of ideas and existing products ▪ Conceptualizing opportunistic user ideas by benchmarking reference products	▪ Case-Based Reasoning to retrieve old solutions (existing products) to match new problems (user ideas)
#5. Scanning potential disruptive signals	▪ Analyzing keyword clusters to identify easily perceptible, homogeneous topics ▪ Assessing keyword intensity to explore disruptive keywords ▪ Developing keyword-based roadmap to find likely path of developing disruptive signals	▪ Self-organizing feature map for keyword cluster map ▪ Treemap for keyword intensity map ▪ Network analysis for keyword relationship map
#6. Extracting rules to build scenarios	▪ Modeling fuzzy cognitive map-based scenario, which consists of scenario concepts and their causal relationships from futuristic data ▪ Extracting causal rules from futuristic data	▪ Fuzzy cognitive map to model and generate scenarios ▪ Fuzzy association rule mining to extract rules

Specific frameworks and scopes of six research modules are represented in Table 1.3. Research module #1 analyzes the patterns of innovation in tech-discourse communities, choosing mobile application ("app") services from App Store as a representative case. In consequence, the module finds that innovation in tech-discourse communities are often based on divergence and convergence of existing products/services.

Research module #2 analyzes the potential of futuristic data in tech-foresight communities. Since the concept of futuristic data is new in technology planning, futuristic data is defined and analyzed in terms of its utility in technology foresight. By comparing it to patent data in terms of future-orientation, information scope, and perspective, the module identifies futuristic data in tech-foresight communities as a potent source of foresight.

Research module #3 scans potential user needs from tech-discourse communities. To this end, the module introduces 'user-centric service map' to discover new service opportunities in service vacuums, and makes suggestions toward those opportunities by using adjacent reference services.

Research module #4 implements on user ideas based on existing products/services. The module focuses on more active and enthusiastic user innovators' ideas, converting them into new product opportunities that are further developed by using reference services. To this end, text mining-based case-based reasoning approach is suggested.

Research module #5 visually scans potential disruptive signals from futuristic data for technology roadmapping. In this module, potential disruptive signals are narrowed down through three successive keyword maps: self-organizing feature map-based keyword cluster map, treemap-based keyword intensity map, and network-based keyword relationship map.

Research module #6 extracts rules to build scenarios from futuristic data. This module focuses on fuzzy cognitive map-based scenario building, and the modeling elements such as concept nodes and their causal edges are identified by text mining and fuzzy association rule mining.

Table 1.3 Research themes and modules

Theme	Modules	Detailed explanation
Analysis of online community information	Analyzing patterns of innovation in tech-discourse community	#1. Patterns of innovation in digital content services: the case of App Store applications (Kim et al., 2012)
	Analyzing potential of futuristic data in tech-foresight community	#2. On the potential of futuristic data as a source of technology foresight: comparison and integration with patent data
Utilization of tech-discourse community information	Scanning potential user needs	#3. User-centric service map for identifying new service opportunities from potential needs: a case of App Store applications (Kim et al., 2013)
	Implementing user ideas based on existing products	#4. Leveraging ideas from user innovation communities: using text-mining and case-based reasoning

Utilization of tech-foresight community information	Scanning potential disruptive signals	#5. A visual scanning of potential disruptive signals for technology roadmapping: investigating keyword cluster, intensity, and relationship in futuristic data
	Extracting rules to build scenarios	#6. Futuristic data-driven scenario building: incorporating text mining and fuzzy association rule mining into fuzzy cognitive map

1.4 Thesis outline

The remainder of this thesis is organized as follows. Chapter 2 provides theoretical and methodological background. Theoretical background involves the studies regarding tech-discourse and tech-foresight community information in order to clarify background of emergence, conceptual definition, and conceptual utility in technology. Methodological background explains the methodologies focused on this study to support the utilization of online communities in technology planning.

Chapter 3, 4, and 5 are main bodies of this thesis, organized according to the three themes of online community information-based technology planning. Each chapter includes two research modules and each module involves its own introduction, background, proposed approach and results, and conclusions. Figure 1.3 describes the overall structure of this thesis.

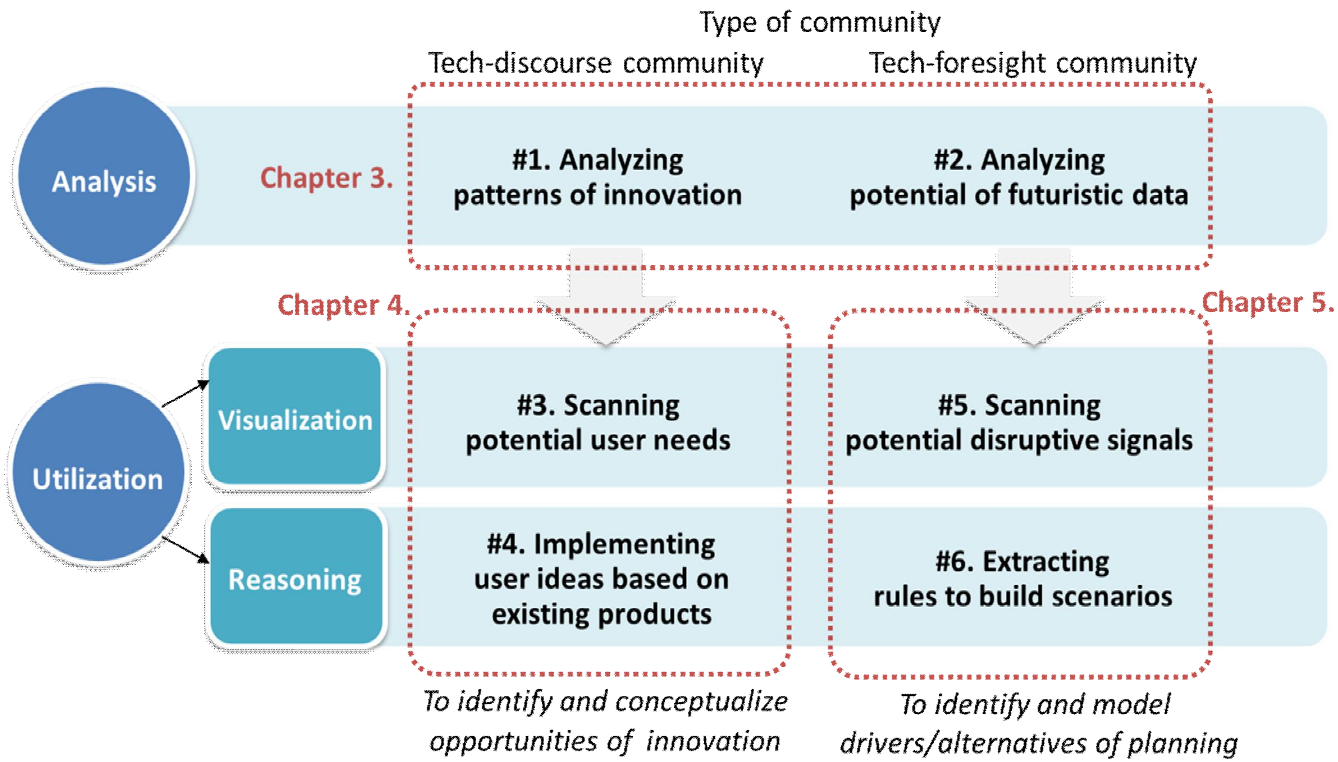


Figure 1.3 Structure of this thesis

Chapter 2. Background

2.1 Theoretical background

To analyze and utilize the online community information, the prerequisite is to understand the online communities themselves. This section clarifies the conceptual backgrounds of tech-discourse and tech-foresight communities and reviews related literature.

2.1.1 Tech-discourse community information

2.1.1.1 Concept of tech-discourse community

The notion of prosumer and lead user— those who participate in the innovative activities and provide valuable innovations— is not a new phenomenon (Bandulet & Morasch, 2005; Tapscott & Williams, 2008; Von Hippel, 2005). User innovation refers to innovation by intermediate users (e.g. user firms) or consumer users (individual end-users or user communities), rather than that by suppliers (producers or manufacturers) (Bogers et al., 2010). In turn, *user innovation communities* are defined as "distributed groups of individuals focused on solving a general problem and/or developing a new solution supported by computer-mediated communication" (Dahlander & Wallin, 2006). LEGO's online platform, LEGO Cuusoo, is an example in which users upload their designs to a webpage and other users vote on the design (Antorini & Muñiz Jr., 2013). Free and open source software is probably the most well-known example, where geographically dispersed individuals collectively develop new software and produce innovation (Dahlander et al., 2008; Kaiser & Müller-Seitz, 2008; Lakhani & Hippel, 2003).

This study focuses on the case of mobile apps in App Store. Recent explosive growth of app services within the App Store reflects the notion of user innovation, where the end users voluntarily generate new product/service that can be incorporated into the firm's innovation. The platform providers such as Apple and Google offer open application program interface (API) and software development kit (SDK), which the users can use as source and toolkit for innovation. This provision facilitates a voluntaristic production mode, where users on their own initiative contribute to innovation and development (Remneland-Wikhamn et al., 2011). Thus, users are becoming prosumers— producers who are also consumers (Bandulet & Morasch, 2005; Tapscott & Williams, 2008). Since any developer with any expertise can freely create a mobile app service (Remneland-Wikhamn et al., 2011), the developers possess varying degrees of expertise, ranging from expert developers for commercial apps to general users who may participate in developing apps that address their needs. In sum, the App Store is a classic example of a user innovation community; however, there are other communities independent of the App Store where the prosumers share their ideas and comments as well.

2.1.1.2 Tech-discourse community information as a source of potential needs

Traditionally, the main sources of opportunity in product and service innovation are the customer needs extracted from market-oriented approaches. A market orientation is fundamentally concerned with developing an in-depth understanding of user needs (Jaw et al., 2010; Narver et al., 2004). User needs – what a user wants, desires or expects from the products or services – is categorized as expressed (explicit) needs and potential (latent) needs. To enhance their understanding of expressed needs, firms can employ traditional market research tools, such as user needs surveys, user interviews, focus group interviews (FGI) and Kelly repertory grids (Leonard & Rayport, 1997; Narver et al., 2004; Witell et al., 2011). However they have severe limitations when it comes to developing innovative products or services (Hamel & Prahalad, 2013). Thus, for firms seeking to develop innovative services, what is important is to try to identify potential, rather than relying on expressed, needs.

Customers' *potential needs* can be understood as what they really value or the products and services they need, but have never experienced or would never think to request (Wagner & Hansen, 2004). For identify potential needs, user-centric approaches have been suggested that users ought to be observed more closely in their own environment, or be more involved in the development process (Alam & Perry, 2002; Prahalad & Ramaswamy, 2000; Witell et al., 2011). It has been suggest that by observing closely how users use products or services in the context of their normal routines, or by involving users who understand the context in which the service will be used, businesses can acquire information about user needs beyond what can be gained from traditional market research (Leonard & Rayport, 1997; Prahalad & Ramaswamy, 2000; Witell et al., 2011). Through a user-centric approach, businesses can acquire information about user needs beyond what can be gained from traditional market research (Kristensson et al., 2008; Stappers et al., 2009).

A user-centric approach attempts to improve the design of the customer experience by capturing users' requirements and insights via ethnographic observation methods such as empathic design (Leonard & Rayport, 1997), participatory observation (Tedlock, 1991), diary keeping (Götze et al., 2009) or task analysis (Kirwan & Ainsworth, 1992), and user involvement techniques such as a lead user method (von Hippel, 1986), or market experiment (Narver et al., 2004). In particular, user involvement techniques are known to realize user co-creation, in which users actively participate in the early phases of the development process by contributing information about their own needs and suggesting ideas for future services that they would value being able to use, or co-design and co-produce their own products and services. This can improve organization innovation processes, especially those concerned with ideas at the fuzzy front end of innovation (Edvardsson et al., 2006; Witell et al., 2011).

The user-centric ethnographic analysis is evolving into online community-based netnography, a hybrid term made up of internet and ethnography (Kozinets, 2002). In this context, the tech-discourse community information, especially regarding the usage and behavior patterns such as reviews in community information can utilized as a source user-centric approach to identify the potential user needs. In research module #3, the study will attempt to find a way to collect the context of use information from user reviews in tech-discourse community and discover new product opportunities from the vacuum area.

2.1.1.3 Tech-discourse community information as a source of user ideas

Tech-discourse communities can be exploited in all stages of new product development: idea generation and concept development (as a source of ideas), design and engineering (as co-creators), and test and launch (as end-users and buyers) (Ebner et al., 2009; Füller et al., 2006). Many studies have investigated how and why this community-based innovation emerged (Dahlander & Wallin, 2006; Franke & Shah, 2003; Füller et al., 2008; Gangi & Wasko, 2009; Lakhani & Hippel, 2003; Lüthje, 2004; Morrison et al., 2000; West & Lakhani, 2008), and in turn have identified avenues to better utilize the user communities for innovative purpose (Antorini & Muñiz Jr., 2013; Füller et al., 2006; Gangi et al., 2010).

Ogawa & Pongtanalert (2013) divide these studies into three groups. In their view, the first group explores user motivation as important factor of building and governing innovation communities, including a device for user reputation (e.g. in music, apps, and open-source software communities), financial reward (e.g. Innocentive.com), or a desire to improve one's skill. The second group discusses ways to identify innovators from existing user communities (e.g. Niketalk), brand communities (e.g. Harley Davidson), or third-party platforms (e.g. Innocentive.com). The third group discusses ways to manage the collaboration process in innovation, such as observing the right communities and user feedback, building short-term in-community projects like questionnaires, polls, and idea contests as well as long-term projects like collaboration with outstanding community innovators.

With regards to the third group, while much effort has been made to foster company-led collaboration processes (e.g. polls and contests) (Antorini & Muñiz Jr., 2013; Ebner et al., 2009; Füller et al., 2006; Jeppesen & Molin, 2003), user-led collaboration processes have not been concretely elaborated, despite repeated suggestions on their potential. Haavisto (2014), for example, states that simply observing the discussions of the user communities, without company interaction, can uncover unmet consumer needs or innovation ideas. An organized approach to collect and utilize the free-flow of user-generated ideas will no doubt be an even more powerful tool.

It should be noted that these innovation communities are a mode of crowdsourcing (Boudreau & Lakhani, 2013), a type of participative online activity in which an individual or an institution proposes to a group of divergent individuals the voluntary undertaking of a task (Estellés-Arolas & Gonzalez-Ladron-de-Guerva, 2012). Per Boudreau & Lakhani (2013)'s categorization of crowdsourcing, crowd communities are at best when participants freely share information to accumulate and recombine ideas as in Wiki or FAQ, but the challenge is that the diverse ideas almost always lack cohesiveness. In research module #4, the study will attempt to find a way to filter through these diverse ideas to isolate new product opportunities.

2.1.2 Tech-foresight community information

2.1.2.1 Emergence of ICT on technology foresight

The challenges in the twenty-first century are quite different than those in the twentieth. Because of constant introduction of dynamic and complex innovations, disruptive events are far more difficult to understand both quantitatively and qualitatively. Consequently, an exhaustive search for a powerful framework that can discover unforeseen circumstances has been prolonged for over two decades. Here, the emergence of ICT has surely improved foresight capability. Indeed, the value of foresight approach has greatly amplified with a support of the ICT due to stimulation of asynchronous communication and collaborative content development within the foresight community (Georghiou, 2008; Keller & von der Gracht, 2014; Raford, 2015; Schatzmann et al., 2013). Many futurists and decision makers thus begin to consider it as an important interface that has a profound consequence on the nature of foresight processes (Haegeman et al., 2013).

Among numerous studies of ICT utilization in foresight process (Cachia et al., 2007; Pang, 2010; Schatzmann et al., 2013), research conducted by

Keller & von der Gracht (2014) is chosen to be one of the most distinguishing studies, which not only qualitatively but quantitatively revealed genuine benefits of ICT. Specifically, performing Delphi study with a global panel of distinguished foresight experts, the literature demonstrates about the future path of ICT in foresight activities by identifying seven ICT drivers that support the foresight process. Yet, they further conclude that foresight remains a creative and human centered activity, where ICT tools are served only as supportive tools. It thus suggests developing ICT-based foresight approaches in the direction of decision support systems (DSS) for improved process efficiency and effectiveness. Ciarli et al. (2013) focus on the advances of quantitative methods caused by ICT developments. They suggest quantitative techniques that incorporate social network analysis, social software (webonomics and altmetrics), Google trends & correlate, prediction markets, RDM, and scenario discovery. Based on the prior studies, the seven main values of ICT are briefly described as follows:

- Accessibility - high availability of and immediate access to future-relevant information produced by experts and general public
- Collaboration - increased interactive participation of stakeholders with rapid provision feedback and knowledge sharing
- Efficiency - optimized foresight process as well as time savings, achieved through automation or real-time communication
- Linkages - effective combination of different sources of knowledge in

foresight by interconnecting various perspectives

- Market - enlarged demand for foresight and growth of the discipline driven by the higher visibility of foresight
- Progress - further development of foresight method and tool with a growth of computer power
- Quantitative data-handling - increased accuracy and credibility of foresight activities with higher usage of data mining, quantitative modeling and simulations

2.1.2.2 Tech-foresight communities of experts

Credited as a crucial antecedent to anticipate uncertainties and offer a better chance at being ahead of others, foresight process is an essential aspect of strategy development (Spiegeleire, 2014). Thus a considerable amount of literatures, by means of Delphi and foresight support system, start to utilize ICT for allowing experts to collaborate over an entire foresight process and thereby supporting future-oriented decisions (von der Gracht et al., 2015). However, they view ICT only as a virtual platform enabling interactive communications and highlight the minor scope of the ICT advantages: systematic collaboration with increased efficiency. In fact, one major drawback of these literatures is that they only involved “nearby diversity”, a subset of experts or stakeholders that organizations know or can invite (Spiegeleire, 2014).

Preliminary foresight-related works with ICT support are carried out through methodologies like Delphi method and scenarios (Bañuls & Salmeron, 2011; Gordon & Hayward, 1968; Turoff, 1971). Gordon & Pease (2006) proposes a modified approach of Delphi study, known as real time Delphi. The method refuses to follow conventional Delphi procedure in terms of omitting sequential “rounds”. Expert participants’ feedback information from one round to the next and move toward the consensus considering Internet websites as platforms of communication. The promising characteristic of this method is an improvement of efficiency in collecting expert judgments through acquiring larger number of participants, increased time and asynchronous participation. Additionally, faster real time procedure with a help of advanced machine, equipped with advanced artificial intelligence (AI) and natural language (NL) processing, is further proposed as the subjects of future work.

The phrase “future support system”, the field with a purpose of integrating foresight methodologies in decision support systems, is first introduced by Walden et al. (2000). Then, Bañuls & Salmeron (2011) reemphasize the concept by setting out the basis of a collaborative IT-based system, which is aimed at supporting communication, decision modelling, and rules of order in foresight processes. The study claims that the traditional scope of future foresight system is delimitated and suggests some implicit challenges in order to improve management and output of the foresight process. In the result, it is found that the primary value of using ICT into foresight support system is to provide a greater collaborative and decision making features with active expert intractability.

Markmann et al. (2012) proceeds to contribute by proposing a systematic development process of innovative web-based foresight platform. The main purpose is to improve the robustness in decision making by collaborative foresight process, especially as a basis for risk management decisions. To this end, an IT-architecture and its composed digital foresight tools are presented: (1) futures platform, personalized communication portal; (2) trend database, a quantitative and qualitative pool of future-relevant knowledge; (3) future workshop, discussion basis and digitally collaborate in workshop environment; (4) prediction market, an innovative foresight method that generate futures knowledge. Most recently, von der Gracht et al. (2015) introduce nine latest informative research on foresight support system. Focusing on the future role of ICT in foresight processes, they elaborate foresight support systems as collaborative computer based systems that support communication, statistical and qualitative data analysis, decision modeling and rules of order in foresight processes. Consequently, it proposes general and solution-oriented foresight process by providing methodologically integrated platform.

2.1.2.3 Tech-foresight communities of everyone

Experts are known as the ideal figures who have more knowledge advantage and thus expect to have advantage at better envisioning the future (Schatzmann et al., 2013). However, these traditional closed-loop foresight approaches have in fact lead experts to foresight with various cognitive limitations (Pang, 2008). Therefore many studies have been suggested integrating opinions of both experts and general public into the foresight studies.

Cachia et al. (2007) provide an overview for the potentials of online communities for foresight and arrive at three conclusions: (1) Interaction and communication in online communities sparks creativity. (2) Online communities are an excellent indicator of rapid changes and trends in sentiment and social behavior. (3) Online communities combine individual thought processes to build records of the bigger picture and therefore nurture collaborative intelligence in the process of debating potential long-term future goals.

Schatzmann et al. (2013) conceptually introduce and discuss the umbrella term, “foresight 2.0” to support the argument. According to the study of Tetlock (2005), expert judgment can have poor foresight performance due to some sort of mole sight after having been too long into a specific field of expertise (Schatzmann et al., 2013; Tetlock, 2005). This term is proposed to enable transparent, efficient, and rapid generation of possible futures with the basis of two main concepts: Web 2.0 and open & collaborative foresight. Many individuals with various perspectives are making use of network effects and collaborating within the platform created by Web 2.0 technology. Furthermore, active communication between insiders and outsiders, between experts and stakeholders are facilitated with the basic premise of open innovation. Most importantly, the authors seek to emphasize the potential of combining expertise and crowd intelligence as the future design of foresight process. The summarization of the status quo of current foresight approaches are presented, and they are subsumed into four categories: (1) databases/wikis; (2) prediction markets; (3) social rating systems; and (4) collaborative scenarios.

Pang (2010) thoroughly reviews the literatures on experimental psychology and neuroscience in order to identify biases of people's ability that act upon the future. By introducing brand-new field, noted "futures 2.0", and its basic premises, the author provides quite interesting guidance to confront such an increasingly complex, chaotic and contingent world. According to Pang (2010), futurists must caution against putting too much faith in the power of experts as forecasters. Twenty first century is the world in which the power to shape the future rests along with growing range of players, including ordinary people, rather than a few experts acting decisively and heroically. It is further suggested that ICT can be helpful to professional foresighting in three ways: (1) social scanning, a basic system that reveal some insights by collective pattern recognition in openly available data; (2) prediction markets, a way to aggregate expertise through participation; (3) reviewing forecast, a tool that serve evaluation of past successes and pasts and better anticipate the future.

Some of the studies mentioned in the conceptual and technological research of foresight support systems also demonstrate the importance of wider range of information. Glenn (2015) reflects on the principles of collective intelligence as an emergent property from synergies among three elements: data/information/knowledge, software/hardware, and experts and others with insights. In addition, gathering the key information sources of expert scholars, scientists, thought leaders and the general public is proposed to be the primary purpose of the foresight system. Raford (2015) emphasizes the concept of crowdsourcing, especially an involvement of larger group of individuals outside a traditional organization, during the foresight activities. Moreover, an importance of amateurs' user-generated content is specifically mentioned by Andersen (2007)'s extended definition of Web 2.0. The proposed online foresight system is found to increase participation in terms of both amount and diversity and increased transparency of the analysis. Therefore, online communities are described as the basis for a bigger brainstorming in which future concepts, ideas or scenarios can be tested and refined (Schatzmann et al., 2013).

2.1.2.4 Concept of tech-foresight community information

The phenomena introduced so far are linking to the formation of futuristic data. A large and growing body of online foresight platforms and forums are currently being established throughout the Internet and so as the enormous amount of future-oriented documents. Thus, this thesis would like to highlight the significance of these future-oriented data and introduce the term, "*futuristic data*". This is referred as the ICT-generated data that holds real-time collected information of possible future depictions related to technology and society. In addition, the data is generated by means of large-scale collaboration within virtual communities of experts and other ordinary people.

The examples of futuristic data contained in tech-foresight communities are summarized in Table 2.1: database and reports, news and wikis, social rating system, collaborative scenarios, and prediction markets.

- Databases and Wikis: A digital archive that provides a classification schema for future-related information such as wildcard databases, prediction databases and reports, trend databases and reports, databases that are used for horizon scanning and databases that are used for mapping strategic foresight; Wikis are one type of database that especially provide the collective knowledge and ontologies of information.
- News and blogs: News and blog posts including replies that offer technological trends and predictions of the individual and their interaction in online websites such as expert forums and trend review websites, etc.
- Social rating systems: The vast set of assumptions, predictions, conjectures, and the rates of them using the scales like relevance, impact, likelihood or desirability
- Collaborative scenarios: The data generated from collaborative scenarios, i.e. the aggregated descriptions on future predictions made

by many participants The focus is on pooling only potential scenarios and solutions to specific future challenges and the ability to aggregate assumptions about the future into scenarios

- Prediction markets: The data generated from prediction markets, i.e. exchange-traded markets created for the purpose of trading the outcome of events; The payoff of contracts depends on the possible events in the future (Wolfers & Zitzewitz, 2004).

Table 2.1 Examples of futuristic data (adapted and modified from Schatzmann et al. (2013))

Types	Example of source websites
Databases and Wikis	Siemens, IBM IT Insight, GE-Technologist, GE-Ideas Lab, iKnow, TechCast, TrendWiki
News and blogs	Gartner, McKinsey, MIT Technology Review, Kurzweil Accelerating Intelligence, Next Big Future, World Future Society, LongBets, iKnow, Trendradar2020, Shaping Tomorrow, SigmaScan, Delta Scan, Forecasting World Events, The Seven Horizons, wrong tomorrow, Future Scanner, TechCast, SKAN, Vanguard Science Daily, Engadget, GSM Arena, TechCrunch, The Verge
Social rating systems	Is it Future proof?, bean sight, The Future of Facebook Project, predicto.net, wefutr, Web of Fate, Wikistrat, The Future of Facebook Project, Forecasting ACE, NY Times Technology Timeline, Real-time Delphi

Collaborative scenarios	superstruct, signtific map, Risk Interconnection Map, Future Timeline, News of Future
Prediction markets	intrade, inklingmarket, Popular Science Predictions, Betfair, Iowa Electronic Markets, Smarkets, iPredict, Predictious, Prediction Lab, PredictIt, SciCast, Hypermind

The providers of futuristic data can be the experts from global technology-leading companies such as IBM and GE, professional technology forecasting or consulting companies such as Gartner and McKinsey, trend reporting websites such as Science Daily and Engadget, the communities of individual expert or futurist such as Next Big Future, World Future Society, and the communities of the public such as social rating system, collaborative scenarios, and prediction markets. The field of technology they focused is mainly ICTs, but other fields such as bio, nano, and energy, and social trends are also part of their concerns. Futuristic data include various level of future-oriented information such as current trend, short-term forecasts, or long-term forecasts. Also the forms of information are various, such as news, report, magazine, web post (blog), forum (tread-reply), etc. The detailed descriptions of source websites are provided in Kim & Park (2014).

2.2 Methodological background

2.2.1 Technology foresight methods

Technology foresight is defined as umbrella term that encompass a variety of pertinent fields, such as technology forecasting, future studies, futures analysis, visioning, future-oriented technology analysis, technology assessment, impact assessment, and forward-looking activities (Porter, 2010). It is considered as the most upstream element of technology development process that provides inputs for the formulation of relevant policies and strategies and guides the development of technological infrastructure. Over the past few decades, technology foresight methods have become widely used in many countries around the world especially in policy-making for science and technology innovation. At the same time, companies' use of foresight activities, i.e. corporate foresight, has also become more professional and widespread (Pillkahn, 2008). Many of them explore the potential of strategic foresight in order to support strategic management, identify new business fields, and increase the innovation capacity of a firm (Daheim & Uerz, 2008; Rohrbeck & Gemünden, 2011).

For a long time, methodological approaches in technology foresight have been carried out in terms of qualitative and quantitative approaches. Several studies (Georghiou, 2008; Haegeman et al., 2013; Mishra et al., 2002; Popper, 2008; Porter et al., 2004) have listed a large number of techniques of technology foresight, and a summary of these techniques is provided in Table 2.2.

Table 2.2 An overview of technology foresight methods

Qualitative methods	Quantitative methods
• Brainstorming	• Bibliometrics
• Delphi method	• Patent analysis
• Technology roadmap	• Quantitative scenarios
• Scenarios	• Benchmarking
• Backcasting	• Indicators/Time series analysis
• Nominal group technique	• Growth models
• Morphological analysis / Field anomaly relaxation	• Substitution analysis
	• Trend extrapolation
• Intuitive logics method	• Trend-impact analysis
• System for event evaluation and review	• Cross-impact analysis
	• System dynamics
• Causal layered analysis	• Agent modeling
• Emerging issues analysis	• Fuzzy cognitive maps
• Relevance trees / Planning assistance through technical evaluation of relevance numbers	• Multi-criteria decision making
	• Multi-criteria decision analyzes (data envelopment analysis)
• Anticipatory thinking protocols	
• Futures wheel	
• Environmental scanning	
• SWOT	
• System of opportunities and negatives charts	
• Voting machines	
• Open pooling	
• Genius forecasting, intuition, and vision	

Qualitative methods have a purpose of obtaining perceptions on the future or directions of future events, rather than numerical outcome. They identify directions of change, casual relations, and discontinuous trends (Cagnin et al., 2013). For example, Derbyshire & Wright (2014) identify critical factors that can enhance innovation of suggested principles by constructing future scenarios. Saritas & Oner (2004) plan the needs of large public institutions in uncertain environments through scenario planning, technology roadmap and Delphi. On the other hands, quantitative methods identify expected changes in the future through and constructing mathematical models, such as statistical models and network models, based on real data. These methods are derived from a computational algorithm, supported by historical input (Agami et al., 2008). Trend analysis methods identify new trends or changes of technologies using techniques such as growth models, simulation, or network analysis. For example, Kim et al. (2013) suggests NEST (New and Emerging Signals of Trends) model. In this model, researchers detect emerging trends and technologies through Bayesian network model. Kwakkel & Pruyt (2013) suggest exploratory modeling combined with system dynamics to gain insights into what kinds of plausible dynamics can occur given a variety of uncertainties of the system.

Among various quantitative data resources that are available, scientific publications and patents are useful sources for science and technology R&D planning (Bengisu & Nekhili, 2006). Since patents are major outputs of R&D

activities and represent characteristics of new technology (Choi & Park, 2009), many researchers have approached technology foresight using patent information. Thus, patent analysis and bibliometrics are the representatives for quantitative methods. For example, Gao et al. (2013) analyze current status of technology life cycle through patent data in order to identify the future development of technology. Santo et al. (2006) conduct bibliometric analysis using data related to nano-technologies and identify future key factors of nano-technologies for Brazil. Such approaches include scenario development and growth curve (Bengisu & Nekhili, 2006; Daim et al., 2006), visualization (Kim et al., 2008; Small et al., 2014), technology roadmap (Lee et al., 2009), analytic hierarchy process (Shen et al., 2010), and data envelopment analysis (Yu & Lee, 2013), etc.

Although the qualitative approaches have been mainly used for technology foresight, they are faced with fundamental shortcoming of subjectivity. The experts and researchers interpret the outcomes of qualitative methods based on their own subjective opinions, and this sometimes create difficulties for everyone to agree upon (Georghiou, 2008; Popper, 2008). Unlike qualitative methods, quantitative methods provide confirmative basis derived from numerical changes of the results (Georghiou, 2008) and new patterns that are not easily perceived by experts (Santo et al., 2006). However, quantitative methods are strictly criticized due to excessive reliance on historical data and the assumption about same trends resulting in the future (Gordon, 2003). In addition, they require high quality data to obtain reasonable outcomes (Popper, 2008).

Thus, qualitative and quantitative methods are recently evolving as combinative (i.e. semi-quantitative, or integrative) ones. In study of Haegeman et al. (2013), combinative methods can be divided into three types. First is treating outputs of qualitative method as inputs to quantitative methods. In many cases, especially in Delphi and scenario methods, researchers are applying mathematical principles to quantify rational judgments, viewpoints and scenarios of experts (Amer & Daim, 2013). For example, Chen et al. (2012) extract and quantify expert's opinions through Delphi method, and those quantified outputs are fed into system dynamics model in order to estimate directions of technological advances. Förster (2015) processes expert's opinion into numerical information through analytic hierarchy process and evaluate success probabilities of emerging technologies. Varho & Tapio (2013) conduct clustering analysis to reduce the variables extracted from expert's opinions and use them for the materials of further interviews.

Second type is about vice versa, where outputs of quantitative method are treated as inputs of qualitative methods. Typical example of this approach is providing references to experts. For example, Kanama (2013) constructs a technology roadmap through Delphi method. In order to identify representatives of expert's opinions, results of statistical analysis are provided to experts. Cuhls et al. (2009) use results of patent analysis during the experts' discussion process.

Final type is the comparing outputs of quantitative methods and that of qualitative methods. That is, quantitative and qualitative methods are applied in same technology foresight problem respectively, and their foresighting results are compared. If a discrepancy exists between the outcomes of two approaches, other confirmatory methods are applied for identifying the reason of difference.

2.2.2 Methods utilized in this thesis

Table 2.3 Methods used in this thesis

Category	Methods
Text mining	• Natural language processing • Latent Semantic Analysis (LSA)
Visualization	• User-centric service map • Technology roadmap (TRM) • Self-organizing feature map (SOFM) • Treemap • Network analysis • Fuzzy cognitive map (FCM)
Reasoning	• Case-based reasoning (CBR) • Fuzzy association rule mining (FARM)

2.2.2.1 Text mining

Natural language processing

TM, which covers the process of finding interesting patterns, models, directions, trends, or rules from unstructured text, is an automated discovery of knowledge from texts (Berry & Kogan, 2010; Lin et al., 2009). To this ends, Natural Language ToolKits (NLTK) is widely used in performing the Natural Language Process (NLP) for text data. Several processing techniques can be involved to determine the part of speech of each word, and remove the stop words such as articles, prepositions, and conjunctions. Structuring the input text usually involves parsing, along with the addition and removal of derived linguistic features, and subsequent insertion into a database. TM assumes that documents in the text format can be featured by keywords and thus a keyword vector or a term-document matrix is the general method of handling large amounts of unstructured text to extract information from structured data (Lin et al., 2009).

Latent semantic analysis

Latent Semantic Analysis (LSA) is a technique that analyzes relationships between a set of documents and the terms they contain by producing a set of concepts related to the documents and terms (Dumais, 2004; Landauer et al., 1998). It assumes that terms that are close in meaning will occur in similar pieces of text. By lowering the dimension of term-document matrix by Singular Value Decomposition, it is able to distinguish multiple words that have similar meanings and words that have more than one meaning. Also, the significance of each semantic textual pattern is figured out through LSA. LSA has been used typically in information retrieval and clustering or classification of documents or terms (Dumais, 2004). Recently, some pionieering works have been introduced to apply LSA to technology foresight area such as classifying applied science research projects (Thorleuchter & Van den Poel, 2013), weak signal tracing (Thorleuchter et al., 2014), cross impact analysis (Thorleuchter & Van den Poel, 2014), and technology opportunity analysis (Zhu & Porter, 2002).

2.2.2.2 Visualization

Technology roadmap

Technology roadmap (TRM) is a flexible technique that have been largely employed as a tool for strategic planning of technology (Gerdsri et al., 2010; Lee & Park, 2005; Phaal et al., 2004). The common structure of TRMs is composed of two-dimensional structure, making the horizontal axis the timeline and the vertical axis the layered structure of market, product, technology, and R&D (Phaal et al., 2004), as described in Figure 2.1. It is time-based layered chart, thus can represent the evolutionary pattern or plan of markets, products, and technologies, together with the linkages and discontinuities between themselves.

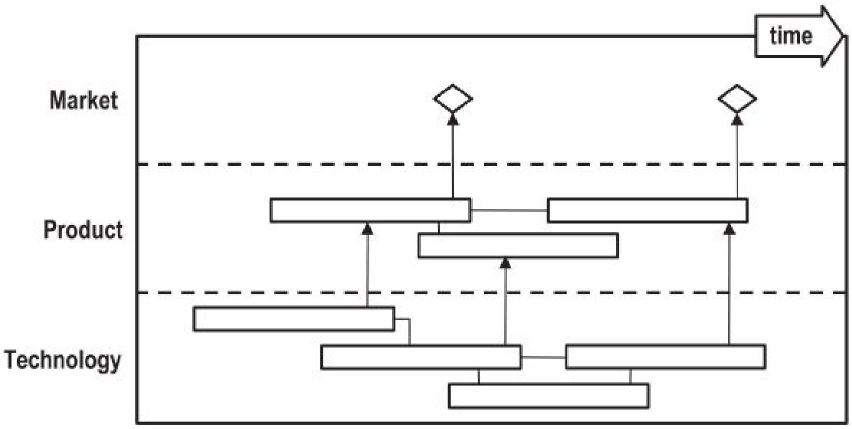


Figure 2.1 Schema of TRM (from Phaal et al. (2004))

Recently, TRM is developing to consider various data sources. Previous attempts have proposed data-driven or keyword-based technology roadmaps (TRMs). They typically have depended on science and technology (S&T) data sources such as patents and literatures (Kostoff et al., 2004; Lee et al., 2008; Lee et al., 2009; Zhang et al., 2013; Yoon et al., 2008; Choi et al., 2013; Jeong & Yoon, 2015; Martin & Daim, 2008).

Self-organizing feature map

Self-organizing feature map (SOFM) is a type of artificial neural network that is a general unsupervised tool for ordering high-dimensional data in such a way that similar input patterns are grouped spatially close to one another (Kohonen, 1998). Without knowledge in the inter-relationships, it produce a low-dimensional (typically two-dimensional), discretized representation of the space of the training data, called a map.

As shown in Figure 2.2, a SOFM is formed of neurons located on a two-dimensional grid arranged as various topologies such as rectangular or hexagonal lattices. Each neuron has actually two positions: one in the input space (i.e., a weight vector) and another in the output space on the map grid. Thus, SOFM is a vector projection method defining a nonlinear projection from the input space to a lower-dimensional output space. On the other hand, during the training, the weight vectors move so that they follow the probability density of the input data. Thus, SOFM is also a vector quantization algorithm (Ultsch, 2003; Vesanto & Himberg, 1999; Yoon et al., 2002). SOFM has been largely applied in information retrieval and knowledge discovery for textual documents (Merkl, 1998; Hotho et al., 2005; Yoon, et al., 2002; Lee & Yang, 1999)

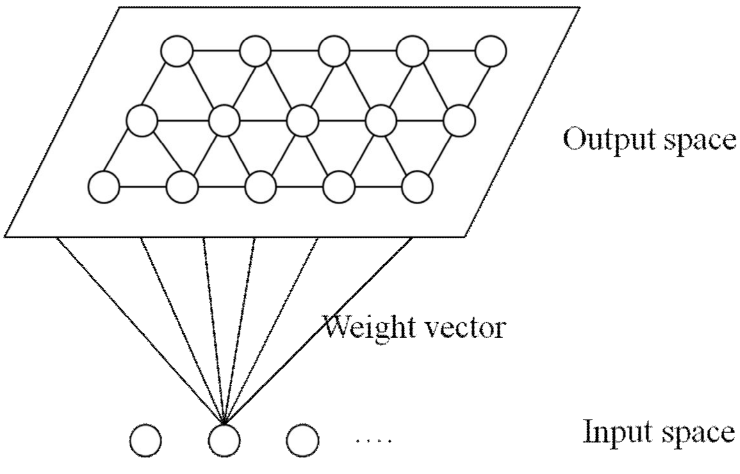


Figure 2.2 Structure of SOFM

Fuzzy cognitive map

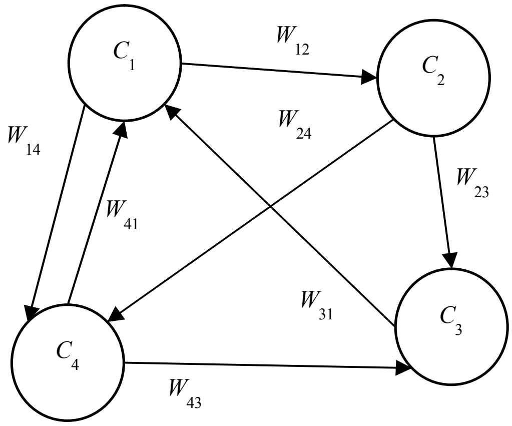
FCM, firstly suggested by Kosko (1986), is the extension and enhancement of cognitive map to present a belief system in a given domain and is developed by experts using interactive procedure of knowledge acquisition (Yaman & Polat, 2009). As its name suggests, FCMs are originated from a combination of fuzzy logic and neural networks (Motlagh et al., 2015; Papageorgiou, 2012). FCMs describe the behavior of a system in terms of concepts and their causal relationships. In FCMs, the nodes stand for the *concepts* that are used to describe the behavior of the system (e.g. an entity, a state, a variable, or a characteristic of the system) and the causal relations between the concepts are represented by *signed and weighted arcs*. The structure of a FCM is shown in Figure 2.3 and the detailed elements are as following:

Concepts: $C_1, C_2, ..., C_n$. These represent the drivers and constraints that are considered of importance to the issue under consideration.

State vector: $A = (A_1, A_2, ..., A_n)$, where a_i denotes the state of the node C_i. The state vector represents the value of the concepts, usually between 0 and 1. The dynamics of the state vector *A* is the principal output of applying a FCM.

Directed edges: $C_1 \rightarrow C_2$, etc. These represent the relationships between concepts, visualized as arrows in the directed graph.

Adjacency matrix: $E = \left(W_{ij}\right)$, where W_{ij} is the fuzzy weight of the directed edge C_i to C_j. The matrix contains the values of all relationships between concepts, usually between -1 and +1. Note that contrary to most applications, non-zero values on the diagonal are considered here.



(a) FCM

$$E = \begin{array}{c|cccc|} & C_1 & C_2 & C_3 & C_4 \\ C_1 & 0 & W_{12} & 0 & W_{14} \\ C_2 & 0 & 0 & W_{23} & W_{24} \\ C_3 & W_{31} & 0 & 0 & 0 \\ C_4 & W_{41} & 0 & W_{43} & 0 \end{array}$$

(b) Adjacency matrix

Figure 2.3 Structure of a FCM and the corresponding adjacency matrix

The strength of FCMs in dynamic modeling comes from *inference mechanism*. The causality relationships of an FCM model are dynamic and cumulative and thus have a temporal dimension. Given an FCM with a number of nodes C_i (where i = 1, … , n), the value of each node in iteration can be updated as:

$$A_i(t+1) = S(A_i(t) + \sum_{\substack{j \neq i \\ j=1}}^{N} A_i(t) \cdot W_{ji}) \qquad [2\text{-}1]$$

Where $A_i(t+1)$ is the is the value of concept C_i at time $(t+1)$, $A_i(t)$

is the is the value of concept C_i at time t, W_{ij} is the fuzzy weight of the directed edge C_i to C_j, and S is a threshold (activation) function that squashes the result of the multiplication in the interval [0, 1] wherein concepts take values. The nonlinear function S can be various types such as bivalent, trivalent, logistic, and sigmoid (Tsadiras, 2008). Based on these concepts, the inference mechanism is implemented as follows (Yaman & Polat, 2009): (1) The FCM is initialized and the activation level of each node for threshold function is set; (2) The node interaction is allowed by repeated matrix multiplication between state vector (A) and the weight of edges (W_{ij}); and (3) This interaction continues until stabilization, limit cycle, or chaotic behavior (Tsadiras, 2008). In stabilization case, the state values of concept nodes are fluctuating in the early iteration (transient-state) but stabilizing as fixed-point equilibrium (steady-state).

FCMs have several advantages that they are simple and intuitive to understand their formalization as well as execution. Thanks to the flexibility in representation (as more concepts/phenomena can be included and interact), individual FCMs from different experts and/or stakeholders can be easily merged (Khan & Quaddus, 2004; Stach et al., 2010). Thus, FCMs can effectively model qualitative knowledge into quantitative structuring and analyzing processes (Amer & Daim, 2013; Jetter & Kok, 2014; Kok, 2009). Since they can consider not only the activation function much like other neural network systems, but weight training to learn about relationships among contributing factors (Motlagh et al., 2015). Thus, FCMs have been applied around problems to predict the outcome by letting the relevant issues interact with one another, or *what-if experiments* (Amer et al., 2013b).The application domain areas are very wide including business and management, engineering, computer science, chemistry, medicine, environment and ecology, education, decision sciences, etc. (Papageorgiou & Salmeron, 2013).

2.2.2.3 Reasoning

Case-based reasoning

Case-Based Reasoning (CBR) is a problem-solving approach that relies on similar prior cases to find a solution (Kolodner, 2014). The principle of CBR is based on an analogy to the human task of “mentally searching for similar situations which happened in the past and reusing the experience gained in those situations” (Kolodner, 2014). The basic idea of CBR, to summarize, is to retrieving and reusing past cases that are similar to the new case. The CBR process and its algorithms (Figure 2.4) are represented below (Leake, 1996):

1) Represent: Describing the current problem. A case representation scheme is determined to model a case by a set of attributes, which are intended to characterize the case for a particular application. Then, case indexing is set to assign indices to cases.
2) Retrieve: Searching and retrieving the case(s) most similar to the problem case, according to a predefined similarity measure. The CBR system responds to a query containing information about the problem and returns

a list of either *n* most similar cases where *n* is user defined or cases with similarity scores less than a user-specified threshold. Many kinds of similarity metrics can be employed here, such as the Pearson coefficient, Euclidean distance, and cosine-based similarity measures. The similarity between two cases is calculated pair-wise between pairs of fields and the most similar cases in a range are searched, using algorithms such as heuristic/analogical, serial search, hierarchical search, and simulated parallel search (Chakrabarti et al., 2011). The most general algorithm is nearest neighbor (NN) algorithm.

3) Reuse: Evaluating retrieved cases in order to decide if the solution retrieved is applicable to the problem.
4) Revise: Revising the solution manually or automatically and validating through feedback from the user. The processes of 'reuse' and 'revise' together are typically called "adaptation." There are many kinds of adaptation approach: parametric adaptation, structural adaptation, and generative adaptation (Avramenko & Kraslawski, 2008).
5) Retain: Adding the confirmed solution and the problem to the database as a new case for future reuse. There is active research in this area, and industrial solutions already exist that show procedures to manage the casebase as well.

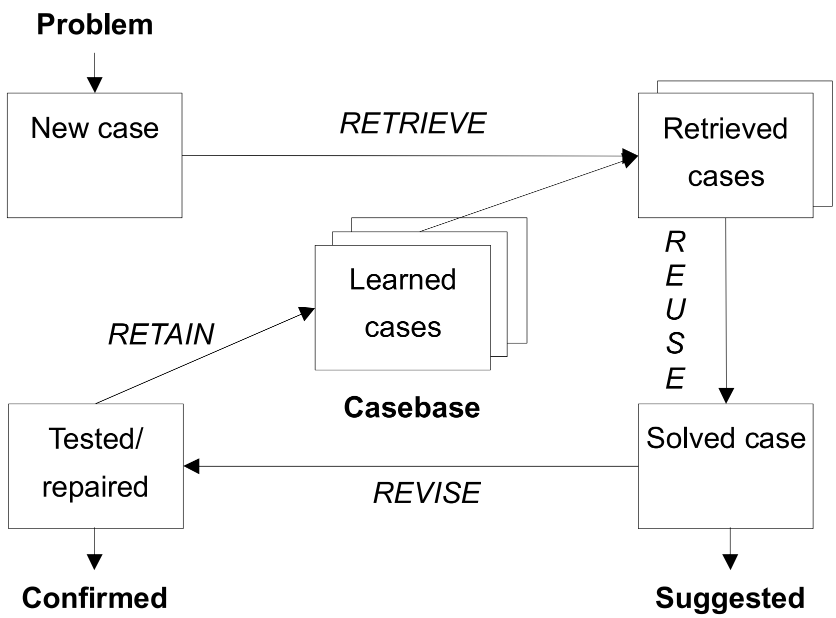


Figure 2.4 CBR cycle (adapted from Aamodt & Plaza, 1994)

Because of its reliance on cases, CBR is often used in task domains that have no strong theoretical model and where the domain rules are incomplete, poorly defined and inconsistent (Kolodner, 2014). It has been used in such diverse areas as planning, diagnosis and design. In the domain of product design and development, CBR has been applied to retrieve existing product data and product design (Aamodt & Plaza, 1994) or previous design knowledge (Belecheanu et al., 2003), to generate new product ideas (Meyer & Detore, 2001; Wu et al., 2006; Wu et al., 2008) and to support various decision makings (Belecheanu et al., 2003). For example, Belecheanu et al. (2003) suggested ways to use CBR to reach decisions on functionality problems, selections between technical solutions, make-or-buy decisions, and tooling investment decisions.

Research on CBR in innovation has emphasized the adaptation phase, which reuses and revises retrieved cases (Verhaegen et al., 2011). This is in part because design cases can be quite complex and thus design adaptation (reuse and revise) is especially hard**.** However, as we increasingly deal with huge number of cases, both problem and solution, achieving efficiency in collection and representation phase before the adaptation phase should receive equal amount of attention. Incorporating massive data into the CBR process, particularly, will require natural language processing techniques like TM to provide coherence to unstructured data.

Fuzzy association rule mining

Association Rule Mining (ARM) is a popular and well researched method for discovering interesting relationships between variables in large databases. Typical application of ARM is market basket analysis for identifying a set of product items frequently purchased together in large-scale customer transaction data (Agrawal et al., 1993). ARM provides information of correlations, frequent patterns, associations or casual structures among sets of items in the form of 'if-then' rules, e.g., {Diapers} → {Beer}. Formally, let $I = \{i_1, i_2, \ldots, i_m\}$ be a set of items, a transaction database $D = \{t_1, t_2, \ldots, t_N\}$ is set of transactions, where each transaction is set of items such that $t_j \subseteq I$. A rule is expressed as $X \rightarrow Y$, where $X, Y \subseteq I$ and $X \cap Y = \emptyset$, which means that if the transaction includes item X "antecedent"), then it also includes item Y ("consequent"). If $P(X)$ is the probability that item X is included in transaction t_j such that $X \subseteq t_j$, $N(X)$ is denoted as the count of transactions containing item X, and N is the total number of transactions in T, ARM includes core three measures to generate and select association rules as represented as shown in Table 2.4.

Table 2.4 Measures of ARM

Measure	Formula	Meaning and implication
Support	$\sup p(X \to Y)$ $= P(X \cap Y) = \dfrac{N(X \cap Y)}{N}$	The usefulness of discovered rules
Confidence	$conf(X \to Y)$ $= P(X \mid Y) = \dfrac{P(X \cap Y)}{P(X)}$	The certainty of the rule
Lift	$lift(X \to Y)$ $= \dfrac{conf(X \to Y)}{\sup p(X)}$ $= \dfrac{P(X \cap Y)}{P(X)P(Y)}$	The statistical dependence between items X and Y If the lift value is greater than one, it shows a positive correlation.

Based on these measures, the typical procedure of ARM consists of two steps (Agrawal et al., 1993): (1) generate frequent itemset– to create all item combinations greater than or equal to a minimum support (*minsupp*) threshold, (2) identify association rules – to select itemsets greater than or equal to a minimum confidence (*minconf*) threshold among the frequent itemsets found in (1).There are several techniques for step (1) and the most representative one is Apriori algorithm.

One fundamental limitation of classical standard ARM is that all attributes of I are required to be binary valued; in transaction database, the values are whether the transaction contains the item or not (Agrawal et al., 1993). Thus, to handle databases with both categorical and quantitative attributes, a quantitative association rule mining method was proposed by (Srikant & Agrawal, 1996). The method finds association rules by partitioning the quantitative attribute domain and then transforming the problem into binary one. Apparently, whatever partitioning methods are applied, "sharp (crisp) boundaries" remain a problem, which may lead to an inaccurate representation of semantics. As a remedy to the sharp boundary problem, the fuzzy set concept has recently been used more frequently in mining quantitative association rules as FARM (Farzanyar & Kangavari, 2012).

The principal idea of FARM is that ranged values can belong to more than one sub-range, thus the value has a membership degree that associates it with each available sub-ranges. Using previous notations, let $I=\{i_1,i_2,\ldots,i_m\}$ be the item set where each i_j is an attribute of the original dataset, $D=\{t_1,t_2,\ldots,t_N\}$. Although each attribute i_j was binary in general ARM, i_j here may have a binary, categorical, or quantitative underlying domain Δ_j. Besides, each item i_j is associated with its fuzzy sets, extending the item set I_f from I. Using the corresponding membership functions defined with each fuzzy set, the original dataset D is changed into a fuzzy dataset D_f. Given the fuzzy dataset $D_f = \{t_1, t_2, \ldots, t_N\}$ with I_f, the discovered rules are of the form same as standard ARM, $X \to Y$, where t_i is a transaction in D_f, $X, Y \subseteq I_f$ and $X \cap Y = \emptyset$. In this setting, the definitions of support and confidence measures of the rule $X \to Y$ for the whole D_f are extended as (Farzanyar & Kangavari, 2012):

$$\sup p(X \to Y) = \frac{\sum_{i=1}^{N} X(a) \otimes Y(b)}{|D_f|} \qquad [2\text{-}2]$$

$$conf(X \to Y) = \frac{\sum_{i=1}^{N} X(a) \otimes Y(b)}{X(a)} \qquad [2\text{-}3]$$

Where $|D_f|$ is the total number of transactions in D_f, which is equal to *N*, the number of transactions in the quantitative database D. $X(a)$ and $Y(b)$ are the membership degree of the elements *a* and *b* with respect to the fuzzy set X and Y respectively, $\otimes$ denotes a 't-norm' that aggregates the intersection of two membership degrees. Based on the notations, the procedure to extracting rules follows same logic using *minsupp* and *minconf* defined by users.

Chapter 3. Analysis of online community information

The objective of this chapter is to analyze the characteristics of information in tech-discourse and tech-foresight communities. The research questions of each module are described in Figure 3.1.

As we noted, this thesis focuses on the mobile App Store as a representative cases of tech-discourse community; the results of user innovation in these communities are mobile apps. Since the mobile app services are digital content services, module #1 identifies the mobile app innovation patterns based on the theories regarding digital content services innovation. The module investigates the patterns of innovations arising in tech-discourse communities by exploring their typologies.

Based on the through reviews in 2.1.2, module #2 conceptualizes futuristic data, empirically analyzes the distinctive characteristics of futuristic data, and encompasses the potential of futuristic data in technology foresight.

#1. Innovation patterns in tech-discourse community

- What are digital content services in tech-discourse community?
- What are the characteristics of innovations in digital content services?
- What kinds of innovations are arising in tech-discourse community?

#2. Potential of futuristic data in tech-foresight community

- What are futuristic data in tech-foresight community?
- What are the distinctive characteristics of futuristic data?
- What is the potential of futuristic data in technology foresight?

Figure 3.1 Research questions in this theme

3.1 Analyzing patterns of innovation in tech-discourse community

3.1.1 Introduction

The innovation in digital content services in tech-discourse communities includes not only an extension or a simple transformation of existing markets, but also an opening of new opportunities because of their unique characteristics. Firstly, digital content services use common digital formats. A network facilitates delivery and share of all kinds of digital content by developing versatile data exchange formats (Singh et al., 2009). Thus, existing content is adapted, repurposed, or augmented for a new platform, especially in a mobile space (Feijóo et al., 2009), enabling to create new form of services.

Secondly, thanks to the digitization, content is edited and modified easily, and further can be combined using multiple available sources (Holzer & Ondrus, 2009). Innovative digital content is created by combining a multiplicity of features that would have previously included in many separate sources, referred to as mash-up in web service (Weiss & Gangadharan, 2010). These two characteristics show the importance of incremental and recombinative innovation from the typologies of general services (Gallouj, 2002) in the digital content services, and this study defines them as two main pattern of innovation: *divergence* and *convergence*. Lastly, digital content services possess the characteristics of both product and service. Since there are various loci of innovation in digital contents services, the coverage of innovation is wider and potential for innovation is increased. This distinctive characteristic of digital content services should be reflected to innovation studies in a sector-specific perspective, following the recent findings that emphasize a great variety of innovative strategies and patterns within services (Tether, 2003; Vence & Trigo, 2009). The loci of innovation can be identified from the components of digital content services which can be changed.

In response, this research proposes to investigate the characteristics of innovation in digital content services and develop a typology of their innovation patterns. In order to make a systematic typology, firstly, this module examines the structure of digital content services and divides digital content services into three components: platform, product, and process. The components can be the meaningful criteria, considering that digital content services tend to innovate through divergence and convergence at the component level. Secondly, 12 different types of innovation patterns were defined based on changes in the components and their relationships during the innovation process. Finally, the characteristics of patterns were described and illustrated with the real case examples from App Store to verify the feasibility of the typology. App Store is a mobile open market where digital content providers can sell their content services in the form of mobile apps, and recently it is the place where the most active innovations are observed. Digital content services such as film and video, photography, and electronic games have been realized in hundreds of thousands of App Store applications. This module can be expected to fertilize the basis of service innovation and provide implications for new service development by re-creating strategies in the digital content service sector. In addition, it can facilitate the understanding of new emerging digital content services in mobile App Store.

3.1.2 Literature review

3.1.2.1 Service innovation patterns

According to the work by Gallouj & Weinstein (1997), a service is described as a set of final characteristics (i.e., benefits provided to the customer), technical characteristics (i.e., organization's tangible and intangible systems used in the production of the service), and competence characteristics (i.e., individual skills of the service provider and customer). Using the change of the characteristics as source or determinants of innovation, they specified different types of innovations. And later, Gallouj (2002) suggested that different modes of innovation, including: radical; ameliorative; incremental; ad hoc; recombinative; and formalization; can occur in virtually all service industries and functions although to varying degrees. Radical innovation denotes the creation of a totally new product replacing all of the characteristics. Ameliorative innovation is a continuous improvement that increases the value of the service. Incremental innovation emerges from the addition, removal, or substitution of new elements that are new technical or service characteristics. Ad hoc innovation implies a significant change in the competences and mostly in the immaterial elements of the technical characteristics. Recombinative innovation is produced by combining (bundling) or splitting up (unbundling) existing service and technical characteristics. Formalization innovation occurs when one or more characteristics are formatted or standardized.

As seen above, the existing studies have made an effort to identify the types of innovation for ‘general services’, concentrating on the analogy or difference from manufacturing innovation. Though the research on taxonomies of innovation in service sectors describes the sectoral particularities, it did not focus on the unique characteristics of innovation in ‘digital content services’. Moreover, although the existing modes of innovation explains well the various ways in which service innovations can be produced, they are too simple to describe the possible loci of innovation (i.e., elements of services which can be changed) concretely in the digital content services (Drejer, 2004; Toivonen & Tuominen, 2009). Thus, more detailed patterns or types should be clarified in the lower level to deal with the innovation in digital content services in depth.

3.1.2.2 Digital content services

Traditionally, the key difference between product and service lies on the degree of separability of production and consumption, or tangibility (Jackson et al., 1995). However, new integrative perspectives assuming that ‘products’ contains the combinations of goods and services elements (i.e., ‘product packages’ or ‘offerings’) have emerged to deal with digital artifacts (i.e., software, content) and ICT (Daniels, 2000; Jack et al., 2008). The digital content is relevant to this integrative approach. Digital content traditionally has been defined as products available in digital format such as code, letters, voice, acoustics, and images, which are delivered through information networks, digital broadcast networks, and digital storage media. However, the scope of digital content is more broadly extended to the bundle of product and service. It can be defined as a bundle of properties which are constituted by electronically produced artifacts (Oberweis et al., 2007; Varian, 2005). In this context, the area of the digital content industry is expanded. Although it was only a part of Knowledge-Intensive Business Services (KIBS) or creative industries (Müller et al., 2009), now it is regarded as the intersection of ICT and the cultural content industry along with the advance of ICT industry. Ultimately the distinction between digital content industry and ICT industry is expected to be meaningless.

Recently, what have been highlighted regarding the new content services are mobile apps in App Store. With the success of App Store, some literatures have made an effort to analyze platform strategies of App Store (Holzer & Ondrus, 2011). Nevertheless, there is little concern about hundreds of thousands of applications in App Store as a direct target of empirical study in terms of innovation in digital content services. Since applications are the primary channels which enable mobile content services to the customer, they can be the best source to exemplify the nature of innovation in digital content services.

3.1.2.3 Service innovation in digital content services

In digital content services, the innovative works using the service and technical features of existing services such as content or function can prominently occur (Hertog & Jong, 2007; Nam, 2008). Among Gallouj (2002)'s types of innovation, incremental and recombinative innovations that utilize service and technical characteristics of pre-existing products are selected as the main patterns of innovation. Other types also can be occurred, but they are not fully engaged with change of service and technical characteristics. The empirical studies also revealed that incremental and recombinative innovations are active in KIBS (He & Wong, 2009), the service sector where digital content services belong. These have advantages of overcoming depleted material of production and the cost of innovation, as well as increasing possibilities to use Internet resources for a wide range. Since they have a competitive advantage and synergy from the market successful service characteristics, it is possible to increase the profitability for a single source of content significantly. Based on incremental and recombinative innovations, this module redefines the innovation in digital content service in the following ways: *divergence* and *convergence*.

Convergence is a co-innovation phenomenon occurring in the course of solving technical problems in a variety of industries, first referred by Rosenberg (1963). According to Wikipedia, digital convergence is the convergence of four industries: information technologies; telecommunication; consumer electronics; and entertainment, encompassing converged devices, converged applications and converged networks. In this area, convergence implies provision of various functions in a single product by which customers do not need to purchase each product separately. It is usually used to designate multi-functionality as the telephone, internet access, and video camera all merge into a single device (Nordmann, 2004). Meanwhile, according to Jeon et al. (2008), digital convergence yields digital divergence, sometimes called the ‘long tail’. In order to respond to diverse and even neatly trimmed taste, service providers can select various products which have limited functionality compared to convergence products. Divergence represents offering of a single function in a product by abstracting function from convergence product. If multiple functions in a single convergent product are separated and specialized as independent products, a convergent product is diverged into multiple products.

So far, previous studies have discussed the concept of divergence and in various contexts such as technological, industrial, or sociological context (Jenkins, 2001). However, the term of divergence and convergence can be specialized to the level of content services, linking with incremental and recombinative innovation. In the digital content services, incremental innovation is the attempt to reuse and reconfigurate a single existing content service by applying it to other content or platforms to develop new services. Recombinative innovation, on the contrary, is the effort to combine multiple sources of existing services to create new services. Incremental innovation corresponds to the concept of divergence in terms of using one existing source into the multiple new services. By contrast, recombinative innovation is associated with the concept of convergence in terms of amalgamating the multiple existing sources into a new, innovative service. Therefore, two concepts of innovation in digital content services can be expressed as Figure 3.2.

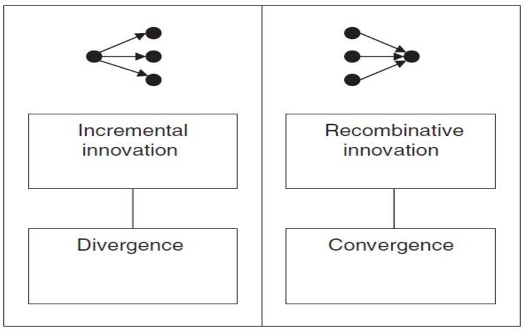


Figure 3.2 Innovation concepts in digital content services

3.1.3 Definition of components of digital content services

This module defines digital content services as '*services which content providers transfer a digital content to end users or interact with the end users through platform'*. Accordingly the digital content services can be represented as the structure in Figure 3.3, comprised of platform, product, and process.

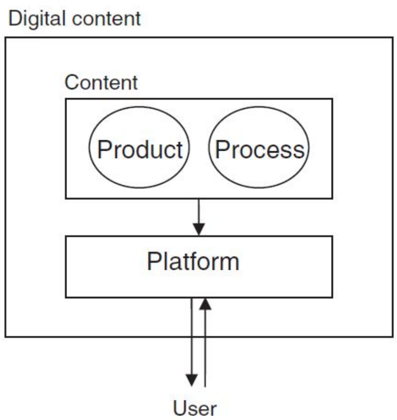


Figure 3.3 Structure and components of digital content services

First of all, the digital content is digitized product and process which is actually delivered to the customers. So it consists of two different elements: *product* and *process*. According to Choi et al. (1997) product refers to 'anything that one can send and receive over the Internet (i.e., paper-based products or multimedia products)' whereas process refers to 'any process involving multiple human interactions and communications'. The criteria for differentiating product and process are tangibility and the way of delivery. The product is tangible goods with functions, delivered via download, streaming or piecemeal fashion (e.g., daily updates). The process, on the contrary, is intangible but exists as a knowledge base, and provides the value through continual two-way interaction, continual connection or a real-time coordination with other processes. An interaction is usually defined as a simple communication between a server and a client, such as a request for a search that is accomplished by sending information and receiving a reply. The examples of product include information (e.g., books, journals, newspapers, magazines, database, and software) and entertainment (e.g., video and audio signals, multimedia products, such as movies, television programs, and sound recordings). Those of process are government services (e.g., forms and welfare payments), commerce (e.g., auctions and electronic market), community, or communication (e.g., a news clipping service and electronic messaging). For instance, an offline game in digital form is product because it is tangible and downloaded, whereas the operation method of an on-line game is process because its interaction is intangible and provided in continual connection.

Finally, the digital platform is an end-device transmitting or receiving content through the media or channel based on the technical subsystems. The digital content services contain the delivery of digital content. The digital content is delivered from a service provider to an end user through digital platform, which is composed of transport media and end-device (Shannon &

Weaver, 1949). The transport media (transmitter and channel) covers both online (e.g., narrowband internet, broadband internet, TV cable, or wireless network) and offline (e.g., CD or DVD). The end-device (receiver) includes fixed device (e.g., desktop PC, TV, or digital TV) and mobile device (e.g., PDA, mobile phone, e-book, or handheld PC) (Rawolle & Hess, 2000). Thus, the digital platform can be a combination of various types of transport media and end-devices. The digital platform can be defined at different levels based on a hierarchy of ICT such as a physical platform of communication or the logical platform for Internet. This study simply regards the digital platform as a terminal device; wired and wireless information devices, including both fixed (PC, digital TV) and mobile (mobile phone, PDA) (Rawolle & Hess, 2000).

3.1.4 Classification scheme

The patterns of innovation in digital content services are proposed based on their components. Figure 3.4 shows the overall classification scheme, which consists of three hierarchies. Fundamentally, the innovation of digital content services can be classified into divergence and convergence, as in other services. *Divergence* is a development of multiple new services by reconfiguration of one existing source service, whereas *convergence* is a development of a single new service by recombination of multiple source services. The number of sources is used as a criterion for the first-level classification, which is one in divergence and more than two in convergence.

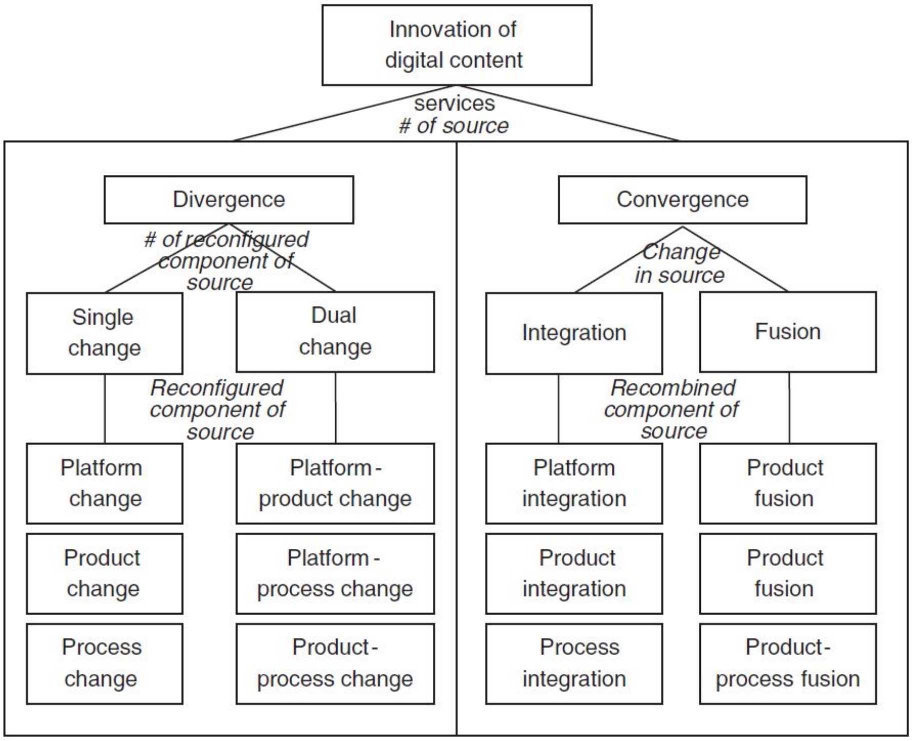


Figure 3.4 Classification scheme

Divergence is then subdivided according to what the reconfigured components of the source are. The components that can be reconfigured are a platform, a product, and a process. Since the three components can be changed separately or together, divergence is divided into *a single change* and *dual change* depending on the number of reconfigured components. The change of three components is excluded, because two dual changes cover this case. For example, platform-product-process change is covered by platform-product change and platform-process change, or platform-product change and product-process change. At the third hierarchy, a single and a dual change of divergence are sorted into sub-categories according to the components used for the changes.

Convergence is categorized into two major types, *integration* and *fusion*, in accordance with whether the purpose of the original source is changed or not. Integration means a phenomenon combining and co-operating multiple technologies vertically or horizontally to perform specific functions (Lee & Hwang, 2005), usually to solve a technological problem in collaboration with various sectors when a single area cannot solve it. Fusion refers to an innovation, combining existing technologies into hybrid technologies, which is nonlinear, complementary, and cooperative (Kodama, 1992). It stands for horizontal combination of multiple technologies to deliver new features that are not in existing technologies. Bringing the concepts of integration and fusion to digital content services, this research redefines *integration* as a physical union maintaining individual property of the element; and *fusion* as a chemical union losing individual property of the element. Accordingly, if the purpose and unique characteristics of the sources are not changed, it is integration; otherwise, it is fusion. Finally, as in divergence, an integration and fusion of convergence are divided again into sub-categories based on the component used for innovation. Table 3.1 shows the suggested typology of innovation patterns in digital content services.

Table 3.1 Identification of sub types

		Component			
		Platform	Product	Process	
Divergence	Single change	O	X	X	Platform change
		X	O	X	Product change
		X	X	O	Process change
	Dual change	O	O	X	Platform-product change
		O	X	O	Platform-process change
		X	O	O	Product-process change
Convergence	Integration	O	X	X	Platform integration
		X	O	X	Product integration
		X	X	O	Process integration
		O	O	X	-
		O	X	O	-
		X	O	O	-
	Fusion	O	X	X	-
		X	O	X	Product fusion
		X	X	O	Process fusion
		O	O	X	-
		O	X	O	-
		X	O	O	Product-process fusion

Unlike divergence, convergence has some blanks in the table. Integration is meaningful only when combining the same types of components from multiple sources as it is a physical union that maintains the original purposes from different sources. On the other hand, fusion is feasible only for content as it is a chemical union. A platform is a medium for service offerings and thus should be used for various purposes in nature regardless of contents and its purpose is unchanged. Therefore, fusion, which changes the original purposes or characteristics, is inapplicable when a platform is incorporated.

3.1.5 Methodology of App Store apps case

In order to verify the feasibility of the suggested typology, we analyzed the services in App Store by assigning the cases of innovation patterns. The applications in App Store are downloadable to the smart mobile device in the form of one-way products or two-way processes, and thus represent one of the most typical cases of digital content services. That is, an individual application can be regarded as one digital content service. App Store applications are the most representative collection of various digital contents services. In App Store, the scope of applications includes books, games, music, finance, social networking etc., and covers most of the digital content services such as commercial art, film and video, photography, electronic games, recorded media, sound recording, information storage and retrieval, etc.. Although they are offered in mobile platforms, the types of contents are relevant to common digital contents services in other platforms such as computer, TV, internet, etc. In addition, the App Store is the place where the most active innovation activities are observed and thus is suitable for innovation research. Actually, the most disruptive event in digital content sector has been the advent of Apple's App Store, a remarkable growing open market of mobile apps, which has more than 100,000 applications and developer revenues topping $900 million (Ankeny, 2010) and thus worth analyzing. A firm, whether it be an online company (e.g., Twitter, Facebook, eBay, Amazon) or an offline company (e.g., Nike, FedEx, AP, Channel), endeavors to make digital content for their own services or service differentiation through mobile platform.

In order to sample applications, this study utilized the service library in Apple's App Store. We studied a total of 200 applications from 20 categories (e.g., books, business, education, entertainment, finance, games, healthcare and fitness, lifestyle, etc.) by sampling the top 10 applications from each category. Firstly, the elements of each application are discriminated referring to the description in App Store. As expected, there are various applications including product content for entertainment or information (e.g., e-book, music, game, news, or photography), process content for communications or community functions (e.g., social networking, finance, navigation or travel), or combination of two types of contents. Secondly, the sources are investigated based on the description in App Store or web-search. Since the applications are regarded as the outcome of divergence or convergence, pre-existing source service should be identified. Some of the applications are including the reference (e.g., 'this application is developed using the other application') in the description, but the others are not, so that we should search for a clue in the web. Needless to say, the services not derived by divergence or convergence of pre-existing services are excluded. As a result, 57 services are identified as divergent or convergent service. Lastly, we investigated the way the elements of source changed or combined. Among 57 services, 12 representative and appropriate applications are extracted for illustration of each innovation pattern.

3.1.6 Characteristics of divergence

First, the types of divergence in digital content services are classified into two major categories: single change and dual change. Both single and dual change uses an existing one source and derives new services to create high value for the customer. However, single change is a reconstruction of one component of a source independently, while dual change is a case when two types of single alternation occur together, leading to changes in two components of the source, and so is more complex. The characteristics of single and dual changes are discussed in Table 3.2.

Table 3.2 Characteristics of two major types for divergence

Type	Characteristics
Single change	- Deriving a variety of new services by changing a single component of a source
Dual change	- Applying two types of a single change simultaneously and dependently

	- Deriving a variety of new services by changing a combination of two components of the source

Second, single change and dual change are again separated into six detailed types: platform change; product change; process change; platform-product change; platform-process change; and product-process change. Table 3.3 summarizes the definitions of six types in divergence based on which the structural characteristics of innovation patterns are displayed in Figure 3.5.

Table 3.3 Definition of six detailed types for divergence

Type		Definition
Single change	Platform change	Providing the source for the new platform by converting digital compression or transmission protocol
	Product change	Reconstructing the existing product by changing its one-way function, information, or genre
	Process change	Reconstructing the existing process by switching the mode of interaction or provision
Dual change	Platform-product change	Providing the source for the new platform, but also reconstructing the existing product creatively by linking with the new platform
	Platform-process change	Providing the source for the new platform, but also reconstructing the existing process creatively by linking with the new platform
	Product-process change	Reconstructing the existing product and process of the source dependently each other

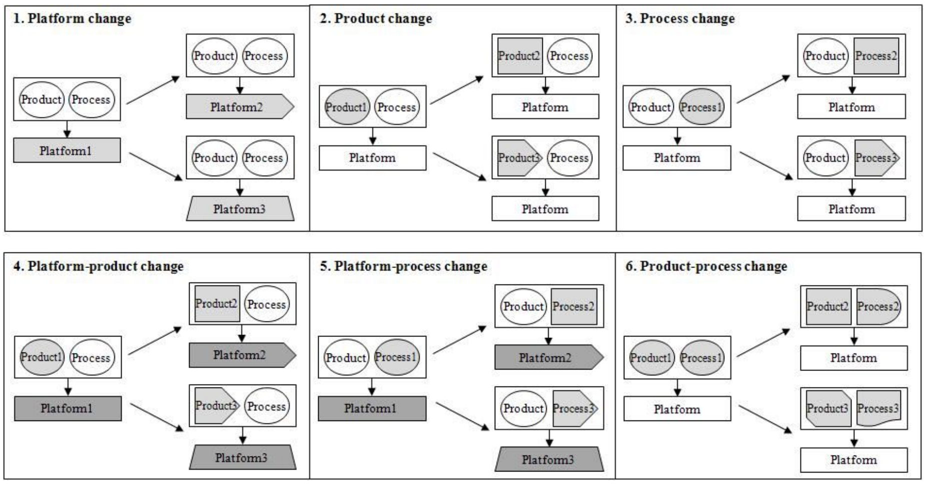


Figure 3.5 Patterns of divergence in digital content services

For divergence-type innovation, after sources of services that have been developed and evolved into new services are identified, features of the original services and new services are analyzed. The case study results of divergence are summarized in Table 3.4 and the screenshots of applications are shown in Figure 3.6.

Table 3.4 Patterns of divergence for App Store app services

Type		Application	Source	Feature	
				Previous	New
Single change	Platform change	eBay Mobile	eBay	PC	Mobile phone
	Product change	BeatRider	Rhythm action game	Internal music	Uploaded music

	Process change	TwitterTime	Tweet	Read & write	Automated view-only
Dual change	Platform-product change	Lightsaber Unleashed	Star Wars	PC, Theater Movie	Mobile phone Motion game
	Platform-process change	Hotel Booker	Hotel information, booking & canceling	PC Search & listing	Mobile phone Near searching
	Product-process change	iPet Dogs	Pet raising game	Raising my pet Communication	Raising friends' pet Community

Figure 3.6 Case of divergence in App Store app services

Platform change provides the new service by applying existing content for another platform, with no change in intrinsic offering of content. Format of user interface of content may be changed because of platform feature, but it is platform change if there is no change in the original function or purpose of source. *eBay Mobile* is the result of transferring the content and function of eBay website used in PC to mobile phone. It has the same product and process of the eBay such as search, bid, and check their activity, but different platform. And so its interface has optimized to a new platform and application features have changed for new platform, not product nor process.

Product change provides the innovative new service by supplementing functions or changing the genre and structure of an existing product. Product or process change transforms sources to other products or processes regardless of platform. Since the outcome of product or process change can be used in the existing platform, product or process change is differentiated with a platform change. *BeatRider* is a button touching game to match with keys coming down and music rhythms, as shown in Figure 3.6. This type of rhythm video game has been enjoyed by users for a long time with a game console (e.g., Beatmania). What has changed is the music. In the traditional game, a list of music songs are embedded in the application, but in *BeatRider*, music songs can be uploaded from users as well. Users can enjoy both the embedded music and uploaded music, as the uploading function is supplemented to existing rhythm video game. The music content is product and critical function is added on the music, thus it corresponds to product change.

Process change offers new service with changed process by switching the mode of interaction or provision. *TwitterTime* provides tweets, short messages posted by users, displaying them automatically. Applications like *Twitterrific* and *Tweetie* offer the original Twitter service, reading and writing tweets, but *TwitterTime* is view-only and automatic just like a slide show. It used tweet as source and changed interaction process of providing it from read and write to automated view-only method. This process is not dependent on the platform, because it can be realized in the other platform.

As dual change is an extension of a single change, the basis of classification is similar to each other. Platform-product change reconstructs both platform and product from an original source. A new product with supplementing functions or altered genre is provided by a new platform. Platform-product change and platform-process change transforms sources to other products or processes associated with new platform. The features of the new platform may affect and be affected by the product change and process change and the outcome of product or process change can be only used in the new platform. *Lightsaber Unleashed* is a unique game. When a user chooses one pair of characters and light sabers of Star Wars, and then he or she swings iPhone, the sound effects are emitted. Since this game utilized items of the Star Wars movie as a source of a new game, product change has happened. In addition to the product change, it also utilized the characteristics of the new platform, the gravity sensor of iPhone and iPod Touch like Wii.

Similarly, platform–process change transforms a switching mode of interaction and provision, linked with the characteristics of the new platform. *Hotel Booker* provides hotel information (e.g., photo, review, maps) and the function just like a hotel booking website (i.e., booking, canceling). What is distinctive is the way of hotel searching. The existing service finds hotels by searching and listing, but this application uses real-time automated near searching, enabling users to find hotels around their location. Not only the platform is altered from PC to mobile phone but also the process is changed from simple information searching to near searching. On top of that, this new process depends on the feature of new platform (i.e., mobile and GPS).

Finally, product-process change reconstructs product and process, which are closely related. *iPet Dogs* is a pet raising game; adopting a pet to feed, to play with, and look after through its life. There have been similar games (e.g., *Tamagotchi*) where users can play with their own pets. The users communicate with other users, (usually friends in the real world), to chat or exchange their online items. Unlike the existing games, *iPet Dogs* is a very social and community-centric game. It provides the community with *Pet World*, where users all over the world become friends and participate in raising each other's pets. In the *Pet World*, they can feed the others' pets as well as their own by saving the pets in the 'favorites' category. The change of raising the object from 'own pet' to 'friend's pet' indicates product change, while the change of interaction among users from 'communication-centric' to 'worldwide-community-centric' falls under process change. Because two changes should be closely connected to be a social pet raising game, it is product-process change.

3.1.7 Characteristics of convergence

First, the types of convergence in digital content services are classified into two major categories: integration and fusion. Integration and fusion have in common that they both use multiple sources to create new value for customers. However, integration is a combination of different sources with no changes in the baseline sources. The characteristics of original sources are valid after the integration. On the contrary, fusion is a combination of different sources with changes in the original sources, resulting in an irreversible innovation. The characteristics of integration and fusion are discussed in Table 3.5.

Table 3.5 Characteristics of two major types for convergence

Type	Characteristics
Integration	- A physical combination of different sources to be a single one - No changes in the original purpose of sources - Maintaining the unique characteristics of original sources when they are separated after integration
Fusion	- A chemical combination of different sources to be a single one - Changes in the original purpose of sources - Losing the unique characteristics of converged content services and being perceived as different content when they are separated

Second, integration and fusion are again divided into six detailed types: platform integration; product integration; process integration; product fusion; process fusion; and product-process integration. Table 3.6 describes the definitions of six types, based on which Figure 3.7 represents their structural differences.

Table 3.6 Definition of six detailed types for convergence

Type		Definition
Integration	Platform integration	Integrating the sources through the interaction of two platforms
	Product integration	Integrating the sources simply by providing additional tangible products
	Process integration	Integrating the sources simply by providing additional intangible processes
Fusion	Product fusion	Combining the sources by overlapping and requiring close relationship between products
	Process fusion	Combining the sources by continuous processing and systematic coordination between processes
	Product-process fusion	Combining the sources from both product and process by providing continually, associating main purpose of each source

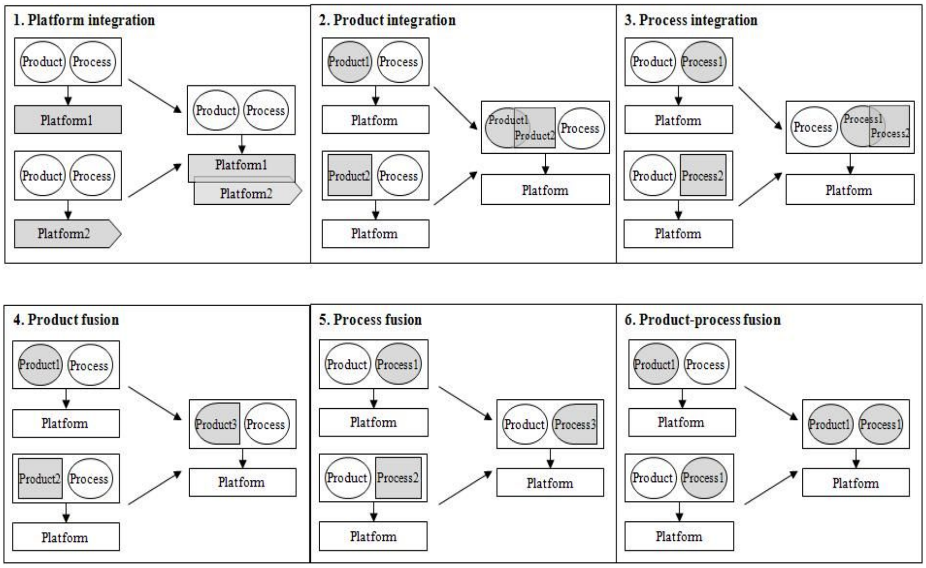


Figure 3.7 Patterns of convergence in digital content services

For convergence-type innovation, applications that have originated from multiple sources, as an outcome of recombining sources, are collected and the sources involved in creating the new application are analyzed. The results are described in Table 3.7 with the screenshots of applications in Figure 3.8.

Table 3.7 Patterns of convergence for App Store app services

Type		Application	Source		Outcome
			Source1	Source2	
Integra-tion	Platform integration	i-Clickr Powerpoint Remote	PC PowerPoint	Mobile phone PowerPoint	Mobile phone as smart presentation pointer

	Product integration	Cooliris	Image (Google, Bing, Ask)	Video (YouTube)	Collection of image/video in real time
	Process integration	Shopper	List-aisle matching	Share	Collection of shopping list managing and sharing
Fusion	Product fusion	Layar Reality Browser	Camera	Local information	Local information on top of reality browser
	Process fusion	QRooQRoo	Barcode matching	Price comparison	Searching the lowest price of recognized product
	Product -process fusion	iFooty	League match (bbc.com)	Chatting	Chatting about league match

Figure 3.8 Case of convergence in App Store app services

Platform integration provides the new service by integrating the different platforms. Sources and contents are provided within the integrated, connected, and interacted platforms. What is at the core in integration is that the original sources are unlikely to be changed, providing the aggregation of multiple sources collectively. '*i-Clickr PowerPoint Remote*' makes iPod or iPhone as a smart presentation pointer by providing complete control of PowerPoint presentation including the view and navigation of slides and slide notes. It combined the two sources, PowerPoint slide show for PC and mobile phone. PowerPoint can be run on each platform, PC and mobile phone; the objective of original source, which is to provide the 'PowerPoint slide show' function, has not changed. However, the contents can be provided more effectively in *i-Clickr PowerPoint Remote* just by connecting the two platforms.

Product integration provides the innovative new service by integrating the different products into new products. *Cooliris* provides a collection of images and videos from a variety of websites such as Google, Bing, Ask, and YouTube. Images and videos are products. The objective of original source, providing photos and videos, has not changed at all; the service connects the separated products from several websites to help search and download easily and quickly. Therefore, products from the existing sources have been integrated to create a new content service.

Process integration integrates the processes from different sources into new processes. In the same way, *Shopper* is shopping management service that offers a collection of the matching process between the user generated shopping list and store's aisle layout (managing the list by multiple store) as well as the list-sharing process to share user's shopping list with their friends. List-aisle matching function and sharing function are processes; they have little relevance and are provided as an option, resulting in preserving original objectives. However, *Shopper* can effectively provide utilitarian and hedonic value together in a single digital content service by aggregating two processes.

Fusion is a combination with changes in the baseline sources, resulting in the overlap and deep interactions between sources to provide the unified and irreversible outcomes. Product fusion combines the sources by overlapping to provide a new type of product. *Layar Reality Browser* is an augmented reality service that overlaps local information on top of camera’ s reality browser as shown in Figure 3.8. Users can find and navigate to the nearest spots in the real scenery of the mobile phone camera. In this case, both camera scene and local information are products. However, their original purpose is changed; the camera is not for taking pictures in this application, but for providing a reality screen specialized for local information. By combining two products in a one digital content service, their interaction created a new service.

Process fusion is the innovation from combining the sources to design a new type of process. *QRooQRoo* is a barcode scanning service for recognizing goods, searching for them on websites, and comparing their prices from several shopping malls successively. Its sources are the barcode matching process and the price comparison process. Their original objective is also changed, because barcode matching is prerequisite for price comparison whereas previously it was simply for recognizing and identifying real goods. As a result, *QRooQRoo* can provide well organized new price comparison function.

Lastly, product-process fusion is the attempt to combine the sources from both product and process to create new types of content services. *iFooty* provides a league match information product as well as a chat room process to discuss league matches. Although physical space is not overlapped, the main purpose of the process has been altered. It has been changed to talking about particular matches specialized for league match information; whereas the original purpose of a chat room was to facilitate users to chat about any topic. In this way, the product of league match information and the process of chat rooms interact to provide a new service.

3.1.8 Conclusions

This module proposes the patterns of innovation in digital content services. The research applied the top-down approach to systematically define innovation patterns and comprehensively investigate the directions of innovation based on the elements of digital content services. We defined the structure of digital content services using three building blocks: product, process, and platform. Basically two types of innovation patterns are established as divergence and convergence, and six types of each pattern are suggested with the illustration of App Store applications.

The typology and examples in this research have theoretical contribution to serve as the basis of service innovation research especially for digital content services. This study identified sector-specific patterns of innovation in digital content service and made an effort to explore the dynamic process to derive and recreate services from existing service. It supplements the previous research that only has focused on the general classification of service innovation, or digital content service innovation in the limited context. Moreover, the research has implications on the most advanced theoretical model of innovation; integrative or synthesis approach (Gallouj & Savona, 2009). This area redefines the product as integration of material − immaterial or goods − services and emphasizes functional approach. Since this module defined digital content service as integrated offering of product (material) and process (immaterial), and considered the elements of service, it can advance a clue to identify new innovation model for digital content service. In addition, this research facilitates the understanding of service innovation for new emerging digital content services in App Store. In the context that smartphone and App Store are explosively developing, this study covered a valuable research subject in terms of how innovation occurs from concept and content standpoints.

This module also delivers the managerial and practical implications regarding technology innovation and new service development. The approach of this study is related to re-creation strategies, investigating the opportunistic sources and exploring the possibilities of divergence and convergence based on the characteristics of content in new service development. Particularly, it tells firms where to concretely find innovative ideas, when they identify the elements of their digital content services. For example, if the developer identified the opportunistic sources (i.e., existing services), he or she can investigate what elements are in the sources (i.e., platform, product, process), and substitute or integrate the elements of sources according to the typology. In this way, developer can map the elements of sources to divergence or convergence approach to create a new service idea. Furthermore, this module is linked to the perspective of open innovation, because the source of divergence or convergence can be internal or external to existing services. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to markets, as the firms look to advance their technology; in opposition to closed innovation that considers only internal ideas and internal market (Chesbrough, 2004). 'Exploration' to utilize external sources can be especially concretized by the typology of this research.

However, this module has some limitations. Firstly, a clear distinction between product and process is still required. Although we provided the definitions and examples of product and process, detailed characteristics and criteria should be supplemented. Secondly, this study takes into account the general facets of innovation in digital content services from a service characteristics' point of view. Since there are other characteristics such as technical or competence characteristics, they can be identified for developing characteristics-based innovation model (Gallouj & Weinstein, 1997). Thirdly, verification issues can be raised because of case examples and the approach to classification. This module utilized only a few cases of Apple's App Store applications for illustration. Also, the process of selecting applications may not support the representativeness of all of digital content services.

There is also room for future research. Firstly, further research should cover the type and characteristics of content. Investigating clear definitions of product and process and applying them to integrative development of digital content service must be a challenge. Secondly, new model or method for digital content service innovation can be developed based on this research. The method to develop divergent or convergent service, including identifying opportunistic sources, extracting the elements from source, and reconfigurating or recombining those elements into new services, can be studied in future research. Lastly, the typology should be elaborated by analyzing the innovation phenomenon in a lot of cases to explore the patterns through a bottom-up approach or verify the result of top-down approach. The empirical test can be applied to a number of App Store applications as well as other cases of digital content service. Since App Store is an attractive source representing active innovation, analyzing them in depth will get much value in future research.

3.2 Analyzing potential of futuristic data in tech-foresight community

3.2.1 Introduction

For tech-foresight community, many research questions on futuristic data may arise: What is futuristic data? Why is futuristic data so important in the previous streams of technology foresight methods? What are the characteristics of futuristic data? How can we exploit futuristic data in future technology foresight approach? As a reminder, the definition of futuristic data in this thesis is a collection of online extracted documents about the future of technology that incorporate large participations of the experts and the public. As we have shown in theoretical backgrounds on tech-foresight community information, many previous researches suggested the opportunities regarding futuristic data as a source of community-based foresight. This module attempts to find exploratory answers to other questions by empirically analyzing the characteristics of futuristic data. To gain a better understanding of futuristic data, we have chosen to juxtapose futuristic data with patent data, as it is one of the most representative indirect data sources utilized in the previous research of technology foresight. An empirical analysis is implemented on the characteristics of futuristic data compared to patent data. We collected data from two sources and analyzed their features of contents in terms of future-orientation, information scope, and perspective. Synthesizing theoretical and empirical evidences, we discuss the future research opportunities to exploit futuristic data in technology foresight.

3.2.2 Methodology

Three experiments were conducted for randomly selected technology areas: (1) cloud computing - a technology which provides users and enterprises with various capabilities to store and process their data in third-party data centers (Haghighat et al., 2015), (2) ubiquitous computing - a concept where computing is made to appear everywhere and anywhere, and (3) wearable computing technology – a concept of incorporating computer and advanced electronic technologies into clothing and accessories. The reason why we selected computing technology was that large volume of futuristic data is mostly dealing with ICT industry.

3.2.2.1 Data

The data source for patent documents is USPTO (the United States Patent and Trademark Office) database. On the other hands, the data sources for futuristic documents are five websites including Siemens, MIT Technology Review, Kurzweil Accelerating Intelligence, World Future Society, and FutureTimeLine, as shown in Table 3.8. The website of Siemens, a German multinational engineering and electronics conglomerate company, provides the future magazine reports that predicted technologies capable of changing the daily after 10 to 20 years. The reports describe R&D-related future scenarios along with the image and interviews with the experts who have been worldwide attention. Other websites including MIT technology review, Kurzweil Accelerating Intelligence, World Future Society, and FutureTimeLine - the communities of future experts or futurists - offer a number of articles (i.e. web posts, blogs, or news) regarding how various products and technologies that have attracted attention recently (e.g. smart watch, electric car, or iPad) will be changed and which elements of the product are future-oriented. The World Future Society is the largest nonprofit educational and scientific organization in the futures field, and they share future trends and perspectives in their websites. FutureTimeLine has a speculative timeline of the future history (from 21st century to beyond 1 million AD), which is based on the collaboration of scientists, futurists, inventors, writers and anyone else interested in futurology.

Table 3.8 Sources of futuristic data for experiments

Name	Technology area	URL
Siemens	IT, energy	http://www.siemens.com/innovation/en/publications/index.htm
MIT Technology Review	communication, computing, business, biomedicine, energy	http://www.technologyreview.com/topics/
Kurzweil Accelerating Intelligence	AI & robotics, biomedical breakthroughs & life extension, biotechnology, computing, cognitive science & neuroscience, etc.	http://www.kurzweilai.net
World Future Society	commerce, earth, futuring, humanity, Sci/Tech, governance	http://www.wfs.org
FutureTimeLine	AI & robots, biology & medicine, business & politics, computers & the Internet, energy & environment, etc.	http://futuretimeline.net/index.htm

3.2.2.2 Method

As illustrated in Figure 3.9, this study analyzes futuristic data and patent data in order to investigate and compare their characteristics and suggests four basic steps: data collection, data preprocessing, topic identification, and comparative investigation. After collecting and preprocessing patent DB (pDB) and futuristic DB (fDB), the topics in each DB are identified as keyword clusters and used for further comparative investigation.

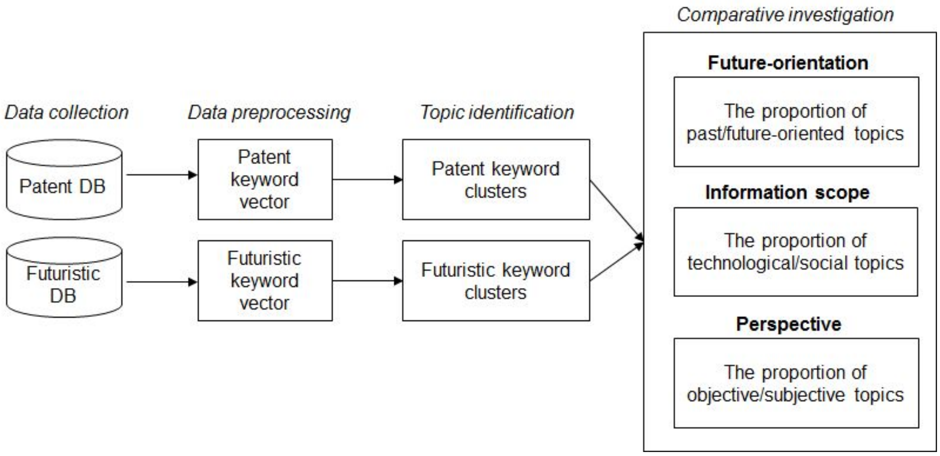


Figure 3.9 Process of experiments

More specific descriptions are as follows. First, patent and futuristic documents are collected by crawling USPTO and five futuristic websites, respectively, and pDB and fDB are constructed. Data are collected by web-crawling technique and cleaned by removing html frames and tags etc. Second, since both DBs are unstructured data composed of natural language, they are processed into an analyzable and structured format by text mining.

The keywords themselves are too fragmented to interpret the meaning of documents; we apply the clustering analysis to the keyword vectors based on the similarity of keyword occurrence among documents. A subsequent cluster of keywords are regarded as a topic. Then, the topics of both data are compared. Since futuristic data includes the investigation on how the social, economic, and technological developments are shaping the future, we hypothesize that following three distinctive characteristics can be identified: future-orientation, information scope, and perspective. Three experts of data and future research domain have evaluated the degree of future-orientation, technology/social-orientation, and objectivity/subjectivity of every topic in five-Likert scale. Since each topic has various keywords, the meaning of the topic can be recognized as both technological and social; therefore, we assessed the degree of technology-orientation and social-orientation separately. Objectivity and subjectivity are evaluated in a similar logic.

3.2.3 Comparison of futuristic data with patent data

3.2.3.1 Results and findings of experiments

First of all, the results of data collection and data preprocessing are summarized in Table 3.9 and Figure 3.10. As shown in the 'keywords extracted' in Table 3.9, the number of keywords extracted from fDB is higher than that from pDB; thus, fDB seems to provide more various keywords. In case of cloud computing and ubiquitous computing, fDB provides more keywords than pDB, even though the volumes of collected documents in two DBs are similar.

Table 3.9 Results of data collection and data preprocessing

Technology	Description	Patent DB (pDB)	Futuristic DB (fDB)
Cloud computing	Time data collected	Jun. 2014	
	Data search	“clouding”, “cloud computing”	
	Data collected	325 documents	390 documents
	Keywords extracted	341 keywords	470 keywords
Ubiquitous computing	Time data collected	Jul. 2014	
	Data search	“ubiquitous computing”, “ubiquitous service”	
	Data collected	224 documents	269 documents
	Keywords extracted	256 keywords	337 keywords
Wearable computing	Time data collected	Apr. 2014	
	Data search	“wearable”, “wearable computing”	
	Data collected	340 documents	454 documents
	Keywords extracted	486 keywords	730 keywords

In Figure 3.10, the ‘common’ keywords appeared in both pDB and fDB are investigated. In cloud computing case, the number of common keywords is 148, which accounts for 43% of 341 keywords of pDB and 31% of 470 keywords of fDB. The number of common keywords in ubiquitous and wearable computing is 86 and 184 respectively. In sum, the average

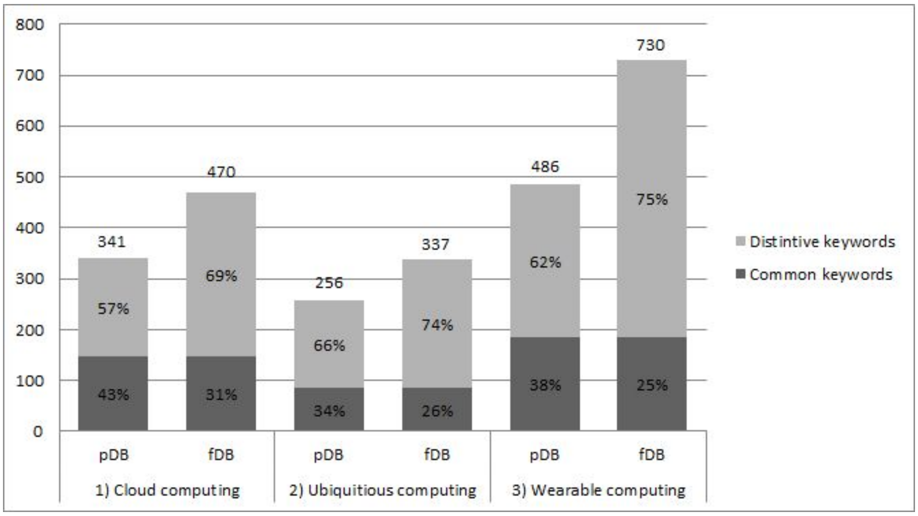


Figure 3.10 Number and proportion of common and distinctive keywords

proportion of common keywords in pDB is 38.3%, and this implies that fDB can capture about 40% of information in pDB. We also compare the proportion of distinctive keywords in fDB among the technology fields. The proportion of distinctive keywords in fDB is 69% (cloud computing), 74% (ubiquitous computing), and 75% (wearable computing). As ubiquitous and wearable computing are known to be more recently emerged technology than cloud computing, the proportion of distinctive keywords in fDB slightly increased in accordance with technology newness. This can be the evidence that fDB can capture more different keywords than pDB as technology advances.

As the results of keywords clustering, topics identified from two DBs in three technology areas are listed in Table 3.10. The percentage in the parenthesis is the proportion of a topic, measured by the number of keywords corresponding to the topic divided by total number of keywords in a DB. Since the number of keywords is larger in fDB than in pDB, the number of topics becomes accordingly more at every technology (greater number of topics is extracted accordingly for each technology).

Table 3.10 Lists of identified topics and their proportion in each DB

Technology	Patent DB (pDB)	Futuristic DB (fDB)
Cloud computing	(1) System element (14%) (2) Data storage (12%) (3) Communication & location (15%) (4) User management (12%) (5) Transmission infra (23%) (6) Transmission constraint (14%) (7) Industrial application (9%)	(1) Stakeholder (10%) (2) Accessibility & interface (9%) (3) Law & property (9%) (4) Device (6%) (5) Emotional application (11%) (6) Data storage (7%) (7) Business model (10%) (8) Individual security (8%) (9) Collaborative work (13%) (10) Industrial application (10%) (11) Office work (8%)
Ubiquitous computing	(1) Physical component (14%) (2) Internal entity (22%) (3) Data storage (10%) (4) User security & manage (15%) (5) Location & environment (16%) (6) Algorithm & principle (12%)	(1) Physical component (17%) (2) Media & communication (18%) (3) Stakeholder (11%) (4) Industrial application (8%) (5) Collaborative work (16%) (6) Health (12%) (7) Business & culture (11%) (8) Computing element (7%)

	(7) Communication (11%)	
Wearable computing	(1) Basic function (16%) (2) Wearing element (8%) (3) Material (9%) (4) Treatment (9%) (5) Health measurement (12%) (6) Artificial organ (10%) (7) Computing elements (12%) (8) Smart & media (11%) (9) Configuring module (13%)	(1) Medical & bionic (13%) (2) Infotainment (9%) (3) Workplace & office (12%) (4) Nanotech (6%) (5) Robotics for the handicapped (6%) (6) Healthcare & neuroscience (7%) (7) Industrial application (5%) (8) Military robotics (5%) (9) Electronics & interactive system (4%) (10) Media (5%) (11) Fitness & wellness (6%)

Finally, the results of comparative evaluation are described in Figure 3.11, 3.12, and 3.13. The degrees of future-orientation, technology/social-orientation, and objectivity/subjectivity of the topics in one DB are aggregated by weighted sum of all degrees of the topics using the proportion of topic as weights. First, in terms of future-orientation, fDB provides relatively more future-oriented information than pDB. In Figure 3.11, the degree of future orientation in pDB is evaluated as 1.8~1.9 out of 5, whereas that of fDB is assessed as 2.2~2.8 out of 5. The future-orientation of fDB of wearable computing is the highest, with high future-oriented topics such as 'robotics for the handicapped' (including distinctive keywords like 'robotic exoskeleton', 'avatar', 'somatosensory', etc.) and 'electronics & interactive system' (including distinctive keywords like 'omnitouch', 'supercapacitor', 'telepresence', etc.). Thus, we can identify that the topics appeared in fDB evaluated as more future-oriented than that in pDB.

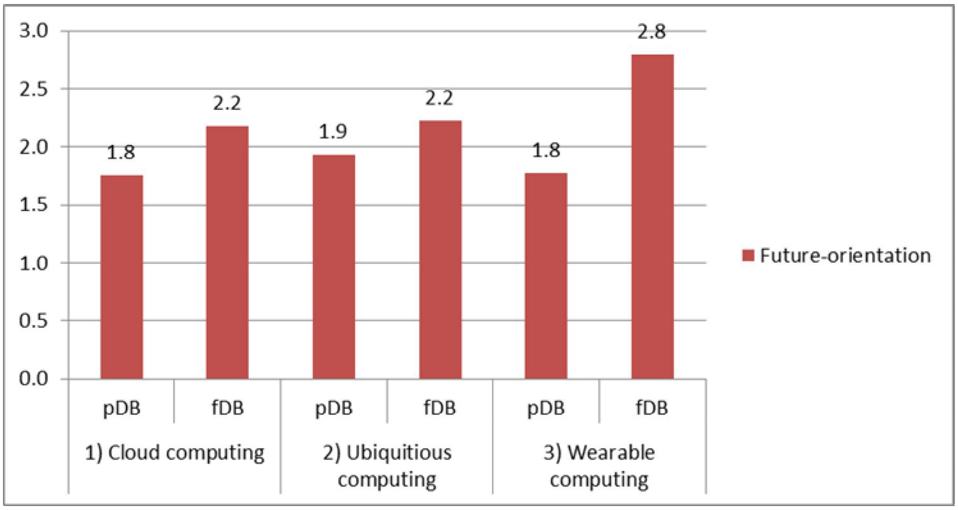


Figure 3.11 Result of comparative evaluation on future-orientation

Second, in terms of information scope, the topics appeared in fDB is less technology-oriented and more social-oriented compared to that in pDB for all three technology area, as shown in Figure 3.12. The social-orientation of fDB of cloud computing is the highest, with high social-oriented topics such as 'business model' (with distinctive keywords like 'revenue', 'beta', 'family', 'webkit', etc.) and even 'law & property' (with distinctive keywords like 'lawsuit', 'standard', 'trademark', etc.).

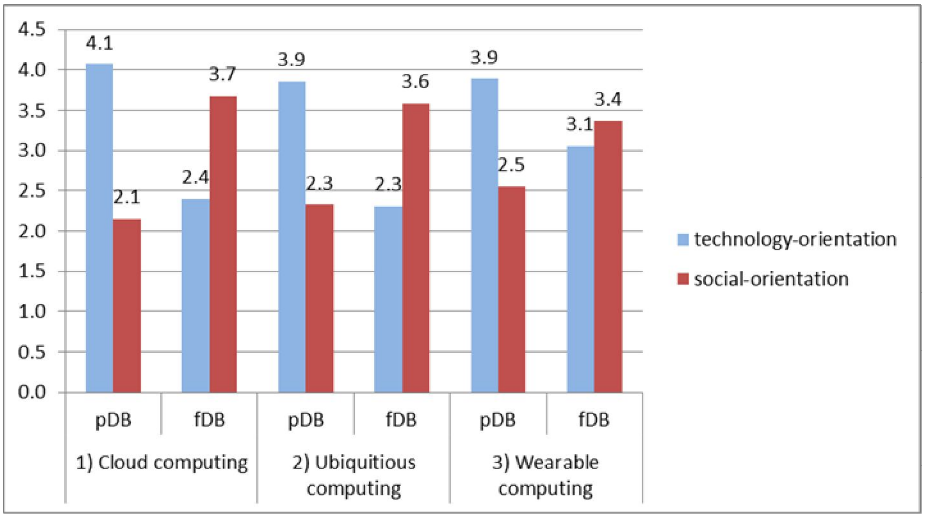


Figure 3.12 Result of comparative evaluation on information scope

Lastly, in terms of perspective (Figure 3.13), fDB tends to include more subjective information compared to pDB for all three technology areas, even though overall perspectives are objective rather than subjective. Contributing topics of fDB are 'collaborative work' and 'office work' of cloud computing, and 'healthcare & neuroscience' of wearable computing.

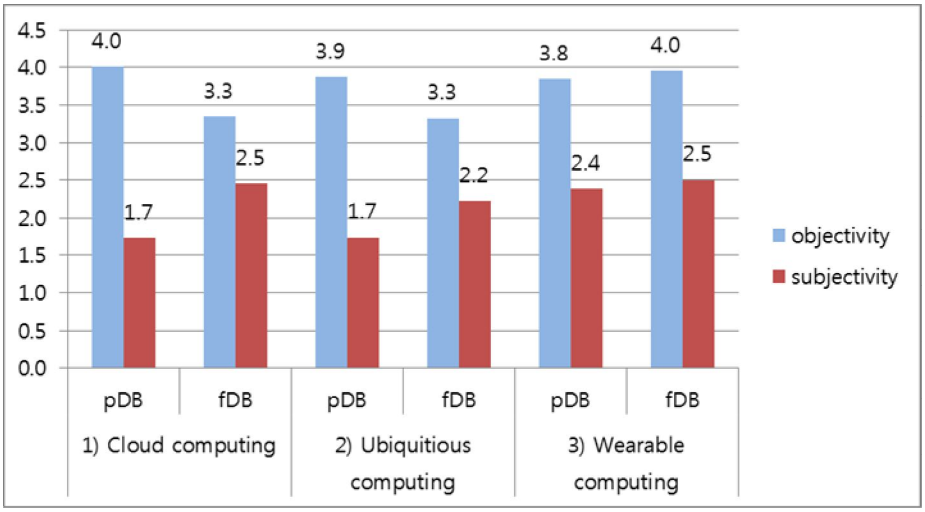


Figure 3.13 Result of comparative evaluation on perspective

3.2.3.2 Comparative characteristics of futuristic data

From the previous theoretical bases and experimental investigations, we identified comparative characteristics of futuristic data and summarized in Table 3.11. First, futuristic data contain information of unrealized or developing technologies, whereas patent data focused on the past and existing technologies. Second, compared to patent data, which mainly deal with technological details, futuristic data contain information of various technological advances and applications specifically related social factors. Third, while patent data are composed mostly of information with high objectivity, futuristic data provide not only objective but subjective information since they are detailed predictions of future technologies generated by various experts, such as futurologists and managers of leading global companies, as well as the public.

Table 3.11 Comparison of patent and futuristic data

Criteria	Patent data	Futuristic data
Provider	Technology developers	Various stakeholders (experts, the public, private firms, public organizations)
Openness	Closed	Open (collective)
Form of data	Refined (semi-structured)	Unrefined (unstructured)
Future orientation	Posteriori (developed technology)	A priori (developing or undeveloped technology)
Scope of knowledge	Scientific information Technological details	Market, social, product, technology trend
Subjectivity	Objective	Objective and subjective

3.2.4 Integration of futuristic data with patent data

3.2.4.1 Application of futuristic data to technology foresight

Based on their future-orientation, knowledge scope, and perspective, futuristic data can be effectively utilized as the core resources and capabilities for scanning discontinuous or disruptive innovation. First, future-orientation of futuristic data may provide remedial opportunity responding to fundamental shortcomings of previous sources in that they only provide posteriori trends of technology evolution, not future trends. Second, a variety of knowledge scope in futuristic data can aid comprehensive scanning, broadening more input for quantitative approaches. If we continuously analyze and leverage them into technology foresight, various future issues related not only to technology but society, economy, culture, or even politics can also be derived and thus lead to more extensive foresight studies. For instance, futuristic data can be applied in scanning approaches such as weak signal, environmental scanning, and emerging issues analysis. Lastly, the mixture of objective and subjective information in futuristic data can complement existing quantitative and qualitative approaches. The subjective opinions play an opportunistic role for supplementing participatory projects; that is, information from subjective part of futuristic data can be utilized as the substitute for expert-based qualitative approaches such as Delphi. Since the number of the writers of futuristic data is extremely greater than a simple participatory approach, futuristic data cover broader opinions (i.e. collective intelligence) with various topics, which can be lacking in the participation of a set of experts (Ciarli et al., 2013). However, the samples can be still biased toward a specific group of stakeholders: those who access to the Internet and use intensively for (social) communication (Ciarli et al., 2013). In this case, the methods of identifying such actors and quantifying and aggregating their subjective opinions should be developed and applied. The objective information of trends also provide new opportunities as databases in capable of supporting the search and scan for various topics. In this purpose, the approaches focused on detecting and extracting topics are needed.

The challenge for leveraging futuristic data into technology foresight can be related to nature of online communities (Cachia et al., 2007). In collecting or developing futuristic data from websites with unstructured and non-hierarchical information management systems, there is an imminent risk of derailing any discussion away from the central topic. In this regards, data collection and preprocessing should focus on identifying only the accurate data related to central research topic and filtering garbage out. Furthermore, utilizing collective consensus index is important to ensure the reliability of the data. Most of futuristic data can be disorganized and unstructured, even more than patent data, in raw textual formats and void of machine-readable semantic relations. There is simply too much information to read. The valuable information and knowledge are buried deep within the data, and it is thus a challenging task to find them with manual analysis. In response, the systematic ways to uncover, interpret and digest knowledge over large numbers of futuristic documents should be explored. Basic approaches can be text mining, semantic analysis, data mining, network analysis, and visualization to structure the unstructured database and extract key topics in the documents.

3.2.4.2 Dimensions and methods for integration

As patent data and futuristic data are mutually complementary, their integration has great potential to support technology foresight. The dimensions of integration can be suggested as the same way of comparative characteristics: contents, timelines, and perspectives. The core of this integration is that they accelerate the combinative approaches of qualitative and quantitative methods in technology foresight.

Integration in terms of contents

Patent data contain detailed description on developed technology while futuristic data involve various social-oriented information, such as markets where the technology will be commercialized, scenarios regarding users' utilization of the technology, and information about social impact of the technology, etc. The integration can arise in terms of technological-social contents of two data. If the technological and social information are integrated in technology foresight process, a wider range of knowledge can be explored in the earlier step to identify key drivers and alternatives of technology foresight and to model their relationships qualitatively. Consequently, two data can be integrated as an input for the variables and alternatives of technology roadmap (TRM), morphological analysis, and casual layered analysis. For instance, in technology roadmapping, the keywords extracted from futuristic data can be the alternatives for market layer whereas that from patent data can be utilized as the alternatives for technology layer. Similarly, the integration of patent and futuristic data can be utilized as an input for scenario modeling associated with cross-impact analysis, fuzzy cognitive map, system dynamics, and agent-based modeling, etc. In cross-impact analysis, for example, the technological and social elements can be selected, and their initial cross-impacts are measured by examining relationships between two data.

Integration in terms of timelines

Although patent data represent the patterns of technology advances from past to present, futuristic data include more future-oriented information of presently developing technology and undeveloped technology. Thus, the integration can be achieved by linking their timelines, covering past to present using patent data and present to future using futuristic data. When applied in probabilistic modeling, for example, the occurrences of technological and their related social events can be patterned over time by modeling them separately and then linking the timelines of two data sources. Representing and estimating the variation of states, the methodologies like hidden markov model (HMM) or Bayesian belief network (BBN) are prime examples of such a case. Moreover, integration of two data may be applied also in trend analysis, where technological evolutions and technology trends are predicted. In trend-impact analysis, after modeling and extrapolating technology development patterns using patent data, we can explore future scenarios and events regarding the technology from futuristic data and incorporate such information for adjusting extrapolation results. This can be helpful to overcome incongruity of the assumption in trend/growth analysis because the future prediction is based not only on trend extrapolation, but on various set of scenarios and their impacts associated with the technology, which can be sourced by collective intelligence.

Integration in terms of perspectives

Lastly, the integration can be also useful in terms of objective-subjective evaluative perspectives of two data. Since patent data are purely objective whereas futuristic data present the subjective opinions of various experts and stakeholders, the integration of two data can reflect a broader range of perspectives especially when evaluating technologies' importance and making decisions for strategic planning. For instance, in participatory foresights in online platforms such as real-time Delphi, futuristic data generated from such approaches are aggregated and patent data regarding the topic of foresight can be suggested as reference material for leading the participants more flexible thinking and decision making. In evaluating future technology alternatives for identifying relatively promising technologies, patent data can provide actual evidence of emerging technology whereas futuristic data can provide collective insights on technology brightness. In this context, two data can be integrated for setting the criteria and priority of evaluation and measuring actual scores in multi-criteria decision making approaches.

3.2.5 Conclusions

This module has suggested the potential of futuristic data as a source of technology foresight. As an exploratory work, this study investigate the theoretical backgrounds regarding the emergence of futuristic data in advancements of technology foresight approaches, and identify the empirical evidence of advantage in exploiting futuristic data for technology foresight. The potential of futuristic data greatly increase when they are combined with retrospective data such as patent data in terms of contents, timelines, and perspectives. Among others, this research is expected to contribute to enhancing the capability for technology foresight responding to disruptive innovation by leveraging the broad knowledge resources emerged from big data. The discussions on comparison and integration with patent data may provide the new avenues and opportunities for exploring and extracting future-oriented knowledge.

Despite the various contributions, however, this module also involves limitation. First, although this module selects the patent data as a target of comparison, many other existing sources of data such as academic papers, can/should be compared with the futuristic data. Furthermore, the future research can categorize the type of futuristic data and compare their characteristics. Second, in the experiments, the comparative investigation only depends on experts' opinion. Thus, the future research may identify the characteristics in the process of analyzing and interpreting futuristic data. Lastly, this research proposes only conceptual opportunities that need to be put in a definite shape. Thus, in the future, a number of sophisticated tools should be adopted for materialization and implementation.

Chapter 4. Utilization of tech-discourse community information

The previous module #1 in section 3.1 identified that the innovation in tech-discourse communities has various patterns of divergence and convergence, which are derived from the change and integration of existing products. Based on this evidence, this chapter aims to identify and conceptualize opportunities of technology innovation using tech-discourse community information.

The research questions of each module are depicted in Figure 4.1. The information of tech-discourse communities can be divided as ‘user behavior information’ and ‘user innovation ideas’. The former can be a source of scanning potential user needs for new product/service opportunities. Thus the module #3 focuses on the defining set of potential user needs, identifying unsatisfied potential needs for opportunities, and conceptualizing opportunities by benchmarking existing product/services. The later which is more enthusiastic users’ inputs can be a direct source of innovation, but they can already exist in the market. The module #4 supports the identification of opportunities from unsatisfied user ideas and the benchmarking of existing products. The core difference of module #3 and #4 is that the source and candidate of opportunity is the vacuum are of potential user needs or user ideas.

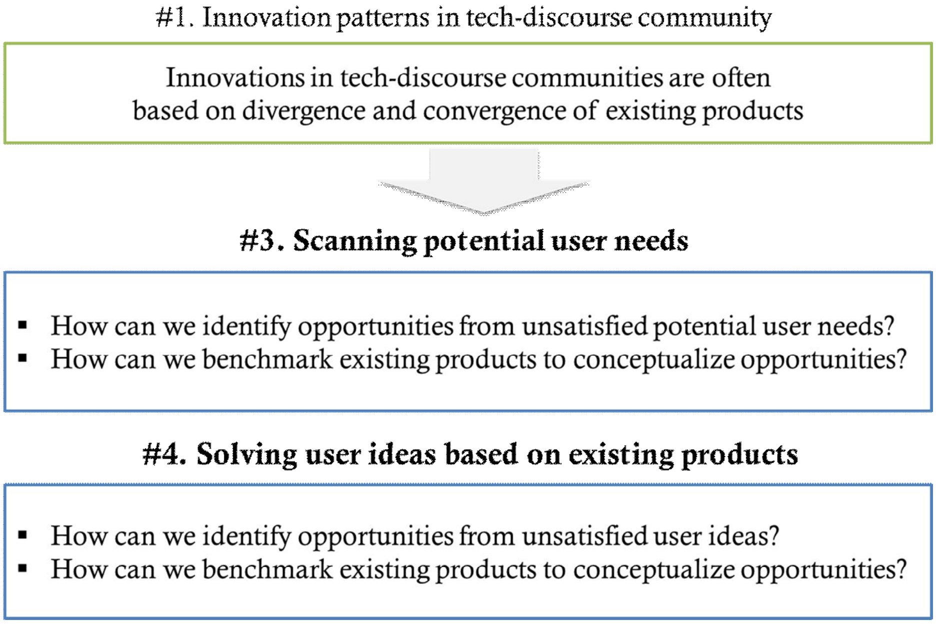


Figure 4.1 Research questions in this theme

4.1 Scanning potential user needs

4.1.1 Introduction

Traditionally, the main sources of opportunity in product and service innovation are the customer needs of market-oriented companies. The most distinctive characteristic of services – as compared to products – is the interaction with customers that occurs as the customer experiences the service (Duverger, 2012; Jaw et al., 2010). The ideation of service is user-oriented rather than maker-oriented, and thus understanding customer needs is essential to successful service innovation (Enkel et al., 2005; Sandmeier et al., 2010). While service firms aim to gain higher customer value by discovering and satisfying both customers' expressed and potential needs, and although the importance of recognizing potential needs to identifying new opportunities is growing (Duverger, 2012; Narver et al., 2004), the main focus has hitherto been on discovering *expressed* needs, typically by using such techniques as focus groups, surveys and interviews (Narver et al., 2004; Witell et al., 2011). Though these techniques are known to be quite useful in understanding customer needs, they will be more limited in the context of innovative services or technology-based innovations. When it comes to developing completely new and innovative services – ones that have not existed before – these customer-led methods have problems, in that customers cannot perceive or articulate their needs accurately, will respond as something that has to be (social desirability bias), and will have trouble imagining and giving feedback about something of which they have no experience (Matthing et al., 2004). Similarly, for technology-based services, customers do not know what they can expect from the services based on new technologies with which they may be unfamiliar. Thus, for firms seeking to develop innovative services, what is important is to try to identify *potential*, rather than relying on expressed, needs.

One effective and proactive tactic for uncovering potential needs is to adopt a user-centric approach to make a closer investigation of users' situations, or to secure their active involvement in identifying their needs (Duverger, 2012; Leonard & Rayport, 1997; Witell et al., 2011). This approach involves the *user context*, engaging them to recognize and specify their potential needs accurately, and thus entails observation methods and user participation (Götze et al., 2009; Leonard & Rayport, 1997). As user context will be uncertain, and may change before and while the service is being used, it influences how the needs can be satisfied (Sweeney, 2003) and thus reflects potential needs. As a result, there has been an attempt to apply user context to derive a potential domain of new services in the conceptualization process (Carayannis & Coleman, 2005; Stappers et al., 2009)

But, despite its apparent potential for encouraging the ideation of innovative services, the application of this user-centric approach to identifying new service development (NSD) opportunities is still only in its early stages. The data that emerges from a user-centric approach should be effectively arranged as an integral part of the NSD process. However, few frameworks have been presented that deal with user context for services in an integrated manner (Kristensson et al., 2008). If it is to be applied successfully to NSD, the following issues require consideration: (1) *information complexity* caused by the generation of various user information; (2) *service variety* since large numbers of new services are continuously emerging in today's fast-moving business environments; and (3) *mapping*, which can allow potential needs to be investigated alongside those satisfied by currently available services (Urban & Hauser, 2004).

In response to these issues, this module aims to develop a comprehensive process to identify new service opportunities from potential user needs by analyzing the needs and existing services. Specifically, we propose a 'user-centric service map', where the x and y axes represent types of needs, and existing services are positioned on the map according to the needs they satisfy.

4.1.2 Context of use and potential needs

User-centric activities entail understanding and specifying the 'context of use'. The term 'context' may refer to time, or to physical or psychological space, as noted in Dey et al. (2001)'s popular definition: 'Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.' The context includes any conditions that users specify for services that correspond to their desire, so context analysis means analyzing a user's interests, needs, goals, motivations, abilities, lifestyles, etc., in general (Oinas-Kukkonen & Harjumaa, 2009). For example, in ubiquitous computing, the purpose of modelling and responding to context is to enhance human activities with new services that can adapt to any circumstances in which they might be used.

Context can be classified according to several criteria. Schilit et al. (1994) claimed that the important aspects of context are: where the user is, who the user is with, and what resources are nearby. They define context to be the constantly changing execution environment, which is threefold: the computing environment (e.g., available processors, devices accessible for user input and display, network capacity, connectivity and costs of computing), the user environment (e.g., location, collection of nearby people and social situation), and the physical environment (e.g., lighting, noise level, etc.). According to Dey et al. (2001), the four essential categories of context are identity, location, status (or activity) and time. Identity refers to the ability to assign a unique identifier to an entity; location is positional information conveying orientation and elevation, spatial relations between entities, and places; status (or activity) identifies intrinsic characteristics of the entity that can be sensed; and time helps characterize a situation in a way that allows the leveraging of its richness and the value of associated historical information. Jang et al. (2005) insist that, to easily generate user-centric context, it is necessary to represent contextual information about users in service environments uniformly without depending on specific sensors or services. For this purpose, they suggested the unified user-centric context dimensions by applying 5W1H (i.e., 'Who, What, Where, When, How and Why').

Acquisition of context data includes both manual and automatic work. In an ideal setting, the service would automatically understand the context in which it was being used (context awareness) and there would be no need for manual manipulation. But in the real world, most user context data cannot yet be sensed automatically and services must rely on the user to provide their usage context manually (Abowd et al., 2001). The context can be defined and constructed either by enumeration and categorization or by generic definition and modelling (Abowd et al., 2001). In case of the former, it is difficult to exploit context information out of definition's range. But, in the case of the latter, it is not easy to share context data among different heterogeneous services because definition is generalized but not unified (Jang et al., 2005).

In this study, an environmental factor is considered as a basis for inferring potential needs, and accordingly the potential needs are defined as *a combination of contexts*. As discussed above, potential user needs are greatly influenced by the conditions of use (Heinonen, 2006; Sweeney, 2003) because, in general, users' potential needs for services are related to enhancing service values in a particular situation of use. For example, if a user is waiting for ticketing at a crowded shopping mall, no alternative system is available, and time pressure exists, the need for mobile ticketing services might emerge. On the other hand, potential needs can also be surfaced (regardless of the situation of its use), where the value of service stems from its own functionality – as in a contents services. The example of game services delivers its emotional or social value without depending on a certain physical situation; in this case, potential needs may not directly depend on the situations in which the service is used, but can be captured by the context of use when broadening the scope of the context to the needs the service addresses. The context of use incorporates both the physical situation in which the needs are generated as well as a broader notion of the needs themselves, which extend to the psychological conditions in which a service is used (Oinas-Kukkonen & Harjumaa, 2009), and accordingly the context can effectively represent the potential needs for both types of services. User needs are often difficult to determine directly, so context cues can be used to help infer this information (Dey et al., 2001).

4.1.3 Proposed approach

4.1.3.1 Concept of user-centric service map

The purpose of this study is to develop a user-centric service map as shown in Figure 4.2 and ultimately to find new service opportunities from the map. A user-centric service map is a two-dimensional grid in which information about potential needs and the needs satisfied by existing services are presented. Therefore, two prerequisite data are required as inputs for the map – a dictionary of potential needs and evaluation results of existing services with respect to the needs that are currently being met.

First, a dictionary of potential needs is assembled, composed of keyword descriptions arranged in a hierarchy, together with their relevant detailed elements. Thus, in the upper left part of Figure 4.2, the need N1 is a group of E111 to E113 needs as its elements, meaning that the N1 need can be satisfied by E111, E112 or E113. Likewise, the need E112 has detailed needs in a second hierarchy from E121 to E124. Second, existing services are evaluated based on the extent to which they meet the identified needs – for instance, S1 service can meet E112 (hierarchy 1) and E122 (hierarchy 2) among N1-related needs and E211 (hierarchy 1) and E221 (hierarchy 2) among N2-related needs. A database of existing services can thus be developed that records existing services in rows and the needs they meet in columns, as shown in the upper right part of Figure 4.2.

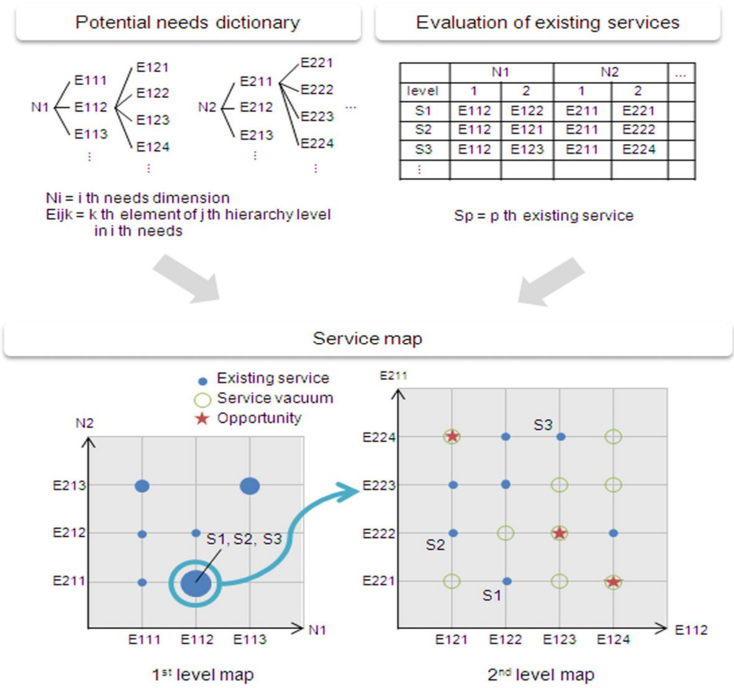


Figure 4.2 Concept of user-centric service map

The dictionary is used to determine the service map dimensions and the results of the evaluation of existing services used to position those services on the map. One service map is only designed to deal with two needs dimensions to investigate the specific meaning of the axis and point at a glance; if there are more than two needs to be considered, multiple 2×2 maps are generated. Compared to map algorithms which compress multiple dimensional information into a single map (e.g., multidimensional scaling (MDS), principal component analysis (PCA), etc.), this method is still useful because no information loss occurs and the meaning of each dimension is tracked in the map. N1-N2 service map, for example, has N1 as the x-axis and N2 as the y-axis. S1, S2 and S3 services has E112 element of N1 dimension and E211 element of N2 dimension, and so are placed into the (2, 1) position in the N1-N2 service map as shown in the first level map in Figure 4.2. In particular, the service map is organized as a hierarchical structure because of the hierarchical needs dictionary. Since the first hierarchy level element has more detailed elements in the second hierarchy level, the lower level map can be drawn up by using one of the points in the higher level as the x-y axis. When the (2, 1) point in level 1 map is zoomed in, the level 2 map appears by posing E112 at the x-axis and N211 at the y-axis and the S2 service is mapped to the (1, 2) position, as it has E121 element of N1 dimension and E222 element of N2 dimension in the second hierarchy. The output of mapping specific services with needs elements in the lower level map, service vacuums, which are unoccupied potential needs areas, can be investigated to decide whether they appear promising or not. They can then be prioritized according to feasibility and validity, and only those with the greatest potential identified as NSD opportunities, after which relevant services can be designed to address the unmet needs revealed by the mapping process.

4.1.3.2 Overall process to develop a user-centric service map

In an attempt to develop such a user-centric service map, this research proposes a method to construct a potential needs dictionary and evaluate existing services for identifying new service opportunities. The overall process consists of three phases as shown in Figure 4.3:

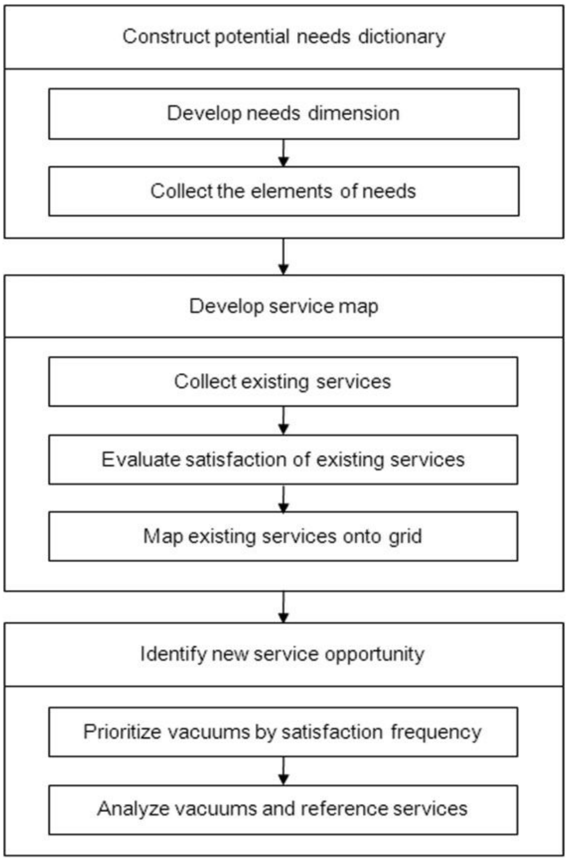


Figure 4.3 Overall research process

(1) Construction of potential needs dictionary, which involves defining the dimensions of the needs and their constituent elements.

(2) Development of user-centric service map, which involves collecting and assessing information about existing services and their elements and

mapping them onto the two-dimensional space.

(3) Identification of new service opportunities: Once identified from the map, service vacuums can be prioritized and opportunities ideated by analyzing the features of vacuums and reference services.

4.1.3.3 Detailed explanations of each step

Step 1) Construction of potential needs dictionary

In this step, the potential needs are abstracted from the perspective of context, and for this, this research utilizes three core user context dimensions: location (L), activity (A) and objective (O), which we have selected from 5W1H as the key user contexts. Firstly, location (L: where a user uses a service), which can be crucial in terms of accessing services within an appropriate working range. Secondly, activity (A: what a user does in a service environment), which can refer to the service activity itself or to other related activities, which can include an event that happens to a user or their status. Lastly, objective (O: why a user uses a certain service), which captures the intention and motivation to use the service, their experience of using it, or the value they gain from its use. Applying LAO, both the context of use and possible needs for a certain service are described or implied. For instance, if a certain service is used when users are at their desk (L), solve work problems (A), and want an instrumental line-up function (O), it is interpreted that this service is satisfying the needs for line-up function, especially to assist office business work

Accordingly, a potential needs dictionary is constructed by collecting elements of needs for these three dimensions. In the collecting stage, an *a priori* approach can be applied based on ethnographic research or general behavior studies. The results of previous research can be taken from a literature review. Furthermore, various user study methods can be adopted: since traditional methods (e.g., survey, interview, FGI) are not very effective in identifying user context, qualitative methods (e.g., participatory observation, empathic design) are applicable to gathering the required types of information. These approaches can detect the cause of the use of services and customer interaction with the surrounding physical environments. In this way, keywords for elements of potential needs are collected, enumerated and categorized for each dimension.

Step 2) Development of service map

A service map is developed based on the evaluation of existing services on each context dimension. First, the object service area of study should be selected, and (if necessary) information about existing related services in that area are collected for analysis. Since collected services are the main source of identifying vacuums and opportunities which significantly affect the remaining processes, the object service should be carefully determined. For example, the service area with emerging technology, the service area related to emerging trends of user behavior, or the boundary of a competitive industry of a focal firm such as user rating can be the criteria to select an existing service. Next, every service is evaluated to judge which elements of each dimension it satisfies. This stage can also be covered by the user study together with potential needs construction, because a user-centric approach is utilized to identify in what context users can be as well as which services are used in that context. Where a service can be used in multiple contexts, multiple records are generated for that one service in a database. Finally, the results of the evaluation of existing services are mapped onto a two-dimensional map, which is often recognized as the effective way for visualizing information (Li, 2004). Inevitably, there will be more than two relevant user-context dimensions to take into account (LAO in this study), so dimensions will have to be matched pair-wise, necessitating a series of service maps.

The mapping process needs to adopt a stepwise approach, starting from a high-order hierarchy map to a low-order map applied to each pair of dimensions. As services are evaluated for all hierarchies of needs dimensions, two-dimensional maps can be developed at any hierarchy level and the existing services can be examined from the perspectives of different levels. However, configuring the map using the lowest hierarchy of dimensions from the beginning can be complex and difficult because too large numbers of elements and services are included at once. Thus, a stepwise approach is adopted that incorporates two kinds of map, starting with the map of the higher hierarchical level and then linking it to the lower level map. The higher level map is used to identify the significant areas of the needs satisfied by existing services, whereas the lower level map enables further analysis of the detailed needs met by existing services, and identifies potential service vacuum areas. A specific important section of the higher hierarchy map can be enlarged to further investigation by using it as the dimension for a lower hierarchy map.

Step 3) Identification of new service opportunities

The user-centric service map reveals empty grid points as service vacuums, which can be considered as potential user needs that have not yet been satisfied by what already exists, and which therefore represent candidates for new service opportunities. Such service areas are ‘empty’ either because no developer has yet realized its significance, or because it has not been developed as there is no value in it. Not all these vacuums will be valuable enough to justify the effort involved in satisfying them, so they must be filtered to prioritize the most promising.

The prioritization process considers a use frequency of each need element by utilizing the services satisfying same context element. The reason why we investigate the frequency of use for context elements is that context influences the triggering of a service both directly and indirectly. If a particular need element shows a high frequency of use, it means that the context occurs frequently in the user’s life, and can therefore indicate an important potential need. So if a service vacuum exists which combines unsatisfied needs with elements of frequent use, it is worth trying to satisfy.

One context point which has the most high use frequency is identified in the higher level map and the vacuums in the lower level map are prioritized by the occurrence frequency of existing services satisfying the elements of vacuum. This is expected to prevent developing the valueless vacuum as a new service.

After identifying such 'important' vacuums, and choosing from them according to their capabilities, a developer can focus on a new service opportunity by analyzing the vacuums' characteristics and explore how to satisfy them by using related services for reference. These processes can facilitate the ideation of novel service concepts through benchmarking or creative convergence of services (Kim et al., 2012). The process to identify new service opportunities is summarized in Table 4.1. One point worth noting is that the level of the map (either higher or lower in the multiple hierarchies) at which the possibility of new services is found can differ depending on the nature of the service.

Table 4.1 Process of evaluating vacuum to derive opportunity

Objective	Description	Criteria
Select evaluating area	Choose the most frequently used context point in the higher level map	High frequency of needs element
Discover service vacuums	Identify service vacuums in the lower level map, enlarging selected context Point	Zero frequency of needs element

Derive promising vacuums	Select top vacuums according to the priority of service vacuums	Total sum of frequency of needs element used in the other services configuring a vacuum
Concretize new service idea	Embody new service ideas after assessing the feasibility of vacuums selected as promising ones	Feasibility of combination of elements configuring a vacuum

4.1.4 Case of App Store apps

4.1.4.1 Background

In order to verify the feasibility of our suggested approach, we analyzed the mobile app services in Apple's App Store and developed a user-centric service map. Our case study subject is not the business model of Apple's App Store, which is an innovative open concept, but the applications ('apps') posted on the App Store. Our definition of apps as services should be noted: apps are (small) software packages that users can download from the App Store to their smart phones (e.g., Apple's iPhone) or other mobile devices (e.g., iPod Touch). Although apps themselves are software products, they are primarily channels which enable mobile services to be delivered wirelessly to the customer's phone. Existing providers, whether of online or offline services, create mobile apps to expand their businesses into the mobile space. There have also been a number of cases where new apps are developed to provide new smart phone-specific mobile services, such as for real-time information, entertainment information, etc. Apps represent an excellent example of how services are provided in the mobile space, and the App Store itself is where highly innovative activities can be observed (Holzer & Ondrus, 2009) – for both these reasons, it represents a valuable research locus. As mobile services are accessed via hand-held devices, they can be used in any context (thus overcoming both spatial and temporal constraints; Heinonen, 2006). Analysis of the usage context and the needs satisfied by apps can reveal service vacuum areas and new service opportunities.

4.1.4.2 Construction of potential needs dictionary

A potential needs dictionary was constructed by collecting the elements according to the three context dimensions of location, activity and objective. Related keywords are collected and categorized for each dimension from the literature. Although a qualitative user study method is applicable, this illustrative case uses literature sources to develop an *a priori* potential needs dictionary. Social psychology literatures (such as leisure studies or motivation theory) and behavioral studies (such as time use surveys) are consulted to identify user context elements. The resulting LAO dimensions are organized as a three-level hierarchy, and the total number of elements collected were 55 (L), 123 (A) and 57 (O), respectively.

The location (L) dictionary is based on the American Time Use Survey (ATUS) (2010), an annual survey that monitors changes and emerging trends in society produced by the US Bureau of Labor Statistic. Many other time-use studies have been conducted for many specific purposes (e.g., to measure exposure to environmental pollutants and to investigate how people spend leisure time), or for many other countries (e.g., American Heritage Time Use Study (AHTUS), Harmonize European Time Use Study (HETUS), and Multinational Time Use Study (MTUS); Partridge & Golle (2008). However, ATUS is known as the largest, most recent and general time-use study (Shelley, 2005) and has been used to study context of use (Partridge & Golle, 2008). Thus we selected it as the source of study. The ATUS interview questionnaire includes the item 'Where were you during the activity?', which captures the respondent's location – home, workplace, someone else's home, restaurant or bar, place of worship, grocery store, other store/mall, school, outdoors away from home, library, car, truck, or motorcycle, etc. Referring to 34 levels of this item, we grouped these elements into four locations: residing, working, visiting and moving to develop the first hierarchy (LH1), and listed and categorized more specific elements within each category for the second and third location hierarchies (LH2 and LH3), as shown in Table 4.2. The same space (e.g. a particular building) could be a working or visiting location, depending on the user's context.

Table 4.2 Dictionary of location (L)

LH1	LH2	LH3
Residing place (1)	Living (1)	Bedroom (1), bathroom (2), study room (3), living room (4), kitchen (5), dining room (6)
	Supporting (2)	Garden (7), garage (8), basement (9), loft (10)

Working place (2)	Office (3)	Meeting room (11), office desk (12)
	School (4)	Classroom (13), restroom (14), schoolyard (15), gym (16), lab (17), library (18)
Visiting place (3)	Indoor (5)	Shopping mall (19), supermarket (20), convenience store (21), theatre (22), concert hall (23), museum (24), gallery (25), game room (26), restaurant (27), cafeteria (28), bar (29), bank (30), gas station (31), hospital (32), pharmacy (33), hair salon (34), health club (35), hotel (36), airport (37), post office (38)
	Outdoor (6)	Swimming pool (39), marketplace (40), sports stadium (41), park (42), playground (43), amusement park (44), resort (45)
Moving place (4)	Private (7)	Taxi (46), car (47), bicycle (48)
	Public (8)	Bus (49), subway (50), street (51), train (52), plane (53), boat (54)
Anywhere (5)	Anywhere (9)	Anywhere (55)

The activity (A) dictionary is prepared by referring to the ATUS and leisure studies. The ATUS activity classification scheme has 18 basic activity groups: personal care, household, caring for/helping household members, work/work-related activities, education, consumer purchases, professional/personal care services, household services, government services/civic obligations, eating and drinking, socializing, relaxing and leisure, sports, exercise and recreation, religious and spiritual, volunteer, telephone calls and travelling (Bureau of Labor Statistics, 2009). Brightbill, (1960) defines leisure as time beyond what is required for survival and individual biological functions (e.g., sleeping and eating), economic value (labour), and social or cultural conventions, while Dumazedier (1967) lists four kinds of activity: remunerative work, family obligations, socio-spiritual obligations and self-fulfillment/self-expression activities. Only leisure corresponds to the fourth of these, as it excludes routine activities necessary for life such as job-related activities, household affairs, religious rituals or academic activities. Based on these literatures, we classified activity into five first-hierarchy (AH1) headings: personal care, household care, economic, purchase and service and leisure, further broken down into AH2 and AH3 lists to construct our full dictionary, as shown in Table 4.3.

Table 4.3 Dictionary of activity (A)

AH1	AH2	AH3
Personal care activity (1)	Food (1)	Eat (1), drink (2)
	Groom (2)	Wash (3), bath (4), dress (5), makeup (6), hair care (7), body care (8)
	Shelter (3)	Sleep (9), rise (10), relax (11), break (12), sit around (13)
	Health care (4)	Take medicine (14), feel sick (15), feel fatigue (16), emergency (17), pregnancy (18), period (19)
Household care activity (2)	Housework (5)	Cook (20), laundry (21), clean (22), sew (23), item store (24), house decorate (25), interior arrange (26), interior repair (27), furniture build (28), garden (29), vehicle maintenance (30), appliance maintenance (31), financial management (32), planning (33), mail (34), home security (35)
	Household member	Physical care for children (36), reading to/with children (37), playing with children (38), homework help (39), medical care

	care (6)	(40)
Economic activity (3)	Work (7)	Train (41), present (42), meeting (43), review (44), write (45), file (46), arrange (47), solve (48), search (49), computer use (50), telephone call (51), attend class (52), surf internet (53), job search (54)
	Education (8)	Take class (55), take exam (56), club activity (57), homework (58), read (59), write (60), study (61), administration (62)
Purchase and service activity (4)	Consumer purchase (9)	Store shopping (63), internet shopping (64), rent (65), research price (66), research sale (67), comparison shopping (68)
	Professional service (10)	Childcare (69), banking (70), legal service (71), medical service (72), personal care (73), real estate (74), veterinary service (75)
	Household service (11)	Cleaning (76), meal preparation (77), dry clean (78), home maintenance (79), pet service (80), garden service (81), vehicle maintenance (82)
	Government services(12)	Police and fire service (83), welfare service (84), license and tax (85), civic obligation (86)
Leisure activity (5)	Socializing (13)	Talk (87), eat out (88), entertain (89), attend party (90), attend meeting (91), telephone call (92), message (93), community (94)
	Viewing (14)	Watch TV (95), listen radio (96), listen music (97), attend movie (98), attend performing art (99), attend museum (100), attend gambling (101), watch sport (102)
	Participatin g (15)	Read book (103), note (104), collect (105), art (106), fishing (107), play game (108), surf internet (109), serve (110), religion (111), drive (112), travel (113)
	Sport (16)	Run (114), walk (115), weightlifting (116), aerobics (117), stretching (118), biking (119), dancing (120), hiking (121), sport (122)
Nothing (6)	Nothing (17)	Nothing (123)

The objective (O) dictionary is based on motivation theory and customer value studies. The basic human needs in life can be projected onto the potential needs for services. The best-known motivation theory is Maslow's hierarchy of needs, ordered as physiological, safety, social, self-esteem and self-actualization needs (Maslow, 1943). The value gained from consuming products and services is frequently classified into utilitarian and hedonistic values (Sweeney & Soutar, 2001). Utilitarian value is extrinsically motivated, and exists in goal directed service use (efficiency needs) (Childers et al., 2001), whereas hedonistic value involves intrinsic motivation and is represented by service uses for experiential, fun and enjoyable ends (entertainment needs) (Novak et al., 2003). As this value framework may not be capable of identifying significant differences in the perceived value of different types of services, a multidimensional view has been suggested as better depicting the different dimensions of perceived value in specific services (Childers et al., 2001; Sweeney & Soutar, 2001).

The literature has defined the independent value dimensions that are important in mobile services as conditional, epistemic, emotional, social, convenience and monetary aspects (Pihlström & Brush, 2008; Sheth et al., 1991). Conditional value is an extrinsic utility derived from the capacity of a service to provide functional value in specific and transient contexts. Epistemic value is related to experience, curiosity, novelty or knowledge gained by using new services and technologies. Emotional value is gained particularly through aesthetic aspects of services and through enjoying the use of services. Social value associates users of the service with a social group and includes aspects of social image, social identification, social self-concept, expression of personality and pursuit of social class membership. Convenience value is relevant to savings of time and effort, psychological comfort and ease of use. Monetary value is measured by price/value for money (Sheth et al., 1991). These experiences and values a user can gain through using a certain service are associated with their objectives, needs and intention in the use in question. In Maslow's needs scheme, physiological needs are related to convenience value, safety needs are connected to conditional value (because they are generated in specific threatening situations) and self-esteem or self-actualization needs are linked to epistemic value. So we can list the experience and the value for the user as shown in Table 4.4. The six objectives noted above represent the first (OH1) hierarchy, and are further classified according to their definitions in OH2, with related elements enumerated in OH3.

Table 4.4 Dictionary of objective (O)

OH1	OH2	OH3
Conditional objective (1)	Reassurance (1)	Check (1), secure (2), prevent (3), alert (4), treat emergency (5), peace of mind (6)
	Ubiquity (2)	Access (7), location-specific (8), time-specific (9), real-time (10), customize (11)
Epistemic	Novelty (3)	Curiosity (12), intelligence (13), random (14)

objective (2)	Self-enhancement (4)	Competent (15), accomplish (16), play (17), create (18), stimulus (19)
Emotional objective (3)	Feeling (5)	Fun (20), thrill (21), beauty (22), comfort (23), pass time (24), gratitude (25)
Social objective (4)	Self-expression (6)	Communicate (26), popular (27), power (28), proud (29), share (30), review (31)
	Social exchange (7)	Care (32), stay in touch (33), keep up-to-date (34), feel involved (35)
Convenience objective (5)	Instrumentality (8)	Alarm (36), schedule (37), calculate (38), tool (39), record (40), navigate(41), location search (42), lineup (43), compare (44), synchronize (45), information (46), multifunction (47), speed (48), effort saving (49)
	Usability (9)	Simple (50), easy to use (51), handwrite (52), scan (53), multitask (54), virtual reality (55)
Monetary objective (6)	Efficiency (10)	Economic (56), numerous content (57)

4.1.4.3 Service map development

With respect to the evaluation of apps, detailed description and reviews of the apps provided by developers in Apple's App Store are utilized to analyze the potential needs satisfied by already existing items. Raw data in the form of information on 64,647 apps was collected from iPhone Apps Plus (http://www .iphoneappsplus.com), an online community that tracks all apps available from the 70 iTunes App Stores around the world, between January and March 2010. Apple's App Store has 20 categories: Books, Business, Education, Entertainment, Finance, Games, Healthcare & Fitness, Lifestyle, Medical, Music, Navigation, News, Photography, Productivity, Reference, Social Networking, Sports, Travel, Utilities, and Weather. Out of these, we selected two – Lifestyle and Healthcare & Fitness – for the variety of services they represented and the contexts of their service use. Lifestyle apps are intended to support a part of the real life of users such as shopping, cooking, styling, relaxing, alarm, birthday, diary, etc. Also, healthcare and fitness apps aid healthcare-related activities such as weight training, diet, sleeping, pregnancy, running, nutrition, weight watching, etc. Lifestyle and healthcare services are closely related to users' natural routines and thus can represent a broader variety of contexts of use than content-oriented services such as books or games. We then sampled the 50 top-rated apps from each category using the app lists aligned with a set of criteria including user review, quality, downloads and grossing by iPhone Apps Plus. We assumed that rating of apps can be interpreted as the degree of prominence of user behavior which can be an important clue to opportunity. The new entry firm may consider these top-rated services as representative and significant services in this area. Also, the apps with a high rating have many user reviews of high quality, enough to derive their usage context, thus we selected some of the top-rated apps as representative of lifestyle and healthcare services. Next, for these existing services, the LAO of their use were assessed based on users' reviews that illustrated their situations of use. As indicated earlier, multiple combinations of context elements can be generated for one service being evaluated, so the database built up for these 100 apps contained a total of 264 records.

Using the evaluation results database, we developed three service maps at the highest level, of which two examples are illustrated here. Figure 4.4 is an L-O map (with locations and objectives on the x- and y-axes, respectively), and Figure 4.5 shows an A-O map (activities and objectives on the x- and y-axes, respectively). Applying the stepwise approach, a specific top hierarchy value is investigated further in the sub-hierarchy, just like a zoom function of a digital map. For example, the distribution of existing services at the first hierarchy level of the L-O map (Figure 4.4, left) indicates that the pair of visiting place/convenience objective is dominant. It means that most apps are used to make people convenient when they visit a particular place. In the same way, the leisure activity/convenience objective pair is dominant in the first level hierarchy on the A-O map (Figure 4.5, left), which again means that the most dominant value the currently available apps provide is to make users feel convenient when they engage in leisure activity. In other words, people use apps to increase convenience when they visit a particular place (L) and do a leisure activity (A). These matches are further explored at the third level hierarchy (the right-hand maps in each case), which show where the service opportunities have been actively exploited and user needs addressed, and where service vacuums still remain as opportunity candidates for developers who can visualize and offer specific related services. Here the development of the second level map was omitted. (See the next stage below for a more detailed analysis.)

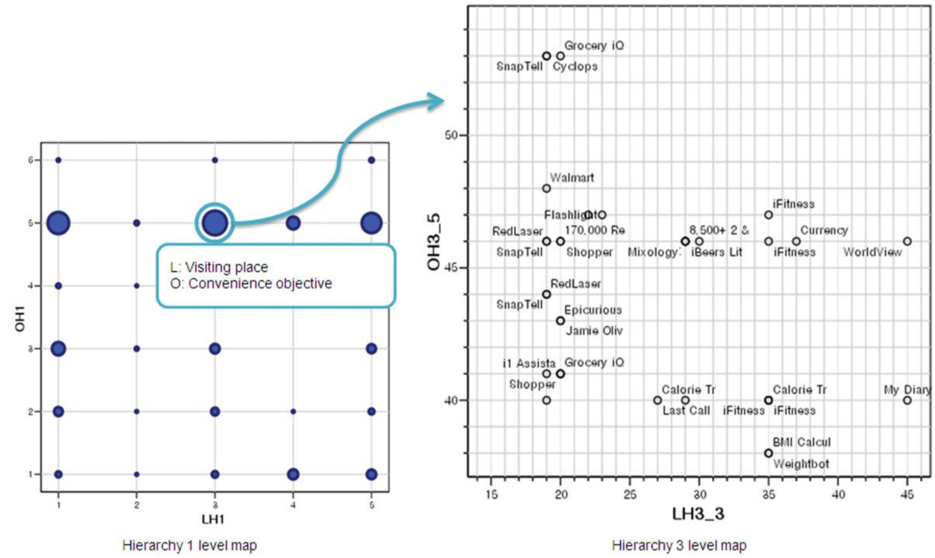


Figure 4.4 User-centric service map of an Apple app (L-O map)

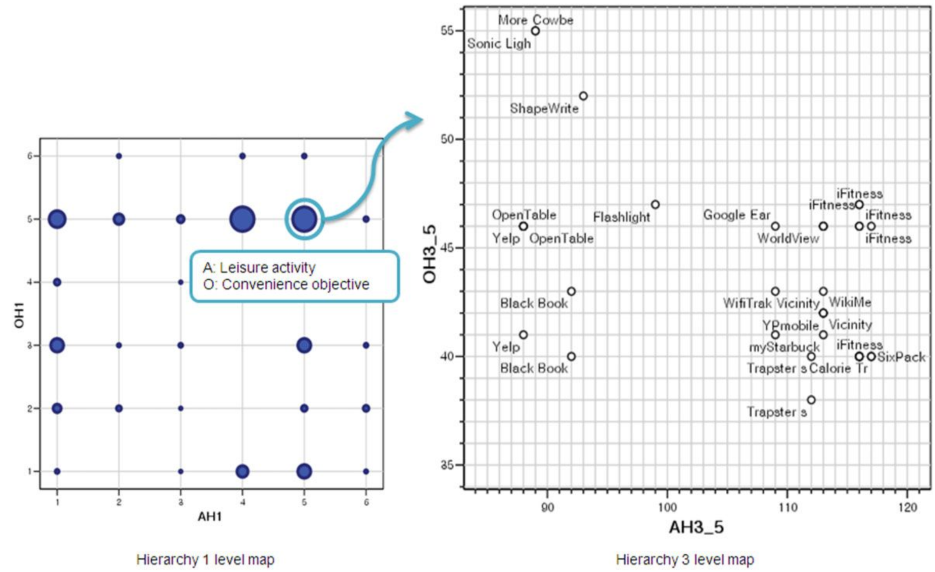


Figure 4.5 User-centric service map of an Apple app (A-O map)

4.1.4.4 Identification of new service opportunities

L-O map

Examining the visiting place/convenience objective pair from the level 1 map of the sampled data, we first prioritized vacuums revealed in the L-O map (hierarchy 3 level) according to the frequency of their occurrence, as shown in Table 4.5. As a result, we identified three elements – the shopping mall, the supermarket and the health club – as locations where services were most frequently used. The objectives users most often wanted were information, recording and navigating services.

Table 4.5 Prioritization of vacuum (L-O map)

Elements for L	Frequency	Elements for O	Frequency
Shopping mall (19)	9	Information (46)	12
Supermarket (20)	8	Record (40)	7
Health club (35)	7	Navigate (41)	4
Bar (29)	5	Multifunction (47)	3
Resort (45)	2	Scan (53)	3
Concert hall (23)	1	Compare (44)	2
Bank (30)	1	Calculate (38)	2
Theatre (22)	1	Lineup (43)	2
Airport (37)	1	Speed (48)	1
Restaurant (27)	1		

Next, the selected vacuums are further analyzed and reference services that could address them identified, and matches of L and O elements that might be contradictory or unrealizable excluded. Figure 4.6 shows the five opportunities identified by the ideation process for the pairs of selected elements, and Table 4.6 lists the vacuums, references and opportunities.

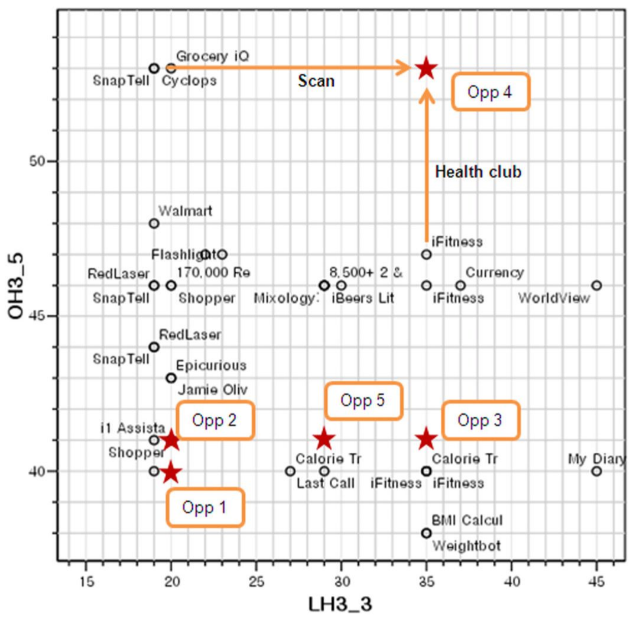


Figure 4.6 New service opportunity identification from L-O map

Opportunity 4 (Opp 4), for example, represents the case where the user is in a health club and requires a scan function (the third level element) to increase usability (the second level element) of health club facilities. In this situation, we found an opportunity from two references: *iFitness* and *SnapTell*. *iFitness* is a comprehensive exercise database that provides clear pictures, videos and instructions. *SnapTell* uses image recognition technology to instantly match a photo of the covers of any book, DVD, CD or video game

Table 4.6 Opportunity ideation from L-O map

No.	Dimension		Reference: Name	Reference: Description	Opportunity
1	L	Supermarket	Grocery iQ	Building shopping lists quickly by simply scanning the barcode for any product or using the predictive search feature	Tracking user's shopping behavior pattern (items and prices from the past shopping list) to suggest the shopping methods adapted to user's goal such as economic or nutritional balance
	O	Record	Last Call	Logging user's alcohol consumption and calculating blood-alcohol level to determine if it's safe to drive after drinking	
2	L	Supermarket	170,000 Recipes – BigOven	Providing access to cooking archive, recipes and food glossary with tips on grocery items	Navigating the nearest location of ingredients of a certain recipe when user is in the supermarket
	O	Navigate	Target	Finding the nearest Target and browsing what's available at stores and online	
3	L	Health club	iFitness	12 routine programs with varying goals such as weight loss, strength	Navigating the location of fitness equipment to match the layout of

	O	Navigate	Shopper	Organizing shopping lists to match the aisle order or layout of stores	health club sequentially according to exercise program
4	L	Health club	iFitness	Exercise database that provides clear pictures, videos and instructions	Searching videos about how to use fitness equipment when scanning each piece of equipment
	O	Scan	SnapTell	Quickly find ratings and descriptions by snapping a picture of the cover of any book, CD	
5	L	Bar	Beer Brands	Information of beer's details with best serving tips	Identifying the nearest bars related to special drink brands and representing bar information such as menu lists or customer reviews
	O	Navigate	Target	Finding the nearest Target and browsing what's available at stores and online	

against a product image database and show a product rating and description plus links to Google, YouTube, etc. Although *SnapTell*'s scanning function is made for finding information while shopping in a store, this objective is just as applicable in the health club location, simply by changing the product database to the fitness instructions in *iFitness*. As the arrows in Figure 4.6 indicate, Opp 4 could be met by the convergence of the existing concepts of two reference services.

Another example is Opp 2: the user is in the supermarket and wants a navigation function to find an assistant to help locate ingredients for a recipe. In terms of a reference service for the supermarket location, *BigOven* is a lifestyle app that provides access to a recipe library and grocery list, while, as a reference for navigation, the *AroundMe* app identifies the point-of-interest position and provides information about surroundings. Like *BigOven*, numerous libraries of recipes and grocery can be contained in apps for supermarkets. Also like *AroundMe*, the navigation of nearby surroundings in street settings can be applied to the specific location of a supermarket. Accordingly, the new service opportunity can be derived, which navigates the user to the nearest location in the store to find the ingredients required for a certain recipe – and this potential need could be easily satisfied by modifying how adjacent services operate.

A-O map

A similar procedure of prioritizing the vacuums, and analyzing vacuums and reference services was conducted on the level 3 A-O map for the level 1 leisure activity/convenience objective pairing. The prioritization of the A-O map vacuums (Table 4.7) revealed travel, weightlifting and eating out as the most frequent activities, while information and recording were the objectives of most users.

Table 4.7 Prioritization of vacuum (A-O map)

Elements for A	Frequency	Elements for O	Frequency
Travel (113)	8	Information (46)	10
Weightlifting (116)	8	Record (40)	8
Eat out (88)	5	Navigate (41)	3
Aerobics (117)	3	Location search (42)	3
Surf internet (109)	3	Line-up (43)	3
Telephone call (92)	2	Multifunction (47)	3
Drive (112)	2	Virtual reality (55)	2
Entertain (89)	2	Handwrite (52)	1
Attend performing art (99)	1	Calculate (38)	1
Message (93)	1		

As before, the ideation process revealed five service vacuum areas which represented opportunities (see Figure 4.7 and Table 4.8).

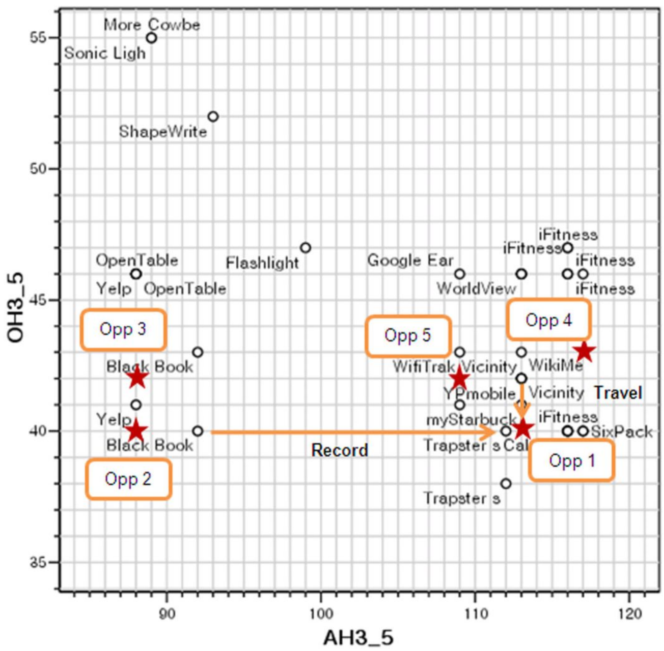


Figure 4.7 New service opportunity identification from A-O map

For example, Opp 1 in this case describes a situation where the user wants recording while travelling, and *Vicinity* and *Black Book* can be applied as the reference services to address this vacuum. *Vicinity* is a lifestyle app that uses Wikipedia content to supply details of nearby businesses to travelling users, while *Black Book* is a contact book app that stores phone numbers, addresses, photos and stats such as ratings, favorites, preferences, description, etc. By storing contact information and descriptions of places the user has visited for the benefit of friends, *Black Book* can act as both as a personal diary and as a travelogue, while *Vicinity* can contribute travel information about locations from sources such as Wikipedia. Consequently, the

Table 4.8 Opportunity ideation from A-O map

No.	Dimension		Reference: Name	Reference: Description	Opportunity
1	A	Travel	Vicinity	Providing guide to nearby services using Wikipedia articles	Recording and tracking travel path and web contents such as Wikipedia articles about places that user visited to support writing of travelogue
	O	Record	Black Book	Storing the past contact information and private photos, potential dates or casual encounters	
2	A	Eat out	Urbanspoon	Picking a good restaurant for user to try randomly and providing ratings and review from fellow eaters	Recording the history of the usage pattern of restaurant (items, prices, and rating of menu user selected) to recommend the restaurants based on other similar users' usage pattern
	O	Record	Calorie Tracker	Providing a diary of user's caloric and nutritional intake to coach customized diet	
3	A	Weightlifting	iFitness	Exercise database that provides clear pictures, videos and instructions	Searching the location of body region and muscle targeted by each exercise

	O	Location search	YPmobile	Providing millions of local Yellow Pages business directory listings nationwide	
4	A	Eat out	OpenTable	Finding the nearest restaurants and mapping results with a location-based map	Lining up the restaurants user visited by cuisine, price, reservation time, or points awarded based on user input information
	O	Line up	Black Book	Sorting contacts by name or user's rating, listing private images of contacts and their details	
5	A	Aerobics	Calorie Tracker	Providing a diary of user's aerobic exercise calorie and fitness goals to coach customized diet	Lining up the list of exercises from best to worst by users' exercising pattern (continued time or total calorie consumption)
	O	Line up	Wi-Fi Finder	Sorting network list from best to worst by access strength	

opportunity here concerns recording and tracking travel routes and web contents (e.g., Wikipedia articles) about places a user visits to support them in writing a travelogue recording their journeys.

4.1.5 Discussion

4.1.5.1 Theoretical implications

This module laid the foundation for proactive market orientation in NSD. The service map suggested in this module is an effective analysis tool to investigate potential user needs and services, identify unmet vacuums, and determine which vacuums represent new service opportunities. Thus, it overcomes a lack of studies on substantial tools to realize proactive market orientation in the fuzzy front end of NSD. The theory has emphasized the importance of proactive market orientation in NSD and the need to determine potential needs because the majority of existing research has only focused on expressed needs. The core element for proactive as opposed to reactive NSD is ‘potential needs’, which can be derived by ‘context of use’, the information about ‘who are users, what services they use, when, where, how, and why the users use certain services’ (Sandberg, 2007). The user-centric approaches, albeit scanty, can evaluate the context of use and uncover potential needs. However, in the process of the user-centric approach, the data should be effectively arranged due to the complexity of needs information, service variety and difficulty in matching needs and services. As a remedy, we proposed the user-centric service map. The user-centric service map can arrange the data from the user-centric approaches and help analyze how to get more intelligent information in the fuzzy front end of NSD.

However, the user-centric service map is only the first element of the fuzzy front end, including a market perspective search for new activities. In order to approve the development of opportunity, organizations should consider the business and technological issues, and resources and capabilities such as time, money and the nature of the service. According to Cooper & Edgett (2008), vital pre-development activities include: preliminary market assessment; technical assessment; source-of-supply assessment – suppliers and partners or alliances; market research – market size and segmentation analysis; VoC (voice of the customer) research; product concept testing; value-to-the customer assessment; product definition; and business and financial analysis.

Although we conducted the case study for illustration, the effectiveness of the service map cannot be strictly verified. As an experiment for partial verification, the results of the case study are compared with real service examples. Since the case study was conducted in 2010, we could assess whether the opportunities identified based on 2010 data had been taken by App developers today (December 2012). Table 4.9 shows the results of the opportunity assessment. Most of them have been successfully taken by developers, and accepted to market as shown by high ratings. Thus, the user-centric service map is expected to be an effective tool in future radical innovation.

Table 4.9 Assessment of opportunity by comparing with real service

Opportunity in 2010			Real service discovered in 2012			
Map	No.	Description	Name	Launch date	Rating	Relevance to opportunity
L-O map	1	Tracking user's shopping behaviour pattern (items and prices of the past shopping list) to suggest the shopping methods adapted to user's goal such as economic or nutritional balance	# Note Lite – Grocery, Shopping List	10 Mar 2011	4.5	Consulting user shopping histories with inbuilt report to grasp frequency of purchase or amount of expense easily with graphs by period, by shopping list, or by category
	2	Navigating the nearest location of ingredients of a certain recipe when user is in the supermarket	AisleMapper	26 Apr 2011	3.5	Mapping the items on user's shopping list while shopping in favourite store
	4	Searching videos about how to use fitness equipment when scanning each piece of equipment	FitnessTracker .eu	3 Sep 2012	5	Scanning QR code to quick add exercise to user's exercise calendar
	5	Identifying the nearest bars related to special drink brands and	Pintley Beer Recommendati	11 Sep 2010	4.5	Beer locator feature that lets users find specific beers in their area

		representing bar information such as menu lists or customer reviews	ons			
A-O map	1	Recording and tracking travel path and web contents such as Wikipedia articles about places that user visited to support writing of travelogue	Cairn Story Lite: GPS, climbing, MTB, travel record	13 Jan 2011	4.5	Saving travel records, point marking that user wants to remember, shooting pictures and videos, and voice recording with GPS location to share their travelogue in CairnStory website
	2	Recording the history of the usage pattern of restaurant (items, prices, and rating of menu user selected) to recommend the restaurants based on other similar users' usage pattern	Ness Dining Guide – Restaurant Search	25 Aug 2011	5	Learning user's unique tastes as user rates restaurants, then showing a short list of personalized recommendations
	3	Searching the location of body region and muscle targeted by each exercise	Muscle Building Workouts for Bodybuilders	1 May 2012	4.5	Helping bodybuilders to choose the exercises that build the major muscle groups

4	Lining up the restaurants user visited by cuisine, price, reservation time, or points awarded based on user input information	Restaurant Recall	8 Sep 2010	4	Allowing users to keep track of their personal dining experiences by restaurant, menu item, and rating, and search favourite and highly rated restaurant items
5	Lining up the list of exercises from best to worst by users' exercising pattern (continued time or total calorie consumption)	Strong	16 Sep 2011	4.5	Recording routines, exercise, and workout, showing exercise progression, and calculating one rep max and total weight lifted

4.1.5.2 Managerial implications

Business firms can practically develop and utilize user-centric service maps based on our processes. They can construct potential needs and context dictionary, evaluate users' service usage for the set of services in the relevant industry by applying user-centric data capturing approaches, develop a user-centric service map using tools such as MS Office Excel, Powerpoint, or SPSS (as in this study), and then identify the new service opportunities from the vacuums identified in the service map.

Market orientation, whether reactive or proactive, addresses organization-wide concerns and organizational culture through the coordination and integration of the firm's resources, human and other, directed towards the creation of superior customer value. Accordingly, it is not limited to the marketing department in an organization. Brand managers, marketers, engineers, R&D specialists, service designers, user-centric approach specialists and other professionals facing challenges to realize proactive market orientation can utilize user-centric service maps. Furthermore, communication between them will be facilitated through the service map, since it is a visual representation that is easily cognizable. In the situation where high levels of conflict between engineers and marketers exist in NSD, user-centric service maps may aid organization-wide proactive market orientation and multi-disciplinary approaches by functioning as an interface of communication and negotiation for development of new services.

4.1.6 Conclusions

This research proposes creating user-centric service maps as a methodology to visualize and identify new service opportunities. First of all, the hierarchical potential needs dictionary is constructed based on user context elements. Each dimension of need is developed in terms of location, activity and objective, with elements collected from the literature. Then, a stepwise approach using a hierarchy of dimensions is employed to evaluate existing services (based on the potential needs dictionary) and is utilized to create a service map which illustrates both existing services and service vacuums, which might indicate new service opportunities. Areas of the higher hierarchy map – which represent the proportion of the overall service area – can be zoomed in on for more specific investigation of the vacuums that are indicated. Potential new service opportunities are then explored by prioritizing the vacuums based on the frequency of occurrence of their context elements, and analyzing their meaning, relating them to reference services in order to design services that can satisfy potential users.

The contribution of this module derives from our use of a user-centric map, a method that supplements previous research, which has focused mainly on expressed user needs, by considering both the range of existing services and the context of potential user needs together. The user-centric service map has several outstanding advantages. Firstly, it can effectively visualize the positioning of existing services on the basis of user context and of potential needs. Customer insight and new service opportunities can both be gained from considerable amounts of data through the flexible visioning ‘zoom’ function. Secondly, the meaning of each dimension is easily tracked, making the interpretation of service vacuum points much simpler. Thirdly, its evaluating process incorporates the user needs study methods (such as observation) to investigate which needs are already fully met by existing services and which remain as service vacuums. The user-centric service map supports user studies by organizing their results and illustrating their implications. Lastly, the map facilitates the ideation of new service concepts by identifying the location of reference services. Cross-business opportunities linked with user needs, which might offer different ways of approaching the market; can be understood in the service map. In summary, the user-centric service map can contribute to gaining strategic insight into new service opportunities from the user’s perspective.

This study also facilitates understanding service innovation in the context of newly emerging ‘app’ services for smart phones by examining applications from Apple’s App Store. The case study illustrates how the user-centric service map method can be employed to explore new service opportunities by creatively converging characteristics from existing services. This approach is expected to be able to provide valuable information for managers of service companies – especially in fast-moving service environments, which require fast and strategic positioning, quick responses to user needs, and earlier development of services – by exploring new service opportunities from the huge amount of data available from user studies. Particularly in the case of

App Store, it not only tells the apps developers, entrepreneurs and software development team which potential needs are promising for strategic focus, but also provides them with guidelines as to how to support ideation to satisfy those needs. The method promotes co-operation between the engineering and marketing functions of the service firm.

Nevertheless, this module has some limitations, and there is room for improvement in the process of developing the service map: the potential needs dictionary, the evaluation of existing services and the identification of opportunity. First, in the case of the potential needs dictionary, this research used only three context dimensions (location, user and activity) to develop a user dictionary, but more dimensions including time (when) and users (who) should be considered to improve it. Also, we collected information about potential needs only from the literature and more active techniques based on user study need to be used, which can be appropriate to investigate potential needs from real users.

Second, the evaluation of existing services remains subjective, even though it is based on user review, because the judgment to allocate the context of service from user review can differ between researchers. Thus, guidelines and elaborated processes should be proposed in future studies to clarify the evaluation stage without researcher bias. This can be especially important when multiple raters can individually evaluate the context elements of collected service. For this purpose, inter-rater reliability to measure the degree of agreement or consensus among raters can be utilized to determine whether the scale is defective or the raters need to be re-trained. Since nominal data that several raters assigning existing services to total categories of context are gathered, statistics such as joint probability of agreement or kappa statistics (Cohen's kappa or Fleiss' kappa) can be applied (Gwet, 2014).

Third, as far as the identification of new service opportunity is concerned, we found some limitations. Although the significance of opportunity is considered twice in the higher service map levels and in prioritizing vacuums at the lower level, only the satisfaction density and the frequency of existing services is utilized in both. However, exploring which vacuums are the most promising requires including more sophisticated assessment stages based on appropriate criteria such as social trends. In addition, when considering all of the pair of elements of vacuums to find out opportunities, a more systematic framework for sorting them out by physical or social contradictions, or business interests of company would be advantageous. A typical example would be the cross-consistency assessment matrix in morphological analysis (Ritchey, 2006). Also, the process of assessing contradictory elements can have researcher-bias issues, thus inter-rater reliability for nominal data (contradictory or not) can be adopted.

As a different dimension, the process of developing user-centric service maps can be elaborated into a more quantitative method. Although we have demonstrated the feasibility of our process in our case study, it remains only a qualitative approach and thus it may take much effort to create the map and analyze the information in the map, which may hinder its use. To solve the problem, a supporting tool to handle the quantitative analysis for huge amounts of data can be developed or the use of existing tools based on TM and searching techniques could be considered in the evaluation of services. Moreover, as context can be represented by generic modelling, not enumeration as used in this study, information gathering of potential needs and the evaluation process could be automated by employing context-sensing devices based on generic context models. Contexts cannot be easily identified or measured, because they vary according to the user's situation, and the relevance of the service in a specific situation may depend on the users' task in hand. Thus future research is needed to suggest better ways to identify context and to assess service.

4.2 Implementing user ideas based on existing produ cts

4.2.1 Introduction

In the world of open innovation and crowdsourcing, community-based innovations have been highlighted as an innovation strategy that aims to leverage the resources and ideas outside the company (Dahlander et al., 2008; Füller et al., 2007; Gangi et al., 2010; Lauritzen et al., 2013). The users in these communities tend to share their information, knowledge, ideas, and even technologies with other members rather than hide them (Morrison et al., 2000), exchanging product or service feedback and in turn developing innovative ideas (Franke & Shah, 2003; Kozinets et al., 2008). This collective knowledge base of *ideas* (i.e. requirements, feedback, and ideas in tech-discourse community) can be an important source of innovation for both the firm and the user (Gangi & Wasko, 2009).

However, user ideas in innovation communities cannot be instantaneously pursued as new product opportunities, because some already exist as developed products/services in the market (Gangi et al., 2010). It can also stand to reason that referencing similar products/services to the idea can help develop ideas into concepts (Avramenko & Kraslawski, 2008; Kolodner, 2014; Meyer & Marion, 2010; Wu et al., 2008; Wu et al., 2006). Thus, it will be ideal if all ideas can undergo a kind of "overlap check"— both in order to identify new products/service opportunities and to help in the conceptualization of the identified idea.

The objective of this research, in response to the above necessity, is to develop an organized approach to leverage ideas of tech-discourse communities into new product opportunities and concepts. To this end, this research utilizes TM and CBR. CBR has been widely accepted as a creative, computer-aided method to solve new problems by investigating prior set of solutions (Meyera & DeToreb, 2001; Wu et al., 2008). As its essence is to retrieve comparable old solutions to match to new problems, CBR can conveniently perform the aforementioned overlap check where new user ideas stand in as 'problems' and existing products as 'solutions'. However, most user ideas and descriptions of existing products are in unstructured text format, generally retrievable as html documents. In order to preprocess this unstructured data into analyzable database, the paper utilizes TM, a tool for automated discovery of knowledge from texts (Belecheanu et al., 2003). The overall process comprises four stages: case collection, case representation, case retrieval, and case adaptation. In case collection and representation, two databases are constructed: problem casebase (user ideas) and solution casebase (existing product). In case retrieval, new product opportunity is identified and similar products are queried in the solution casebase. In case adaptation, the opportunity is developed into concept by referencing the similar products.

4.2.2 Attempts of textual CBR

Textual CBR is a subfield of advanced CBR on case-based reasoners where some or all of the knowledge sources are available in textual format. It became a frequently used term to denote methods that deal with texts in the design of CBR systems in computer science or artificial intelligence communities, encompassing such techniques as TM or information retrieval (IR) (Bartsch-Spörl et al., 1999). Reviewing the existing literature on the subject, Weber et al. (2005) and Richter & Weber (2013) lucidly categorize textual CBR into four groups. The first group concerns transforming texts into structured case representations. It introduces a typically semi-automated approach to populate case templates from textual documents, where relevant attributes in the templates are selected by the experts. The second group deals with the similarity between textually represented cases. It uses a variety of techniques adapted from IR, such as ontology and thesaurus. The third group concerns adapting textual cases. For example, one approach examines the retrieved text cases and categorizes its sentences to identify which portions are reusable. The fourth group considers automated case representation and retrieval. It introduces novel natural language processing techniques such as association rules, graph representation, and clustering with unlabeled data, to discover general knowledge that represents textual cases.

The research on textual CBR is growing, but many CBR applications still depend on handwork in the process of case representation and casebase development. Most have largely focused on technical aspects of case representation, retrieval, and adaptation (Begum & Ahmed, 2011; He, 2013), rather than seeking and expanding areas for application. Only a few researches have so far identified TM as a beneficial complement of CBR: He (2013) suggests that TM and Web 2.0 technologies should be incorporated into the CBR design and development process for the benefit of CBR users. Geum et al. (2015) has utilized TM to structure the data and identify core service functions, and in turn used CBR to differentiate the function of new service to that of the existent services in the market. This module too will go the route of application, specifically on leveraging ideas from tech-discourse communities.

4.2.3 Proposed approach

4.2.3.1 Overview of the proposed approach

This module proposes using TM-based CBR to extract ideas from tech-discourse communities for the ultimate aim of developing new product/service concepts. To fit this context, we revised the general CBR a bit, referring to similar revisions in CBR for product design as well as suggestions from the extant TM-CBR literature. Changes from the revision are noted in Table 4.10.

In general CBR, Kolodner (1993) defines a case as “a contextualized piece of knowledge representing an experience, which typically contains the problem that describes the state of the world when the case occurred, the solution that states the derived solution to that problem, and/or the outcome which describes the state of the world after the case occurred.” In existing research on CBR for product design, the problem case is a typically new product/service design or development issue whereas the solution cases are previously developed product data or product designs (Meyer & Detore, 2001; Wu et al., 2008).

In understanding our choices for elements of Table 4.10, consider the context of leveraging user innovation. If the firm were to adopt a user idea into practice, it is essentially faced with a *problem* to solve: the idea, after all, will now need to be developed into a new product concept. Hence, this module defines user ideas as *problem* element. The *solution*, or past attempts to solve similar problems, naturally becomes detailed concepts of existing products in the market, much in the similar way to the CBR for product

Table 4.10 Comparison of previous CBR and proposed approach

Element	General CBR	CBR for product design	TM-CBR for leveraging user ideas(suggested)
Problem	The state of the world when the case occurred	New product requirements or design problem	Ideas from tech-discourse community
Solution	The derived solution to the problem	Previously developed product data or product design	Detailed characteristics of existing product/service in the market
Case collection	Collecting solutions into casebase	Collecting product data into casebase; Identifying new problem such as design problem	Collecting two casebases: (1) problem casebase (user ideas), (2) solution casebase (products/services)
Case representation	Constructing casebase according to predefined attributes	Constructing casebase according to predefined attributes such as interface modality, task, and physical structure (Wu et al., 2006)	Constructing casebases using TM; attributes determined from the data
Case retrieval	Retrieving closest cases for a single new problem	Retrieving closest cases for a single new problem	Retrieving multiple sets of closest cases for multiple problems; Evaluating to: (1) identify opportunities within problem casebase, (2) identify reference cases within solution casebase
Case reuse	Manual/automatic	Manual/automatic	Keyword-based adaptation of reference cases

design. But unlike the CBR for product design, where one *given* problem case is referenced to the solution casebase, the goal of our model is to *identify* desirable problems (i.e. opportunistic ideas) within tech-discourse communities. Therefore, two casebases must be constructed, the problem casebase for user ideas and the solution casebase for existing products, as demonstrated in case collection and case representation stages of Figure 4.8. The casebases are constructed through TM, because most ideas and product descriptions are available in textual format. Finally, as there are multiple problems, the case retrieval stage yields multiple sets of similar cases to be evaluated.

The evaluation within the case retrieval stage is twofold: identification of new opportunities for innovation within the problem casebase, followed by identification of reference cases within the solution casebase. The reference cases then will help develop the identified ideas into new product concept in the case adaptation stage, using keyword-based adaptation. Detailed descriptions of these stages will be discussed sequentially hereafter.

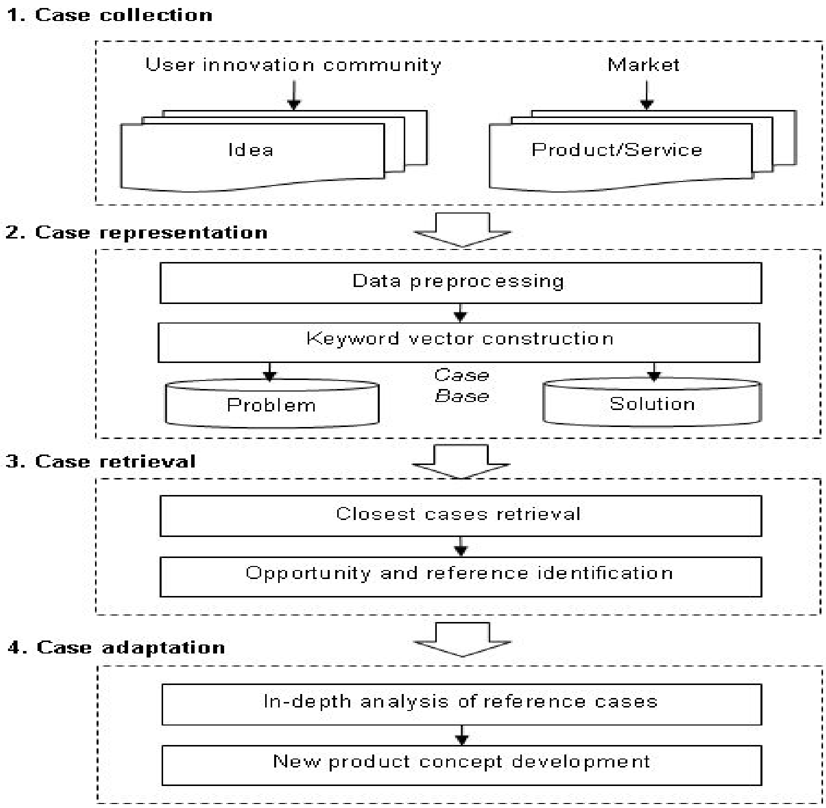


Figure 4.8 Research framework (from Kim et al., 2012)

4.2.3.2 Detailed procedure

Step 1) Case collection

The case collection stage's aim is to create databases of ideas and products to be used in succeeding stages. Ideas are gathered from tech-discourse communities, and the detailed information about existing products is collected from firms. Data source for the idea DB can include postings in existing customer forums and communities of service groups, the articles posted in projects or idea contests of established communities, and the articles in third-party platforms that offer users tools for product development or an opportunity to share ideas. For example, in case of mobile app service, there are customer forums or community websites such as Apple Discussions (http://discussion.apple.com), Modmyi (http://modmyi.com/forum/), iPhone Application List (http://iphoneapplicationlist.com), and iPhone Owners (http://www.iphoneowners.com). The unit of idea DB is not limited to a post or blog of one user, because the collective activities such as feedback and comments can reinforce or reframe the original idea (Kozinets et al., 2008). Second, the data source for product DB can also include such information as the catalogs of online shopping websites, product/service review websites, and the reports of industry analysis, etc. In the mobile app service, for example, open marketplaces such as App Store or Android Market contain the information of functions and features of the mobile app services.

Step 2) Case representation

The case representation stage is a preprocessing of collected DB's to suit the CBR format. CBR requires cases to be represented in structured forms such as index, feature vector, hierarchy, and categorization (Maher et al., 1995); TM, the process of finding interesting patterns, models, directions, trends, or rules from unstructured text (Berry, 2003), can be used to this end. The idea DB and product DB are unstructured data that consist of natural language, and contain massive data. In extracting valuable information from such data, TM can discover meaningful patterns in large quantities of multi-dimensional data and transform them into structured, analyzable format.

In TM, it is assumed that documents in text format can be defined as sets of keywords, and ‘keyword vector’ is the general method of handling large amounts of unstructured text to extract information as structured data. In this study, a keyword vector is constructed as shown in Figure 4.9. The column represents the keyword dimensions, and the row denotes documents of customer ideas (problem) and the product features (solution). The value of each cell in the matrix can be binary values signifying the existence of keyword (i.e. occurrence) or the number of occurrences of keyword (i.e. frequency).

		Keyword *1*	Keyword *2*	...	Keyword *n*		
Problem *1*	(	1	0	...	5	)	Problem casebase
Problem *2*	(	0	1	...	2	)	
⋮				⋮			
Problem *n*	(	1	2	...	0	)	
Solution *1*	(	0	1	...	0	)	Solution casebase
Solution *2*	(	7	3	...	5	)	
⋮				⋮			
Solution *k*	(	2	1	...	0	)	

Figure 4.9 Example of keyword vector

In context of the framework outlined above, we provide below the steps specific to the creation of the keyword vector. Note that in extracting and determining keyword sets, only the keywords that commonly appear in the two DBs are selected, as two DBs may yield different keywords. Also note that as identifying opportunities is the chief aim of this study, we first select keywords from the idea DB and then cross-check within the product DB.

1) Preprocess data to transform html files into text files and eliminate source codes
2) Extract and select keywords in the idea DB
3) Investigate whether they also appear in the product DB
4) Confirm common keywords as a keyword set
5) Categorize the keyword set according to functional characteristics
6) Construct keyword vectors using the keyword set for idea DB and product DB
7) Filter and eliminate idea and product with low frequency
8) Finalize problem and solution casebases

Step 3) Case retrieval

After preparing the two casebases, a case retrieval algorithm is applied to find the best solution for new product development. First, closest cases are retrieved by investigating similarity between problems and solutions. This study chooses the cosine similarity metric, a representative measurement for the similarity between two vectors of n dimension by the cosine of the angle between them (Geum et al., 2015). The cosine similarity is represented using a dot product and magnitude, as below:

$$Cosine\ \ similarity = \frac{P_i \cdot S_j}{|P_i||S_j|} \quad [4\text{-}1]$$

where P_i is the keyword vector of *i* th problem (user ideas) ($i \in [1, n]$), S_j is the keyword vector of j th solution (products/services) ($j \in [1, k]$).

Second, opportunistic ideas are identified by examining the likeness of all ideas to their respective closest cases. If the ideas and the retrieved closest cases are very similar or the same, that means the idea is already developed in the market and therefore the problem is solved; these sets of problem cases will be filtered. The problems that do not have the same retrieved closest cases will, on the other hand, be identified as opportunities, the problems of interest. To summarize, *new product/service opportunities* are defined as user ideas that exist in the product/service vacuums (i.e. unsolved problems without completely matching solutions).

Once the opportunities are identified, it makes sense to review their similar cases to further develop the idea into concept. In browsing the retrieved closest cases, a few useful cases may be identified as *reference cases*. Utilizing these, one may, for example, adopt functional or interface elements from the cases to enhance the idea. For each opportunity, we investigate the closest retrieved cases and select reference cases for benchmarking. These processes are demonstrated below in Figure 4.10.

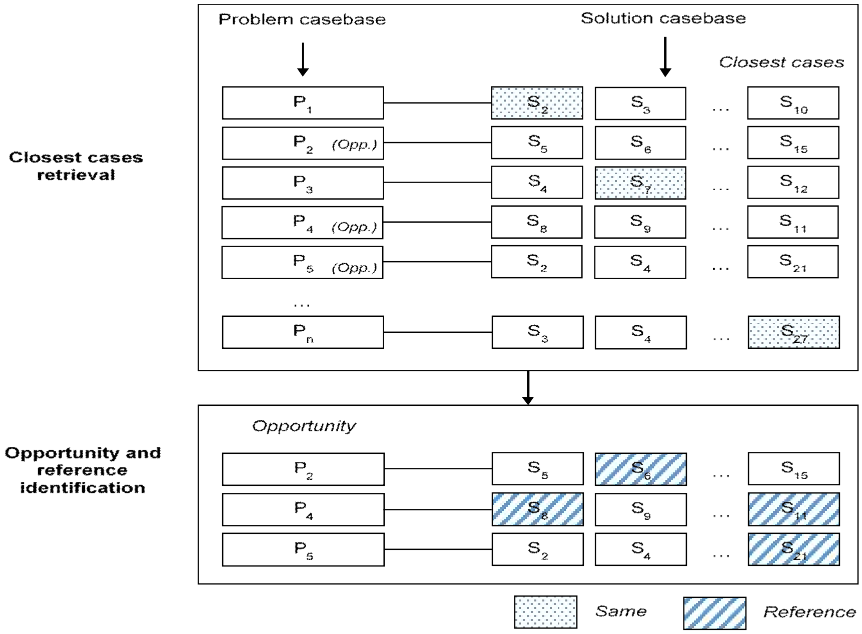


Figure 4.10 Example of opportunity and reference identification

Step 4) Case adaptation

In the case adaptation stage, the opportunities selected in the third stage are refined and elaborated by considering the reference cases. The adaptation is to compensate for the differences between an old situation and a new one, essentially trying to adapt an old solution to a new problem (Avramenko & Kraslawski, 2008); as TM provides common keywords and distinct keywords to be analyzed, we will be using keyword-based adaptation in this module.

In order to implement in-depth analysis of reference cases, we suggest analyzing keyword and functional features. *Common keywords* that appear in both opportunity and reference cases can help investigate common features and operational logic; *distinctive keywords* that appear only in reference cases can identify valuable features that can be benchmarked**.** These analyzes can help develop ideas into more specific product concepts, resulting in new product concept development.

4.2.4 Case of App Store apps

4.2.4.1 Case backgrounds

The following case study on mobile apps in App Store illustrates the overall process of leveraging ideas from online community for innovation**.** Mobile industry has come into a watershed moment in that mobile data traffic has been dramatically growing, driven by new mobile devices and application services. As popular mobile devices such as smartphones, smartbooks, and tablet PCs now connect to mobile broadband networks, mobile app services embodied in such devices have strongly influenced data usage. The App Store concept introduced by Apple in July 2008 allows iPhone users to browse and directly download such app services from the app marketplace.

For one who wants to leverage ideas from these tech-discourse communities, the challenge is overabundance; there are too many mobile apps the App Store market, making it difficult to identify which idea can be an opportunity. We believe that TM-CBR approach can help filter through the profusion of information and help identify and develop opportunistic ideas.

4.2.4.2 Methods and results

Step 1) Case collection: Data collection and preprocessing

The study needs two kinds of data: user idea and product. For the user idea DB, we selected Modmyi (http://modmyi.com/forum), one of the largest independent Apple and iPhone communities, numbering at 775,000 members. Within 'Forums' section in the website, we found '3rd party apps requests' section where the users discuss and suggest app ideas. We selectively collected the threads and replies containing app ideas, excluding questions for existing apps or app reviews. 107 ideas were collected in April 2013, and one idea suggested by the community user is reproduced as follows:

Hello there! Thought this could be the place for posting an app/tweak idea ... I think my situation could be similar to many more people, I got an iPhone/iPad I use at work but once at home my little kids take them from my hands and start to see videos, playing games, fooling around all my apps, etc... It's not the first time they involuntarily send an email to a colleague or even uninstall some of my apps. I think it could be a good idea to have some way to lock the screens you choose from the ipad with a password, but not individual apps (that just exists on cydia), a full screen with icons "grayed" and a button that could pop up a password window that activates all the icons on the screen, for example, until next time iPad goes on standby mode…

For construction of the product DB, we utilized Appshopper (http://www.appshopper.com), one of the largest iPhone, iPad and Mac app directories that include information on price, rating, version, and detailed description of the app. Because most user ideas collected were about ‘utility’ apps in the mobile app category, we chose the utility category of Appstore as the target for the product DB; and since our focus is on functions and concepts, we chose only to collect ‘description of apps’ using Java webcrawling codes. We collected 10,000 utility service description documents from Appshopper in Sep 2013 as a result.

Step 2) Case representation: Construction of casebases

To format the collected data into structured casebases, we applied TM using TextAnalyst 2.1 software, extracting keywords and constructing keyword vectors. As outlined in *4.2*, we first preprocessed data to transform html files into text files and eliminate source codes (step 1). Then we extracted and selected 87 keywords (step 2), but the number of finalized common keyword sets was 69 (step 3 and 4). We categorized the keywords according to characteristics like hardware, software, content, and network (step 5), as shown in Table 4.11.

Table 4.11 The keyword set for keyword vector construction

Category	No. of keywords	Keyword set
Hardware	12	keyboard, camera, volume, slider, speaker, replacement, brightness, battery, headset, viewer, tablet, mobile
Software	20	library, icon, folder, siri, flac, setting, reminder, copy,

		backup, dialer, integration, font, directory, timer, notification, control, auto, manager, alarm, arrange
Content	25	text, music, song, password, multi, photo, information, driving, conversation, audio, video, menu, status, pics, airport, youtube, facebook, artist, employee, car, qrcode, passcode, history, tv, voice
Network	12	sms, mms, wifi, email, bluetooth, gps, download, update, connection, internet, imessage, remote

Using these 69 keywords, we constructed 107 idea keyword vectors as well as 10,000 app keyword vectors (step 6). We filtered keyword vectors with no frequency value less than 4 (step 7), and among the 28 idea keyword vectors that remained, further excluded 14 idea keyword vectors that were either trivial or technically infeasible. Likewise for the product keyword vectors, we filtered to reach the final count of 2352 app keyword vectors. The problem casebase was therefore finalized with 14 idea keyword vectors, and the solution casebase with 2352 app keyword vectors, both with 69 dimensions (step 8).

Step 3) Case retrieval: Identification of opportunistic ideas

In order to retrieve the closest cases for the ideas included in the problem casebase, we calculated the cosine similarity between keyword vectors of problems and solutions. For each idea, we selected 20 closest apps using n-nearest neighbor algorithm. As opportunities in this module are defined as ideas that exist in product/service vacuum, the 20 closest cases are examined for their likeness to their respective idea. Table 4.12 shows the ideas that were filtered as the result of the closest cases retrieval because the examination yielded the same app already in commercialization. The cosine similarity values between these pairs were more than 0.4.

Table 4.12 The results of the closest cases retrieval (ideas excluded)

Ideas		Same apps
Document title	Description	
Anti-speeding ticket app	Speedometer that records time, date, speed, and location Alarming when a driver is going the speed limit	A+ Voice Speedometer
Flac player app in iPhone	Player that supports flac codec	AnyPlayerAD
Several app ideas	Increasing keyboard size Larger keys for keyboard Larger/adjustable typing area	Color Keyboard Pro
Several app ideas	Notifications for when apps that aren't available on cydia (or compatible) become available	AppAlerts - Instant alerts for new app releases!
Several app ideas	One click turn on/off bluetooth pairing Sync all devices	My Bluetooth
Several app ideas	Forcing websites to remember password when browsing	DirectPass
Replacement phone dialer app	Protecting speech or SMS by encryption and decryption	Burner - Disposable Phone Numbers
Shortcuts app	Creating shortcut to the wifi	Easy Wifi

	automatically connecting a lot of wifi spots	
Simplified note taking app	Categorized note with alarm function	E&Q Notes

For example, the idea 'Anti-speeding ticket app' suggested a speedometer app that records time, date, speed, and location, and alarms when a driver is going above the speed limit. However, as our closest case retrieval yielded the 'A+ Voice Speedometer' that already provides almost the same functions, this idea cannot qualify as an opportunity.

After filtering, we selected 5 new service opportunities as follows:

1) Music app for car: easy-to-use mobile app while driving; bigger play, forward, and back buttons; including time of day by default; bigger font in song titles and artist names.
2) Multiple accounts for one mobile phone: allowing creating more than two user profiles; admin full control and guest control.
3) Auto-arrange icons: auto-arrange icons of apps or shortcuts, filling open spaces between icons; arranging by name and kind.
4) YouTube video translator: translating many languages in any YouTube video; showing the translations across the bottom of the screen.
5) Medication reminder: allowing alarms and/or pop-ups to let users know when to take next dose of medicine.

For these five opportunities, we reviewed the algorithm-suggested closest cases and selected one or two reference apps for each, considering their utility and benefit. The results of this review are shown below in Table 4.13.

Table 4.13 The results of reference cases identification

Opportunity	Reference cases		
	Title	Launched date	Price
1. Music app for car	iUnarchiver Pro	Dec, 2011	\$0.99
	Marvel Clock	Dec, 2012	\$0.99
2. Multiple accounts for one mobile phone	FileSafe - Double password folder	Jul, 2012	\$0.99
3. Auto-arrange icons	Desktop Saver for Icon Positions	Sep, 2012	\$1.99
4. YouTube video translator	Voice Translator - Pro Speech Translate	Sep, 2013	\$0.99
5. Medication reminder	E-Reminder - Easy & Efficient Reminders & ToDo List	Oct, 2010	free

Step 4) Case adaptation: Development of ideas to concept

Having identified opportunities and their reference cases, we then performed an in-depth analysis of reference apps to develop the ideas into concepts. By comparing keyword vectors, we identify common keywords and distinctive keywords within four preset categories: hardware (H), software (S), contents (C), and network (N). Table 4.14 denotes the common keywords/features and distinctive keywords/features to be considered in each opportunity-reference app pairing.

As an example of the kind of analysis that will drive idea development, the reference apps identified for 'music app for car' opportunity were '*iUnarchiver Pro*' – an archive management app that includes a music player, and '*Marvel Clock*' – an alarm clock. Since the opportunity is about the interface of a music player, the common features with '*iUnarchiver Pro*' such as playlists, backward and forward control, and font adjustments, can be adopted as basic functions in developing the player. However, as the opportunity mainly suggested bigger size of buttons and fonts for ease of use, the 'font adjustment' option should allow greater flexibility and preset/savable settings. The ease of use for the opportunity can be improved if the remote control function (one of the distinctive features of '*iUnarchiver Pro*') is included in the development. The opportunity's suggestion about including a

Table 4.14 The results of in-depth analysis

Opportunity	Reference apps	Common keywords		Common Features	Distinctive keywords		Distinctive features of reference apps
1. Music app for car	iUnarchiver Pro	H	volume	Music player that supports playlists, forward and back control, and font adjustment	H	-	- Manage folders with playlist (reorder, repeat & shuffle songs) - Display song's info on lock screen - Multimedia remote control support
		S	font, control		S	folder, icon, auto, library, manager	
		C	music, song,		C	text,passcode	
		N	gps		N	remote	
	Marvel Clock	H	-	Touch and move the time label, change color and font	H	camera	- Take photos or choose photos from photo album for background and alarm - Choose default ringtones or record your own voice for alarm
		S	font		S	alarm	
		C	time		C	photo, voice	
		N	-		N	-	
2. Multiple accounts for one mobile phone	FileSafe - Double password folder	H	-	Two secret areas, accessible with two different passwords	H	-	- Dropbox integration: download and upload files from users' Dropbox - Copy files using iTunes or 'open in' function on iPhone
		S	-		S	manager, directory, integration,	

						copy	- Intrusion detection: take a photo when someone types the wrong password
		C	multi, password		C	photo, video	
		N	-		N	download	
3. Auto-arrange icons	Desktop Saver for Icon Positions	H	-	All icons are arranged neatly on top of each other at lightning speed with the 'stacking function'	H	-	- Save and restore up to three desktop profiles to sync icon positions on multiple devices - Perfect integration into the menu bar, allowing a user to change the profiles quickly
		S	icon, arrange		S	integration	
		C	-		C	menu	
		N	-		N	-	
4. YouTube video translator	Voice Translator - Pro Speech Translate	H	-	Translator that utilizes audio or voice as an input through Siri	H	tablet, mobile	- Export translations to email and SMS - Display voice recognition confidence level
		S	siri		S	auto	
		C	voice		C	qrcode	
		N	-		N	SMS	
5. Medication reminder	E-Reminder - Easy & Efficient Reminders & ToDo List	H	-	Reminding users at predefined time	H	-	- Password locks to protect to-do lists - Backup and restore to-do lists - Send a reminder or to-do lists to friends through email and SMS
		S	reminder		S	backup	
		C	-		C	multi, password	
		N	-		N	SMS, email	

default clock can be achieved by referring to the common features of '*Marvel Clock*' controlling time label. In addition, benchmarking the distinctive features of '*Marvel Clock*', we can choose to include alarm functions with selectable background photos and importable alarm tracks from the app's playlist. As seen, multiple reference cases can provide different perspectives on how to refine the idea into a more concrete concept.

As another example, the 'YouTube video translator' opportunity had the reference case of '*Voice Translator - Pro Speech Translate*' – a translation assistant that translates user's voice to another language instantly, with accurate voice recognition. The common features of the opportunity and this reference case were their usage of the Siri function embedded in the iOS device for voice recognition and natural language processing. As the possible rough idea for using Siri was confirmed by the existence of a commercial Siri-driven app, the new service developer can include choose to recognize voice inputs from the video by Siri with relative certainty. Combining the ideas in whole, the new service developer will create a YouTube Video Translator that automatically extracts audio from YouTube video with Siri, translates it into other languages, and reproduces the translations as subtitles under the video. The distinctive features of the reference app that can be adapted to the opportunity are: (1) displaying the confidence level of voice recognition and (2) exporting the translations to email and sms. The remaining three opportunities followed a similar process in using reference cases to refine the idea, and the results for the new service concepts are depicted in Table 4.15.

Table 4.15 The results of developing new service concepts

Opportunity	New service concept
1. Music app for car	- Change size, color, and font for buttons and song info - Preset and savable settings - Multimedia remote control by Bluetooth (i.e. options of music app controlled by in-car buttons) - Set the size, color, font, and location of clock - Take photos or choose photos from photo album for clock and alarm background - Choose song from playlist in the music app as alarm track
2. Multiple accounts for one mobile phone	- Lock the user-selected screens in iPhone with a password - Grey the locked screen to make the content invisible until the password is input in the pop-up window - "Fake area" and "secret area" - Support automatic account linking by scanning QR code - Support multiple accounts on the same device, admin account and guest account - Additional layer of security when managing account details and playing games
3. Auto-arrange icons	- Arrange app lists by name, category, or download date with stacking function - Fill open spaces between apps with stacking function - Identify and sort newly added app icons to existing app lists with stacking function - Save the arrangement with a single click - Save and restore profiles in order to sync icon positioning on multiple devices - Integrate the menu bar allowing a user to change the profiles quickly
4. YouTube video translator	- Translate many languages in any YouTube video - Show the translations as subtitles across the bottom of screen - Use the voice recognition ability of Siri - Display voice recognition confidence level - Export the translations to email and sms
5. Medication reminder	- Track medication including dosage and time of medication - Alarms and pop-ups to let users know when to take next dose - Security function that protects medication history with password lock - Backup and restore medication tracks and schedules - Send a reminder to users' friends through email and sms

4.2.5 Discussion and conclusions

4.2.5.1 Theoretical and managerial implications

This module proposed TM-based CBR approach to exploring and developing new opportunities from ideas in tech-discourse communities. In responses to the lack of approaches to leverage massive quantities of ideas from user communities for product/service innovation, this module contributes to the previous literature by providing a semi-automated approach. First, the case collection and representation stages construct idea DB and product DB, and structures the DBs into problem and solution casebases using TM and keyword vector. Second, the case retrieval stages identifies the opportunities from the problem casebase by running an overlap check, and in turn identifies reference cases from the solution casebase. Third, the case adaptation stage develops the opportunities into concept by running an in-depth analysis of reference cases. The approach distinguishes itself from general CBR in that (1) it constructs two casebases, (2) it uses TM to achieve automatic representation of cases, (3) it runs an overlap-check to screen from multiple problems, and (4) it uses keyword-based adaptation. We believe these methodological aspects can contribute to broaden CBR's application area, especially when more than one problem exists as well as when problems and solutions are in textual format.

In assessing the validity of our approach, perhaps it would be helpful to see whether the service concept results of Table 4.15 have actually been developed since the initial idea was presented. Table 4.16 shows the status of real-world development for each of five user ideas that we selected as opportunities in the case study. The “similar services” in the third column, the earliest services with the most similar functions to the suggested concept, were identified by searching the App Store and other websites.

Table 4.16 Identifying real world developments

New service concept		Real world development			
Service concept	Date suggested	Similar service	Date launched	Price	Rate
1. Music app for car	Apr. 17, 2010	Car Music Player	Jul. 19, 2012	0.99	3.5
2. Multiple accounts for one mobile phone	Jun. 9, 2011	Multi-user support of Android 4.2 tablets (Patel, 2012)	Nov. 13, 2012	-	-
3. Auto-arrange icons	Jun. 24, 2008	SpringSorter (Cydia Tweak)	Oct. 2009	-	-
4. YouTube video translator	Apr. 12, 2012	Auto-translate caption of YouTube using Google Translate service (not for mobile app) (Youtube, 2010)	Mar. 4, 2010	-	-
5. Medication reminder	May. 20, 2009	MedCoach Medication Reminder	Jun. 28, 2011	Free	4

Two of five service concepts (i.e. ‘music app for car’ and ‘medication reminder') appear in the App Store for iPhone. Another two service concepts (i.e. 'multiple accounts for one mobile phone' and 'auto-arrange icons') appear as component of Android OS or Cydia Tweak, a software app for jailbroken iOS, although they are not registered in App Store. 'YouTube video translator' concept was developed by YouTube, although not for the mobile version. As compared in the 'date suggested' and 'date launched' columns, most ideas were suggested one or two years before the launch of comparable services, demonstrating the viability of the concepts suggested by our approach.

The proposed approach can help both firms and users/developers in the tech-discourse communities. For firms, the key challenge in R&D is always in identifying opportunistic ideas, whether they are found internally or externally. Since our approach can both identify opportunities from tech-discourse communities and also suggests ways to improve on the ideas based on reference cases in the market, firms can benefit from incorporating it to their R&D efforts. Note that the approach can be useful for independent users/developers seeking innovation on their own as well, as reference cases can facilitate community discussions and further development of their ideas. The transparency and intuitiveness of CBR, we believe, permits easy understanding and adoption to even non-firm users.

4.2.5.2 Limitation and future studies

In spite of its contribution, the paper has room to be filled in future studies.

We identified two issues: definition of opportunity and methodological combination.

Definition of opportunity

In this study, we defined new product/service opportunity as user ideas that exist in product/service vacuums. The proposed approach therefore involved a process where we screened and filtered ideas based on the overlap with existing products/services, specifically, retrieving 20 closest cases and qualitatively identifying whether the retrieved cases were the same as the user idea. We realize, however, that this minimal criterion for identifying opportunities can and should be elaborated. There are many established criteria to identify creative and valuable opportunities such as novelty, feasibility, relevance, and specificity (Dean et al., 2006), and adopting some of these elements into the screening process will improve the quality of opportunities. The screening methodology can be elaborated as well. There are various attempts to develop systematic screening methods such as fuzzy Analytic Hierarchy Process (AHP), which prioritizes ideas that tend to be more valuable (Meyer & Detore, 2001).

Methodological combination

The case adaptation stage, intended to facilitate conceptualization of the idea, can become more systematized by integrating supplementary methods. In our case study, the opportunities were developed simply by contextualizing, modifying, and combining the characteristics of the reference apps into the new problem. In general CBR, there are various techniques for case adaptation, including parameter adjustment, abstraction/respecialization, critic-based adaptation, reinstantiation, derivational replay, model-guided repair, and case-based substitution, etc. (Avramenko & Kraslawski, 2008). In this regard, various types of such adaptation methods as genetic algorithm and bayesian networks (Mitra & Basak, 2005) can be integrated into the adaptation stage of our approach. Moreover, perhaps QFD (Quality Function Deployment) or TRIZ can be utilized to determine the point of modification in benchmarking the reference apps. Although several previous research has integrated CBR and TRIZ to achieve synergy (Robles et al., 2009), the attempts to apply them to product/service innovation have been scarce.

Finally, the shortcoming of TM should be considered. The utility of the proposed approach depends largely on extracted keywords, but the specific criteria for selecting keywords is ill-defined. Moreover, in the in-depth analysis of case adaptation, the common and distinctive keywords alone did not fully reveal the contents of reference apps. We expected that the common keywords, by themselves, would provide specific methods to develop opportunities, and that the distinctive keywords would identify new features that can be added to opportunities. Our expectations were partially satisfied, and we had to explore beyond keywords to developing our final concepts. To overcome this limitation, future studies may attempt using ontology-based or semantic approach to process textual data, which considers the contexts.

Chapter 5. Utilization of tech-foresight community information

In the module #2, the advantages of futuristic data in tech-foresight communities are identified in terms of future-orientation, social and technological knowledge scope, and objective and subjective perspective. Citing these evidences, this chapter aims to apply futuristic data in tech-foresight community to identify and model drivers and alternatives of technology foresight. As shown in Figure 5.1, this chapter integrates futuristic data into existing technology foresight and planning methodologies, TRM (module #5) and FCM-based scenario analysis (module #6).

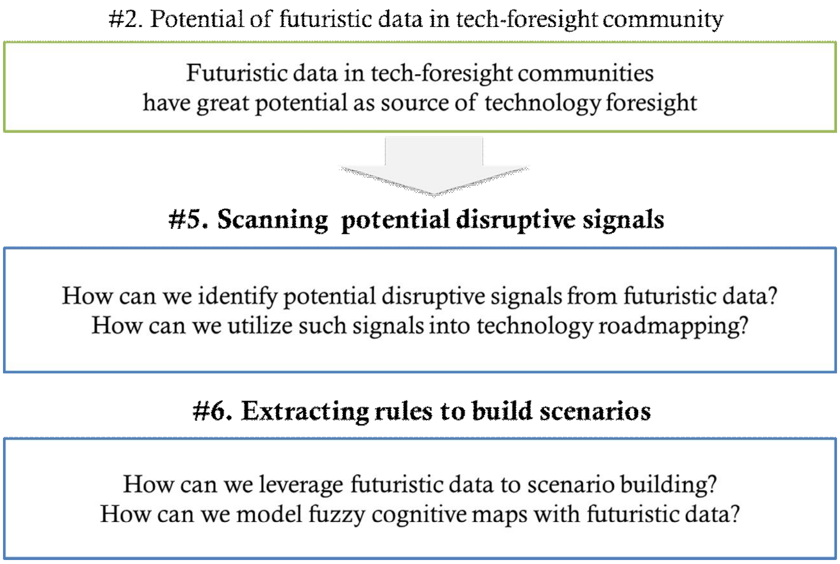


Figure 5.1 Research questions in this theme

5.1 Scanning potential disruptive signals

5.1.1 Introduction

Today's shortened technology lifecycles, hyper-competitions, and uncertain business environments present disruptive forms of innovation. Disruptive innovations that stimulate new forms of competitive dynamics and business models are contrasted with sustaining types of innovation that do not upset existing industry patterns (Christensen et al., 2004; Drew, 2006). The core capabilities to build technology strategy for disruptive innovation have been discussed in literatures (Christensen et al., 2004). First, organizations need foresight into the possible future paths of technology and innovation and their accompanying uncertainties (Carlson, 2004). Second, organizations should have the capacity to absorb and manage new knowledge and to make sense of disruptive signals of impending change from periphery (Christensen et al., 2006; Hamel, 2002). This can be achieved by exploring multiple sources of expert advice and analysis of developments in business environments to develop creative and critical thinking (Drew, 2006).

In response, technology roadmapping, the process for exploring and communicating the evolution of markets, products, and technologies, together with the linkages and discontinuities between various perspectives (Phaal et al., 2004), is developing to consider various data sources. Previous attempts have proposed data-driven or keyword-based technology roadmaps (TRMs). They typically have depended on science and technology (S&T) data sources such as patents and literatures (Kostoff et al., 2004; Lee et al., 2008; Lee et al., 2009; Zhang et al., 2013; Yoon et al., 2008; Choi et al., 2013; Jeong & Yoon, 2015; Martin & Daim, 2008). S&T data can offer valuable information on the patterns of technological change and trajectory; however, they have fundamental limitations to respond disruptive innovations. First, they are limited to only 'posteriori trends', not future trends. This makes firms tend to support continuous or sustaining innovation only, which is based on previous technology evolution. Since the discontinuities and disruptions show a significant departure from the past or from the smooth extrapolation based on the past (Ansoff, 1975; Holopainen & Toivonen, 2012), the anticipation based on posteriori trends often fails and firms confront an unfamiliar threatening or opportunistic events. Second, S&T data are limited to 'technology' viewpoints. Although the disruptive innovation stems from the emergence of a disruptive technology (Kostoff et al., 2004; Walsh, 2004), actual 'disruption' occurs when a disruptive technology is applied to the business model i.e., new product and market needs (Christensen et al., 2004, 2006; Paap & Katz, 2004). Thus, the signs of disruption should be scanned from integrated information of technologies, products, and markets.

In this regard, futuristic data from tech-foresight communities may provide remedial opportunity and be exploited as a potential source of technology roadmapping (Cachia et al., 2007; Pang, 2010; Schatzmann et al., 2013; Veugelers et al., 2010). The futuristic data have three unique features. First, they are information regarding a priori trends of technology innovation.

Second, various types of information on society, market, product, and technology can be easily extracted and incorporated as the components of technology planning. Third, they contain collective intelligence of many experts and organizations. According to Walsh (2004), a roadmap for a disruptive innovation must encompass a wide range of stakeholder and in a more active manner than roadmapping efforts, which focus on sustaining technology. Thus, futuristic data can be an effective source for TRMs.

The primary objective of this research, in response, is to develop a supporting system for technology roadmapping for disruptive innovation using futuristic data. To this end, we suggest keyword-based visual analysis approach to exploring key trends and integrating foresights of multiple sources from the vast amount of futuristic data. Using TM and information visualization algorithms, three types of keyword maps are constructed in consecutive order. First, keyword cluster map is for scanning potential disruption areas appeared in futuristic data. Second, keyword intensity map is for assessing the strength of keywords and selecting potential disruptive signals based on planning viewpoints. Third, keyword relationship map is for gaining insight into the likely development paths of disruptive innovation and constructing keyword-based TRMs. This process can capture the environmental landscapes in a technology or application area and facilitate the efficient and effective technology planning for disruptive innovation.

5.1.2 Related works

5.1.2.1 Keyword-based visual analysis

In the era of big data, the importance of keyword-based visual analysis for technology intelligence has been highly increased in technology management (Yoon, 2008; Yoon, 2010; Zhang et al., 2013; Zhu & Porter, 2002; Morris et al., 2002). Since many databases of technological information (e.g., patent data, bibliometric data, R&D project databases, etc.) are textual data, keyword-based approaches are utilized. In extracting keywords from massive textual data, TM is often utilized for an automated discovery of knowledge from texts (Berry & Kogan, 2010). Information visualization is a set of technologies that use visual computing to amplify human cognition with abstract information (Keim, 2002; Zhang et al., 2012). It efficiently produces visual representations of abstract or multi-dimensional data to reinforce human cognition, thus enabling the viewer to gain knowledge about the internal structure of the data and causal relationships in it (Keim, 2002). The advantage of visual data exploration is that it can rapidly present findings understandably by digesting the enormous amounts of data and the user is directly involved in the data mining process (Zhang et al., 2012). According to thorough review of Yoon (2010), technology information is often visualized as tree, map, network, matrix, curve, and dictionary; for the purpose of technology acquisition strategy, development planning, trend monitoring, trend valuation, capability analysis, technology negotiation, technology infringement analysis, and technology planning. Among them, the technology map is the representative visualization method that covers most various applications.

5.1.2.2 Weak signal theory

In order to identify the potential disruptive signals, this study grounded on weak signal theories (Hiltunen, 2008; Yoon, 2012; Mendonça et al., 2012) since weak signals are the early signs for future disruptions, discontinuities, trends, or other emerging big changes (Eckhoff et al., 2014; Rossel, 2009; Saritas & Smith, 2011). According to Ansoff (1975) who coined weak signal, a weak signal is defined as 'seemingly random or disconnected pieces of information that at first appear to be background noise but which can be recognized as part of a larger pattern when viewed through a different frame or by connecting it with other pieces of information'. In general, the typical examples of weak signals are messages and signs associated with early developments in technologies, societal innovations, conflicts, origins of conflicts, demographic shifts, new rivals, new regulations etc. (Day & Schoemaker, 2005; Saritas & Smith, 2011).

Citing from Ansoff, Hiltunen (2008) proposed the three dimensions of future sign: signal, issue, and interpretation. Specifically, (1) signal is the number and/or visibility of signals, (2) issue means the number of events or the diffusion of phenomenon to a variety of other units, and (3) interpretation is the receiver's understanding of future sign's meaning; for example, an organizational point of view of this can be the importance of the sign for an organization in the future. A sign of which all dimensions are small is a weak signal and it strengthens to a strong signal when there is a rise in at least one of the dimensions. Thus, we utilize these dimensions to assess keyword strength. Using signal and issue dimensions, Yoon (2012) suggested the keyword-based weak signal detection approach in web news. He quantitatively measured the 'degree of visibility' (i.e. signal) based on keyword frequency and 'degree of diffusion' (i.e. issue) based on document frequency, and then constructed keyword portfolio maps to discriminate weak signals and strong signals. Since the strengthening of weak signals into strong signals requires a time period (Mendonça et al., 2012), the strength of signals can represent whether the signals are related to short-term or long-term future. These criteria are utilized in developing keyword intensity map.

5.1.3 Proposed approach

The objective of this module is to propose the keyword-based visual analysis approach to support technology roadmapping from futuristic data. The potential disruptive signals are scanned at keyword level in this module. The research process consists of five steps, as shown in Figure 5.2.

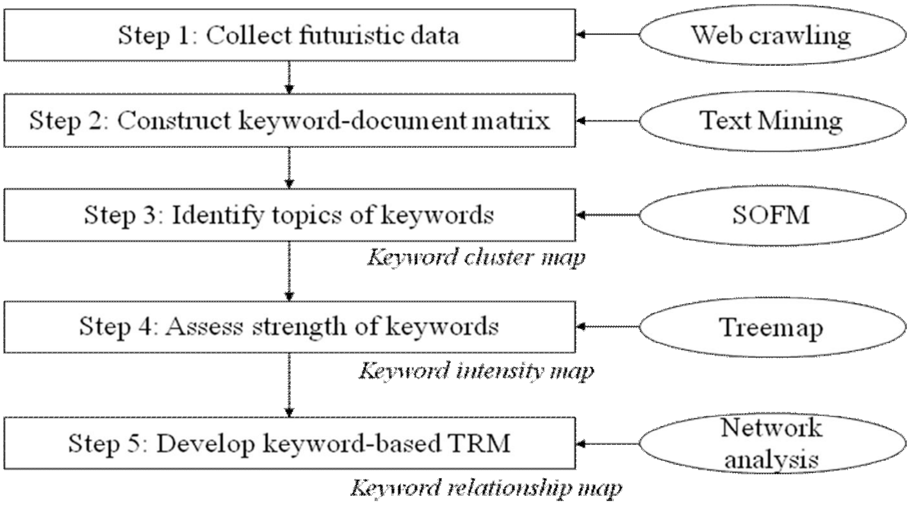


Figure 5.2 Research process

First, futuristic data are collected from the tech-foresight communities using web crawling techniques. Second, futuristic data, which consist of unstructured textual documents, are transformed into *keyword-document matrix* as an analyzable format using TM. Third, *future topics* are identified from keyword cluster map. Since the extracted keywords are too massive and fragmented, a cluster of keywords that frequently co-occur in documents can represent a homogeneous topic and help to interpret the meaning in text easily. Thus, this module primarily classifies the keyword clusters and identifies their topics regarding future. Fourth, the keywords for each topic are assessed in terms of *strength* using keyword intensity map. Based on Hiltunen (2008) and Yoon (2012)'s conceptualization, this module assesses the intensity of keywords using the dimensions of future signals, i.e., visibility, diffusion, and interpretation, and then classifies the keywords into short-term, mid-term, and long-term keyowrds. Lastly, the keyword-based technology roadmaps (TRMs) are developed using keyword relationship map. In this stage, the keywords are classified into TRM metaphors that constitute the layers, i.e., purpose, delivery, and resources; their *intra-layer and inter-layer relationships* are measured by similarity; and finally TRMs are constructed.

Step 3 to 5 involve three types of keyword maps based on 'visual algorithms': keyword cluster map, keyword intensity map, and keyword relationship map. *Keyword cluster map* facilitates scanning future topics appeared and discussed in futuristic data; in this purpose, we apply self-organizing feature map (SOFM) as a visual clustering algorithm. *Keyword intensity map* represents the keyword signals' visibility and diffusion in the purpose of classifying and selecting keywords as short-term, mid-term, and long-term keywords; for this, we utilize *treemap* visualization approach as visual filtering method. *Keyword relationship map* uncovers the relationships among keywords; this can be achieved by *network analysis* approach. The map helps gaining insight into the likely development paths of innovation. The detailed explanations of the proposed approach are provided in following sections.

5.1.3.1 Collecting data

The data sources of this study are the futuristic data posted in tech-foresight communities. Since boundaries of futuristic data are wide and variety of information can be collected, technology strategists should certainly decide objectives (why we analyze futuristic data) and targets (what to focus in futuristic data). They first decide the objective of planning (connecting with vision and mission) and the area of target technology (or market), and second identify and select relevant tech-foresight communities. For the selected websites, the futuristic documents are collected through web crawling technique.

5.1.3.2 Constructing keyword-document matrix

The futuristic data are collected as the html documents which consist of unstructured texts. In order to build maps, the data should be processed into structured format. TM tools analyze futuristic documents as inputs, identify keywords in the whole documents, and measure the frequencies of their occurrence in each document. In TM, it is assumed that documents in the text format can be featured by keywords, and a keyword-document matrix (KDM) is the general method of handling large amounts of unstructured text to extract information from structured data.

TM starts with extracting terms from documents. Since there are meaningless keywords such as stop-words, or the keywords with low frequency, the overall keyword set is refined by eliminating such keywords. Then, KDM, as shown in Eq [5-1], is constructed. The row represents the keywords whereas the column denotes each futuristic document. The value of each cell in the matrix, kf_{ij} denotes the normalized frequency of i th keyword in j th document ($i \in [1,n]$ and $j \in [1,d]$). Since the length of document, i.e., the sum of total keyword frequency in j th document, can be various, we utilize the keyword frequency divided by the length of documents as kf_{ij}. Row vectors of KDM are keyword vectors of d dimension.

$$KDM = \begin{array}{c|c} & \begin{array}{cccc} period_1 & & \dots & period_T \\ doc_1 & doc_2 & \dots & doc_d \end{array} \\ \begin{array}{c} keyword_1 \\ keyword_2 \\ \dots \\ keyword_n \end{array} & \begin{bmatrix} kf_{11} & kf_{12} & \dots & kf_{1d} \\ kf_{21} & kf_{22} & \dots & kf_{2d} \\ \dots & \dots & \dots & \dots \\ kf_{n1} & kf_{n2} & \dots & kf_{nd} \end{bmatrix} \end{array} \qquad [5\text{-}1]$$

5.1.3.3 Identifying future topics: keyword cluster map

First visualization is a keyword cluster map to identify the main topics referred in futuristic websites. Among many clustering algorithms, this study selected SOFM as the visual analysis algorithm.

Using the keyword vectors as the input data, keywords are mapped onto 2-dimensional grids (i.e., by reducing dimensions from d to 2) as SOFM training, and then are clustered using k-means clustering. Since SOFM has ability of doing both clustering and visualization at the same time or *clustering via visualization* (Flexer, 2001; Morris et al., 2002), the clustering process can be implemented in an interactive manner; for instance, if SOFM visualizes the distribution of keywords in 2D keyword space, then the analyzer can determine and iteratively refine the number of clusters to fit the distribution. Thus, the algorithm is appropriate to identify effective clusters from vast of futuristic documents. As a result of constructing the keyword cluster map as Figure 5.3, topics and keyword sets assigned to the topics are extracted.

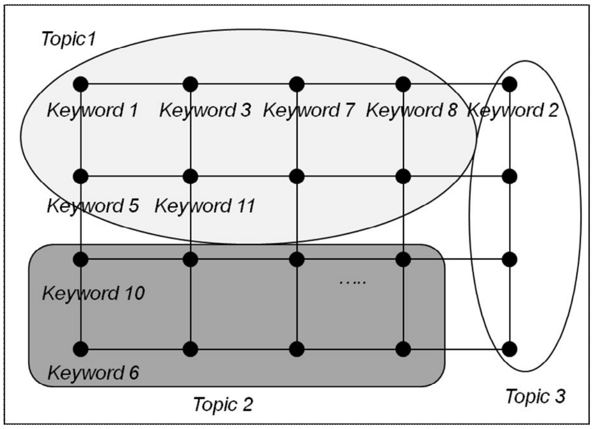


Figure 5.3 Keyword cluster map

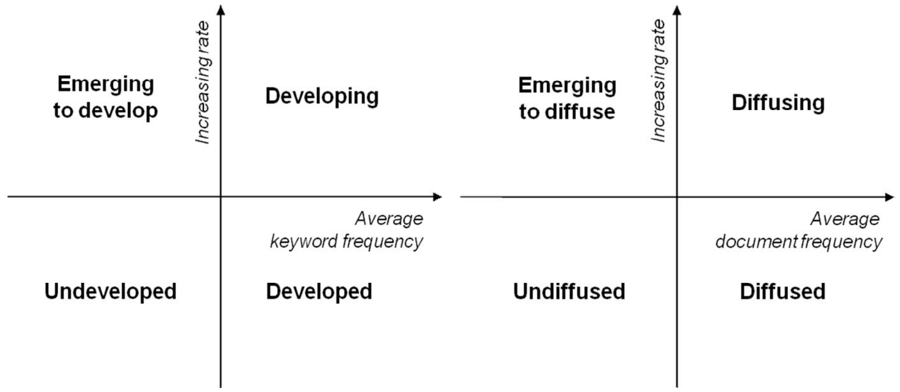
5.1.3.4 Assessing keyword strength: keyword intensity map

For each topic of future, a keyword intensity map is constructed to assess keyword strength. As mentioned before, the map is based on the visibility, diffusion, and interpretation of weak signal theory. First, we measure average keyword frequency (KF_i) (i.e. the average frequency of i th keyword for all documents) and document frequency (DF_i) (i.e. the number of documents that includes i th keyword) and their average increasing rates between periods $t \in [1, T]$ as following Eq [5-2] and [5-3]:

$$\text{Average increasing rate of } KF_i = \frac{1}{T-1}\sum_{t=2}^{T}\frac{kf_i(t)-kf_i(t-1)}{kf_i(t)-kf_i(t-1)} \qquad [5\text{-}2]$$

$$\text{Average increasing rate of } DF_i = \frac{1}{T-1}\sum_{t=2}^{T}\frac{df_i(t)-df_i(t-1)}{df_i(t)-df_i(t-1)} \qquad [5\text{-}3]$$

Where $kf_i(t)$ is average keyword frequency of i th keyword in period t and $df_i(t)$ is document frequency of i th keyword in period t. Using these variables two types of keyword intensity maps can be constructed as Figure 5.4: keyword visibility map and keyword diffusion map. The maps can visualize the portfolio of keywords which are again classified into four quadrants. Keyword visibility map classifies keywords into four visibility categories: (1) developed sign that already gained visibility and so increasing rate is low, (2) developing sign that is actively obtaining visibility at high increasing rate, (3) emerging to develop sign that increasing rate of visibility is high even though absolute visibility is low, and (4) undeveloped sign that both are quite low. In the same manner, keyword diffusion map can classify keywords into four diffusion categories: (1) diffused, (2) diffusing, (3) emerging to diffuse, and (4) undiffused sign. For example, diffused sign means the sign already diffused to a variety of people and does not actively increase.



(a) Keyword visibility map (b) Keyword diffusion map

Figure 5.4 Conceptual definition of keyword intensity map (adapted from Yoon (2012))

In Yoon (2012)'s framework, weak signals are identified in the intersection of 'emerging to develop' and 'emerging to diffuse' quadrant whereas strong signals are the intersection of 'developing' and 'diffusing'. However, there are other intersections such as 'emerging to develop' and 'undiffused'; these also have potential to be weak signal or strong signal.

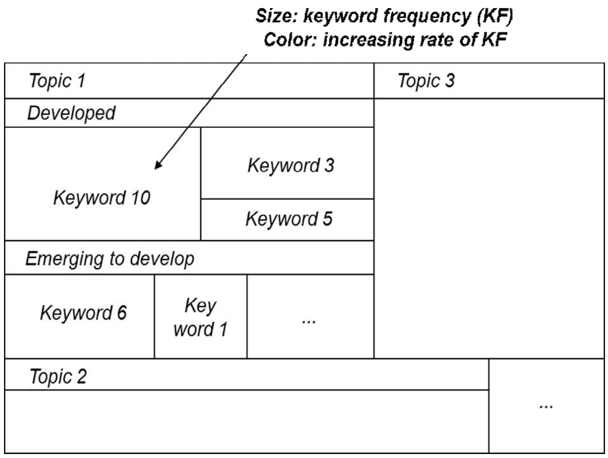
Rather to find the clear distinction of weak signal and strong signal which is ambiguous (Hiltunen, 2008), this study views every combination of the quadrants of visibility map and diffusion map can be potential disruptive signals because they exist in the blurry zone of weak signal and strong signal. In return, the combinations of developed-diffused and undeveloped-undiffused which can be regarded as certainly strong and weak signals are excluded, as shown in the grey-colored cells in Table 5.1. In the table, a keyword gets weaker when it moves from upper-left to lower-right. Since many of studies argue that a weak signal is strengthening into strong signal through graduated stages thus requires time lag (Choo, 2002; Mendonça et al., 2012; Rossel, 2009), we assume that ‘a category closes to weak signal (lower-right) will be prevail in long-term future and thus be considered in long-term planning’. Based on this conceptualization, the classification of keywords according to strength into short-term, mid-term, and long-term is suggested as Table 5.1.

Table 5.1 Classification of keywords according to keyword strength

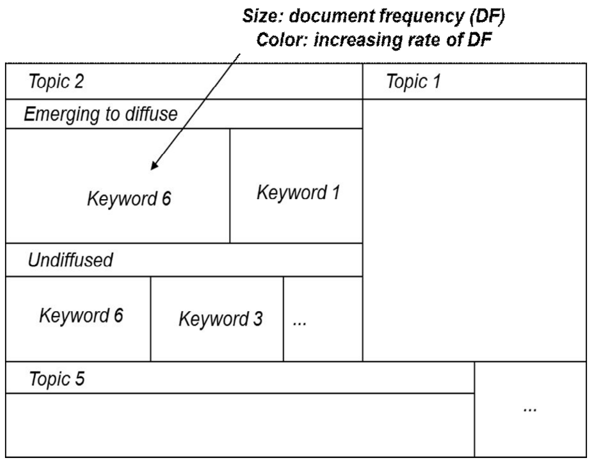
Visibility / Diffusion	Developed	Developing	Emerging to develop	Undeveloped
Diffused	(strong)			
Diffusing		Short-term signal		Mid-term signal
Emerging to diffuse			Long-term signal	
Undiffused		Mid-term signal		(weak)

Still, the classified keywords are required to be ‘reassessed’ in terms of organizational importance because not all keywords are strategically fit in organization’s planning. This can be ‘interpretation’ dimension in Hiltunen (2008)’s future sign model. However, interpreting and reviewing and those numerous keywords with various classes are too complex and time-consuming. As a solution, this module suggests developing keyword intensity maps using treemap algorithm, rather than portfolio map (i.e. Note that Figure 5.4 shows 'conceptual definition' of map). Treemap is a space-filling approach for displaying hierarchical data by using nested rectangles (Shneiderman, 2006; Shneiderman et al., 2012). Previous studies hold that hierarchical (tree) displays can potentially alleviate the problems of traditional list display such as hypertexts based on the advantages in an effective information access tool, particularly for browsing and information retrieval (Chung et al., 2005).

As the multi-variables of derived from hitherto analysis for keywords (i.e., topics, KF, increasing rate of KF, visibility category, DF, increasing rate of DF, diffusion category) are complex and hierarchical, treemap is appropriate to use its visual coding such as hierarchical filling, size, or color simultaneously. Figure 5.5 describes the suggested treemap structure of keyword intensity map; in keyword visibility map, for example, topic-visibility category-keyword hierarchy is represented by space-filling, the size of each keyword is set to KF, and the color is coded as increasing rate of KF. Although two maps are separated, they should be developed and read simultaneously for each topic in order to (1) categorize keyword into short-term, mid-term, and long-term, as well as (2) select strategically significant keywords. This process can be supported by 'drill-down interaction' of treemap; if one clicks a topic, the keywords assigned in the topic are specifically illustrated. Thus, analyzer easily explores the keyword timelines by comparing two maps and select strategically important keywords in a comprehensive manner.



(a) Keyword visibility map



(b) Keyword diffusion map

Figure 5.5 Keyword intensity map

Since Table 5.1 uses the level of visibility and diffusion, the gap between visibility and diffusion can lead to general interpretation guidelines to filter out the insignificant keywords as below:

- Keywords of currently established trends; if so, they may be not disruptive in future
- Keywords from the opinions of the minority: The keywords in lower-left section in Table 5.1 with high visibility in spite of the relatively low diffusion is expected to be this case when the minority is very focusing on documenting a certain keywords; since these can be still disruptive signal, analyzer should carefully interpret the meaning of keywords
- Keywords of everyday terms that the majority can freely refer to: The keywords in upper-right section with high diffusion in spite of the relatively low visibility can correspond to this case
- Keywords of garbage which had to filtered out in preprocessing

5.1.3.5 Developing keyword-based TRMs: Keyword relationship map

As an output of keyword intensity map, the set of potential disruptive keyword signals and their timelines are identified. For developing TRMs, the relationships among keyword signals should be uncovered. To this end, keyword relationship map is constructed using network analysis, a quantitative technique derived from graph theory, facilitates the analysis of interactions, or ‘edges,’ between actors, or ‘nodes’. This can help to answer the question like which product attributes should be developed for market disruptions? or which technology aspects are relevant to future product attributes?.

The process of developing keyword relationship map is as follows. First, topics and keywords are classified into the elements of strategic innovation planning. Typical example can be technology roadmapping metaphor suggested by Phaal et al. (2004). They referred to key elements of technology planning as follows:

- Purpose (know-why): The organizational purpose that is driving roadmap, e.g., what future customers want to receive, or how the social trends changes (market, customers, competitors, environment, industry, business, trends, drivers, threats, objectives, milestones, or strategy)
- Delivery (know-what): The bridging or delivery mechanism between purpose and resources, e.g., which function the future product/service provides (products, services, applications, capabilities, performance, features, components, families, processes, systems, platforms, opportunities, requirements, or risks)
- Resources (know-how): The resource that will be deployed to address the demand from the top layers of roadmap, e.g., which technological aspects the future products wants (technology, competence, knowledge, skills, partnerships, suppliers, facilities, infrastructure, organization, standards,

science, finance, or R&D projects

Second, the linkage of topics and keywords are measured using similarity measures. Among various similarity measures, this study uses cosine similarity, a representative measurement for the similarity between two vectors of multi-dimension based on the cosine of the angle between them. The cosine similarity is represented using a dot product and magnitude, as shown in Eq [5-4].

$$S_{ik} = \frac{keyword_i \cdot keyword_k}{|keyword_i||keyword_k|} \qquad [5\text{-}4]$$

where $keyword_i$ and $keyword_k$ are the row keyword vectors of the i th and k th keyword ($i,k \in [1,p]$) in KDM. The cosine similarity ranges from -1 (exactly opposite) to 1 (exactly the same), with 0 usually indicating independence and the in-between values indicating intermediate similarity or dissimilarity. In the case of information retrieval, the cosine similarity of two keywords ranges from 0 to 1 because the keyword frequency values are all positive. As a result of measuring cosine similarity, similarity matrix in Figure 5.6 is developed. Since we classified the TRM metaphors, the sub-matrices of same metaphors located in diagonal describe intra-layer relationships; and the other matrices denote inter-layer relationships.

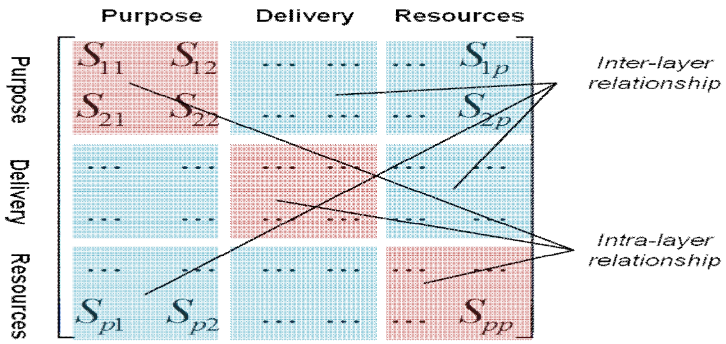


Figure 5.6 Similarity matrix

Lastly, keyword relationship map is developed. The map represents keywords with their categorization of technology planning metaphor in TRM layers (Y-axis) and with their categorization of strength in X-axis, as shown in Figure 5.7. From the keyword relationship map, analyzer can simplify the task of identifying which purpose affect which delivery attributes. It also gives some knowledge on which out of several alternative resources should be selected for application to a new delivery, in addition to being used to identify which new ideas for resource can address particular delivery requirements.

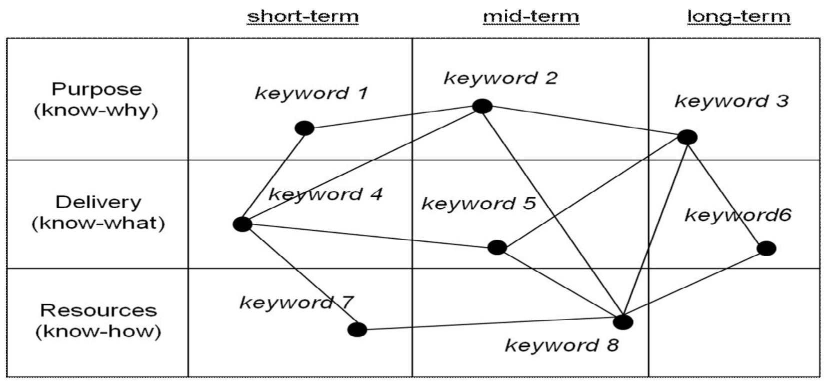


Figure 5.7 Keyword relationship map

5.1.4 Illustrative case of wearable computing technology

The case study illustrates the overall process of a keyword-based visual analysis of futuristic data. This module especially focused on wearable computing technology area. Without a doubt, wearable computing technology is the most prevailing disruptive technology in 2015, as in examples smart glasses or smart watch. As the convergence of IT and BT accelerates, wearable computing technology is predicted to be integrated into everyday life and revolutionize the mainstream society. However, since the shape of future in wearable computing technology is quite uncertain, strategic planners cannot easily identify the disruptive signals that can be either opportunity or threat to their business especially in long-range planning. In this context, we apply the visual scanning approaches to aid the organization to seize the opportunity or evade the threats prior than a competitor by leveraging the opinions and predictions of various experts and the general in technology foresight communities.

5.1.4.1 Data collection and preprocessing

First, we identified and selected the tech-foresight communities considering the relevance of technology area. The selected websites were five: Siemens, MIT Technology Review, Kurzweil Accelerating Intelligence, World Future Society, and FutureTimeLine.

Then, we searched posts using two keywords i.e. “wearable” and “wearable computing” from five tech-foresight communities in Feb 2014. Using the web crawling program by JAVA language, we collected total 454 futuristic documents as HTML files. To format the collected futuristic data into structured keyword-document matrix form, TM was applied using TextAnalyst 2.1 software. Before applying TM, we cleaned data to transform html files into text files and eliminate source codes. As a result, 1777 keywords are extracted from 454 documents. A preprocessing is also conducted to remove meaningless keywords and keywords with low frequency (below five); as a result, 730 keywords are fixed. Then, the original keyword frequency is normalized according to the length of documents. Consequently, the KDM is constructed as 730x453 matrix.

5.1.4.2 Identifying topics using SOFM-based keyword cluster map

In order to identify topics, SOFM-based keyword cluster map is constructed using “SOM Toolbox” based on matlab (Vesanto & Himberg, 1999). By inputting the keyword vectors in KDM, SOFM is initialized and trained. We arrange the keyword neurons as a hexagonal lattice. From the iterative training of SOFM, the optimal size of grid in output space is determined as 13x10. Then, keywords are again clustered using k-means clustering algorithm. In order to select the number of cluster (k), k-means is implemented with several values for k and their results are visually and quantitatively evaluated. For visual evaluation, we investigated the keywords of each cluster represented in SOFM; in terms of whether they are interpreted as a single, homogeneous topic or not. For quantitative evaluation, we utilized Davies-Bouldin index (Davies & Bouldin, 1979) that indicates the similarity of clusters which are assumed to have a data density which is a decreasing function of distance from a vector characteristic of the cluster. Taken together, we identified 11 topics in the Figure 5.8 and Table 5.2 From the number of keywords, the futuristic data includes many keywords regarding 'medical and bionic' topic; thus, it seems to be important in the future of wearable technology.

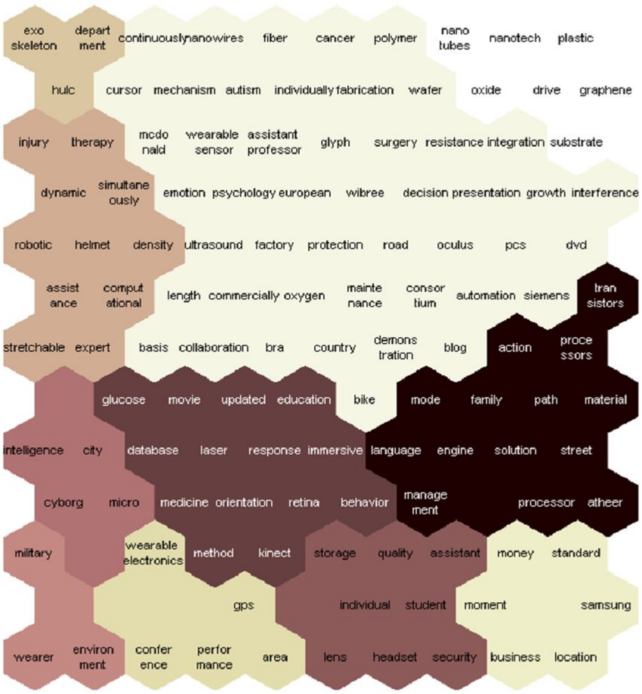


Figure 5.8 Result of building keyword cluster map

Table 5.2 Results of identifying future topics

#	Future topics	No. of keywords	Part of keywords list
1	Medical and bionic	259	kidney, neuroengine, nervous system, stroke, cursor, sensory feedback, bionic, emotion, expression, surveillance, dementia, ultrasound, stimulation, humanity, transcranial, wearable sensor, psychology, detection, factory, earbuds, torso, ...
2	Infotainment	68	movie, fabric, artificial intelligence, mountain, education, optics, fluid, awareness, sale, lumus, eyewear, kinect, accelerometer, laser, response, society, retina, eyeglasses, wristwatch, response, database, ...
3	Workplace and office	90	action, server, enterprise, competition, customer, processors, worldwide, dream, sunlight, mode, path, infrastructure, language, identification material, rapidly, servers, engine, antenna, workplace, solution, ...
4	Nanotechnology	44	nanotube, carbon nanotubes, nanoparticles, indium, nanotech, piezoelectric, electricity, plastic, treatment, detector, depression, rfid, reader, graphene, oxide, semiconductor, ...
5	Robotics for the handicapped	46	exoskeleton, robotic exoskeleton, avatar, cortex, paralyzed, wheelchair, somatosensory, affectiva, hulc, rechargeable, texture, wearable robot, ...

6	Healthcare and neuroscience	48	injury, rehabilitation, improvement, warrior, therapy, biotech, dynamic, aging, eyetap, comparison, humanoid, robotic, darpa, strength, virtual reality, helmet, sensation, public healthneurocam, survival, ...
7	Industrial application	33	intelligence, frequency, laboratory, equipment, longevity, biomed, city, cyborg, micro, hospital, temperature, lightweight, unit, ...
8	Military robotics	35	military, robotics, man, wearer, robot, movement, news, enhancement, human enhancement, ui, infotech, environment, wirelessly, shirt, ...
9	Electronics and interactive system	26	wearable electronics, conference, telecom, performance, pressure, director, generation, feedback, automatically, entertainment, privacy, GPS, area, pc, interactive, ...
10	Media	39	storage, manager, controller, microphone, download, quality, knowledge, mouse, audio, connection, assistant, car, conversation, individual, walker, magnitude, lens, recognition, online, innovation, demo, headset, vuzix, tv, music, keyboard, security, communication, application, memory, tablet, photo, president, ...
11	Fitness and wellness	42	money, party, driving, standard, consumer electronics, fitbit, nike, moment, wrist, office, fitness, wristband, business, attention, bluetooth, smartphone, gadget, ...

5.1.4.3 Assessing strength of keywords using treemap-based keyword intensity map

In the purpose of categorizing keywords for their strength, two types of keyword intensity maps are constructed using “TIBCO®Spotfire” software as shown in Figure 5.9. The keyword visibility (diffusion) map represents keyword (document) frequency as the size and average increasing rate of keyword (document) frequency as the color (i.e., red as min and green as max). Note that all keyword cells of ‘undeveloped’ and ‘developed’ are red because they have low increasing rate; and ‘developing’ and ‘emerging to develop’ are green, although the color get darker when the increasing rate is lower or higher. Also, the hierarchical information of topics and visibility (diffusion) categories are visualized. The treemap structure leads to simple and intuitive perception because the keywords are filling spaces in ordered manner.

From Figure 5.9, we ‘interpret’ and select keywords that seem to be significant for organizations in wearable computing. The interactive evaluation and filtering can be possible by drill-down into lower level of hierarchy. As illustrated in Figure 5.10, when clicking a topic (e.g. ‘medical and bionic’), and individual keyword cell (e.g. ‘british’ and ‘ultrasound’), we can identify the keywords can be disruptive signal or not. In this example, the keyword ‘british’ is categorized as ‘undeveloped’ and ‘emerging to diffuse’; thus, can be classified as long-term signal. However, the keyword ‘british’ is only one of general terms that anyone can freely cite and meaningless in

(a) Keyword visibility map

(b) Keyword diffusion map

Figure 5.9 Result of building keyword intensity maps context of medical and bionic applications; thus filtered out. While, the keyword ‘ultrasound’ of the combination of ‘developing’ and ‘undiffused’ is included as mid-term signal because it can be important technical role to medical and bionic application of wearable computing. As a result of the interactive evaluation and filtering, we extracted 241 potential disruptive signals among total 730 keywords. The ‘nano technology’, ‘workplace and office’, and ‘healthcare and neuroscience’ topics include short, mid, long-term keywords in balanced way; but, others are not: ‘medical and bionic’ and ‘robotics for the handicapped’ topics are weighted to long-term signals and rest of the majority are weighted to short-term signals.

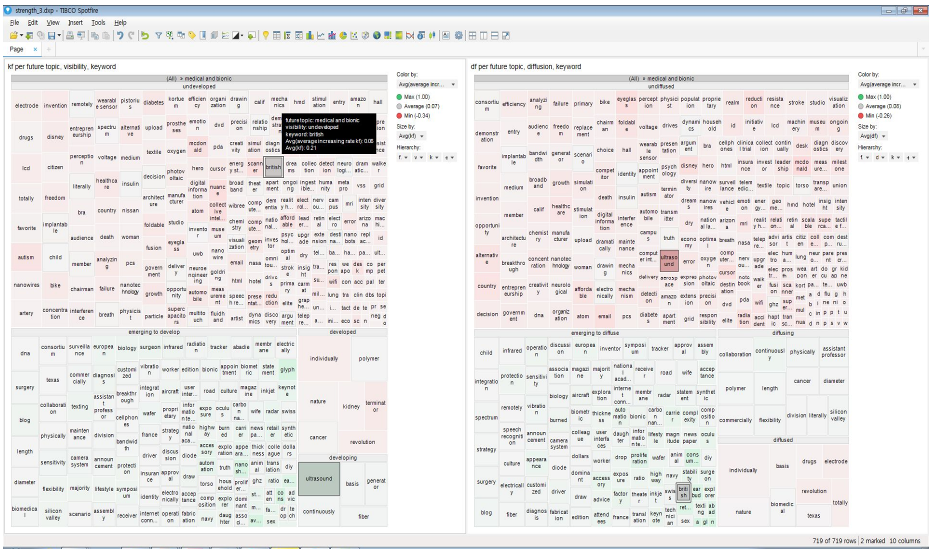


Figure 5.10 Interactive drill-down to interpret and select keywords

5.1.4.4 Developing TRMs using network-based keyword relationship map

The selected potential disruptive keywords are again classified into the TRM metaphor of strategic innovation planning, i.e., purpose, delivery, and resource. For illustration, 'workplace and office' and 'medical and bionic' topic are selected to build keyword relationship map, considering that they have large proportion of keywords and are divided into short, mid, long-term. The cosine similarities among potential disruptive keywords are measured and the networking software package "UCINET 6" is utilized to visualization. Building maps, the cut-off value is applied for the similarity as 0.05, i.e., the edges of which similarity is lower than 0.05 are not linked. The X-axis is timeline of the keywords coded by the shape of the nodes (i.e. up-triangle, square, and circle), whereas the Y-axis is the TRM layers coded by the color of the nodes (i.e. yellow, orange, and green). The result of keyword relationship maps are as shown in Figure 5.11 and 5.12.

These results provide several interesting implications for TRM planning. In the 'workplace and office' example in Figure 5.11, the wearable computing will pursue the rapidity (i.e., 'rapidly' in purpose layer) in the workplace with development of 'analysis' and 'desktop' products and 'processor' technology in a short-term future. The development of 'processor' technology is associated with 'myo', an armband that provides wireless control with gestures and motion, in the mid-term, and 'myo' is related to the 'sunlight' purpose in the long-term. The gesture control armband is different from previous ones, since previous remote control products have depended on the camera but it measures the electrical activity from the users' muscles and

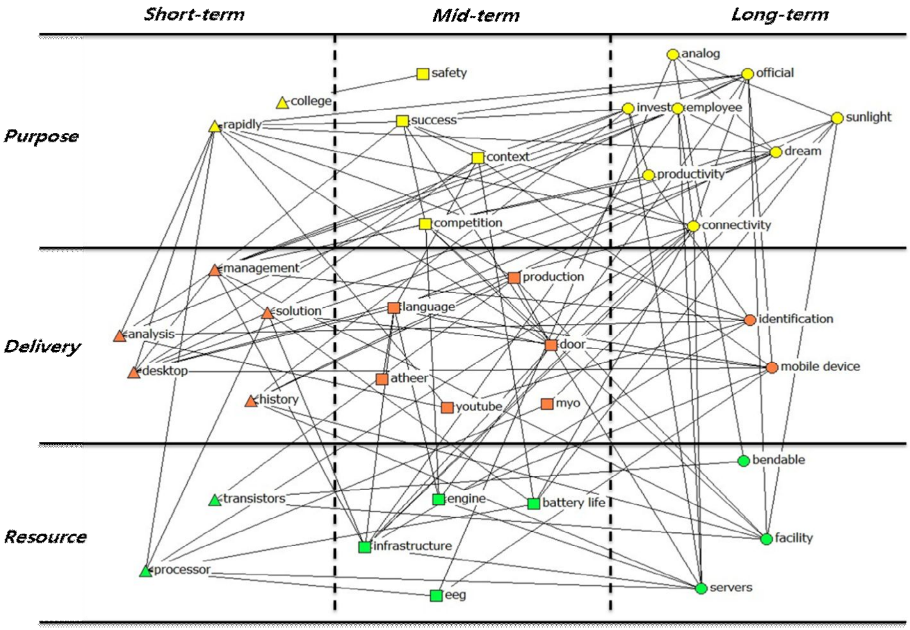


Figure 5.11 Keyword relationship map for ‘workplace and office’ topic

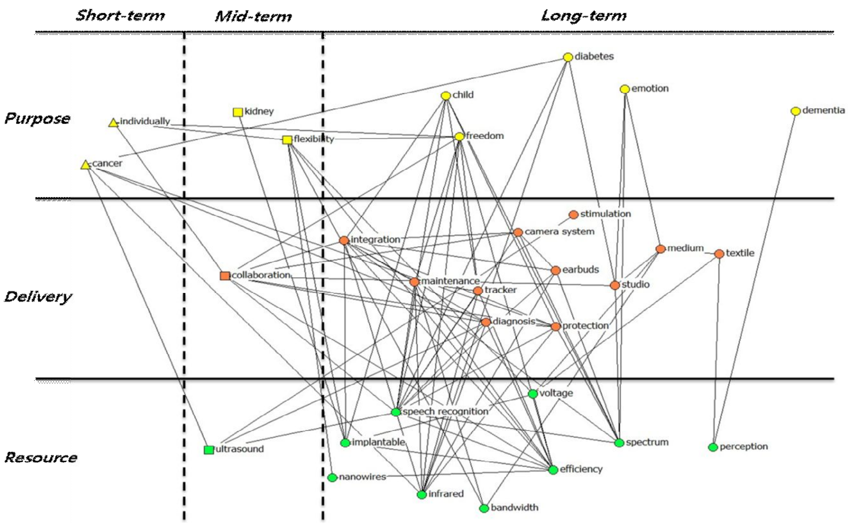


Figure 5.12 Keyword relationship map for ‘medical and bionic’ topic

determines the poses of hands. This can overcome the limitation in the constraints such as small workplace or the place with sunlight. Although the armband is applied in office works such as presentation or drone controlling, it is expected that in mid-term future the product will be prevail and in the long-term future it will generate more application such as in sunlight environment. The keyword ‘door’ in delivery layer is interesting: in the mid-term future, the door in workplaces will be changed as or associated with wearable products triggered by ‘infrastructure’ and ‘server’ technology, and will be applied for ‘competition’, ‘success’, ‘connectivity’ and ‘official’ purposes. The door can embed sensors to measure the status of passing people and utilized as motivating bulletin boards or social networking boards.

In example of the ‘medical and bionic’ in Figure 5.12, most of keywords are distributed in long-term; thus, wearable computing for medical and bionic area seems to be realized in relatively long-term future. Also, compared to Figure 5.11, there are less intra-layer relationships especially in purpose layer: the needs from market or business may emerge without the sequenced evolution. Regarding ‘cancer’, the needs appear in short-term future, but delivery for this such as ‘diagnosis’ and ‘protection’ are in long-term future: in any case, the cancer will be detected and protected by wearable computing technology. The significant resources seems to be ‘speech recognition’ and ‘infrared’ technologies, because they are linked with most of deliveries such as ‘collaboration’, ‘integration’, ‘maintenance’, ‘tracker’, ‘diagnosis’, ‘earbuds’, and ‘protection’ as well as the purposes such as ‘freedom’ and ‘diabetes’.

5.1.5 Discussions and conclusions

5.1.5.1 Theoretical implication

This module suggested a visual scanning approach to exploring potential disruptive signals from futuristic data and leveraging them into technology roadmapping. From a theoretical perspective, the proposed attempt can contribute to identifying opportunities and building foresight for disruptive innovation. Using futuristic data, this module addresses the shortcomings of previous research that simply utilized posteriori sources for TRMs. The use of futuristic data can offer the potential disruptive areas in current as well as other markets; examine facts, stimuli, and inspiration from many stakeholders’ insights; and discover the disruptive applications of existing technologies and explore un-served or over-served market segments.

From a methodological perspective, the visual analysis approaches can provide proper intelligence for technology roadmapping by dealing with vast amount of futuristic database. First, using TM, the textual futuristic data are structured as analyzable KDM. Second, responding to the diverse and wide range of information from futuristic data, the SOFM-based keyword cluster map identifies topics as potential disruption areas in the future of technology. Without information loss, the SOFM identifies homogeneous topics which includes various timelines as well as the drivers of market/business, key products, and technologies in the future trend. Thus, the rest of two maps focus on the classification and selection of keywords contained in topics. Third, the treemap-based keyword intensity map explores the strength or weakness (visibility and diffusion), and the strategic importance (interpretation) of the keywords in order to construct the timelines of TRM. Although the number of keywords can hinder the clear cognition, the treemap's space-filling and drilling-down capability helps manage complexity in analysis. Fourth, the network-based keyword relationship map investigates the fields of keywords in order to construct the layers of TRM and intra-layer and inter-layer relationships. This offers basic evidence and support to technology planning.

Lastly, the most important advantage of the framework is the improved efficiency and effectiveness for fast-developing TRM. The previous data-driven and keyword-based TRMs focused on the efficiency in terms of time and costs, or the objectivity compared to expert-based qualitative approaches. This module holds this points since more valuable objectivity and systematic planning can be set up from futuristic information. However, we should not overlook that in data-driven TRMs, expert (or strategic manager) knowledge often still paly a decisive role. Although keyword-based TRMs are apparently efficient than qualitative approach, they still needs keyword selection and filtering processes which lengthen the time to construct TRM. In these viewpoints, the 'interactive' visual analysis can involve not only the data-driven information but the analyzer-driven knowledge: the analyzer can determine which keyword to be focused on from the map. As shown in Figure

5.13, the keyword selection process in this module can be reconstructed as keyword filtering funnel. The funnel arises in preprocessing filter to filter stop-words or meaningless keywords out (step 2), visibility/diffusion filter to exclude too strong or weak keywords (step 4), and interpretation filter to discard insignificant keywords (step 4). Before second and third filters, keyword topics are divided so that helps to percept and select keywords. The guidelines of these can lead to improve effectiveness and efficiency.

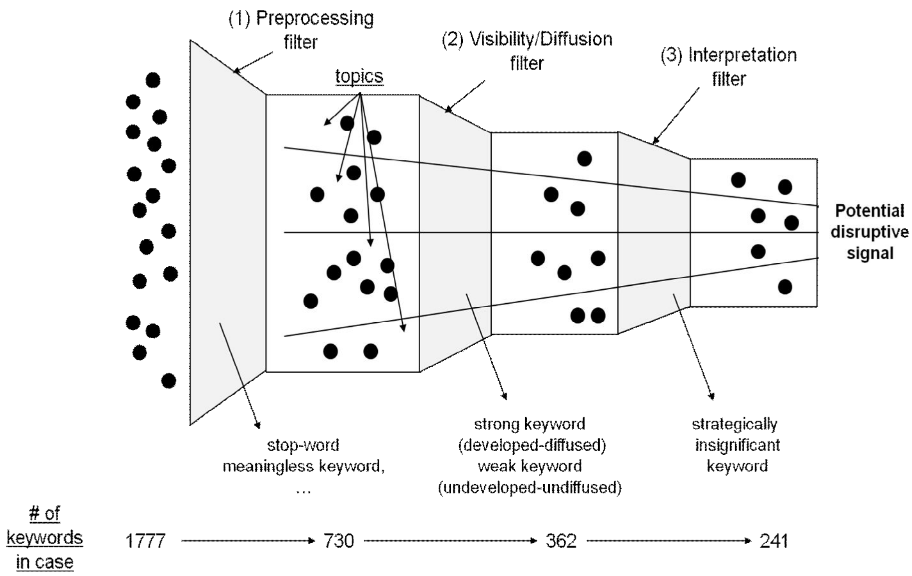


Figure 5.13 Keyword filtering funnel

5.1.5.2 Limitation and future studies

In spite of the contribution, there are limitations and rooms to be elaborated in future research. First, the research of futuristic data is in infant stage, the comparison and integration with S&T data can be further elaborated. Second, this study only considered the knowledge from outside the organization; the factors from inside the organization (e.g. vision, strength, weakness) can be integrated by using interactive visualization functions. Lastly, although this study borrowed the weak signal theory, the linkage between disruptive innovation and weak signal should be investigated more. Since there are arguments on the definition and criteria for identifying weak signal, our criteria based on keyword frequency, document frequency, and their increasing rates can be further extended and elaborated. For instance, the factors for evaluating technologies (e.g. potential of acquisition, implementation, use, diffusion, securing, future, and technological impact) can be involved and guided in treemap analysis. Also, there are other opinions in the assumption that weak signal is realized in long-term future; these can be experimented and compared.

5.2 Extracting rules to build scenarios

5.2.1 Introduction

The uncertainty of the business environment has highlighted the strategic gravity of scenario in technology foresight and strategic planning (Bishop et al., 2007). Scenarios are defined as a set of hypothetical events in the future constructed to clarify a possible chain of causal events as well as their decision points (Kahn, 1967); or a disciplined methodology for imagining possible futures in which organizational decisions may be played out (Schoemaker, 1995). As the consideration of scenarios can significantly enhance the ability to deal with uncertainty and the usefulness of overall decision making process, scenario planning has been adopted in technology planning or strategic analysis (Drew, 2006; Hirsch et al., 2013).

Fuzzy cognitive map (FCM), among various scenario development approaches, has recently drawn attention due to its relative advantage of combining qualitative (creative) knowledge and quantitative structuring process (Amer et al., 2013a, 2013b; Biloslavo & Dolinšek, 2010; Jetter & Kok, 2014; Jetter & Schweinfort, 2011; Kok, 2009; Salmeron et al., 2012; Soler et al., 2012). FCMs are cognitive fuzzy inference graphs, within which the nodes stand for the concepts that are used to describe the behavior of the system and the causal relations between the concepts are represented by signed and weighted arcs (Kosko, 1986). Since the FCMs simulate dynamic evolution based on its initial model, they can be used to analyze and test the influence of parameters and predict the behavior of the system. Thus, FCM-based scenario approach is known to cover most of the generic set of steps for scenario planning (Jetter & Schweinfort, 2011)

The formalization of FCMs has been achieved by two main groups of methods: deductive modeling using an expert knowledge about the domain of application, and inductive modeling using learning algorithms based on historical data. A number of previous studies applied FCM to model expert-based systems (Khan & Quaddus, 2004; Lee & Lee, 2015; Salmeron et al., 2012; Stach et al, 2010; Tsadiras & Bassiliades, 2013). Although these *deductive modeling* methods are well-established, they have shortcomings in that they require domain knowledge which can be limited to relatively simple systems and subjective or biased models. To address such shortcomings, several *inductive modeling* methods are recently proposed and examined to generate FCM models from input historical data, and without human intervention (Chen et al., 2015; Papageorgiou, 2012; Stach et al., 2005). Papageorgiou (2012) provides the types of learning algorithms as Hebbian-based ones to produce weight matrices that lead the FCM to converge into a given decision state or an acceptable region; and Population based ones (e.g., genetic algorithm, particle swarm optimization, divide and conquer, etc.) to compute weight values on the basis of historical data that best fit the sequence of the states of concept nodes. However, the attempts of inductive modeling are also subject to fundamental limitations. First, the greater part of their focus is on the identification of weight values when the set of concept nodes are given by experts (Papageorgiou, 2012). Second, they rely on only historical data, a list of the phenomena regarding target system, and assume that same trends will prevail in future.

In this context, we propose that the futuristic data can be supplementary or even alternative knowledge source for FCM-based scenario development. As tech-foresight communities are emerged by many providers, meaningful and massive futuristic database are accumulating. Thus, a concept of future-related database has been suggested by a number of literatures. Since the futuristic data are a priori, i.e., not historical data containing issues and argues for new directions, expectations, and predictions of future, they are suitable source to scan not only future drivers of changes and resulting impacts, which will be used as the concept nodes of FCM, but the relationship among them, which will be used as the edges of FCM.

Taken together, the primary objective of this research is to propose the approach to applying futuristic data to FCM-based scenario development. Despite the utility, extracting the future drivers and their causal relationships from the vast amount of futuristic data can make scenario building more time-consuming (Mietzner & Reger, 2005). Thus, several data mining techniques are applied to systematically find patterns from futuristic database for developing FCM. First, in order to identify the concept nodes of FCM, keywords and textual patterns are extracted from futuristic database using TM (Berry & Kogan, 2010; Lin et al., 2009) and Latent Semantic Analysis (LSA) (Dumais, 2004). Second, in order to identify the causal relationships and weights among concept nodes of FCM, Fuzzy Association Rule Mining (FARM) is applied because FARM can provide if-then rules from large database (Agrawal et al., 1993). Unlike the traditional standard ARM, which requires the binary valued input data set, FARM can deal with a numeric attribute that can take a range of values; thus, it can consider the importance and frequency of concepts appeared in futuristic database. The suggested approach can be expected aid to improve the effectiveness and efficiency of scanning knowledge for FCM-based scenario development.

5.2.2 Fuzzy Cognitive Map-based scenario planning

Many previous studies have focused on the application of FCM into future scenario building (Amer et al., 2013b; Biloslavo & Dolinšek, 2010; Ferreira et al., 2015; Jetter & Kok, 2014; Jetter & Schweinfort, 2011; Salmeron et al., 2012). The main purpose of scenario planning is to focus on the uncertain aspects of the future and develop a limited number of possible states that tell a story of how various elements might interact under certain conditions (Schoemaker, 1995). For this, FCM-based scenario approaches elicit diverse experts' knowledge of uncertain driving forces that shape the future and simulate what-if experiments to create the alternative scenarios (Jetter & Kok, 2014). The following framework is typical process for development of FCM-based scenarios by integrating scenario planning and FCM modeling processes (Jetter & Schweinfort, 2011):

(1) Scenario preparation: Clarification of the objective, time frame and boundaries of the scenario project.
(2) Knowledge capture: Identify relevant concepts/potential scenario drivers through experts and literature review, merge mental models of various experts and subsequently translate these into conceptual FCM scenario model.
(3) Scenario modeling: Streamline the causal links and assign weights and signs to all links, choose threshold functions for all concepts.

(4) Scenario development: Calculate the FCM model for different *input vectors* that represent plausible combinations of concept states.
(5) Scenario selection and refinement: These raw scenarios developed after step 4 are further assessed and refined by scenario simulation.
(6) Strategic decisions: The developed scenarios are used for making strategic decisions.

In step 4, in order to construct the input vectors, the uncertain and important concepts as well as their plausible combinations should be identified. To this end, several previous studies have been utilized a static analysis for identifying important concepts based on network theory such as centrality (Ferreira et al., 2015; Khan & Quaddus, 2004; Yaman & Polat, 2009) and a morphology analysis (Ritchey, 2006; Yoon et al., 2008) to investigate raw scenarios the combination of important concepts (Amer et al., 2013b). On the other hand, in step 5, a dynamic analysis is conducted for identifying the final results of simulating the input vectors of the raw scenarios using upper mentioned inference mechanism (Amer et al., 2013b).

5.2.3 Futuristic data-driven scenario building

5.2.3.1 Outline of proposed approach

The core idea of this module is the application of TM and FARM to FCM in order to leverage the textual futuristic data into scenario building. To this end, the proposed method consists of five stages, as shown in Figure 5.14.

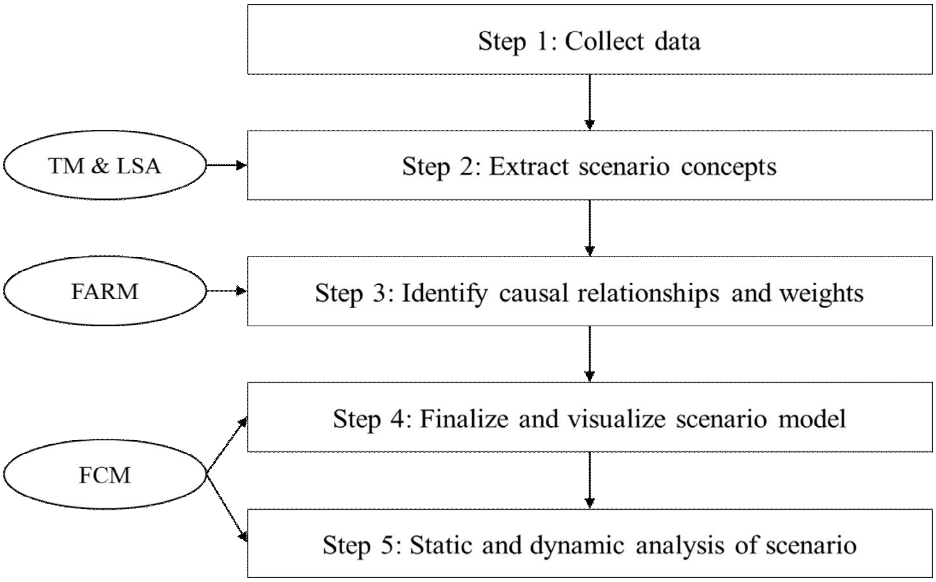


Figure 5.14 Overall research process

First, futuristic data are collected from the tech-foresight communities. Second, a set of terms are extracted and structured as the term-document matrix and scenario concepts are constructed, by applying TM and LSA to collected data. The '*scenario concept*' in this module is technically defined as a topic which consists of the set of keywords with similar meaning; LSA is applied for identifying the coherent set of keywords (i.e. semantic textual patterns) and defining scenario concepts. Third, the causal relationships and weights are identified as the result of FARM. Fourth, a scenario model is finalized and visualized as a FCM. Lastly, the FCM-based scenario is analyzed in static and dynamic viewpoint.

5.2.3.2 Detailed process

Step 1) Collecting data

Futuristic data is defined as a collection of future-oriented opinions extracted from websites and online communities of large participation and collaboration of many experts and the general (Kim & Park, 2014). The examples of futuristic data contained in such websites can be: database and wikis, news and blogs, social rating systems, collaborative scenarios, and prediction markets.The providers of futuristic data can be various stakeholders such as IBM and GE, professional technology forecasting or consulting companies such as Gartner and McKinsey, trend reporting websites such as Science Daily and Engadget, communities of experts or futurists such as Next Big Future, World Future Society, and communities of the public such as social rating system, collaborative scenarios, and prediction markets. The field of technology they focused is mainly ICTs, but other fields such as bio, nano, and energy, and social trends are also part of their concerns. Futuristic data include various level of future-oriented information such as current trend, short-term forecasts, or long-term forecasts. Also the forms of information are various, such as news, report, magazine, web post (blog), forum (tread-reply), etc.

From these various sources of futuristic data, a scenario developer should identify which websites are offering the information regarding future scenario he/she want to build. Since the scenarios can also focus on various technology fields (e.g. IT scenario, BT scenario, etc.) or level of future-oriention (e.g.

short-term scenario or long-term scenario), the source websites can be selected by considering the information characteristics of websites such as technology field and future-orientation and data volumn of searching targeted scenario subjects.

Step 2) Extracting scenario concepts

This module identifies scenario concepts (i.e. concepts that configure a FCM) by extracting a set of keywords that have semantic similarity. Since the futuristic data are textual, unstructured corpora (i.e. set of documents), TM is necessary to process their natural languages. TM starts with extracting terms from corpora. Since there are meaningless keywords such as stopwords, or the keywords with low frequency, the overall keyword set is refined by eliminating such keywords. Then, the term-document matrix (TDM) with the normalized frequency of keywords is constructed, as below:

$$TDM = \begin{array}{c} \\ t_1 \\ t_2 \\ \cdots \\ t_n \end{array} \begin{array}{c} \begin{array}{cccc} d_1 & d_2 & \cdots & d_m \end{array} \\ \begin{vmatrix} tf_{11} & tf_{12} & \cdots & tf_{1m} \\ tf_{21} & tf_{22} & \cdots & tf_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ tf_{n1} & tf_{n2} & \cdots & tf_{nm} \end{vmatrix} \end{array} \qquad [5\text{-}5]$$

Where t_i is i th term extracted from corpora (where i = 1,…, n), d_j is jth document (where j = 1,…, m), and tf_{ij} is the normalized term frequency of t_i in document d_j. However, t_i, keywords in TDM are not enough to grasp the context of textual data and analyze their latent meanings. The reason is that the futuristic data are online documents freely written by many users who can have different writing styles or use different words for same meaning. In this case, LSA is effective to identify the set of keywords with similar meanings, which delivers one topic of documents. Thus, as we defined previously, the scenario concepts are defined by semantic textual patterns that LSA derives as the set of term dimensions that can be integrated as one dimension in TDM. To do this, Singular Value Decompositionis performed on TDM to reduce the dimension of the matrix (Dumais, 2004) as follows:

$$TDM = U \Sigma V^T \qquad [5\text{-}6]$$

$$U = \begin{array}{c|cccc|} & v_1 & v_2 & \cdots & v_p \\ t_1 & u_{11} & u_{12} & \cdots & u_{1p} \\ t_2 & u_{21} & u_{22} & \cdots & u_{2p} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ t_n & u_{n1} & u_{n2} & \cdots & u_{np} \end{array} \quad \Sigma = \begin{array}{c|cccc|} & v_1 & v_2 & \cdots & v_p \\ v_1 & \Sigma_1 & 0 & \cdots & 0 \\ v_2 & 0 & \Sigma_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ v_p & 0 & 0 & \cdots & \Sigma_p \end{array} \quad V = \begin{array}{c|cccc|} & v_1 & v_2 & \cdots & v_p \\ d_1 & v_{11} & v_{12} & \cdots & v_{1p} \\ d_2 & v_{21} & v_{22} & \cdots & v_{2p} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ d_m & v_{m1} & v_{m2} & \cdots & v_{mp} \end{array}$$

Where, u_{ik} is the impact of *i* th term on *k*th semantic textual pattern for *U* (where *k* = 1,…, *p*), *n* x *p* matrix with orthonormal columns, Σ_k is the importance of *k* th semantic textual pattern for Σ, *p* x *p* diagonal matrix with the entries sorted in decreasing order, and v_{jk} is the impact of *j* th document on *k*th semantic textual pattern for *V*, *m* x *p* matrix with orthonormal columns. Thus, the semantic textual patterns $v_1, v_2, ..., v_p$ are directly mapped into scenario concepts, $C_1, C_2, ..., C_p$ in FCM. For each v_k, the terms highly impacting v_k are identified by investigating u_{ik} in the matrix U, and corresponding scenario concept C_k is defined considering the meaning of allocated terms with high u_{ik}.

Step 3) Identifying causal relationships and weights

In order to extract association rules for the scenario concepts, $C_1, C_2, ..., C_p$, the matrix V, the impact of documents on concepts is used as the input of FARM. The reason why we apply FARM is to extract causal rules among concepts such as $C_k \rightarrow C_l$, considering the quantitative impact values of concepts in documents. As described in Figure 5.15, the fuzzy item set I_f here corresponds to set of scenario concepts $C = \{C_1, C_2, ..., C_p\}$, whereas the fuzzy transaction data set $D_f = \{t_1, t_2, \ldots, t_N\}$ here can be a set of documents containing the strength or impact of occurrence of C. Since the impact values v_{jk} of V matrix denotes the degree that document d_j impacts on C_k by containing the concept C_k in them, we interpret this as the degree of membership to be C_k.

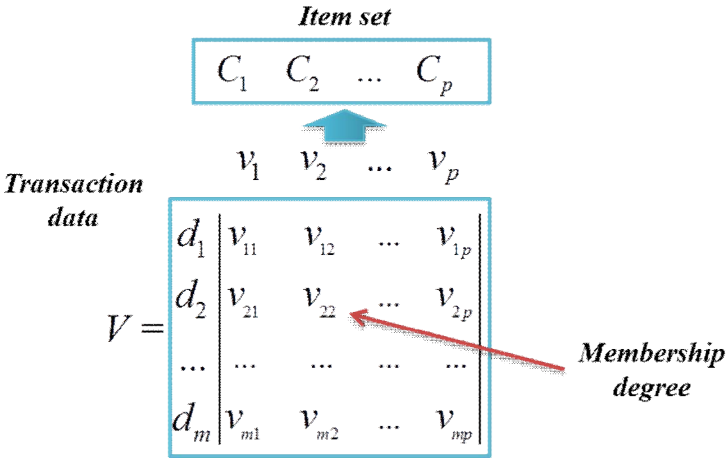


Figure 5.15 Structure of input data for FARM

The support and confidence measures are modified as follows:

$$\sup p(C_k \rightarrow C_l) = \frac{\sum_{j=1}^{m} v_{jk} \otimes v_{jl}}{m} \quad [5\text{-}7]$$

$$conf(C_k \rightarrow C_l) = \frac{\sum_{j=1}^{m} v_{jk} \otimes v_{jl}}{v_{jk}} \quad [5\text{-}8]$$

The output rules of FARM are represented as $C_i \rightarrow C_j$. Thus, the aggregation of extracted rules leads to the FCM building.

Step 4) Finalizing and visualizing scenario model

As shown in Figure 5.16, this study utilizes the support measure to eliciting significant concepts from the set of concepts $C_1, C_2, ..., C_p$, by maintaining concepts with *minsupp*. If every rules engaged with a concept has support values less than minsupp, the concept is filtered out from FCM. Likewise, the confidence values are also used for identifying association rules satisfies with *minconf*. Furthermore, the confidence values are utilized as the weight of edges, which corresponds to the 'absolute' values of W_{ij}. Since the confidence is the conditional probability of rules, or causal relationships, it directly corresponds to the impact of occurrence of one concept to another or the relative strength of relationships. Lastly, the signs of weights are determined by analyzer.

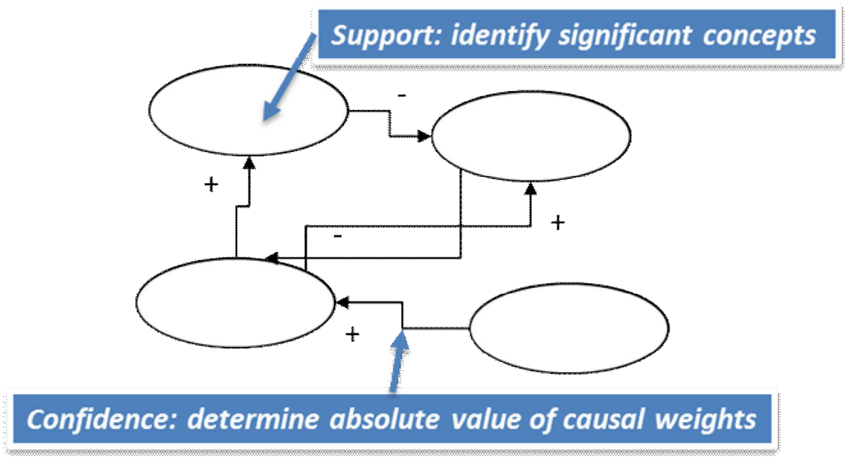


Figure 5.16 Concept of applying ARM to FCM modeling

Step 5) Analyzing scenarios

For the constructed FCM, two types of analysis can be conducted. First, an

FCM can be used for a *static analysis* of the domain for establishing the relative importance of concepts, and indirect and total causal effects between concept nodes (Khan & Quaddus, 2004; Yaman & Polat, 2009). The centrality of network theory can be a measure for determining the importance of nodes in an FCM, as follows:

$$Concept \quad centrality = IN(C_i) + OUT(C_i) \qquad [5\text{-}9]$$

Where indegree, $IN(C_i)$ is the sum of the weights of causal links constituting all path connecting nodes C_j, $i \neq j$, to C_i and outdegree, $OUT(C_i)$ is the sum of weights of causal links constituting all path connecting node C_i to all nodes C_j, $i \neq j$. Concepts with high centrality values deserve special attention in any analysis for decision support.

Second, an FCM can be used for a *dynamic analysis* to observe and explore the impact of changes and the behavior of system with time (Amer et al., 2013b; Khan & Quaddus, 2004; Lee & Lee, 2015). Using dynamic analysis, a range of what-if analyzes can be done by subjecting the FCM to a range of initial state vector values of interest. The important factors with high centrality can be utilized. According to Amer et al. (2013b), the input vectors of raw scenarios are constructed by a morphology analysis that combines and selects variations of important concepts. Then, the output vectors of several raw scenarios are identified by repeated multiplication of input vector and adjacency matrix until stabilization as discussed in FCM inference mechanism.

5.2.4 Illustrative case study: Electric Vehicle (EV) scenarios

5.2.4.1 Background

In order to illustrate the applicability of the proposed approach, a case study of electric vehicle (EV) is conducted. EV is a collection of diverse technologies such as battery, motor, and recharging system. With the recent widespread deployment of EV technologies, urban mobility is expected to become more environmentally sustainable. In addition to technological aspects, however, there are a lot of social, economic, and political factors acting in a highly complex manner. Thus, a notable change may occur by one of the factors in the future development of EV.

There have been some studies to comprehend or assess the impact of EV in the near future (Lin et al., 2009; Zhang et al., 2013). For example, Lin et al. (2009) applied the DEMATEL technique, which is a comprehensive method for building and analyzing a structural model involving causal relationships between the complex factors to construct a cognition map of alternative fuel vehicles. Meanwhile, Zhang et al. (2013) generated global EV technology roadmap using hybrid model that combines bibliometric approaches, and experts' knowledge. However, the presented results mainly depend on few experts; and are lack of consideration of the collective intelligence on various factors. In this illustration, we consider a lot of opinions and predictions about the future of EV which have been discussed in futuristic database.

5.2.4.2 Process and results

Step 1) Collecting data

As the data sources for futuristic documents, five websites are selected as Siemens, MIT technology review, Kurzweil Accelerating Intelligence, World Future Society, and FutureTimeLine. As of March 2015, we collect documents related to future of EV from five foresight communities and the total corpora is constructed as 2017 futuristic documents.

Step 2) Extracting scenario concepts

First, the futuristic data are processed as TDM, which consists of 92 keywords with 2017 documents. Part of the matrix is shown in the following Table 5.3 After that, normalized frequency of keywords with respect to the length of document is used as a value because frequency depends on the length of document.

Table 5.3 Part of the term-document matrix

	Doc 1	Doc 2	Doc 3	Doc 4	…	Doc 2017
acid battery	3	1	0	0		3
atmosphere	1	3	2	0		0
biofuel	0	8	1	0		0
…						
vibration	0	0	0	1		2

For the next step, to figure out latent meaning of each term in the context of textual data, LSA is conducted with Matlab code. The reduced matrix by performing Singular Value Decomposition provides information on whether a higher impact of term in a particular semantic textual pattern. Thus, each semantic textual pattern can be defined as a concept in FCM considering the meaning of allocated terms with high impact value. From the data in Table 5.4, for example, it is apparent that the first semantic textual pattern is related to tourism. Consequently, the first concept is defined as 'application to tourism' in accordance with the top five terms with high value of impact. Total 15 concepts of FCM derived through the same procedure as above are presented in Table 5.4.

Table 5.4 Defining scenario concepts from semantic textual patterns

Semantic textual pattern (v_k)	Allocated term (t_i) (impact of term to pattern (u_{ik}))	Definition of scenario concept (C_k)
v_1	consumer (0.116), customer (0.108), tourism (0.223), growth (0.137), economy (0.15)	Application to tourism
v_2	automation (0.221), sensor (0.256), network connection (0.098), software (0.175), comfort (0.163), assistant (0.083), internet (0.097)	Usability
v_3	company (0.131), startup (0.216), university (0.097), laboratory (0.297), investment (0.073), partnership (0.066), entrepreneur (0.093), grid (0.084)	Industry-university cooperation
v_4	renewable energy (0.137), diesel (0.152), biofuel (0.102), biomass (0.086), geothermal (0.077), petroleum (0.059), gasoline (0.128), hybrid (0.094), photovoltaic (0.065), solar energy (0.058)	Alternative energy technology
v_5	regulation (0.162), incentive (0.081), policy (0.148), government (0.148), limitation (0.124), standard (0.093), tax reduction (0.117), policy (0.137)	Government regulation
v_6	engine (0.164), inverter (0.155), magnet (0.076), DC (0.203), AC (0.106), torque (0.059), capacity (0.108), motor (0.122)	Motor technology
v_7	wireless power (0.182), charger (0.266), recharge (0.243), power transmission	Charging technology

	(0.097), charger (0.177)	
v_8	transportation (0.19), electric bus (0.15), driver (0.11), passenger (0.106)	Application to public transportation
v_9	safety (0.344), driverless (0.324), collision (0.12), vibration (0.104), pressure (0.179), security (0.143), stability (0.071), obstacle warning (0.068)	Safety
v_{10}	economy (0.32), growth (0.15), sales (0.09), investment (0.09), revenue (0.085), GDP (0.181), trade (0.097), import (0.068), export (0.109)	Economic revenue
v_{11}	energy efficiency (0.138), energy consumption (0.097), efficiency improvement (0.088), energy density (0.067), mileage (0.104)	Energy efficiency
v_{12}	temperature (0.137), environment (0.185), pollution (0.216), atmosphere (0.207), carbon dioxide emission (0.516), greenhouse gas (0.107), CO2 (0.114), eco (0.068)	Air pollution
v_{13}	job (0.311), worker (0.158), manufacturing (0.103), services (0.112), employment (0.217)	Job creation
v_{14}	lithium battery (0.275), ion battery (0.31), acid battery (0.12), storage (0.124), battery life (0.227), lightweight (0.098), BMS (0.103)	Battery technology
v_{15}	cost reduction (0.208), incentive (0.094), support (0.103), maintenance cost (0.098)	Costs reduction

For the preliminary understanding of scenario concepts, we classified 15 concepts into STEEP (S: Social, T: Technology, Ec: Economics, En: Environment, P: Politics) framework. This framework has been utilized in researches predicting the future society for the purpose of considering various aspects. Table 5.5 provides an overview of scenario concepts with abbreviation and corresponding sector in STEEP framework.

Table 5.5 Scenario concepts classified as STEEP framework

Type of STEEP framework	Scenario concept (C_k)	Abbreviation
Social (S)	Application to tourism	AT
	Job creation	JC
	Application to public transportation	PT
Technology (T)	Alternative energy technology	AE
	Battery technology	BT
	Motor technology	MT
	Charging technology	CT
	Usability	US
	Safety	SF
Economics (Ec)	Economic revenue	ER
	Costs reduction	CR
Environment (En)	Air pollution	AP
	Energy efficiency	EE
Politics (P)	Industry-university cooperation	IU
	Government regulation	GR

Step 3) Identifying causal relationships and weights

To identify causal relationships and weights, the FARM is implemented using the Fuzzy Apriori-T software (Coenen, 2008). The impact values of concepts in documents derived matrix V from LSA are used as the input of FARM. It can be interpreted as the degree of membership to be particular concept in each document. Table 5.6 below illustrates part of the transaction matrix for FARM. For instance, the degree of membership to be concept JC in document 1 is 0.108, and AE in document 3 is 0.014.

Table 5.6 Part of transaction data for FARM

	S			T						Ec	
	AT	JC	PT	AE	BT	MT	CT	US	SF	ER	CR
Doc 1	0	0.108	0	0.033	0.222	0	0	0	0.175	0	0
Doc 2	0.186	0	0	0	0.664	0	0.177	0	0.13	0	0.059
Doc 3	0	0	0	0.014	0	0.068	0	0.093	0	0	0
Doc 4	0	0.225	0.142	0	0	0.141	0.102	0	0	0	0
Doc 5	0	0	0	0.009	0.148	0	0	0	0.201	0	0
Doc 6	0	0	0	0	0	0	0.084	0	0	0	0
Doc 7	0	0.131	0	0.062	0	0.062	0.102	0.259	0	0.095	0.042
…											
Doc 2017											

Then, to apply FARM, value of minimum support and minimum confidence are established: minsupp = 0.1, minconf = 0.23. Confidence values of the derived 72 rules are as follows in Table 5.7.

Table 5.7 Part of output association rules with confidence value

Antecedent	Consequent	Confidence	Antecedent	Consequent	Confidence
EE	AP	0.51	AT	ER	0.29
CT	AP	0.46	PT	ER	0.29
AT	AP	0.44	EE	GR	0.29
AP	GR	0.44	EE	AT	0.28
EE	BT	0.43	EE	ER	0.28
PT	AP	0.42	EE	AE	0.27
GR	AP	0.41	GR	AT	0.27
CT	PT	0.39	AT	JC	0.27
CT	AT	0.38	SF	PT	0.27
IU	JC	0.36	GR	PT	0.27
BT	PT	0.36	EE	MT	0.27
PT	SF	0.36	CR	ER	0.27
US	SF	0.36	BT	AP	0.27
AE	AP	0.36	CR	AP	0.27
BT	EE	0.36	US	AT	0.26
PT	AT	0.35	CR	AT	0.26
AP	BT	0.34	IU	BT	0.26
SF	US	0.34	BT	CT	0.26
GR	CR	0.34	JC	ER	0.26
AP	AT	0.33	AP	ER	0.26
EE	PT	0.33	MT	CR	0.26
AT	BT	0.33	EE	CR	0.26
PT	CT	0.33	IU	AP	0.26
ER	AP	0.33	AP	AE	0.26
PT	IU	0.33	AE	BT	0.25

Step 4) Finalizing and visualizing scenario model

As was pointed out in the detailed process of this module, sign of the relationship between concepts constituting the FCM should be decided by researcher. Therefore, the sign was given for the 72 rules as shown in Table 5.8. The table is filled with confidence value with given sign, which means the strength of impact. Meanwhile, rules that do not exceed minsupp or minconf are left in space because those two concepts are regarded as not having a meaningful causal relationship.

Table 5.8 Part of adjacency matrix

	S			T						Ec	
	AT	JC	PT	AE	BT	MT	CT	US	SF	ER	CR
AT		0.27	0.30		0.33		0.24		0.31	0.29	
JC										0.26	
PT	0.35	0.29					0.33	0.31	0.36	0.29	
AE					-0.25						0.25
BT	0.32		0.36			0.25	0.26				0.25
MT											0.26
CT	0.38		0.39		0.25						0.32
US	0.26								0.36		
SF			0.27					0.34			
ER											
CR	0.26									0.27	

In the following step, the FCM is constructed using the FCMapper (http://www.fcmapper.net) and Pajek software packages. First, characteristics of vertices and arcs are calculated based on the adjacency matrix, which are generated through Table 9. Second, they can be transformed as a net-file, which Pajek software packages can handle with. Lastly, FCM is visualized in Figure 5.17 over set of additional options such as size and color. The size of each concept node is determined by the centrality value; and the color of each concept is classified according to the type of STEEP framework explained in the previous pages. For edges, the solid line means the positive cause and effect relation, otherwise, the dotted line means the negative cause and effect relation.

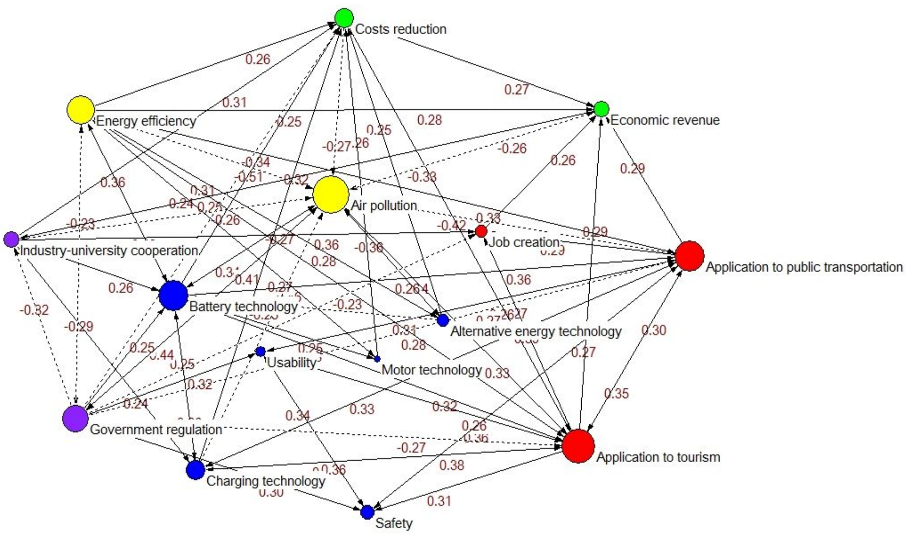


Figure 5.17 FCM for EV

Step 5) Analyzing scenarios

(1) Static analysis

In the purpose of identifying important scenario concepts, the static analysis gauged the outdegree, indegree, and total centrality, as Table 5.9. High centrality value means that the concept is important in network or system since concepts not only receive an impact from the concept, but also affect the concept in the FCM. The interesting results are in two concepts: ‘EE’ and ‘AP’ have relatively large difference value between indegree and outdegree. ‘Air pollution (AP)’ can be interpreted as to receive more influenced by other concepts. On the other hand, in the case of ‘energy efficiency (EE)’, the degree of impact on other concepts is relatively higher than others. Consequently the important concepts with high centrality value that should be emphasized in scenario planning are derived as: application to tourism (AT), application to public transportation (PT), battery technology (BT), air pollution (AP), energy efficiency (EE), and government regulation (GR).

Table 5.9 FCM indices

STEEP	Concepts	Outdegree	Indegree	Centrality
Social (S)	Application to tourism (AT)	2.18	2.45	4.63
	Job creation (JC)	0.59	1.15	1.74
	Application to public transportation (PT)	2.35	1.92	4.27
Technology (T)	Alternative energy technology (AE)	1.17	0.54	1.71

	Battery technology (BT)	2.07	2.11	4.18
	Motor technology (MT)	0.50	0.52	1.02
	Charging technology (CT)	1.80	1.07	2.87
	Usability (US)	0.62	0.97	1.59
	Safety (SF)	0.61	1.33	1.94
Economics (Ec)	Economic revenue (ER)	0.58	1.65	2.23
	Costs reduction (CR)	0.80	1.99	2.79
Environment (En)	Air pollution (AP)	1.63	3.73	5.36
	Energy efficiency (EE)	2.93	1.14	4.07
Politics (P)	Industry-university cooperation (IU)	1.43	0.90	2.33
	Government regulation (GR)	2.94	0.73	3.67

(2) Dynamic analysis

The input vectors of dynamic analysis are generated over a combination of binary variation (0 or 1) of six important scenario concepts. As a result derived from the static analysis, the five concepts and corresponding meaning of variations are suggested in the morphology matrix of Table 5.10. Total of 64 (2^6) combinations of input vectors are possible, however, there are inconsistent combinations of concepts which are excluded. For instance, it cannot be expected to increase energy efficiency without improvements in battery technology. Thus, all the input vectors having a relation of ‘BT’ and ‘EE’ in (1, 0) or (0, 1) are excluded.

Table 5.10 Morphology matrix

	AP	AT	PT	BT	EE	GR
Variation A (1)	increase (1)	increase (1)	increase (1)	develop (1)	increase (1)	increase (1)
Variation B (0)	no increase (0)	no increase (0)	no increase (0)	not develop (0)	no increase (0)	no increase (0)

As a result, we constructed the input vectors of six raw scenarios including basic scenario, which have input vector as (1, 1, 1, 1, 1). Raw scenarios are represented in sequence of each concept's value of variation as below:

- Basic scenario (AP1-AT1-PT1-BT1-EE1-GR1)
- Scenario 1: No increase in applying EV to tourism (AP1-AT0-PT1-BT1-EE1-GR1)
- Scenario 2: No increase in applying EV to public transportation (AP1-AT1-PT0-BT1-EE1-GR1)
- Scenario 3: Failure to develop battery technology and energy efficiency (AP1-AT1-PT1-BT0-EE0-GR1)
- Scenario 4: Increase of air pollution because of failure of EV (AP1-AT0-PT0-BT0-EE0-GR1)
- Scenario 5: Relax of government regulations for vitalizing EV (AP1-AT1-PT1-BT1-EE1-GR0)

The output vectors of scenarios are drawn by iterations of multiplying input vector and adjacency matrix until stabilization. The number of iteration until stabilization, and the input and output values of concepts in raw scenarios are represented in Table 5.11.

Table 5.11 Dynamic scenarios – input (I) and output (O) vectors

Concept		Basic		Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
		I	O	I	O	I	O	I	O	I	O	I	O
S	AT	1	0.76	0	0	1	0.71	1	0.67	0	0	1	0.79
	JC	1	0.63	1	0.57	1	0.57	1	0.61	1	0.52	1	0.66
	PT	1	0.73	1	0.67	0	0	1	0.62	0	0	1	0.76
T	AE	1	0.55	1	0.55	1	0.55	1	0.51	1	0.52	1	0.55
	BT	1	0.70	1	0.65	1	0.70	0	0.00	0	0	1	0.68
	MT	1	0.58	1	0.58	1	0.58	1	0.50	1	0.50	1	0.58
	CT	1	0.68	1	0.63	1	0.62	1	0.62	1	0.53	1	0.68
	US	1	0.65	1	0.64	1	0.59	1	0.64	1	0.59	1	0.61
	SF	1	0.71	1	0.65	1	0.64	1	0.69	1	0.59	1	0.68
Ec	ER	1	0.72	1	0.66	1	0.66	1	0.66	1	0.55	1	0.73
	CR	1	0.70	1	0.69	1	0.70	1	0.61	1	0.60	1	0.74
En	AP	1	0.12	1	0.17	1	0.16	1	0.21	1	0.33	1	0.09
	EE	1	0.61	1	0.61	1	0.61	0	0.00	0	0	1	0.64
P	IU	1	0.56	1	0.55	1	0.55	1	0.55	1	0.53	1	0.60
	GR	1	0.47	1	0.47	1	0.47	1	0.52	1	0.54	0	0.00
Number of iterations		25		23		23		23		21		26	

From the Table 5.11, various what-if experiments can imply the impact of scenario concepts on the whole model of future of EV. Comparing the gap between the basic scenario with other scenarios can identify the impact of raw scenarios. In the scenario 1, if the application of EV in the tourism industry decreases, the successive negative impacts arise in the level of job creation (-0.06), the application to the public transportation (-0.06), safety technology (-0.06), economic revenue (-0.06), and air pollution (0.05). If the application of EV in the public transportation decreases in scenario 2, the principal negative effects are emerged in job creation (-0.06), charging, usability, and safety technologies (-0.06 and -0.07), as well as the economic revenue (-0.06); thus, the impacts of applying EV technology to tourism and public transportation seem to be similar. Reversely, we can identify some implications: if electric vehicles are utilized for tourism or public transportation, related jobs may be available; the application to tourism and public transportation can cause economic benefits by reducing the level of air pollution due to reduced environmental restoration costs; and since increasing of application to tourism and public transportation promote technological factors, those technologies should not be developed without such motivation.

Scenario 3 shows the negative impacts of failure to increasing energy efficiency caused by the un-development of battery technology: application to public transportation (-0.11), application to tourism (-0.09), cost reduction (-0.09) and air pollution (0.09); that is, the battery technology associated with energy efficiency is key to EV success and market vitality because it contributes the industrial applications (AT and PT), as well as cost reduction. Although the previous scenarios represent the impact of sole factors, the scenario 4 describes the integrative results of all important scenario concepts. If the all important factors fail to implement EV, expected results are significant as the increase in air pollution probability (0.21), decrease in economic revenue (-0.17) and decrease in associated technologies such as charging technology (-0.15) and safety (-0.12), etc. Finally, in the scenario 5, the impact of relax in government regulation such as tax reduction and incentive policy is identified: increase in industry-university cooperation (0.04), cost reduction (0.04), and energy efficiency (0.03).

5.2.5 Discussion and conclusions

This module suggested the method of futuristic data-driven scenario building by incorporating TM and FARM into FCM. The paper insists that futuristic data containing the opinions and discussions on the shape of future from large-participation, as a significant and proper source of a scenario development. In order to apply futuristic data into scenario building, LSA of TM is applied to extract scenario concepts that are defined as the coherent cluster set of keywords; FARM is utilized to identify the causal rules among concepts and measure the weight values of their rules; and finally FCM is constructed and analyzed in terms of static and dynamic viewpoints.

The study is motivated from the prior inductive and deductive developments of FCM-based scenario: the dependence on limited domain knowledge and subjectivity (deductive modeling), and the lack of deriving concept nodes and tendency to utilize historical data (inductive modeling). Considering these points, the proposed method has several advantages. First, the leverage of futuristic data can capture a priori, future-oriented information for scenario, not posteriori information. In our case, in the future of EV, the concepts such as application of tourism and public transportation are future-oriented factors, as if they are extracted from the scenario planning. Second, in terms of variety, the knowledge span can be various as the scenario concepts are widely spanning on STEEP fields. Since large participants from different domains, whether they are experts or ordinary people, freely share any types of future-oriented information, the extraction of cognitive models of these can be said to be based on collective intelligence. Furthermore, the dynamic analysis implements various what-if scenarios, which can help to generate a variety of scenarios. Third, not only weights, but concept nodes of FCMs can be identified from futuristic data. As we involved the LSA to extract scenario concept nodes and the FARM to identify the weights of causal relationship, these algorithms can aid to deal with vast amount of futuristic database and improve the effectiveness and efficiency of scanning knowledge for FCM-based scenario development.

Despite the contributions, there are limitations and rooms to be elaborated in future research. First, the framework considered support and confidence of FARM as the measure of interestingness of rules; however, other alternative measures can be incorporated such as lift, leverage, conviction, etc. Likewise, the centrality of static analysis also can be extended to other measures such as betweenness, closeness, eigenvector centrality, etc. Second, although futuristic data can involve multiple stakeholders, we did not separate and integrate models in terms of different viewpoints. Since the FCM has advantage in combining different FCMs, future research can attempt to compare and integrate multiple stakeholders' insights by deriving FCM model based on consensus. Lastly, the scenario concepts are defined at the level of semantic textual patterns; however, this can be elaborated in more hierarchical ways. For example, the keywords in each semantic textual pattern can be defined as micro-scenario concepts for building more specific and detailed micro-level scenarios. In this case, FCMs are modeled in macro-level FCMs consisting of semantic textual pattern, as well as in micro-level FCMs consisting of keywords.

Chapter 6. Conclusions

6.1 Summary and contributions

This thesis can contribute to provide concrete and systematic tools responding to disruptive innovation, crowdsourcing, and user innovation in technology planning. The specific theoretical and methodological implications of each research module is summarized as Table 6.1.

Table 6.1 Contributions of each module

Modules	Implications
#1. Analyzing patterns of innovation in tech-discourse community	Linking to re-creation strategies, investigating the opportunistic sources and exploring the possibilities of divergence and convergence based on the characteristics of service in tech-discourse communities
#2. Analyzing potential of futuristic data in tech-foresight community	Enhancing the capability for technology foresight responding to disruptive innovation by leveraging the broad knowledge resources emerged in tech-foresight communities
#3. Scanning potential user needs	Suggesting concrete method to visualize the positioning of existing services on the basis of user context and facilitate the ideation of new service concepts by identifying the location of reference services

#4. Implementing user ideas based on existing products	Helping both firms and users/developers benefit R&D efforts by identifying opportunities from tech-discourse communities and improving the ideas based on reference cases; Easy understanding and adoption based on transparency and intuitiveness of CBR
#5. Scanning potential disruptive signals	Offering the potential disruptive areas in current as well as other markets; examining facts, stimuli, and inspiration from many stakeholders' insights; discovering the disruptive applications of existing technologies and explore un-served or over-served market segments; and improved efficiency and effectiveness for fast-developing TRM
#6. Extracting rules to build scenarios	Capturing a priori, future-oriented information for scenario, not posteriori information; Extracting the various scenario concepts based on collective intelligence; and investigating the methodological synergies among LSA, FARM, and FCM

Overall, the contributions of this thesis can be three folds. First, the paper provided both conceptual and empirical research basis to developing methodologies. Two important online communities are suggested: tech-discourse community and tech-foresight community. The characteristics of two communities in the perspective of technology innovation are analyzed and discussed.

Second, from the findings that innovations in tech-discourse communities have patterns of divergence and convergence of existing products, two methodologies are suggested to identify and conceptualize new product opportunities from the existing products. Since previous literature is lack of methods for scanning and leveraging user-leading innovations, the suggested methods of user-centered approach and text mining-based case based reasoning can help proactively investigate user innovations and recreate the novel opportunities.

Third, from the findings that the futuristic data from tech-foresight communities have great potential in terms of future-orientation, knowledge scope, and perspectives, two frameworks are proposed to identify and scan the alternatives or drivers of future technology planning and foresight. Responding to lack of supporting tools for exploring and extracting knowledge from futuristic data, the proposed approaches contribute to effectively absorb collective and collaborative knowledge and identify factors and effects of future technology. Therefore, overall, the research contributes to broaden the focus of online community-based innovation and foresight from conceptual area to methodological and analytical area.

6.2 Limitations and future research

Despite various contributions, the thesis is subject to some limitations which can be a room for future research. The detailed limitations per modules are depicted in Table 6.2

Table 6.2 Limitations of each module

Modules	Limitations
#1. Analyzing patterns of innovation in tech-discourse community	Need for characteristics such as technical or competence aspects, rather than service characteristics Need for studying other tech-discourse community information
#2. Analyzing potential of futuristic data in tech-foresight community	Limited target of comparison i.e. patent data Need for classifying types of tech-foresight community information
#3. Scanning potential user needs	Need for incorporating user-centric approach to construct potential needs dictionary Need for guidelines and elaborated processes to clarify the evaluation stage Need for considering criteria to prioritize vacuums other than the satisfaction density and the frequency of existing services
#4. Implementing user ideas based on existing products	Need for elaborating the criterion for identifying opportunities, e.g. novelty, feasibility, relevance, and specificity
#5. Scanning potential disruptive signals	Need for integrating factors from inside the organization, e.g. vision, strength, and weakness, using interactive visualization functions Need for elaborating the criteria to assess disruptive signals

#6. Extracting rules to build scenarios	Need for considering alternative measures of causal rules, e.g. lift, leverage, and conviction Need for considering alternative measures of static analysis, e.g. betweenness, closeness, and eigenvector centrality

To sum up, the limitation and avenues for future research can be three folds. First, this study only considered two types of online communities, which are comprehensive. They can be further classified or other types can be added. For example, in case of tech-discourse community, company-led communities (i.e., although the thesis focuses on user-led communities) can be utilized or compared with user-led communities to suggest proper methods. In case of tech-foresight community, the specific types of futuristic data, e.g., prediction market, social ratings, etc. can be considered to elaborate into customized approaches.

Second, the conceptual basis of this thesis can be clarified and extended in the future research. In chapter 4, the definition of opportunity is simply defined as the unsatisfied potential needs or user ideas. This seems a significant issue to improve methods to identify opportunities. In chapter 5, the elements of technology foresight can be specifically defined and elaborated.

Lastly, the methodological advances should be considered in future research. TM can be advanced with ontology-based or semantic approach. Although the module #6 identified semantic textual patterns, the polarity of keywords can be measured or the ontology in Semantic Web can be used to classify the terms, characterize possible relationships, and define possible constraints on using those terms. For the tech-discourse community, methods such as QFD, TRIZ, and synectics can be involved to determine the point of modification in benchmarking of reference products. For the tech-foresight community, the methods to integrate futuristic data with retrospective data such as patent data can be great opportunities for future research.

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초 록

최근 기술 혁신은 불연속적, 파괴적 혁신의 형태로 발생하며, 이에 대응하기 위한 기술 기획의 핵심 역량은 여러 외부 소스로부터 정보를 탐색하고 분석하는 데 집중되고 있다. 특히 웹 2.0 등 정보통신기술(ICT)의 발전으로 접근 가능한 소스 중 하나는 온라인 커뮤니티 정보이다. 온라인 커뮤니티에서 다양한 개인들이 자발적으로 의견, 아이디어, 데이터 등을 공유함에 따라 다수의 데이터가 축적되고 있으며, 이러한 정보는 기술 기획을 지원하는 데 효과적인 소스 중 하나로 대두되고 있다. 그러나 온라인 커뮤니티 정보에 대한 개념적 유효성에도 불구하고, 기존 연구에서는 온라인 커뮤니티 정보를 기술 기획 과정에 활용하는 실질적이고 구체적인 접근이 부족한 실정이다.

본 학위논문에서는 온라인 커뮤니티 정보의 특성을 분석하고, 온라인 커뮤니티 정보를 기술 기획의 목적으로 활용하는 방법을 탐색한다. 특히 기술 기획과 관련한 온라인 커뮤니티로서 기술-토론(tech-discourse) 커뮤니티와 기술-예측(tech-foresight) 커뮤니티에 초점을 맞춘다. 첫째, 기술-토론 커뮤니티는 기술 혁신에 관련된 유형적이고 가까운 미래가 사용자 혁신자 간에 공유되는 커뮤니티로 정의한다. 기술-토론 커뮤니티의 정보는 사용자가 소비자의 역할 뿐 아니라 혁신가 또는 개발자의 역할을 수행하는 사용자 혁신(user innovation)의 집합으로서, 사용자의 사용 패턴 및

상황 관련 정보뿐 아니라 사용자가 제시한 아이디어를 담고 있다. 따라서, 사용자의 잠재 니즈(potential needs) 및 신제품 기회를 추출할 수 있다. 특히, 본 학위논문은 기술-토론 커뮤니티의 대표적인 예시인 모바일 앱스토어(app store)에 초점을 맞춘다.

둘째, 기술-예측 커뮤니티는 기술 변화의 개념적이고 먼 미래가 전문가, 대중, 기업 등 다양한 다수의 참여자 간에 공유되는 커뮤니티로 정의한다. 기술-예측 커뮤니티의 등장에 따라 개방형, 협력적 기술 포사이트가 가능해지고 있으며, 기존 포사이트 방법보다 넓은 미래기술 탐색의 장을 창출하고 있다. 따라서 기술-예측 커뮤니티 정보는 미래 기술의 주요 동인과 대안을 파악함으로써 잠재 파괴 신호(potential disruptive signal) 및 시나리오(scenario)를 제공할 수 있다. 특히 본 연구에서는 기술-예측 커뮤니티 정보를 '미래 데이터(futuristic data)'로 명명한다.

본 학위논문은 온라인 커뮤니티의 유형과 분석-활용의 접근방법에 따라 3개의 세부 주제와 주제별로 두 가지씩 총 6개의 논문으로 구성된다. 첫 번째 주제는 기술 혁신과 관련된 온라인 커뮤니티 정보의 특성을 분석하는 것이다. 커뮤니티를 활용한 기술 기획은 새롭고 선도적인 접근이므로, 우선 두 커뮤니티의 특성을 개념 및 실증적으로 분석하는 연구를 수행한다. 연구 #1은 기술-토론 커뮤니티 정보의 혁신 양상을 분석하기 위하여 앱스토어의 모바일 앱서비스를 대상으로 하였다. 그 결과 모바일 앱서비스의 혁신은 기존 제품의 파생(divergence) 또는 융합(convergence)을 통해 흔히 일어난다는 점을 파악하였다. 연구 #2는 기술-예측 커뮤니티

내 미래 데이터의 잠재성을 분석하는 것이다. 미래 데이터는 새로운 개념이므로, 기술 기획과 포사이트에서의 활용 가치를 중심으로 그 특성을 분석하는 것을 목적으로 하였다. 이를 위해 특허 데이터와 미래 지향성, 정보 범주, 관점을 중심으로 실증적인 비교를 수행하였다. 그 결과 미래 데이터의 기술 기획을 위한 잠재 소스로서의 유용성 및 기회를 발견할 수 있었다.

두 번째 주제는 기술-토론 커뮤니티로부터 혁신의 기회를 파악하는 것이다. 구체적으로 연구 #3에서는 기술-토론 커뮤니티로부터 잠재 고객 니즈를 탐색한다. 이를 위해 사용자 중심 서비스 지도를 제안하고 서비스 공백으로부터 신 서비스 기회를 발견하고 주변 참조 서비스를 파생 및 융합하여 기회를 구체화한다. 연구 #4에서는 사용자 아이디어를 기존 제품에 기반하여 개념화한다. 여기서는 활동적이고 열광적인 사용자 혁신가의 아이디어에 초점을 맞추는데, 사용자 아이디어로부터 신 서비스 기회를 발견하고 참조 서비스를 파생 및 융합하여 기회를 개발한다. 이를 위해 텍스트 마이닝 기반 사례 기반 추론 접근을 제시한다.

마지막 주제는 기술-예측 커뮤니티 정보를 기술 기획에 활용하는 것이다. 연구 #5에서는 미래 데이터로부터 기술 로드맵을 위한 잠재 파괴 신호를 탐색한다. 본 연구에서 잠재파괴 신호들은 자기조직화지도 기반 키워드 군집 지도, 트리맵 기반 키워드 강도 지도, 네트워크 기반 키워드 관계 지도라는 세가지 지도를 순서대로 구축하면서 좁혀진다. 연구 #6은 미래 데이터로부터 시나리오 작성에 필요한 규칙을 추출한다. 여기서는 퍼지인식도 기반

시나리오에 초점을 맞추며, 개념 마디(concept node)와 이들의 인과적 모서리(causal edge)와 같은 모델링 요소들은 텍스트 마이닝과 퍼지 연관 규칙 기법으로 파악한다.

전체적으로 본 학위논문은 기존 문헌에서 주로 개념적으로 다루어졌던 온라인 커뮤니티 기반 기술 혁신 및 기술 기획에 관한 논의를 분석적, 방법론적 영역으로 확장했다는 점에서 의의를 가진다. 기술 기획의 요인과 영향을 사전적으로 탐색하며 학습과 협력을 바탕으로 새로운 지식을 흡수하고 재창출할 수 있는 분석 체계 및 절차를 제안함으로써 파괴적 혁신에 효과적으로 대응 가능할 것으로 기대된다. 또한 크라우드소싱, 사용자 혁신, 개방형 혁신을 위한 실질적, 체계적 도구를 제공한다는 점에서 의의를 가진다.

주요어: 온라인 커뮤니티 정보, 기술 기획, 사용자 혁신, 파괴적 혁신, 앱스토어, 미래 데이터
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