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VIET NGUYEN

A PROPOSED FRAMEWORK OF INNOVATION MANAGEMENT FOR DISRUPTIVE TECHNOLOGY -

The Case of Bluetooth Low Energy Technology

Master of Science Thesis

Examiners: Professor Saku Mäkinen and Assistant Professor Leena Aarikka Stenroos
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ABSTRACT

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Companies commonly focus on reducing operation cost and increasing sales to gain more profit. In order to do those, innovation can be considered as a key for success in recent decade. Moreover, the introduction of disruptive technologies with various advantages has grasped much attention from public. Hence, the combination between innovation and disruptive technology is expected to bring companies tremendous benefits when competing with others. Nevertheless, this complex combination poses a major burden for managers in companies on how to manage and gain the most out of it.

Acknowledging the above issue, the objective of my paper is to develop my own framework for managing innovation process in the context of disruptive technology. This framework will be formed by different concepts about innovation process management, disruptive technology and the integration of market pull, technology push and corporate interest theories. The proposed model will provide not only a holistic view but also a detailed guideline that companies could use to manage the innovation projects from the very beginning to the end. In more particular, my study aims to answer the following research questions to achieve the objective of the paper. The theoretical background questions are: *What is disruptive technology? What are key aspects in innovation management theory?* And the main research questions are: *What is the proposed framework of innovation management for disruptive technology? Whether this proposal matches with the real activities happen in innovation process management for disruptive technology?*

The proposed model is conducted in the case company. The outcome verifies that the proposed model matches all activities carried out during the whole innovation project of the case company. Therefore, the proposed framework is able to be used in the real business world. Moreover, the study also reveals new insights and lessons for managers and

directors who would like to use the framework as a managerial guideline in innovation projects in the context of disruptive technology in the future. Despite remarkable achievements, there are still some limitations in terms of validity and reliability in the study, which are expected to be further improved by future research.

PREFACE

In May 2016, I was recruited as a Summer Market Research Trainee for a company in Tampere, Finland. The objective of the job was to understand the Bluetooth Low Energy Technology and explore its potentials. After spending four months in doing the research on this topic, I became fascinated about it. In September 2016 when the summer contract ended, I proposed to my manager about the possibility in continuing the current work for my master thesis and I got the approval. Consequently, the research was carried on until the second week of January 2017 due to the postpone decision of the director of the case company. However, in terms of the expectation from the position, the objective was reached.

Having more than 9 months working on this project, I learned a lot about the innovation process for the selected technology of the company. I got chance to participate as a member of the project from the beginning until January 2017 to experience every activity during that period. Besides, it was my great honor when working with a great team of the project including management team and engineers of the case company. During that period, I could have a lot of chances to acquire not only new knowledge towards this innovation but also working style as this is the first time I work for an international Finnish based company.

I would first like to thank Dr. Leena Aarikka Stenroos for her advices and guidance during the whole process of my writing. Besides, it was so grateful that Dr. Leena Aarikka Stenroos thoroughly supported my work during the time I worked remotely which caused a lot of difficulties. In addition, I also want to thank Prof. Saku Mäkinen for his encouragement and reviewing during my writing process. Furthermore, I also owe a big thank you to the management team and project members of the case company. Last but not least, I am deeply grateful to my wife and my family for their supports during my study and writing process.

Finland, 02th September 2017

Viet Dung Nguyen

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LIST OF SYMBOLS AND ABBREVIATIONS

CEO	Chief Executive Officer
BLE	Bluetooth Low Energy
Bluetooth SIG	Bluetooth Special Interest Group
GPS	Global Positioning System
RF	Radio Frequency
RFID	Radio Frequency IDentification
RTLS	Real-Time Locating System
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UWB	Ultra-WideBand
PET	Polyethylene terephthalate

1. INTRODUCTION

1.1 Background

Sustaining and developing businesses in the competitive market is a very challenging task. The economy of Finland in recent years can be taken as a salient example. According to Statistics Finland (2016), the number of company closures was increased by 9,1%, more than four times to the openings in the third quarter in 2016 compared to the same quarter of the previous year. As a result, searching for a sustainable solution has never been an old-fashioned topic for both scholars and managers in companies around the world. Among different solutions, innovation has drawn much attention. According to Diess (2004), innovation takes a significant role in the development of humanity in most aspects of life. In more particular, managers in companies around the globe have been using this key to unlock their business potentials. Innovation helps companies not only minimize the operation costs but also increase the sales (Rowley, 2011). Vaughan (2013) also states that the success of a company depends heavily on how innovative they are. Interestingly, the term innovation can be used in various aspects of doing business. For instance, internal process optimization can be considered as a typical area of innovation in an organization (Rowley, 2011). Another example of innovation activities is providing new and innovative products or services to customers which brings more value and benefits than previous ones (Diess, 2004). However, seeking a proper way to approach and manage the innovation is not an easy task due to its complexity. Even when a company has defined a suitable way for itself, there is no single solution for all success in the coming future. Different methods and approaches will be applied depending on situations. In some cases, customization is necessary in order to maximize the outcome of the innovation.

Nowadays, people can enjoy a better and more comfortable life as a result of the development of technology. When it comes to business world, technology development becomes an interesting topic for companies, especially research and development department. Among different types of technology, disruptive technology is very well-known in helping companies create a new market or value network which potentially brings tremendous benefits in the near future (Bower and Christensen, 1955). In general, there should be a mechanism to manage the technology development throughout its lifecycle in order to get the most out of that new technology (Artto el. al., 2011). Otherwise, companies are likely to end up in spending a large amount of money for doing nonsense in research and development activities. With advantages of disruptive technology, managers in companies around the world have recently started to use this technology as a source of innovation. Hence, putting the concept of disruptive technology in innovation management creates new values that could help managers in their business development.

Acknowledging the potential of combining disruptive technology and innovation, it is necessary to have a systematic guide line which managers can apply in their business management. In addition, theories undoubtedly play an important role in helping managers around the world run companies. Almost every phenomenon happens in the real business can be explained by applying correctly theories from books in a certain degree. When examining a phenomenon related to a technology, it is worth to mention two fundamental theories which are technology life cycle and product life cycle. The technology life cycle theory describes different development stages in which a typical technology will go through (O'Leary, 2009). Meanwhile, the product life cycle theory looks at the technology in a different way which considers technology is embodied in a form of a product or service offered (Shahmarichatghieh et. al., 2015). This theory views the phenomenon from the business perspective. In more particular, the money earned from the product is considered as the most important figure that every company should look at when considering the success of a product or the embodied technology (Cox, 1967). These two theories are significantly essential in understanding the disruptive technology. Disruptive technology represents the idea of a technology which creates a new market or value network based on its advanced features with lower cost (Bower and Christensen, 1955). In addition, innovation definition and its importance are also necessary. On top of that how to manage innovation throughout its process is extremely important for managers. Consequently, innovation stage gate model, the most common framework about innovation management is worth mentioning. This model describes different stages and gates on how an innovation should be processed from the beginning to the end (Cooper, 1999). Theoretically speaking, innovation process is impacted by two different aspects which are technology push and market pull. These aspects not only shape the outcome of the innovation but also the way mangers should manage the whole process (Schumpeter, 1947). In addition, the corporate's interest is also a crucial aspect in managing innovation. According to Burgelman and Sayles (2004), corporate's interest represents the idea that strategic decisions and management activities should favor the expectation of top management or the owner of the company. Thus, innovation activities in this case should do too.

Theoretically speaking, the literatures about disruptive technology and innovation seem to have no connection. In more particular, innovation theories use variety of subjects from business process to technologies but they do not consider disruptive technology as a source for the input. Moreover, disruptive technologies are usually described from general business perspective like market or value network which is derived from its novel features. Despite a large number of advantages that innovation and disruptive technology could bring for companies, there has not been any theory or framework mentioning the combination of these two elements. Whatever this such "new tool" is, it should be backed by fundamental literatures. Nevertheless, there is still a pitfall when approaching a practical issue with theories. It could be too far from the reality which makes managers hard to apply in their managing work. Moreover, it is a common issue when theories are built in a very high level and too generic (Lazzarotti and Manzini, 2009). Hence, it is suggested that the expected tool should meet the criteria about practicality. Specifically, the solution should be tested and verified first in the real business world and then easy to use.

In short, existing theories about disruptive technology and innovation provided valuable insights for managers. However, there has not been any study about managing innovation process in the context of disruptive technology. Thus, it is necessary to develop a new framework which is theoretically strong and practical. The expected model should utilize ideas from existing literatures related to this topic and consider other aspects about applicability and usability in real business world.

1.2 Objective

There has been a controversy along the history of business about the application of conceptual theories in managing companies. Some claim that theories certainly take a significant part as a foundation for running a business. For example, the introduction of technology life cycle in 1986 by Foster is considered as a powerful theory to understand the nature of the development of a technology. It helps managers predict the next phases of a technology to adjust business strategy accordingly. However, others argue that theories are too generic and at high level which is hard to apply in the real world (Lazzarotti and Manzini, 2009). It takes more efforts from managers to imagine the linkage between a theory and the present situation. It is even more complicated in some cases where one issue requires many theories to be used simultaneously. Moreover, there is a fact that some theories contain irrelevant concepts and novel terms. In recent years, academic writers have been trying to minimize the gap between theories and reality, however; it is still a long way to work on so that a theory can be practical and ready for use.

As discussed above, innovation seems to be an attractive way of doing business. It helps company not only maintain core competence but also increase business performance (Diess, 2004). Hence, it has drawn much attention from public in recent decades, leading to a situation that there are a number of innovation practices are proposed by different scholars around the world. On the one hand, it proves the high potential of innovation in helping managers run their businesses. On the other hand, it poses a problem for managers in companies when selecting the most suitable solution for their situations. Other than innovation, the concept of disruptive technology has emerged recent years, which is considered as a new area of interest for not only technology oriented companies but also for sales and services ones because of its advantages (Adner, 2002). When combing innovation and disruptive technology, these two concepts seem to perfectly match since disruptive technology is a source for innovation and the key to manage every aspect in the innovation management activities.

This combination can be considered as powerful tool for companies endeavoring for the success. It has also been recorded that there are many cases that companies around the world applied this combination in their business. However, these companies just follow their experience and gut feelings to manage the innovation activities for disruptive technology rather than using any systematic approach. The reason behind this phenomenon is that there has not been any framework for this combination. Theoretically speaking, utilizing a generic innovation theory could be a solution. It is observed that there are a number of theories for this demand in the scholar world which are built to serve the purpose of managing any type of innovation, not only for disruptive technology. Nevertheless, there are various disadvantages in this approach. For example, it would make the applying process from the theory to the real world very challenging due to the increase efforts in scanning irrelevant ideas or linking to the situation, especially in the case of innovation of disruptive technology.

Acknowledging the missing piece between the business need and the scholar world, with this paper, my objective is to…

> *…develop my own framework of innovation process management for disruptive technology.*

The above objective can be broken down into two main research question groups which are theoretical background and actual research. First, the paper needs to answer the questions about very fundamental concepts which are disruptive technology and innovation process. As discussed above, the whole paper is about the innovation process in the context of disruptive technology. Consequently, understanding deeply about disruptive technology is crucial for the whole study. However, this concept is rather complex. Hence, starting with basic theories about technology which are technology life cycle and product life cycle is a necessary step to provide the background information. Then the theory about disruptive technology will be introduced with the supporting concepts from recent described theories. Second, the next key component in this study is the innovation process. Initially, some discussions regarding the definition of innovation will be presented aiming to provide a comprehensive understanding about this concept. Subsequently, it comes to one of the most important theories about innovation management process which is innovation stage gate model. Technology push and market pull are two different fundamental theories in terms of managing innovation. Each of them has its own advantages and disadvantages. Thus, those aspects will be discussed in detail to provide a holistic view towards the innovation process. In summary, the first two questions are…

> *What is disruptive technology? And what is innovation process and what are the technology push and market pull theories in terms of innovation?*

Secondly, after gathering knowledge towards theoretical background, the paper will answer the main research question about what will be the theoretical proposed framework to be used in managing innovation process in the context of disruptive technology. This proposed framework should be built strongly based on the literature reviews. Every piece of information and concepts of the disruptive technology and innovation theories are linked and integrated together to form a novel framework proposed by the author. Among different components in the framework, the integration between technology push, market pull and corporate's interest plays a significant role. The combination can be considered as the centric of the whole proposed framework. Technically speaking, all above concepts are defined in a logical way to support each other concretely. Consequently, a holistic and theoretical model will be proposed based on theories discussed previously. To sum up the above discussion, the third question is…

> *What is the theoretical proposed framework combing the integration of technology push, market pull and corporate's interest of innovation management for disruptive technology?*

On the grounds of the above discussion, the proposed framework seems to be theoretically strong. However, it might face the situation that this proposal is far from the real business world. As a result, the fourth question is…

> *Whether the proposed framework matches with the real activities happen in innovation process management for disruptive technology?*

To answer this question, the outcomes from the research in the case company for the innovation project for Bluetooth Low Energy technology will be taken as the base. Given that the study is not only complex but also requires an intensive research over a long period of time, the author decided to select the longitudinal qualitative case study method as the research strategy. Furthermore, in order to improve the reliability of the paper, multiple data sets from different research methods such as exiting materials, interview, observation were used to analyze the case. Moreover, matching the concepts and ideas of the proposed framework to the activities happened in the case study was also carried out which aims to prove the applicability and practicality of the proposal in the real business world.

In conclusion, with this paper, the author aims to develop his own framework which can be used in managing innovation process in the context of disruptive technology. To achieve the objective, there are two main research question groups needed to be answers. Starting from basic concepts, the author tried to combine and integrate fundamental theories in order to build a novel framework on his own. Then, by matching data gathered from the single case study in the case company with multiple data sets, the framework is then assessed and verified its practicability in the real business world.

1.3 Structure of the Thesis

This thesis is divided in a logical sequence. There are nine chapters in the paper where the previous chapters not only introduce new concepts but also support the ideas and statements in the next chapters. The content of the paper as well as main ideas in each chapter are described briefly as follows:

1. Chapter 1 discusses the background information as well as the objective of the paper. It also gives a first glance about what the paper is going to present in next chapters.
2. Chapter 2 introduces some technology related concepts. Starting with the basic ones which are technology life cycle and product life cycle. These mentioned concepts will be the base ideas to consequently discuss the disruptive technology which is the main focus in this paper.
3. Chapter 3 discusses the innovation definition and innovation management process. The Innovation Stage Gate model will be selected to describe as it is one of the most popular models in terms of innovation management. Then, two factors of innovation which are technology push and market pull are mentioned.
4. Chapter 4 then proposes a new innovation model. Instead of jumping directly to the proposal, the chapter builds the framework step by step. The first piece of the information starts with the discussion about disruptive technologies as the source for innovation. Then, the introduction of corporate's interest comes next into the picture, followed by the integration of three different facts in terms of innovation: technology push, market pull and corporate's interest. Consequently, a comprehensive model of innovation in the context of disruptive technology is introduced.
5. Chapter 5 presents methods to conduct the study as well as the research strategy. This chapter provides not only a holistic but also detailed view about how data is collected throughout the research process and how it will be analyzed.
6. Chapter 6 briefly introduces the company where the author conducted the study. Moreover, it provides the background information which will be used to describe how the innovation project impacts the business directions and strategies of the company in the next chapter.
7. Chapter 7 is divided into sub-sections which follow the order of innovation process happened in the case company. In addition, each sub-section is linked to the proposed model which was introduced in Chapter 4.
8. Chapter 8 first highlights the linkage between the proposed framework and the outcomes from the case study. Then, new findings related to the framework are also presented. Moreover, the limitation of the research is discussed in this chapter as well.
9. Chapter 9 concludes the paper.

2. TECHNOLOGY LIFE CYCLE AND DISRUPTIVE TECHNOLOGY

Technology surely plays an important role in every aspect of human life and business is not an exception. According to Chesbrough and Rosenbloom (2002), a successful business heavily depends on technologies the company uses to create value, especially a technology based company. One of the most attractive terms regarding technology for innovation which has been grasped a lot of attention from managers and scholars around the world in recent decades is disruptive technology. Generally speaking, key aspects of disruptive technology are rapid changes in performance and market penetration over the time throughout its life cycle. Given that the notion of disruptive technology is complex, it would be easier to start with fundamental theories around this concept.

Among different theories about technology, technology life cycle is seen as a very basic and widely-used theory. It describes different stages and the development process of one technology from the beginning to the end. Thus, it can be considered as a stepping stone in doing the study towards advanced concepts related to technology. By understanding different phases in the development process of one technology, managers in companies can adjust the business strategy to maximize the benefits. Moreover, it is noted that technology does not bring the money directly for the company. It must be embodied in a form of a product or a service company offers to its customers. In other words, the final target of every company when investing money in a technology is having physical products to sell to customers. According to Shahmarichatghieh et. al. (2015), the success of a technology is measured by the sales of the product in which it is embodied. For almost every company, the sales are considered as the key indicator to measure the health of a business. The introduction of product life cycle theory helps managers see the relationship between the sales of a product throughout its development. From the above arguments, it is seen that there is a strong connection between technology life cycle and product life cycle. The background study on these theories will provide an essential and fundamental step in getting to know in-depth about disruptive technology which is the key concept in this paper.

2.1 Technology Life Cycle

Generally, the term life cycle is used to represent the changes in different sequential and continuous phases of an organism. When it comes to the field of business management, one of the most well-known adoptions is technology life cycle which refers to the evolution or development of a technology (Nieto et al., 1998). To be specific, it is used to demonstrate the changes in the performance of a technology during its life cycle (Levitt, 1965). With the support of incredible development of science in recent decades, there are more and more technologies invented to facilitate all aspects of human life. To have a better understanding about how a technology is developed during its life cycle, technology life cycle theory can be used as a powerful tool. For example, basing on the observation among different technologies which have been used in public transportation and energy, Lee and Nakicenovic (1998) employed technology life cycle to analyze the evolution between those technologies (Nieto et al., 1998). By acknowledging different stages in the life cycle of a technology, companies especially high-tech ones can develop their strategies accordingly to maximize profitability (Agarwal and Audretsch, 2001). Interestingly, Cooper and Schendel (1976) claim that new technologies are often invented by entering companies rather than giant ones. They also point out that leading firms widely build their products and organizational structure based on maturing technologies. Therefore, when there is a new technology coming, big-sized companies usually fail in adapting to the changes which leads them to lose their well-established positions in the market (Christensen, 1992).

The development of the technology life cycle started in 1971 when Fisher and Pry firstly proposed an S-curve model to represent the evolution of a technology. The model was the outcome of the observation and investigation of 17 different technologies in fabrics and plastics industry (Heijer, 2010). Later on, the model was gradually developed, mainly focused on different stages of the life cycle, by some consultants (Nieto et al., 1998). In 1986, Foster, director of the consulting firm Mckinsey (Nieto et al., 1998), proposed a technology life cycle which includes four different phases: embryonic, growth, mature and aging. Until now, this proposal has been used widely and it is also known as the Technology S-Curve. The below figure illustrates these stages visually.

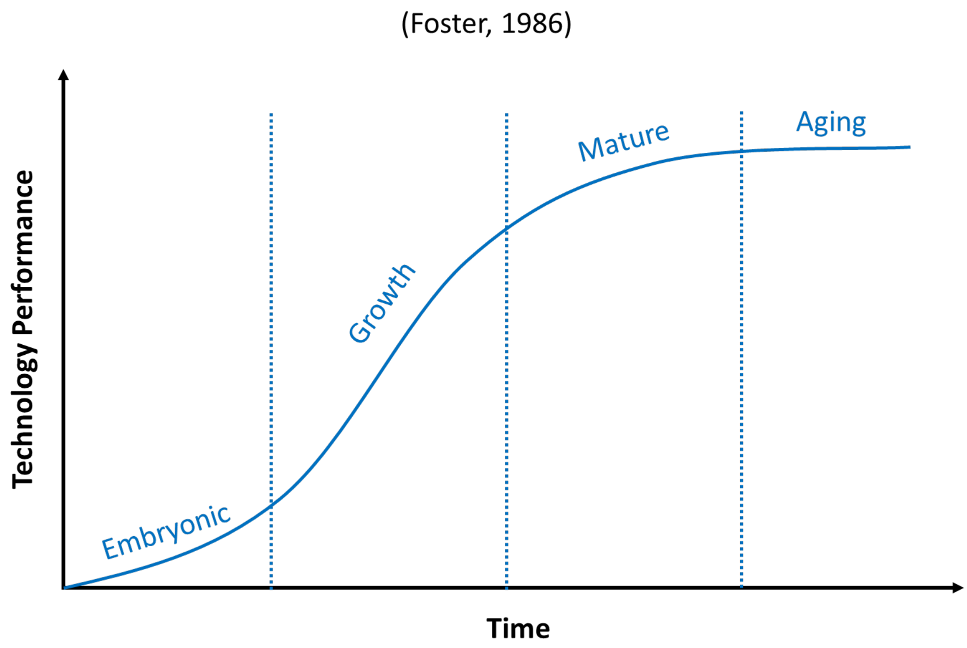

Figure 1. *The Technology S-Curve (Foster, 1986).*

As indicated in the above figure, every technology in its life cycle starts with the embryonic period. This is the stage when the technology has just invented (Foster, 1986). Generally, new technology is created with a hope to bring more benefits and better performance than existing technologies as well as generate novel features which did not exist before. It is noted that there are many uncertainties in this stage as no one can guarantee whether the technology will be successful or not in the future. There have not been any empirical studies or tests to prove that the technology is potential (Hevner et al., 2004). As a result, the questions about "right things" or "wrong things" are still big question marks (O'Leary, 2009). Majority of the development efforts towards the technology come only from the inventor since it has not been widely acknowledged. As a result, the performance of the technology is increased slowly during this period.

The next phase of the Technology S-Curve is growth which is also called emerging period (O'Leary, 2009). The most eye-catching point in this phase is the significant improvement of the technology's performance. The period begins when the technology, with its real and concrete evidences about the potential, is introduced to the market by innovators. The technology starts grasping attentions from market, both public and scientists. Consequently, it experiences a rapid development as the result of joint efforts from different institutions and organizations (O'Leary, 2009). The potential is also clearer for researchers as they begin to see what is feasible for that technology and not. The sources of evidence may come from internal experiments of educational institutions (Siokla and Keil, 1998) or external tests and surveys with customers and suppliers (O'Leary, 2009). Together with development activities happened in research labs, the technology begins being put into use in order to find the best practices. The questions about "right things" and "wrong things" now are placed in the context of application. Barker and O'Connor (1989), basing on their investigations, concluded that the most important point during this stage is providing insights into how the technology can be applied in the real world and what are related issues need to be addressed.

After enjoying the growth period, technology will then experience the maturity phase. The performance of the technology starts slowing down and there are fewer opportunities for researchers and organizations to address and develop further (O'Leary, 2009). At this stage, technology development is not an area of interest anymore unless there is a huge effort to push the technology back to the growth phase (O'Leary, 2009). However, it is necessary to consider that it would be very expensive and maybe unprofitable in the long term to invest money in new improvements because the majority of the technology's features were developed before in the previous phase. As a result, it will be very likely that those companies will end up in spending a large amount of money for very small and minor enhancements. From the market perspective, the technology has reached out its territory and been used widely (Nieto et al., 1998). In addition, finding the questions on its application in business world does not grasp much attention from market as the technology has been already deployed in many cases (O'Leary, 2009).

Finally, the technology reaches its aging phase when there is no or very little improvement. As shown in the above diagram, the performance curve experiences a plateau during this phase. In other words, it comes to legacy environment or reaches its technological limit. Nevertheless, it starts experiencing a large number of deployments in the market (O'Leary, 2009). Consequently, the uses and applications of the technology have been widely aware of. Moreover, from the technology perspective, majority features and issues also have been addressed. Unless there is a huge development effort from organizations to bring the technology up again by customization or modification, the technology will become a legacy (Nieto et al., 1998).

In reality, the duration of each phase in the Technology S-Curve can be different. While some technologies take few months to be invented then developed before going to the growth phase, others consume years and even decades just in embryonic period (Andersen, 1999). There are a number of reasons behind this difference such as environment impacts, changes in the market demand, and financial factors. In addition, it is observed that not all technologies will go through every step in the Technology S-Curve. The below graph illustrates the above difference.

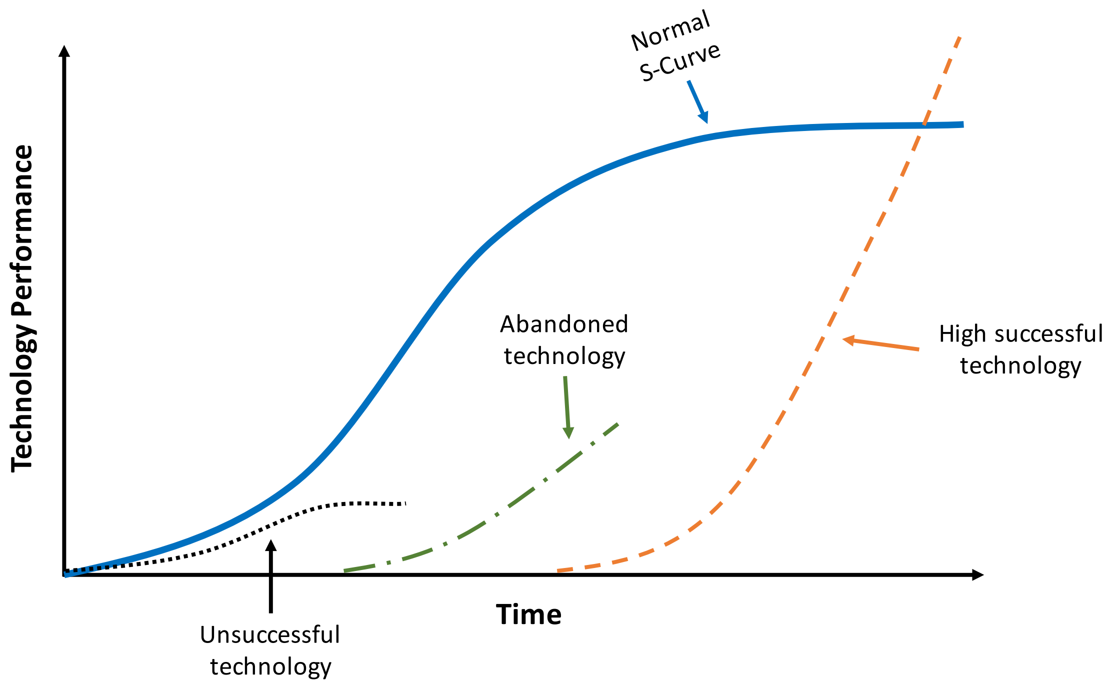

Figure 2. *Some scenarios in technology life cycle.*

Figure 2 shows some different development curves of technologies during their life cycles. The black dotted line illustrates the idea about unsuccessful technologies where their main life cycles are just stuck in embryonic phase. After invented, unfortunately, this kind of technology receives few development efforts before forgotten. Inventor is the main actor contributing to this phenomenon since the technology has not been widely well-known (Shahmarichatghieh et. al., 2015). On the one hand, the insufficient capability in terms of finance or knowledge of inventors is one of the main reasons behind this failure. On the other hand, the preliminary results of the technology are not attractive enough to put further effort is also a good explanation behind this (Shahmarichatghieh et. al., 2015). Moreover, there is another case when some technologies are abandoned as shown in the green dash-dotted line in the Figure 2. Despite the fact that these technologies are in the growth phase with some concrete evidences of their potentials, they can still be forgotten. In the majority of cases, the reason behind this matter does not come from the technology itself but from the market. Some technologies can be very potential and advanced, however, the continuous investment effort is very high or market is experiencing a downsize (Andersen, 1999). In addition, there is also a case that well-established organizations use their powers to eliminate these emerging technologies as they could be a big threat to them in the future (Nguyen and Kleiner, 2003). The last scenario from the Figure 2 describes highly successful technologies which experience a shorter embryonic period with significant increase during their growth (Shahmarichatghieh et. al., 2015). However, there is a fact that no matter how successful a technology is during the life cycle, sooner or later, it will reach its technological limit. Hence, managers should take this in mind when dealing with every technology (Andersen, 1999).

In conclusion, it is crucial for every company, especially technology-oriented ones, to adopt the technology life cycle theories. The Technology S-Curve can be seen as the common theory among them. By capturing the suitable technology at the right time, managers could increase their business competencies considerably (O'Leary, 2009). It is a challenging job for managers to decide which technology is the most potential one as there are a number of factors impacting the development of technology. Therefore, actively participating in market research and technology study is highly recommended for every manager.

2.2 Product Life Cycle

It is noted that a technology does not work by itself, it is instead embodied in a certain type of a physical product or service (Shahmarichatghieh et. al., 2015). According to Nieto et al. (1998), the life cycle of a product depends on the core technology used. In addition, Nieto et al. (1998) also point out that there is a close relationship between the diffusion speed of a product and its embodied technology. When the development speed of a technology increases, the performance of product at the same time will be increased (Nieto et al., 1998). Interestingly, the development of a product throughout its life cycle is also described by different and sequential stages which is quite similar to technology life cycle. The below figure illustrates it.

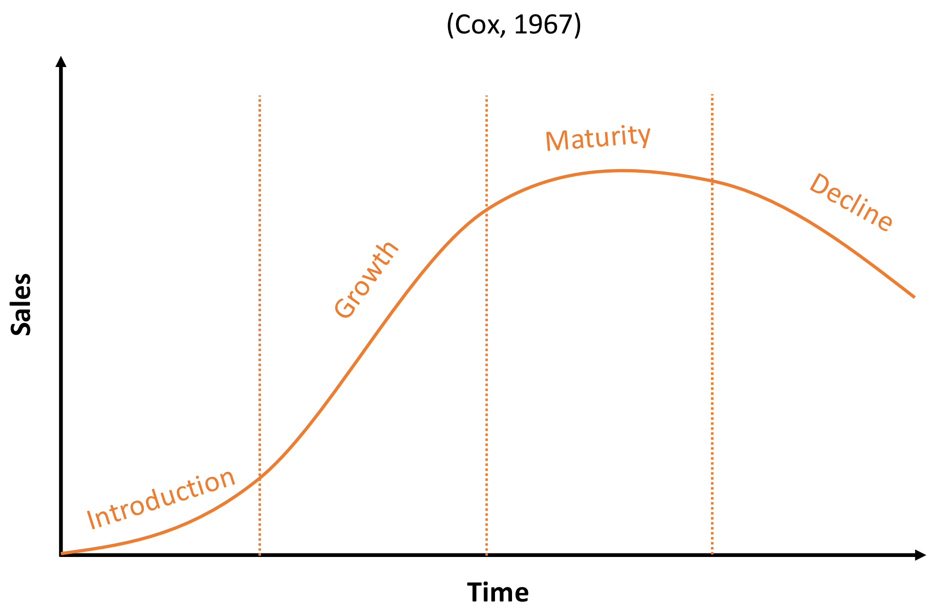

Figure 3. *Product life cycle (Cox, 1967).*

As shown in the above figure, the curve of product life cycle is similar to technology life cycle. There are four different phases in product life cycle which are: introduction, growth, maturity and decline. These phases are presented in two dimensions: time and sales volume. As can be seen from Figure 2 and Figure 3, there are two different points between product life cycle and technology life cycle which are: measurement indicator and ending phase of the curve. First, Cox (1967) does not view the product from the perspective of its performance during the life cycle, but from the sales volume of the product. In terms of business, sales volume brings more senses than the performance of the product, given that the health of a business is mainly measured by the revenue from the sales (Cox, 1967). Generally speaking, top management usually looks at the numbers rather than the actual performance of a technology, except product managers. Second, while the curve of technology life cycle ends with the aging phase where there is no or very little improvement in terms of performance for the technology, declining phase is the last stage of the curve of product life cycle. During this phase, the sales volume of the product decreases over the time until it disappears from the market (Shahmarichatghieh et. al., 2015). Hofstrand (2007) states that in this stage, buyers start moving to other offerings with better performance and more benefits than the current product.

According to Artto el. al. (2011), there are a lot of reasons behind the decline in the sales volume of a product in its decline phase. Some of them are new regulations or company's strategy changes. However, the aging of the core technology used in the product is the main reason (Artto el. al., 2011). After a long operating time, the product starts having more flaws which lead to the increase in the maintenance cost. As a result, it makes the profitability level decrease over the time. At this stage, the product has been widely used and grasped a lot of attention from the public. Apart from the good reputation, it also receives some criticisms. Commonly, the product and its core technology in this phase face a lot of issues related to legislation (Artto el. al., 2011). Thus, it poses serious problems for companies and raises the need for a replacement dramatically.

It is a huge investment for companies to develop a technology as well as launching a product to the market. Therefore, there are many cases that companies try to extend the lifecycle of a product or technology as long as possible in order to maximize the profit earned. The thin-firm technology used in disk manufacturing can be taken as a typical example. At the beginning of the 1990s, this kind of technology was anticipated to reach its performance limit when engineers thought it was impossible to write more data on the same disks (Bower and Christensen, 1995). A few years later, engineers successfully improved the ferrite heads and oxide disks performance, thus thin-firm technology was pushed back to its growth phase (Bower and Christensen, 1995). However, no matter what technology is, at the end of the day, it will reach the aging period as a natural phenomenon.

2.3 Disruptive Technology

Putting a technology back to its previous phases in the life cycle is not always the case for all technologies. Even if it is possible, it would require huge efforts with a large number of risks of the dead end (Nieto et al., 1998). As discussed earlier, sooner or later, a technology will reach its limit leading to the decline in the sales of the product it is embodied. A technology is introduced to the market when there is a need to be fulfilled (Floyd, 1996). However, market's need is not static, rather it changes and increases over the time (Floyd, 1996). The relationship between market's need and technology life cycle (Technology S-Curve) is shown in the below figure.

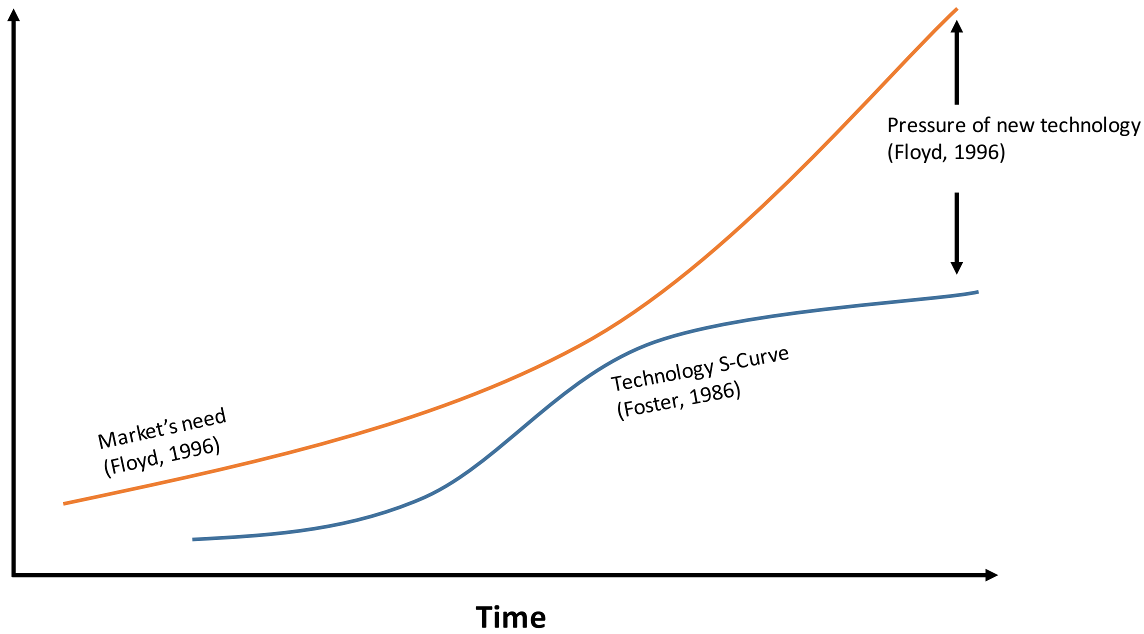

Figure 4. *Relationship between market's need and Technology S-Curve.*

According to Floyd (1996), the gap between market's needs and technology performance is mostly visible during one technology life time. At some points, one technology could fulfill almost needs from the market, especially during the maturity phase when majority of its features have been developed. However, after a period of time, the technology performance cannot catch up with the market. This is due to the reasons that the market's needs always increase over the time meanwhile the technology starts reaching its limit (Floyd, 1996). Consequently, it is critical for companies to find a new technology with a hope to bring more profits and better performance, especially in the later phase of their products' life cycle.

According to Bower and Christensen (1955), there are two type of technologies which are sustaining technologies and disruptive technologies. First, sustaining technology aims to improve and develop the performance of the existing products. Its targeting market and value network also remain the same during its life cycle (Bergeka et al., 2009). Hence, comparing to others, the advantage of this kind of technology is sustainability. Any change always comes with risks which well-established enterprises do not prefer. Therefore, most of large companies favor sustaining technology since they often want to maintain their strong footprint in the current value network including customer base, supplier and dealer network (Bower and Christensen, 1955). In addition, it is not only safer for them to invest the money in this kind of technology (Bergeka et al., 2009). Secondly, the term disruptive technology was firstly introduced by Bower and Christensen (1955). Disruptive technology represents the idea of a technology innovation which creates a new market or value network based on its advanced features and lower cost (Bower and Christensen, 1955). Furthermore, it is noted that disruptive technology will eventually replace a legacy market or a portion of it which was previously created by old technologies (Utterback and Acee, 2003). Disruptive technology could potentially bring significant impacts or even redefine the development direction of an industry (Utterback and Acee, 2003). Unlike sustaining technology, disruptive technology is more attractive for small and medium sized companies rather than big organizations (Bower and Christensen, 1955).

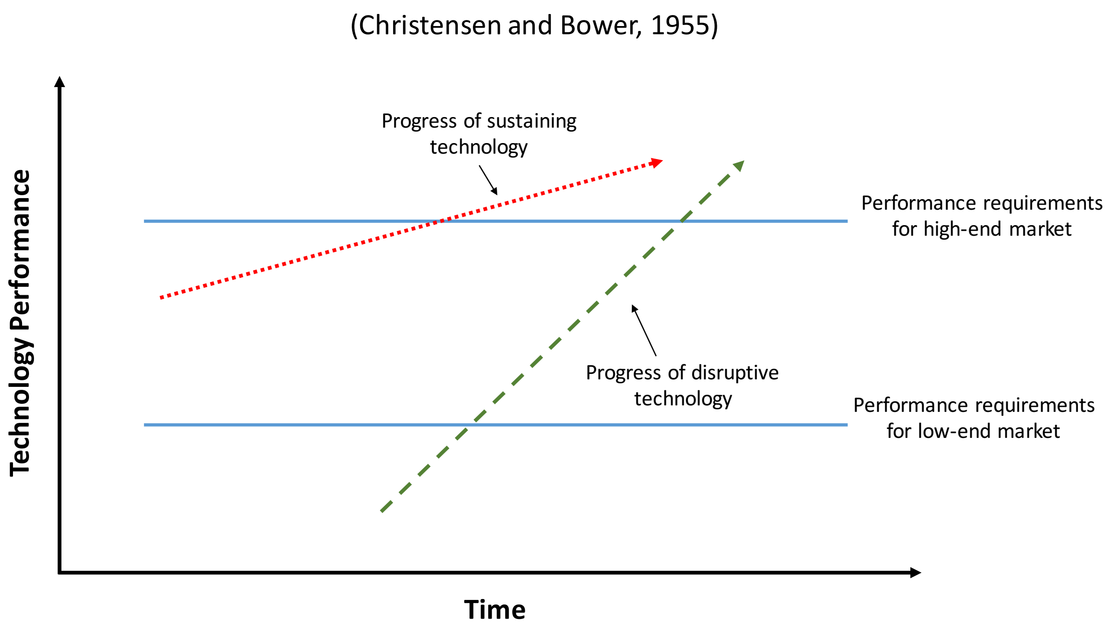

Figure 5. *Sustaining and disruptive technologies (Bower and Christensen, 1955).*

As shown in the above figure, sustaining technology usually has a good starting point with considerable high performance. Hence, it can easily catch up the demand of the high-end market only after a short period of time. This also explains why large firms usually prefer spending their money on sustaining technologies (Bower and Christensen, 1955). By contrast, disruptive technology is considered as the low performance one which serves the needs of the low-end market (Bower and Christensen, 1955). Surely, these two types of technology need to be developed after a certain period of time to meet the performance requirements of each certain market. However, it is noted that the disruptive technology's performance increases more significantly and rapidly than sustaining technology. Thus, the disruptive technology will eventually catch up or even surpass well-established technologies (Bower and Christensen, 1955).

Apart from its advantages, the high level of uncertainty and risk of disruptive technology are the main reasons behind the reluctance of large firms towards the investment. When this kind of technology is introduced to the market, given the low performance in initial phase, it is usually ignored by the mainstream customers and companies (Rosenberg, 1972). According to the research of Bower and Christensen (1995), inferior features and low profit margin are biases of market leading companies towards this kind of technology. Therefore, the disruptive technology is commonly pioneered by small and medium sized companies or entrepreneurs. Moreover, it is favored by most of low-end markets where the performance is sacrificed by cost (Adner, 2002). After a short period of time, this kind of technology will enter the high-end market with significant increase in performance. More benefits and lower cost are key advantages of the disruptive technology over others (Bower and Christensen, 2003). In addition, there is a possibility that the technology will reshape the value network as well as the market situation. As a result, it will pose serious threats to incumbents. However, Bower and Christensen (1995) state that disruptive technology rarely occurs in the market. While the development cost for disruptive technology is rather low in the beginning phases, there are some cases of advanced enhancement requiring huge effort and investment. Unfortunately, the main actor to push the technology forward is small and medium sized companies where the financial capability is limited (Bower and Christensen, 2003). In addition, there are some cases that by using strong powers and footprint, incumbents can affect development of disruptive technology in order to remain their competitiveness and positions in the market (Johnson et al., 2008). For example, large firms can set up a high entering barrier or lock-in strategy with their customers so that small and medium sized companies find it hard to introduce advanced features of disruptive technology to their potential clients (Johnson et al., 2008).

Technically speaking, every technology has its development life cycle from embryonic to aging stage which is presented through the Technology S-Curve model (Foster, 1986). In order to be commercialized, each technology must be embodied in a certain type of a product or service (Shahmarichatghieh et. al., 2015). Among different theories, product life cycle can be seen as a powerful tool to illustrate the development of a product. Hence, there is a close relationship between product life cycle and technology life cycle. In addition, each product or technology will sooner or later reach its limit and decline which poses serious threats to the business of companies. Thus, it is highly recommended that every type of companies, regardless of their sizes, should actively look for new technologies to stay competitive in the market. According to Bower and Christensen (1955), there are two kinds of technologies which are disruptive and sustaining ones. From the viewpoint of management, disruptive technology can be seen as a weapon for enterprises to grow and dominate markets.

3. INNOVATION STAGE GATE MODEL

The previous chapter introduced one of the two key literatures of the paper which is disruptive technology. This chapter will describe the remaining one which is innovation. Given the term innovation has been widely used for a variety purposes in business world, it is necessary to have an in-depth understanding about what is innovation and how it is important to the survival of the companies in the competitive market. Furthermore, one of the key aspects in innovation is timing. Innovation is considered beneficial as long as it remains novel and unique in the market. Over the time, when reaching its limit, any innovation will become a legacy with less value like a natural phenomenon. Hence, entering the flow of an innovation at the right time is crucial for the business to maximize the profit. Consequently, the Diffusion of Innovations theory will be introduced in order to provide insights into different stages of innovation.

Once having a fundamental understanding about innovation and its diffusion model, it is necessary to get to know the methodology in managing innovation. The Innovation Stage Gate Model will be described consequently to serve this purpose. This model proposes essential steps to manage innovative ideas from exploring until earning the first money out of it. Hence, it is beneficial in providing a holistic view for managers in companies towards innovation. Furthermore, this model is a very generic framework which can be applied in a wide scope. This point is an advantage of the model since managers can use it in many cases. However, it is also a disadvantage as it makes managers hard to get in-depth insights in a specific area of innovation.

In order to have a successful innovation, it is essential to follow a systematical and logical approach from the beginning to the end to ensure the accuracy in every activity. The introduction of innovation stage gate model can be seen as a very powerful theory which companies can apply in their innovation projects. However, this model does not provide a high level perspective on influencing factors throughout the innovation projects. Thus, the technology push and market pull theories are consequently introduced to complement the whole picture of innovation management. On the one hand, the Technology Push theory advises managers to focus more on technology development. In other words, the features of the final product are shaped by the technical specification of the technology (Brem and Voigt, 2009). On the other hand, market pull theory suggests to consider the market aspect which means customer's expectation when managing innovation process (Brem and Voigt, 2009). Given the significant impacts on the innovation, it is highly recommended that managers should consider carefully before applying any theory.

3.1 Innovation

In order to survive in the competitive market nowadays, all companies regardless of their sizes have to maintain and increase their competencies (Johnson et al., 2008). Some firms try to reduce the costs in operation whereas others try to increase profit by boosting the sales on existing offerings or creating new products to capture new market share. Recently, one of the trendiest strategies for companies to maintain competitive advantage is innovation (Vaughan, 2013). Interestingly, the success of tech giants has been measured by the level of innovation. In 2012, Boston Consulting Group ranked Apple as the most innovative company while Google as the second one (Taylor et al., 2012). This consulting company also pointed out that innovation is the key for success and incredible financial performance of these companies (Vaughan, 2013).

While innovation is crucial for business, surprisingly, there is no unified definition about innovation. Rowley (2011) looks at the innovation under the perspective of process in business. He states that it can come from a small scale such as a department to whole company's strategy. He also stresses that the core idea of innovation is the newness which helps things better or improves things. Damanpour (1996) defines innovation in a broad perspective which encompasses a wide range of different types, from new services, products, technology to new organization structures or development strategies. It is well noted that the concepts of innovation from the above definitions are more from the company's perspective itself. Moreover, Diess (2004) made a big difference in innovation definition when suggesting that innovation should be also seen from the customer's perspective. He states that apart from creating new products, improving internal process, innovation can also provide new values to customers. This definition is perfectly aligned with the customer value definition. To complement the idea, Kaser (2011) claims that innovation is not only doing or creating something different but also providing new values for customers.

Apart from opportunities, new things always come with uncertainties which are considered as a threat to every company, especially for giants which already has a well-established position in the market with strong processes and structure. However, the business world is an ever-changing environment with intensive rival competition. Thus, failing in keeping up the development pace will lead to severe consequences, even bankruptcy (Anderson et al., 1993). The downfall of Kodak in 2012 can be taken as a typical example. Kodak, founded in United States of America, was known as a technology giant in photography industry located in New York (Kodak Company, 2017). Back in 2012 when technological discontinuous challenges had significant impact on imaging industry, given its resistance, Kodak did not take the change but keep staying with old strategies and consequently failing down (Kotter, 2012). Given the case of Kodak, it is seen that innovation is vital for companies in order to not fall behind others.

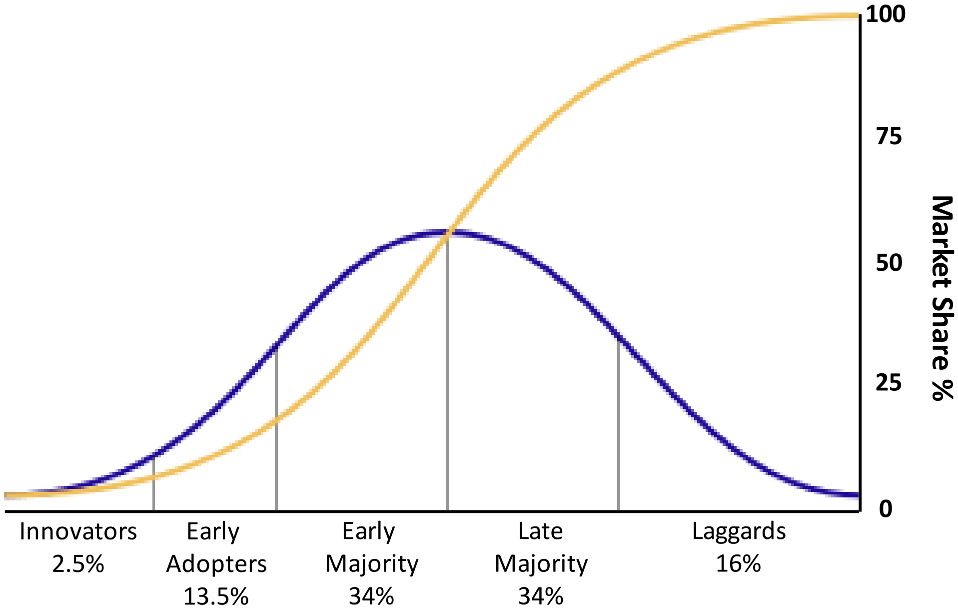

Figure 6. *Diffusion of innovations (Rogers, 1962).*

As discussed, innovation takes a crucial role in managing business in recent decades. Similar to a technology or a product, an innovation also has its own life cycle (Roger, 1962). It is well-accepted that jumping into a flow of innovation at the end of its life will bring very little or even no profit for companies. Hence, taking the innovation at the right time help the organization have more opportunities to increase profit and maintain its competency. Among different theories related to innovation, Diffusion of Innovations is considered as a remarkable one to gain insights into the spreading of an innovation in the business world (Rogers, 1962). The key idea of the theory is to explain the rate and the process together with related actors in innovation. Rogers (1962) categorizes five different groups of innovation's adopters which are innovators, early adopters, early majority, later majority and laggards. These adopters are categorized by the time they adopt an innovation, starting from innovators as the pioneer to laggards as the last. The sooner one jumps into the innovation, the higher profit it can capture from large market share. However, benefits come with risks. Although the uncertainty in the success of an innovation restricts companies from investing the money, every company has to take innovation as a successful critical factor in business strategy in order to maintain competitive advantages (Vaughan, 2013).

3.2 Innovation Stage Gate Model

When doing a deep research on the connection between innovation and company's success, Vaughan (2013) concludes that innovation is one of the rightest things companies should do. Therefore, actively looking for a novel idea from both internal and external is highly recommended in every organization. Every innovative idea deserves an investment effort as no one knows whether it would be beneficial in the future or not until they actually look into it (Lynn et. al., 1996). Given the variety of ideas in innovation, there should be a systematical approach that company could apply for both good and bad initiatives. In addition, it is crucial that poor ideas should be filtered as soon as possible to reduce the investment costs for companies. Meanwhile, promising initiatives must receive adequate effort to maximize the profitability in the future (Hamilton, 1991).

Every innovation should be linked to the development of company's strategy, either in saving cost or producing new products. In this ever-changing market, expanding the product portfolio with new offers is considered as a trendy strategy. Therefore, finding a right business process which can quickly turn a new idea into a successful product is critical. The first product innovation process was used in a NASA project in the 1960s (Cooper, 1983). The basic idea of this approach is to break the process into many phases and each of them is ended by a checking point. In 1983, Cooper improved this first model in many aspects. He stated that the innovation process should be detailed enough that companies can easily use as a guideline for their moves (Cooper, 1983). In addition, instead of looking at the innovation process from technical perspective, it should be business oriented which involves different stakeholders both inside and outside the company (Cooper, 1983). The below figure illustrates his idea.

(Cooper, 1983)

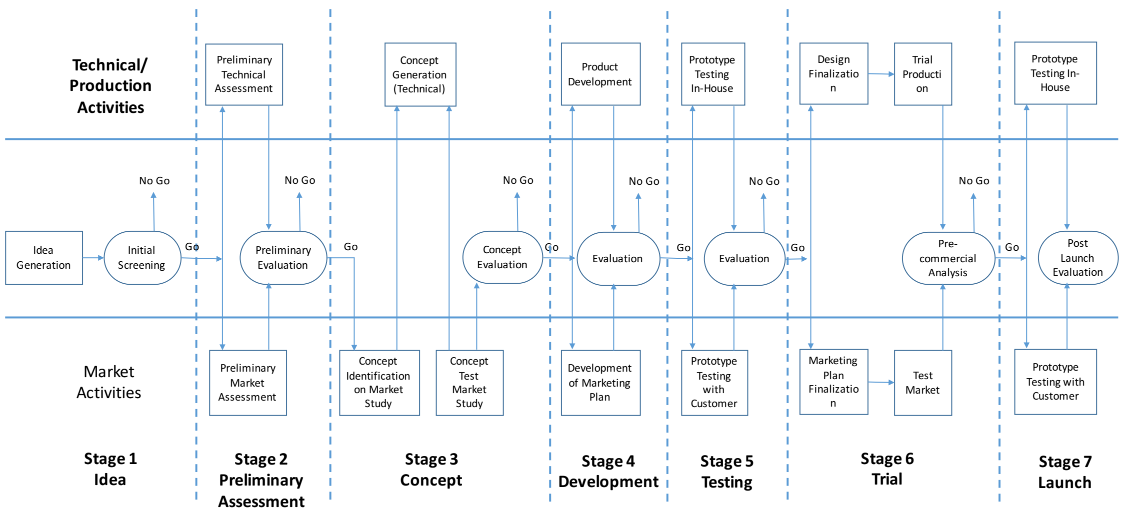

Figure 7. *Seven stage innovation process (Cooper, 1983).*

As shown in the above diagram, the whole process begins with generating ideas and ends with launching the product into the market. Each phase is separated by a decision-making point which is go or no-go. These checking points are called gates. In the effort of reducing the complexity of the 1983's proposal, in 1999, Cooper together with his partners introduced the Innovation Stage Gate model which is considered as the most common innovation process nowadays. This improvement can be seen as a big achievement which is much more simplified and standardized than the previous one. The new version has five stages and one pre-stage in the whole process instead of seven. In addition, the terms and shapes are also modified and improved. The below diagram illustrates this new model.

(Cooper, 1999)

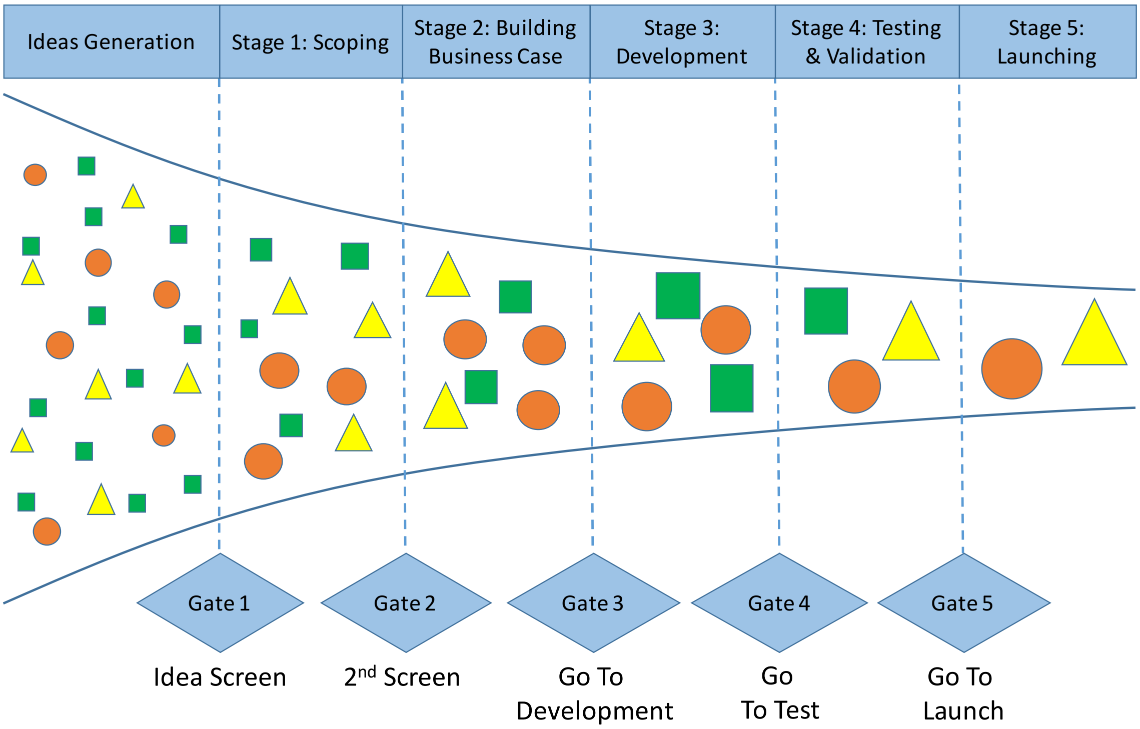

Figure 8. *The Innovation Stage Gate model.*

Ideas generation is a prestart activity of the Innovation Stage Gate model. This activity aims to discover as many ideas related to innovation as possible. This step plays a critical role in the whole process since it creates the input for next ones. According to Cooper (1999), innovative ideas can come from both internal and external sources. Companies can initiate idea creation program within the company to gather inputs for innovation (Edgett, 2015). Moreover, actively doing market research is also a good source. Ideas will be screened in the first gate. Cooper (1999) defines some criteria for filtering ideas such as company's competitive advantage, strategic alignment and feasibility of the idea. However, the screening is a very quick method with minimum effort.

Scoping is the first stage in the Innovation Stage Gate Model. The objective of this stage is accessing the ideas again but with a deeper evaluation towards the inputs from the idea generation activity (Pour, 2015). According to Edgett (2015), scoping activities are often quick and inexpensive, mainly utilizing desk research method. There are some commonly used techniques in this stage such as competitive analysis or conceptual testing (Cooper, 1999). Moreover, additional criteria such as financial evaluation or forecasting profit are usually applied (Cooper, 1999). Therefore, involvement from different departments in the companies are necessary in this step.

The second stage of the model is building business case. As described from its name, the most crucial activity in this step is to find real business cases. According to Edgett (2015), this step requires an intensive research in terms of market and customer. This idea is well-aligned with the concept of customer oriented of the Innovation Stage Gate Model as discussed before. Moreover, it is the last step before actual development of the innovation. Therefore, this step usually requires much effort from high level management team to make the go or no-go decision precisely (Edgett, 2015).

The next stage in the process is development. This step involves technical activities from designing to developing prototype (Cooper, 1999). The designing activities start with transferring the ideas from business case to technical specification. This step takes a significant role as it could help avoiding unnecessary costs to modify the product in later phase. Hence, it requires an intensive effort from not only technical team but also business team to work together in order to build the design thoroughly. In addition, some simple and early tests are also carried out during this phase. Furthermore, the justification for every feature of future product are also justified in this stage. The ultimate outcome of this stage is a real and physical prototype which will then undergo a number of tests and assessments in next phase (Cooper, 1999).

Testing and validation is the subsequent stage of development. The main objective of this phase is to ensure that the developed prototype meet the original expectations and requirements of the previous stages (Cooper, 1999). In addition, it also helps minimizing the risks for companies in spending money in mass production of error products in the future (Pour, 2015). This stage usually consists of two sequential sub-steps which are internal testing and external testing. First, in-house or internal testing is carried out inside the company by its own employees, especially technicians. After that, fixing detected flaws and issues in the prototype will be done if there is any. Second, some samples or prototypes are also made to be evaluated by customers (Cooper, 1999). It is recommended to select some friendly customers with well-established relationship for the testing. In this way, the supplier can get more informative and detailed feedbacks and inputs from its customers.

The fifth stage is launching which is also the last phase of the process. In the perspective of product offering, firms need to make sure all business requirements are met with the highest quality (Cooper, 1999). In addition, it is crucial that managers need to estimate how many products they need to produce and deliver to the market (Cooper, 1999). Moreover, there are some cases that suppliers may provide very good products at the right quantity but still fail to approach customers due to poor marketing and sales strategy. Therefore, a proper launching plan including production, marketing and sales is critical in this step. Furthermore, it is necessary to point out that launching is not the final step for business in innovation. Product improvement, after sales support and monitoring the production and selling activities still need to be implemented (Pour, 2015).

The Innovation Stage Gate model has a shape of a funnel which has many innovative ideas as the inputs, and few launched products as outputs (Cooper, 1999). To be more specific, companies often acquire many ideas from both internal and external contributors, however; only a small number of them can turn into money at the end. Majority of ideas are eliminated when going through gates during the process (Edgett, 2015). In addition, the deeper the idea goes in the funnel, the more attention and investment effort it receives.

3.3 Technology Push and Market Pull Theories of Innovation

Given the important role of innovation in the survival of companies in this high rival market, actively engaging in innovation activities is the critical tasks of managers. Innovation does not happen in a short period of time. Rather, it requires company’s investment over and over to sustain the business. The previous chapter discussed the innovation process, however, a high level perspective about influencing aspects towards innovation is still missing. Hence, there should be strategic theories which can help to guide decision-makers in managing innovation and act as a strategic view point for the whole innovation activities. Among research in innovation, technology push and market pull theories which are proposed by Schumpeter (1947) are considered as the most common ones. Subsequent sections will discuss further these theories.

Technology push theory holds the core idea that technology is the centric of innovation (Brem and Voigt, 2009). Regarding source of innovation, it implies that innovative ideas are original from the research and development process. Thus, this innovation approach heavily depends on the findings and research of technical department (Schoen, 1967). Consequently, it requires huge attention from management team on this division. Companies pay attention on developing features out of the selected technology during a majority of time in innovation process. Hence, there is no or very little impact from market such as customers or partners towards the innovation (Brem and Voigt, 2009). In addition, this core idea also impacts significantly the outcome of the innovation which is final product. Furthermore, a physical product always embodies one or many technologies as the core. If the concept of technology push theory is applied, the offering will contain all possible features from the chosen technologies no matter whether they meet the expectation from the market or not (Brem and Voigt, 2009). Hence, there is a huge risk that the development may end up with a very pricey product due to expensive investment, which may be useful but no one can afford with (Kline and Rosenberg, 1986). In addition, marketing and sales plan are affected as well. The typical message to customers is either the comparison between an inferior technology and the selected technology or the introduction of novel features of the selected technology. To some extent, this approach in sales and marketing is quite attractive, especially for customers who want to try new things.

In contrast to the technology push approach, the market pull or demand pull theory concentrates on the market side for innovation. In other words, business need is the main focus for every step in the innovation process. For the ideas generation step, the theory states that innovation is original from customer needs (Schumpeter, 1947). Thus, listening to customers is a very good way for innovation. The market pull approach starts from the market study activities. On the one hand, the needs could be identified when customers approach company and asks for new products or services. On the other hand, the demand can also be found when company actively run market surveys. Brem and Voigt (2009) claim that market demand is never fulfilled and the market is always full of inadequate satisfaction. In other words, current products or services in the market do not meet all customer expectations. In addition, there are always new needs coming up as the nature of consumption. Market pull theory considers innovators as the problem solvers; and the innovation is to solve issues (Nemet, 2008). This approach could guarantee the return of investment for companies as there is an obvious demand in the market towards the upcoming product. Hence, the effort for launching the final product is also minimized. Yet, this kind of innovation approach still receives some criticisms. First, finding a suitable technology to develop the offering is a big question mark (Mowery and Rosenberg, 1979). It is common that customers may ask for products with novel features that no technology can provide (Nemet, 2008). Therefore, the company might end up with spending a large amount of money on searching for the right technologies. Second, the ever-changing nature of market demand also causes headaches for suppliers. It takes them much time to create and provide products to customers as there are a number of activities have to be done. Consequently, there is a risk that the demand may be expired and the supplier will end up with stocking a large amount of products in warehouse (Simon, 1955).

In short, technology push and market pull process theories propose two different strategic directions for innovation. Technology push theory pays attention on the technology while market pull theory focuses on the market side. The below table summaries differences between these two theories.

Table 1. *Differences between technology push and market pull theories.*

Factor	Technology Push	Market Pull
Source of innovation	Technology	Market needs
Focusing activities	Technology development	Market research
Opportunities	Easy in development phase Capturing a new market	Easy to gather ideas Ensuring the return on investment
Risks	Matching customer needs Pricey products	Finding suitable technologies Change in market demands

Innovation is considered as a complex process with a large number of interrelated activities. Furthermore, there are many different factors impacting the innovation process both inside and outside the company (Brem and Voigt, 2009). In addition, although technology push and market pull theories are theoretically different, many convincing studies claim that the distinction between these two theories in real business world is not always well-defined (Geschka, 1995).

4. A PROPOSED FRAMEWORK OF INNOVATION MANAGEMENT FOR DISCRUPTIVE TECHNOLOGY

Among different strategies, innovation stands out as a measurement of the success of companies around the world (Vaughan, 2013). There are different kinds of sources of innovation such as internal process optimization, product improvement. In recent decades, disruptive technologies have drawn much attention from managers. Given its advantages, disruptive technologies are considered as a very potential source of innovation. Unfortunately, there has not been any theory discussing this combination. Therefore, in the following sections, the author will propose his own novel framework which describes the innovation process management in the context of disruptive technologies. Chapter 4.1 starts with the first step in developing the framework which discusses the situation that disruptive technologies as the source of innovation. Then, in Chapter 4.2, the author proposes a new model which integrates different aspects in innovation which are technology push, market pull and corporate's interest. Finally, the final framework was formed by combining the models in Chapter 4.1 and 4.2.

4.1 Disruptive Technologies as The Source of Innovation

According to Cooper (1983), every innovation should start with ideas generation activity. The main goal of this step is to seek for innovative ideas as many as possible. There is a wide range of different areas both inside organization and in the market that researchers can look into. Innovative ideas can be found in many areas inside the company such as manufacturing process or operation. Moreover, actively engaging in business discussions with clients or new emerging technologies are considered as valuable sources for innovation. While there are a large number of new technologies introduced over the years, this poses a burden for companies to choose a suitable technology to bring them the most benefits. As discussed in the above section, disruptive technologies have the potential of making companies become the market leaders or even displacing old technologies by their advanced features and lower cost (Bower and Christensen, 1955). Thus, disruptive technologies could be used as a valuable source to generate innovative ideas, which is illustrated in the model below.

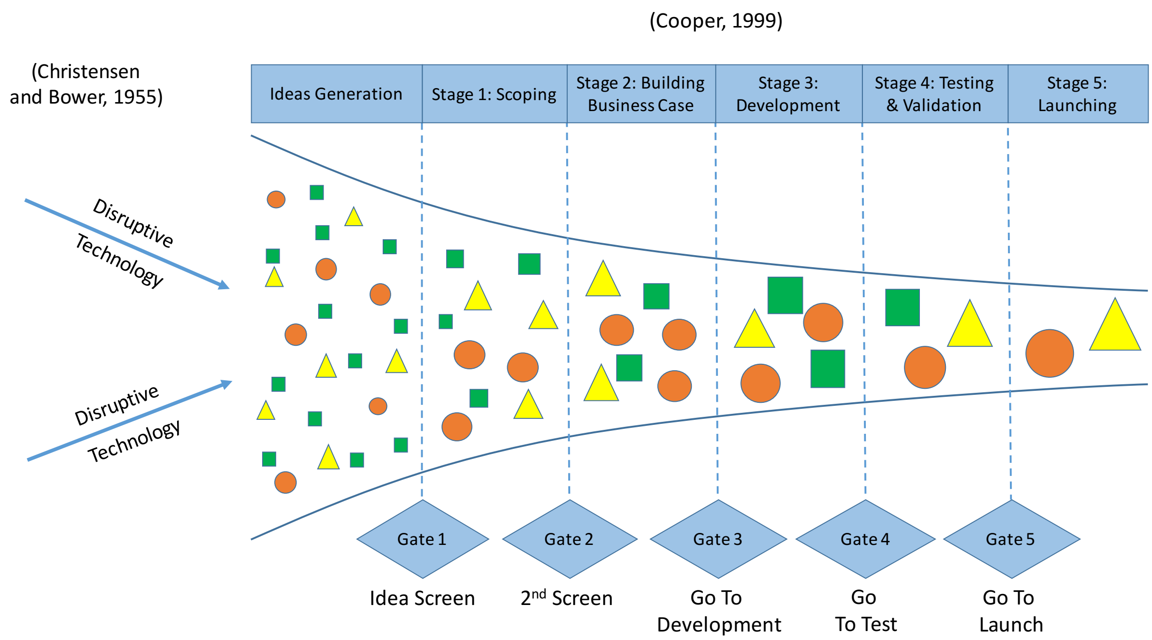

Figure 9. *Disruptive technologies as the source for the Innovation Stage Gate model.*

Given its advantages, disruptive technologies can be seen as the ideal source for innovation in terms of technology. According to Utterback and Acee (2003), disruptive technologies at the beginning of their life cycle could generate a large number of ideas. This characteristic suits the expectation of the ideas generation phase of the Innovation Stage Gate model which aims to find as many ideas as possible. Moreover, Utterback and Acee (2003) states that the development effort for disruptive technology is considered lower than others. As a result, this could help companies save more cost in developing innovative ideas further. Nevertheless, as discussed, using disruptive technologies as the source for innovation seems to be unattractive to well-established companies. It is common that disruptive technology's performance is inferior to sustaining technology in the beginning phases (Bower and Christensen, 1955). However, there has been many real cases that some disruptive technologies surpassed sustaining technologies and shape the market dramatically (Utterback and Acee, 2003). It explains why recently, there has been a large number of merge and acquisition cases where giants actively buy small or startup companies to gain their technological competencies as well as gathering catalysts for innovation (Nguyen and Kleiner, 2003).

4.2 Integration of Technology Push, Market Pull and Corporate's Interest

Technology push and market pull are two different theories to approach innovation. Technology push focuses on the new technology development while market pull is derived from market needs (Schumpeter, 1947). As a result, these two theories theoretically differ from each other. Interestingly, in the real business word, the distinction between them is not well-defined. There are many cases that companies applied technology push and market pull theories at the same time for one innovation project (Hauschildt, 2004). In this way, companies may not only utilize advantages but also reduce weaknesses of these models. The below figure illustrates the integration between these two approaches.

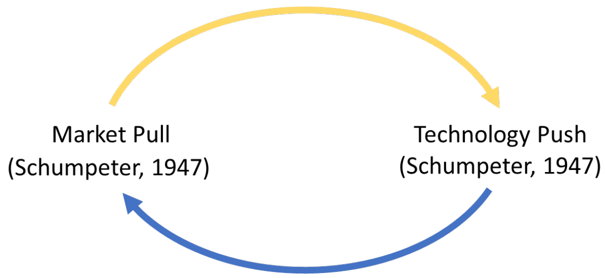

Figure 10. *The integration between technology push and market pull.*

In general, this integration model should be applied throughout the whole process of innovation management from the beginning to the end. Starting with the ideas generation step, instead of narrowing down the scope of the search to either potential technologies or customer's needs, company can use both technology push and market pull theories to maximize the number of ideas gathered. In the next phases, managers can apply this integration in order to not only reduce the risks of innovation but also increase business competency. First, market pull theory helps companies avoid spending money to build unnecessary features offered by the technology which do not match potential markets. In this sense, it saves company's cost in product development and manufacturing. Second, technology push theory can provide novel features which differentiates company's offerings from others. Hence, this integration of market pull and technology push theories help enhancing company's flexibility to react to the ever-changing business world (Brem and Voigt, 2009). However, this approach also causes threats in the innovation management. First, searching innovative ideas in various topics in both market and technology is time consuming and cause resource overloads. Thus, finding the right balance between time, budget and scope is highly recommended (Brem and Voigt, 2009). Second, the complexity in process management is another considerable issue. This approach requires more effort and a wide range of knowledge from managers to assess the inputs for each gate during the process.

However, it seems something is still missing in the big picture. The author claimed that these two theories only concentrate on external factors including technologies and markets. He pointed out that the role of company is absent although it is the main actor adopting the technology and gathering business needs from the market. According to Burgelman and Sayles (2004), corporate's interest is a critical factor which heavily impacts the success of an innovation. Therefore, the author proposed a new model to complement the weaknesses of technology push and market pull theories by adding corporate's interest factor into the integration model. The below figure illustrates the author's proposal.

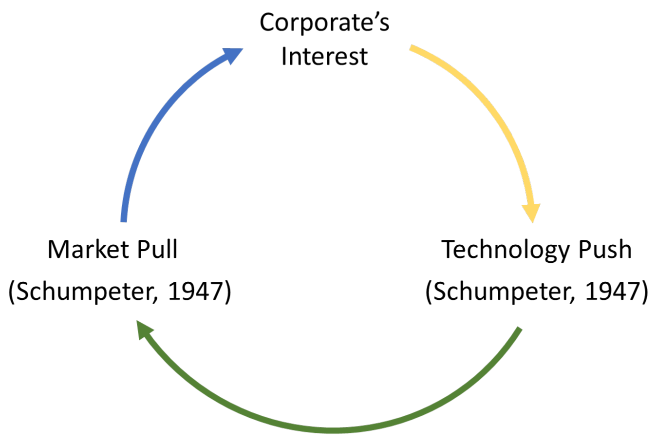

Figure 11. *The proposed integration model of corporate's interest, technology push and market pull.*

Brem and Voigt (2009) states that corporate's interest is defined and controlled by the top management or owners of companies. Hence, strategic decisions or management activities which favor their expectation catch their attention. Basically, organization's goals are defined by top level managers. Therefore, innovation has to encourage and support their expectations as well (Brem and Voigt, 2009). Regarding the corporate's interest, the ownership model is considered as a useful tool to explore management expectations (Johson et. al., 2008). The most common ownership models will be briefly introduced as follows. First, public companies, which their shares are sold publicly, are one of the most typical types. These companies are run by hired professionals to achieve the expected financial return for owners (Johnson et. al., 2008). Therefore, innovation is managed in a way that brings the most profit out of the investment. Second, state-owned enterprises are another type which are managed by governments (Johnson et. al., 2008). Hence, innovation activities should be aligned with government policies such as national development, citizen well-being. Third, entrepreneurial business is owned and managed by a person or a group of persons who founded it (Johnson et. al., 2008). Afterwards there will be involvements of hired managers and investors to boost company's business. The main objective of this model is gaining profit and/or achieving founder's interests. Therefore, innovation should favor these expectations. Another common model is family business where the company's ownership is passed from the founders to next generations (Johnson et. al., 2008). This model is quite the same as entrepreneurial business except in the scope of a whole family, not individuals.

It is well-aware that innovation is the key for success of companies. However, selecting the right innovation strategies is a difficult decision to make. There are a large number of factors affecting the innovation management of companies. In an effort to provide managers a holistic view, the author proposed a model which integrates technology push, market pull and corporate's interest theories. As each theory has both strengths and weaknesses, the integration can help giving a comprehensive view about innovation from different angles and at the same time utilizing advantages of each approach. Hence, both defining innovation strategy and managing innovation activities would be much more concrete and precise with the support of this proposed integration model.

4.3 A Proposed Framework of Innovation Management for Disruptive Technology

As discussed above, disruptive technologies are considered as a very good source for innovation. On the one hand, there have been a large number of disruptive technologies introduced given the development of science in recent decades. Thus, it reduces the burden for organizations in finding inputs for their innovations (Cooper, 1999). On the other hand, companies still remain skeptical about this kind of technology due to its uncertainty in development (Utterback and Acee, 2003). Hence, seeking a solution to address the above issue is crucial for companies when dealing with disruptive technologies. In this sense, the introduction of the Innovation Stage Gate model not only helps reducing the degree of uncertainty level of disruptive technology but also accelerating its development process. By dividing the innovation process into many phases, firms can manage the innovation activities better and save more cost. Each phase of the model is ended by a checking point which is also called gate. Each innovative idea needs to pass these gates to move to the next phase in order to receive bigger investment. In this way, companies can filter risky and unpromising ideas as well as save more resources to develop potential ones.

In addition, there are two different theories which are widely applied in innovation management: technology push and market pull (Schumpeter, 1947). Throughout the business history, there is no single approach for the success of innovation and customization highly recommended. The integration between technology push and market pull was then introduced to not only reduce the weaknesses of each theory but also utilize benefits of them both (Brem and Voigt, 2009). However, company's factor is still missing in the whole picture. Therefore, the author tried to integrated technology push and market pull theories with corporate's interest factor. The introduction of corporate's interest complements the innovation theories and empowers the major forces in the whole innovation process (Burgelman and Sayles, 2004). It also helps companies stay in the right track and support managers in making better decisions.

Innovation can be seen as a powerful tool for the sustainable success of companies. Among different methodologies to manage innovation, the Innovation Stage Gate model stands out as one of the most effective one. Moreover, the first activity for every innovation project is finding inputs and disruptive technologies are considered as a very potential source for innovation. Apart from innovation management methodology and sources, fundamental theories about innovation such as technology push, market pull and corporate's interest have to be considered as well. They play a significant role in guiding the direction of the innovation to the right track. However, there has not been any existing model describing these theories and concepts in one picture. Hence, the author proposed a framework to manage innovation which combines the Innovation Stage Gate model, disruptive technologies and the integration of technology push, market pull and corporate's interest. The below figure illustrates more about the proposed framework.

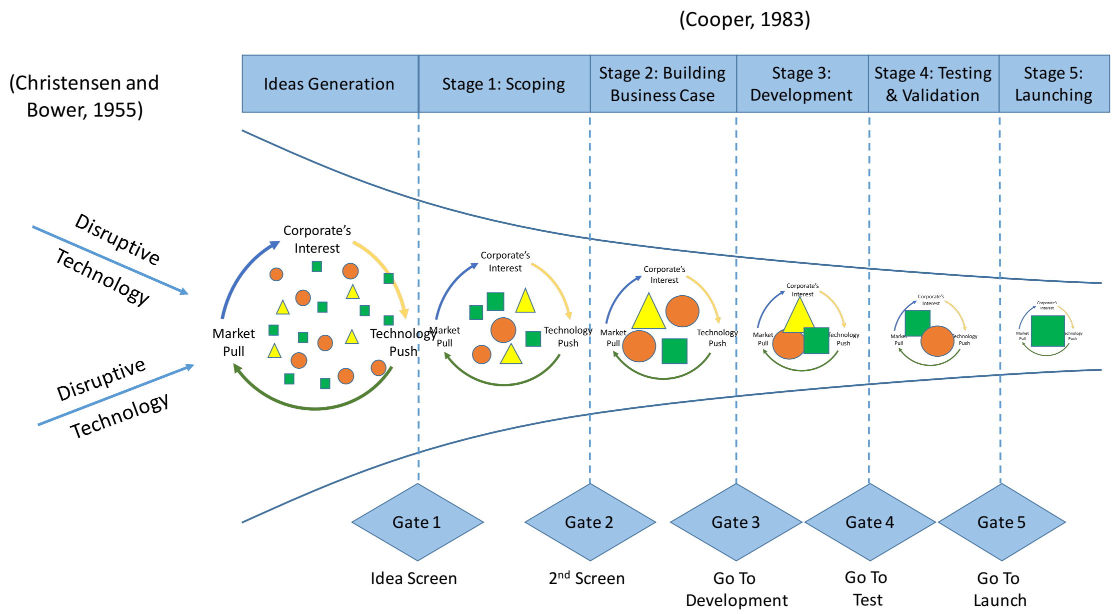

Figure 12. *The proposed framework of innovation management for disruptive technology.*

The proposed framework is a combination of different theories and models and presented in a systematic way. The framework describes the Innovation Stage Gate Model with the disruptive technologies as the inputs. It is important to note that disruptive technology and technology push theory are somehow related, however; they are two different concepts. Disruptive technology refers the source of innovation as a technology while technology push theory focuses on the whole innovation project and views it as a technology development process. In reality, companies can have many sources as the inputs for innovation. Depending on searching effort and opportunities, company can gather one or many disruptive technologies as the inputs. Interestingly, even one disruptive technology can generate a lot of innovative ideas. These ideas can be put in different categories such as internal process optimization, production improvement or new product development. The integration of technology push, market pull and corporate's interest plays the role as the boundary of innovative ideas throughout the process. As seen from the proposed framework, there is a big gap between technology push, market pull and corporate's interest in initial phases in the Innovation Stage Gate model. However, throughout the innovation process, this gap will be minimized gradually. Basically, technology push, market pull and corporate's interest focus on different aspects, and even contrast each other. Therefore, finding an innovative idea which can satisfy these approaches is a very challenging job. However, when putting into the context of disruptive technology, this integration opens up a lot of ideas. First, technology push theory focuses on the technical side of the disruptive technology. In other words, all possible functionalities, features and advantages of the selected technology will be studied and developed. Second, market pull looks at the customer's perspective of the disruptive technology during the innovation process. For instance, features of the selected disruptive technology are related to current market's issues to see whether they can solve any problems or not. Third, the corporate's interest towards the innovation is also a critical factor. In the innovation project, it is certain that management team of companies will not select all but suitable features of the disruptive technologies and some specific demands from the market to develop further. As the result, companies can save more time and efforts to concentrate on the most potential ideas in the innovation project.

In the beginning phases, it is necessary that company should gather as many ideas as they can no matter how good they are. In most of the cases, ideas are just thoughts or simple suggestions based on new technologies or new demands from the market. Throughout the time, potential ideas receive more and more development effort while irrelevant ones are eliminated. The integration of technology push, market pull and corporate's interest theory plays the main role in filtering ideas during the innovation process. As illustrated in the above figure, the deeper the ideas go in the innovation process, the bigger they become. When the innovation process approaches its final phases, just few or even one idea remaining which satisfies all requirements from technology perspective, market demand and management team's interest.

Basing on intensive studies, Brem and Voigt (2009) claim that a single methodology is never adequate for success in terms of innovation. Customization and adjustment according to the real situation are highly suggested for all companies. The proposed framework of innovation process in the context of disruptive technologies introduced a comprehensive approach which is backed by many technology theories and innovation models. The framework is applied in the context of using disruptive technologies as the inputs for innovation. By following this framework, companies are equipped with a systematic approach to manage the innovation process through the Innovation Stage Gate Model. In addition, the integration of technology push, market pull and corporate's interest forms a strategic boundary which helps firms stay on the right track in their innovation journey.

Basically, the proposed framework is formed by combining different theories which are innovation management, disruptive technology, market pull, technology push and corporate's interest. Some may claim that the proposed framework is rather similar to customer involvement management and design science approaches. However, the proposed framework is way different from these approaches. First, while customer involvement approach includes customers during the product or service development process (Kaulio, 1998), the proposed framework takes into account not only customer involvement but also other aspects such as market study and forecasting, potential customer targets during the innovation process. Second, the proposed framework, instead of paying attention to a specific focus such as customer or technology only, combines different theories related to innovation which are technology push, market pull and corporate's interest as the core. These aspects could help companies in guiding the right direction during the innovation journey. Other than that, the proposed model is formed exclusively for the innovation process management in the context of disruptive technology, not in general contexts. Regarding design science research process, it is a very powerful tool to design or develop artifacts which follows a set of sequential steps and related outputs (Takeda et al., 1990). However, this approach seems to be inappropriate to the context of my study. The innovation project in my study starts with a new technology which is disruptive technology while design science approach begins with a problem (Takeda et al., 1990). In addition, the selection of the Innovation Stage Gate model in the proposed model is based on the funnel design and clear separation between phases. These factors are crucial and more relevant to the context of the innovation project of the study while design science approach does not support. Given the above discussions, the proposed framework by the author is considered as a novel approach to manage innovation in the context of disruptive technology.

5. RESEARCH METHODOLOGY

5.1 Research Strategy

Case study method can be used as a practical tool for researchers in examining the data in a particular context (Eisenhardt, 1989). In other words, small and narrow geographical areas with a limited number of actors suit the case study method the most (Zainal, 2007). Moreover, this kind of method is also used to explore and gain understandings about contemporary real-life phenomenon and help reduce the level of uncertainty inside the doors of social science (Yin, 2003). According to Zainal (2007), case study research has been widely used in discovering and understanding complex issue in many aspects such as education, business. In addition, previous studies also show that in some researching areas such as government or sociology, scientists have been using this method intensively. There are two common approaches for case study method which are quantitative and qualitative. Comparing to quantitative research method, qualitative case study is more suitable for researchers in gathering deeper and more holistic insights about the research topic (Zainal, 2007). Furthermore, qualitative case study method is preferred in studying complex process related to the study subjects (Tellis, 1997). Other than that, longitudinal study can be used as a systematic approach which involves in observing and analyzing information over a long period of time (Zainal, 2007). It is noted that there is no specific definition for how long a longitudinal study should be conducted as it differs case by case. For example, longitudinal study has been used in researching the language development of children which took months or even years to complete (Zainal, 2007). By observing a phenomenon over a long period of time, researchers can easily see the development and changes of the study subject. According to Yin (2003), the longitudinal qualitative case study is a powerful approach in researching natural phenomenon at the micro level.

Despite advantages of longitudinal qualitative case study, there are some disadvantages of this method which researchers should take into consideration. First, since this method targets at a limited number of subjects or even only one, it is not sufficient for scientific generalization (Tellis, 1997). Second, it requires more efforts from researchers than other methods such as a large number of data gathering and researching activities. Hence, there are some cases the studies are unmanageable by researchers (Zainal, 2007). Third, the subjective conclusion in case study method is one of the most criticisms (Yin, 2003). Many records indicate that researcher's bias has strong influences on the findings of the study (Zainal, 2007). Thus, it poses a big threat to the reliability and validity of the study.

This study is based on an innovation project of an emerging disruptive technology in a company in Finland. The project started from the beginning of 2016 and lasted for approximately one year. In May 2016, the author was recruited as a member in the innovation project. During this period, the author had opportunities to participate in almost every activity in the project from studying a new technology to shaping the future product requirements. More than 9 months doing research for the case company provides the author a very comprehensive and holistic view about the topic. Hence, it enabled the author to have a better data gathering and analysis about this innovation project. There were a large number of activities carried out both inside and outside the case company. In addition, the project required involvements from different stakeholders in the company such as company's CEO, engineer as well as potential customers. Another aspect which is worth mentioning is the selected technology: Bluetooth Low Energy. It is expected to disrupt the short range out-door and in-door positioning market in the near future which fascinated the project team at the beginning. Therefore, instead of having a broad innovation project, the company decided to focus on this disruptive technology business only. Since the study is complex and specific in a small business area and being conducted over a long period, the longitudinal qualitative case study method is the most suitable approach. This decision was made after considering both advantages and disadvantages of the selected research methodology.

5.2 Data Collection

According to Gummesson (1992), data gathering is the key element in case study method. Hence, selecting the right data gathering method takes a significant role in the study. Gummesson (1992) categorizes it into five different methods shown in the below table.

Table 2. *Data gathering methods (Gummesson, 1993).*

Method	Description
Existing materials	Refers to data from media other than human knowledge such as the internet, library, company files repository
Questionnaire Surveys	Standardized and formalized questions or interviews
Questionnaire Interviews	Guiding questions for the formal and qualitative interviews with open-ended questions to facilitate the interview flow
Observation	Data can be collected based on the observation the subject
Action Research	Refers to action science when researcher plays the role of a changed agent and involves as an active actor during the research process of the study

In this study, action research is selected as the primary method for data gathering as the author involved in the whole process and acted as a change agent. Given the complexity of the case, many secondary data gathering methods were also used. The study went through many phases and each phase's objective differs from each other. Thus, the author decided to use different methods which accordingly suits the best for each phase's analysis objectives. The below figure illustrates more on this.

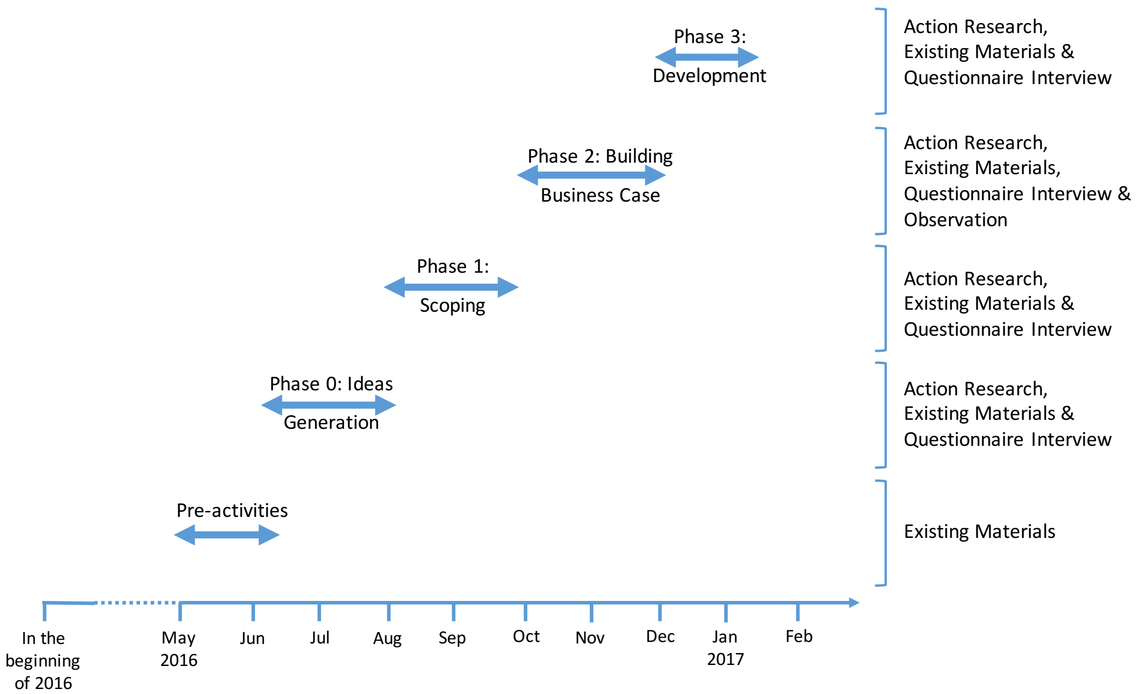

Figure 13. *Data gathering methods during the research process.*

The company actually started the innovation project at the beginning of 2016. However, there were not many activities done at the time, mainly unofficial discussions and ideas. Until 9th May 2016 when the author joined the company as the summer market research trainee, the project was officially kicked off with an approved research plan. The existing material research method was used during May 2016 to get to know more about the selected technology – Bluetooth Low Energy. During this period, the author spent all researching time in the company office. Data was mainly gathered through existing sources such as websites, technology research papers discussing the technology. The below table summarizes some key points related to the data set of the research in this phase.

Table 3. *List of data sets collected in the pre-activities phase.*

Data Type	Source
Existing material: Websites	• Organization: Bluetooth SIG • Firm: ABI Research, Bluegiga Technologies, Accuware • Magazine: CNET
Existing material: Documents	• ABI Research presentation about Bluetooth Low Energy version 4.0 • Four research papers and presentations about indoor and short range outdoor location tracking of BLE and other technologies

Websites from different companies and magazines discussing BLE technology were also studied. As their targeting audiences are non-technical readers, the content did not include detailed technical information. Therefore, Bluetooth SIG, the official website of Bluetooth technology is particularly helpful to complement the knowledge. It provides not only technical details about the Bluetooth Low Energy technology but also its current experiments. Moreover, research papers and presentations from ABI Research in relation to the BLE and other technologies for indoor and short-range outdoor location tracking are also valuable. Researchers of those papers shared real experiments and implemented projects in the market, which were then utilized for the technology performance comparison between different technologies, including BLE. All pieces of information from above mentioned sources were collected and documented in a document.

In the ideas generation phase, from the beginning of the June 2016 to July 2016, existing material, questionnaire interview and action research methods were used. The first objective for data collection in this phase is to gather information about applications in different markets of the disruptive technology to generate ideas as many as possible. Most of the time, the author surfed for the information on the internet. Similar to the previous phase, this phase also used websites and newspapers to collect desired data. The below table lists down sources of data collected through existing material data gathering method.

Table 4. *List of existing material sources collected in the ideas generation phase.*

Data Type	Source	Description
Existing material: Websites	• Organization: Bluetooth SIG • Firm: Bluegiga Technologies, Accuware, Q-Track, Lighthouse, Hilti, Cisco, Estimote • Magazine: RFID Journal	• Potential applications of BLE technology • Implemented BLE projects

As show in the above table, the website of Bluetooth SIG was again a very useful resource. Apart from publications of technical specifications about the Bluetooth technology, successful implementation projects in retail and public transportation markets and potential applications in different markets such as manufacturing and construction of BLE are also listed in this website. In addition, RFID Journal which is a technology magazine specialized in BLE, NFC, RFID and Wi-Fi technologies also provide valuable information about BLE projects in retail and public transportation markets. Moreover, webpages from different companies around the world in researching on the potential of BLE applications were helpful. However, the information from those websites are not so reliable in some markets as they do not have much supporting evidence. All information related to applications of BLE in public transportation, manufacturing, construction from all mentioned resources are merely assumptions. The retail and public transportation markets are the only areas which have real and concrete cases and projects. Nevertheless, it did not impact the aim of the study as the objective in this phase is to gather as many applications of location tracking system as possible. The verification about whether the idea is correct or not will be carried out later in next phases. Furthermore, data collected from those websites is quite simple as these companies want to make it straightforward and easy to understand for their potential customers.

The second objective in the ideas generation phase is to gather ideas about roles and responsibilities of different actors in the value network of BLE technology business. In many cases, one project is a joint-effort of many companies with various roles. Some supply products when others provide services. In order to gather more information about the topic, an interview with the Product Director of the company was conducted. Interestingly, outcomes of the interview show that the value network of BLE is the same as the one of RFID. Consequently, the value network in BLE business was shaped and detailed roles as well as responsibilities of each actor in the network were defined. The below table summarizes the information about data gathering in the interview.

Table 5. *Detailed information about data gathering in the interview with the product director of the company.*

Data Type	Source	Description
Questionnaire interview: Responses from interviewee	Interviewee: the Product Director of the case company	• Carried out in the office of the case company in mid-July • Followed by mainly 4 open-ended questions about the value network of RFID and BLE

During this phase, together with data gathering, the author also acted as an active contributor in terms of ideas generation. Some ideas about markets, applications and the roles of different actors were added as the result of many year working experience in similar business of the author. Furthermore, there was a large amount of data collected in terms of applications and value network. As a result, it causes a lot of difficulties in organizing the information. To overcome the above-mentioned issue, a well-structured word document was created to capture ideas and insights during the gathering process in a systematical way.

The data for scoping activities in the second phase, from the beginning of August 2016 to the end of September 2016, were based on discussion during meetings and interviews with management team of the case company and the information gathered on the internet and insights from action research method. The phase began with the meetings between the author and the management team. Discussion in these meetings was considered as a valuable source for the research analysis of the topic. In addition, the technology online magazines also provided a lot of information and insights for the authors. Given that being unique in the market is the key criteria for innovation, existing projects and competitors in particular market were studied in order to verify this crucial criteria. Therefore, the author decided to gather as many cases as possible in each researching market. In addition, the pros and cons for each possible move in the value network in terms of BLE technology business was collected by interviews with the Product Director of the case company who has a long working experience in this domain. Consequently, based on analysis from the collected data, a list of possible strategic choices was identified by the author. Accordingly, during the Strategy Week of the company from 19 September to 22 September, these findings were proposed to management team of the company to make the go or no-go decision for each of them. The meeting was held in the company, including senior managers of the company from different departments: finance, sales, technology and top management team. All decisions from that meeting were collected officially through a meeting minute as it is a critical path for next phases. The below table summarizes data set used in this phase.

Table 6. *Data set used in the scoping phase.*

Data Type	Source	Description
Existing materials: Websites	• Magazine: NFC World, Proximity Magazine, DigiDay, Business Insider, IoT Analytic • Firm: Beaconstac	• Successful projects of BLE in retail and public transportation markets, especially airport industry • Searching for real cases in construction and manufacturing market • Exploring the potential of construction and manufacturing
Questionnaire Interview: Responses from interviewee	• Interviewee: the Product Director of the case company	• Carried out in the office of the case company in the end of September • Followed by 2 sets of questions which are earning model in BLE and RFID business and pros and cons for each move from hardware suppliers to integrator or solution provider.
Insights from action research	• Project team meeting in the middle of August 2016 • The author's own experience in previous companies • Strategy week in the end of September 2016	• Narrowing down the scope of the project from the previous phase • Providing more inputs and ideas for earning model and pros and cons for each move in the value network • Decision about focusing on construction market in next phases

The next phase - building business case, from October to November 2016, was rather complex with several different data types collected. The third phase was the most challenging one during the whole project which caused a lot of difficulties. In order to maximize the outcome, the author decided to use action research, existing materials, questionnaire interview and observation methods at the same time. There has not been any real business case for the disruptive technology. Therefore, the author decided to start with the existing business pain points of construction companies which BLE technology could potentially provide the solution. The data source in this step was mainly online newspapers and websites of companies around the world. Consequently, the collected information from existing materials method was captured in a structured document. In addition, questionnaire interview method was also used in this phase in order to gather more insights for the research. During the period, the author had many chances to conduct face to face discussions with construction workers of some construction companies like

YIT, NCC. The replies were captured by notes in the author's notebook and audio recordings. Moreover, on 10th October 2016, the author travelled from Tampere to Helsinki to participate in the FinnBuild– which is the biggest event about construction in Finland. The trip provided a lot of insights for the research. He had opportunities to discuss in person with some construction companies' representatives, mainly managers and directors. All inputs and comments about potential business cases were written down thoroughly. Furthermore, observation in some ongoing working sites in Tampere area such as Hervanta, City Center also delivered valuable information for the study. The data gathered by method was mainly captured through images or note takings. Consequently, some findings were found and then documented. The below table summaries key data sets for this phase.

Table 7. *Data sets in finding business case phase.*

Data Type	Source	Description
Existing material	• Magazine: International Journal of Production Economics • Firm's website: Hilti, Sokanu, Trimble • Research papers: Society for Industrial and Applied Mathematics	• Searching business pain points of construction companies around the world
Responses from interviewees	• Two YIT workers in Tampere construction sites • Two Managers/Director of construction companies: Styrud, Skanska, • Three Managers and Salesperson of equipment rental/manufacturing companies: Betonikoneet, Kallioinen Yhtiot, Skanka • Two Directors of software companies: eRent, Adalia • The Product Director and BLE engineer of the case company	• Verifying the business pain points of construction companies around the world • Gathering high level expectations for the future product and solution

Observation	• Four big construction sites in Tampere: Hervanta, City Center.	
Insights from action research	• Project team meeting in the end of December 2016 • The author's own experience in previous companies	• Providing more inputs and ideas for business pain points as well as narrowing down the scope • Mapping the technology features and business pain points

During the development phase, as the result of dedicated involvement during the whole project and different data collection methods, the author gathered a lot of ideas and insights. The main objective of the development phase is to build a prototype for the final solution based on BLE technology. Existing material was the first method the author used in order to have an overview about the solution related to real-time location tracking for indoor and outdoor short range scales. Websites of solution providers, author's documents from previous phases together with company's brochures played a significant role in this step. These materials did not provide any information about the solution in terms of BLE technology but similar technologies such as Wi-Fi or RFID. However, technology does not impact the overview and the working methodology of the whole solution in terms of real-time location tracking. Therefore, Wi-Fi and RFID solution in this business was used to extract insights for the study. Then, questionnaire interview was applied to gather requirements from representatives of some construction companies like eRent, NCC, and Kallioinen Yhtiot. As a result, the detailed expectations about different components in the solution were defined clearly. Moreover, on weekly basis, the project team organized meetings to update the status and share ideas. Through these meetings, the author contributed to designing the prototype of the future solution and each component. The ideas and sharing were captured through meeting minutes by the author as the inputs for the research. Finally, in the first week of January 2017, the author had a chance to participate and contribute in the official team meeting with the CEO of the company. During this meeting, feedbacks from CEO and project team members were also collected. Especially, the decision of the CEO about postponing the project was also made. The below table summarizes data sets used during this phase.

Table 8. *Data sets for development phase.*

Data Type	Source	Description
Existing material: Websites	• Firm: Cisco, Trimble, OnyxBeacon	• Overview about the real-time location tracking solution in industrial market • High level about different components in solution
Existing material: The author's documents	• Documents from previous phases	• Providing detailed requirements about each component in the solution
Existing material: Company's brochure	• Specification of different RFID products of the company	• Providing detailed requirements about each component in the solution
Responses from interviewees	• One engineer of construction company: NCC • One director of software company: eRent • The Product Director and BLE engineer of the case company	• Providing detailed requirements about each component in the solution
Insights from action research	• Weekly project team meeting • The author's own experience in previous companies • Official meeting with the CEO in January 2017	• Providing more inputs and ideas for solution during weekly team meetings • Decision to postpone the project

In the second week of January 2017, due to the company situation, the CEO of the case company decided to postpone the whole innovation project for BLE technology at the development phase despite the fact that there are still other steps. Therefore, the findings of this research are limited until the development phase.

5.3 Data Analysis

Among different methods of analyzing qualitative data, framework analysis which follows a systematic approach is considered as the most suitable one (Ritchie and Lewis, 2003). This method was developed by a group of United Kingdom researchers when doing their study in social policy (Ritchie and Spencer, 1994). Until now, it has drawn attention of researchers in different fields around the world. The base of the framework analysis contains interconnected but distinct stages (Rabiee, 2004). Framework analysis method implies that managing and analyzing data should follow a structured way or systematical theme which is developed by existing ideas or theories (Smith, 2011). According to Srivastava and Thomson (2009), the analysis process of this method is very flexible which allows researchers to either analyze after collecting all data or analyze and gather data at the same time.

This study applies the framework analysis of the qualitative research to analyze the gathered data. The main objective of this paper is to develop an innovation process in the context of disruptive technology. The case study was conducted to serve the purpose of verifying and assessing the proposal. The proposed framework of innovation process in the context of disruptive technology was used as the main frame to analyze the data gathered. It also has different phases which matches with the features of framework analysis. In addition, as described above, in this study, data gathering and data analysis were carried out concurrently. Given the above mentioned facts, framework analysis is the best choice for this study in terms of data analysis.

6. THE CASE COMPANY

6.1 The Case Company

The case company is a Finnish company which was founded in 2005. The company has been well-known as the leading company in manufacturing and selling high performance RFID tags and labels around the world. The company offers a wide range of contactless tickets and industrial tags for global customers. Since 2005, the company has been proud of its specialized services including tag designing, RF engineering and manufacturing. Regarding business strategy, the company aims to provide the best products and services with highest performance. The company's expertise in RFID technology has been the key driving its business forward. According to a senior manager, the company's success is based on its core values which are: trust, expertise and commitment:

> *"To our customers, we provide what we promised as we want to build a strong and sustainable relationship with them. We believe that collaboration will make the work more effective and efficient. Inside the organization, the integrity of our employees is the critical factor for the survival of the company. We show our expertise through excellent products, professional services offered to clients. Our company is fascinated by new ways of thinking and creativity as we believe those elements drive our business forward. In terms of commitment, dedicated and high qualified personnel is our foundation for success."*

Currently, the company has its headquarter in Tampere, Finland and manufacturing plant in China along with many sales offices around the world. In order to increase its footprint, the company also partners with many system integrators and solution providers to ensure that its products can reach almost nations in the globe. With regard to the target markets, the management defines five key verticals which are public transportation, access control, manufacturing, traffic management and authentication. For each segment, the company is capable of delivering high performance and robust products which can meet the highest requirements from demanding clients. Despite the fact that high volume orders in short delivery time, the high performance and the best quality of the products are never compromised.

Table 9. *Financial summary of the case company (Iltasanomat.Fi).*

Index	December/2013	December/2015
Turnover (EUR)	13,569,188	21,391,763
Profit of the period (EUR)	137,488	237,060
Profit margin (%)	3.1%	2.4%
Personnel	137	204

Even though the financial information of the year 2014 is missing, it can be seen that the company has been growing remarkably in recent years as shown in the above table. Given its promising development, the company has recently received new investments from some big investors. On the one hand, it provides the company more funding to run its business. On the other hand, it poses a heavy burden to management team in achieving aggressive profit margin as expected from these new investors.

6.2 Current Company's Position in Value Network

As discussed above, it seems that the company has been doing well in operating the business. After more than a decade, the company has earned creditable reputation with customers and partners around the world. From the perspective of RFID business, the company is currently positioning itself as a hardware supplier. The company supplies products to its customers which are integrators. The below figure shows the whole value network of RFID business.

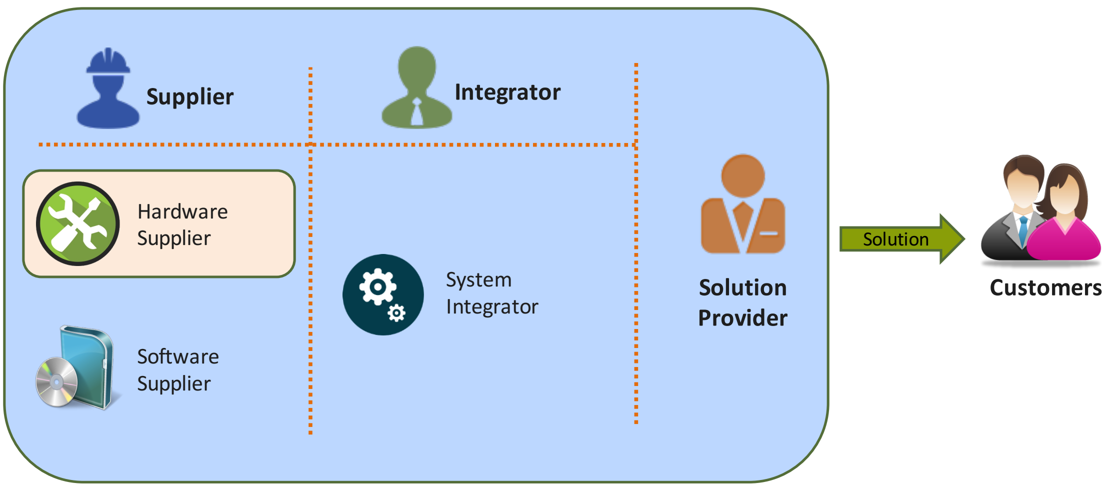

Figure 14. *Value network of RFID business.*

There are two kinds of suppliers in RFID business: hardware supplier and software supplier. Hardware supplier, which is the case company, supplies different kind of physical products such as tags, labels and readers while software provider sells software applications. The customers of these suppliers are system integrators or integrators for short. The responsibility of system integrators is to integrate and pack hardware and software together to make sure the whole system works smoothly. It is noted that sometimes system integrators can produce hardware and software as well. The last actor in the value network of RFID business is solution provider which is responsible for selling activities, project management and after sales services. As shown in the Figure 14, solution provider is the main and the only contact point that customers know since he or she take care the delivery in all aspects from the user's perspective.

The case company has been developing the business based on its position in the value network and technology expertise in RFID. Until now, with a large customer base and product portfolio, the company is well-known as the leading hardware supplier specialized in tags and tickets manufacturing in the world.

6.3 High Quality RFID Tag Manufacturer

Currently, the company concentrates on two main sectors: smart mobility and smart industry. With the smart mobility, public transportation and authentication are the focusing markets for the company. The company proudly offers high quality and cost efficient tickets for customers around the world. On average, more than 15 million contactless tickets are produced every month by this company (Company's website). In addition, it is also recognized as the leading ticket supplier in this business. Advanced materials and in-house large volume production capacity are core business competencies of the company (Company's website). Moreover, the company is also capable of designing different security options and memory capabilities as requests from its customers. Since the company was founded, it has been offering a wide range of high quality products which are used in different applications such as contactless smart tickets for public transportation, ski passes, and personal cards (Company's website).

Together with ready-made tickets, in order to capture more profit, the company also offers customized products which are produced according to customer's specific requirements. However, this business is challenging since it requires not only intensive knowledge about the RFID technology but also professional customer relationship management. The case company is proud of its full-service offerings with regard to customization from designing to production and delivery. In addition, with its competencies, the company is able to provide customized products which fit almost every technical requirements in the market in relation to RF technology. In terms of customization, the company currently offers four different services for its customers which are physical format, customizing the tickets and optimizing the ticket tracking and delivery (Company's website). For physical format, the tickets can be delivered in the form of either reel or fanfold format depending on the vending machines of the customers. The company also offers Polyethylene terephthalate (PET) material tickets which are very durable and resistant in the tough environment. Furthermore, with customization services, the tickets can be encoded with different encryption methods. For the ticket delivery, the company provides different possibilities in tracking the movements of the tickets in electrical format log files.

In the product portfolio of smart industries, the company offers both RFID tags and labels. High mechanical quality and superior radio frequency performance are highlights of its products. Being the trusted hardware supplier, the company has been supplying more than 10 million tags and labels for customers worldwide. Regarding targeting industries, its products have been used in different sectors from automotive, construction and mining to supply chain. The below table shows some product's families in the company.

Table 10. *Some product families (The case company's website).*

Family	Description
Transportation family	- Hard tags and robust labels which are specialized for containers and other returnable items. - Single-use disposable labels
Manufacturing family	- Very durable hard tags for the toughest environments in manufacturing industry - Bolt tags with high chemical resistance

From the above discussion, it is seen that the company is very professional and experienced in providing high quality RFID products such as tags, labels and tickets. Its expertise is demonstrated not only in designing forms and selecting the materials but also featuring functionalities specifically for different applications and industries.

7. INNOVATION MANAGEMENT PROCESS FOR BLUEETOOTH LOW ENERGY TECHNOLOGY IN THE CASE COMPANY

7.1 The Pre-activities – Understanding BLE Technology

Previously, the company run its business based on Radio Frequency Identification (RFID) technology only. All offered products and services based on this technology are narrowed down in the scope as a hardware supplier. The company has gotten many achievements since 2005. At the beginning of 2016, given the aggressive growth expectation of investors, the company had to find a new business strategy along with current business model. Even though the company heavily depends on RFID technology, management team realized that sooner or later this market will reach its saturation. Moreover, new business strategy has to be aligned with current business model to utilize the current knowledge and core competencies. Therefore, investing in a new technology was a wiser selection than changing business model or jumping into a new market. After some preliminary discussions, the company decided to look into an emerging technology which was Bluetooth Low Energy (BLE). However, what that technology is in detail, how potential it is and what needs to be done were still big question marks. Therefore, hiring a summer market research trainee was the first move of the company.

On 9th May 2016, the research process officially started when the author was recruited to do the market research for the company. In the beginning, the research mostly focused on gaining understanding about the new technology – Bluetooth Low Energy. The company hardly knew this technology. The management team of the company got to know the technology by chance when reading some newspapers and reports. However, what that technology is and how it works were still question marks. Being aware of this issue, the author started the first step by doing the research basing on existing materials on the internet about this technology. Bluetooth Low Energy is also called as Bluetooth Smart which was invented in 2010 (Bluetooth SIG, 2017). The first version of BLE is also known as Bluetooth 4.0 which is the newest version of Classic Bluetooth technology developed in 2010 (Bluetooth SIG, 2017). It cannot be denied that this newer version of technology shares some similar features with Classic Bluetooth technology. However, it is also superior with new features than the predecessor such as better broadcasting range, and very low power consumption. In addition, BLE is used in different and novel applications that Classic Bluetooth is not. Given those advantages, BLE can be seen as a new emerging technology rather than the development of Classic Bluetooth (Bennett, 2012).

After some intensive research on BLE version 4.0 specifications, Collins and Schatt (2014) conclude that indoor and short-range outdoor positioning application is the target market of BLE technology. Before exploring the superior features of this technology in terms of positioning, the basic logic of location tracking system in almost technologies in general and BLE in specific was examined. The foundation of the system is based on the logic of three reference points (Collins and Schatt, 2014). The logic points out that in order to locate one moving item, there are at least three fixed and pre-located stations. These stations will constantly measure the distances between the moving item and them. Hence, the exact location of the tracking item is calculated. Furthermore, the statement about the target market of BLE, which is indoor and short-range outdoor positioning application, is also supported by concrete evidences based on the features of this technology. First, BLE version 4.0 has a capability to broadcast the signal up to 100 meters (Bluegiga Technologies, 2011) which is adequate to use in indoor scale or short-range outdoor to track physical items or people. Second, the accuracy level of this technology is around 3 meters to 5 meters for two dimensions tracking (Collins and Schatt, 2014). Third, latency between unconnected state and sending data is less than 6 milliseconds (Bluegiga Technologies, 2011). Thus, every movement can be tracked in real time easily and smoothly with the advanced features of BLE technology. Last, the 128 bit AES, which is the most developed security method, is also supported by this technology. However, when comparing the above features of BLE with other technologies, it seems this technology is still inferior in terms of indoor and short-range outdoor positioning technologies. The below figure demonstrates some different technologies used for indoor and short-range outdoor location tracking in medium scale (Tarr, 2017; Alarifi et. al., 2016; Mautz, 2012).

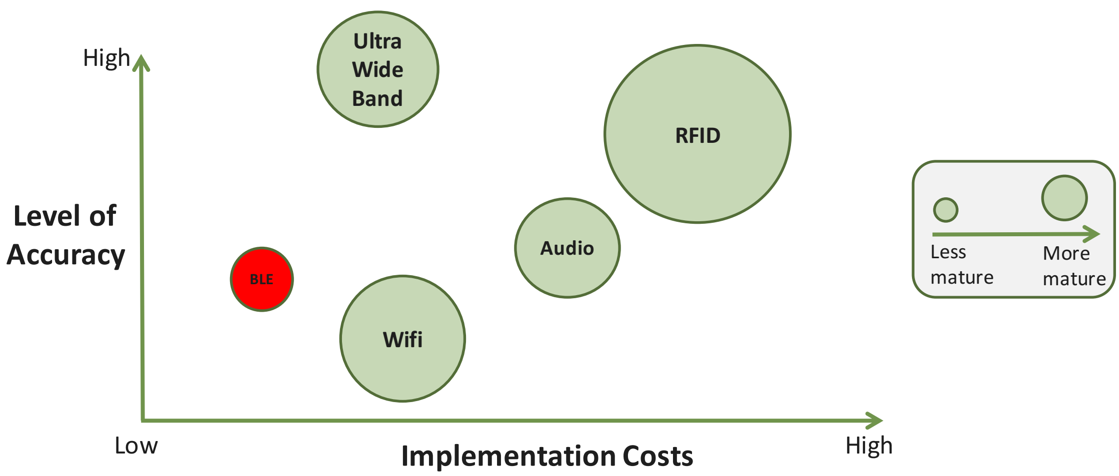

Figure 15. *Comparison of some indoor and short-range outdoor positioning technologies.*

Figure 15 compares technologies in two aspects implementation costs and level of accuracy. Implementation costs mean the whole cost including hardware cost, software cost and services cost for implementing the positioning system for a particular technology. Meanwhile, the level of accuracy depends on the surrounding environment. The rankings for those technologies are based on the clear environment meaning that there is no or very little interference to the transferring signals. As shown in the above figure, Ultra-Wide Band is ranked at the top in terms of accuracy with around 0.1 to 0.3 meter deviation but the cost is pretty high (Alarifi et. al., 2016). Another interesting technology is RFID whose accuracy level is around 1 to 3 meters but still very costly (Mautz, 2012). The RFID technology used for positioning system is in the maturity phase. In other words, almost advanced features for location tracking of RFID were developed. Thus, RFID seems to reach its limit in terms of technology performance (Mautz, 2012). As seen from the Figure 15, BLE technology is rather younger than other technologies. Its features can be considered to be inferior when compared to giant competing technologies like Ultra-Wide Band, RFID in terms of accuracy level. However, the cost of implementing the indoor positioning system for this kind of technology is much lower than other technologies. Hence, since invested in 2010, the BLE technology focused on low-end markets such as retail and public transportation which require rather low expectation from the technology's features to sacrifice with the money (Collins and Schatt, 2014). In addition, given the above-mentioned reasons, BLE technology in the beginning stage only attracts small enterprises or start-up companies in the market. According to Babu (2016), the biggest BLE development in the world since 2010 values approximately 15,000 Euros for the hardware cost. This amount of money is quite small and unattractive for big enterprises.

However, the year 2016 was great for BLE technology when it enjoyed a large number and great investments. The official release of BLE version 5.0 in December 2016 marked as a big milestone in the development of BLE technology (Bluetooth SIG, 2016). Actually, from the mid of the year 2015, there were a number of papers and articles described upcoming advanced features of BLE in the version 5.0. Until December 2016, it was officially announced in Bluetooth SIG website. According to Bluetooth SIG (2016), the introduction of BLE version 5.0 will disrupt the indoor positioning market by its superior features. First, this new version will boost the current performance up to 4x the range which means Bluetooth Low Energy version 5.0 can broadcast the signals more than 350 meters (Bluetooth SIG, 2016). In addition, there are also some real experiments conducted by scientists in the world claim that it can reach more than 500 meters. With this improvement, the technology will replace the active RFID and surpass Ultra-Wide Band. It is also noted that this broadcasting range is adequate for big indoor scales like supermarkets or manufacturing plants. Second, message transferring speed will be double. One of the most important criteria for indoor positioning system is the latency. People expect to get the new position in real time basis, therefore, this new improvement is very crucial. Third, 8x the broadcasting message capacity is another improvement of this version. The demand of information capturing and transferring between devices increase significantly in the recent years. Thus, this new feature of broadcasting capacity will play an important role for Bluetooth Low Energy to compete with other technologies. Interestingly, according to Bluetooth SIG (2016), these improvements do not impact the power consuming level of the BLE devices. Tarr (2016) states that with a standard coin battery which is CR2302, containing 225 mAh, one small size BLE tag with simple features can last up to 5 years comparing to approximately 3 years in its previous version.

When invented 7 years ago, BLE drew the attention of the companies around the world with its advanced features and low implementation cost. Since then, this technology has undergone a large number of improvement. The introduction of BLE version 5.0 with major enhancement indicates that BLE is qualified for in the high-end market with high performance and low cost. One of the most attractive features of this disruptive technology is the accuracy level in location tracking. Based on some recent experiments, the current accuracy level of BLE is from 1 to 3 meters and it is expected to be around 1 meter in near future (Accuware, 2016; Kriz et. al., 2016). Therefore, BLE can be considered as a disruptive technology which can displace existing technologies in indoor and short-range outdoor positioning application (Bluetooth SIG, 2016).

After one month of researching, a short introduction about the BLE technology aiming to inform business users in the company was documented. It marks as a stepping stone in exploring a new business opportunity for the company. In addition, given preliminary research discussed above, it seems that the company is on the right track as the BLE is a very promising technology and expected to disrupt the indoor positioning market in the future. Getting back to the proposed model, it states that disruptive technology is the source for innovation. As discussed above, BLE is considered as a very promising disruptive technology which perfectly matches the pre-condition of the proposed framework.

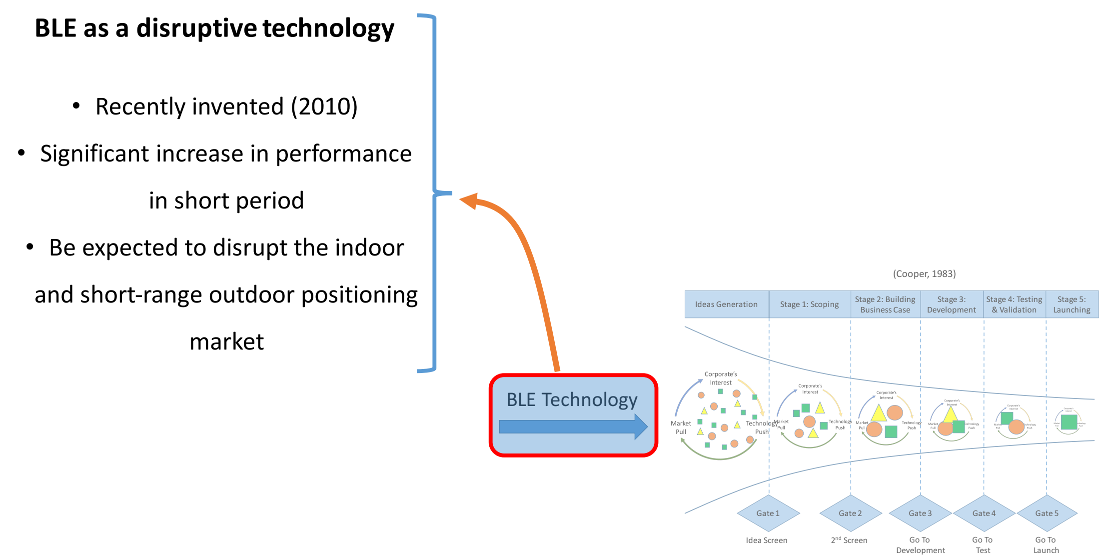

Figure 16. *BLE technology as the source of innovation in terms of disruptive technology.*

It is noted from activities in this step that understanding the BLE technology is a critical. As discussed previously, not only history and fundamental knowledge about the BLE technology but also its key advantages and disadvantages are studied. Moreover, one important aspect in doing research on this technology is the future development or possible improvements in the next few years to see how it will be developed. Thus, a comprehensive knowledge about BLE technology was gathered from different perspectives in order to have a holistic view towards this disruptive technology. In addition, these research will provide a concrete foundation for the upcoming activities in next phases.

7.2 Ideas Generation - Exploring The Possibilities of the New Technology

The outcomes of the pre-activities discussed above seem to be very promising for the case company to continue the research on this topic. Particularly, the preliminary study provided insights and knowledge about features of the Bluetooth Low Energy technology which is very useful for the next phases. Then the author continued another two-month research for the ideas generation phase, from the beginning of the June 2016 until the end of July 2016. There is no technology that can fit for all applications and all markets since each technology has both strong points and weaknesses. Thus, it is necessary to take the features and functionalities of the BLE technology into consideration when doing the information gathering and idea generating activities. Given findings from the pre-activities step, some advanced features of this technology were identified. In addition, BLE is considered as a disruptive technology in the indoor and short-range outdoor positioning application (Bluetooth SIG, 2016). Hence, medium scale positioning is the key target of market research in terms of technology aspect. To be more specific, indoor and short-range outdoor positioning application consists a lot of different sub-applications such as indoor navigation, item positioning. When it comes to different markets, different features of BLE technology in terms of indoor and short range outdoor positioning application will be tailor-made to meet specific demands such as indoor navigation for shoppers in supermarkets or item tracking for factory workers. Thus, idea generating activities need to consider the market demand as an important aspect. The author decided to use the top down approach starting from broad markets then narrowing down to specific applications to minimize the risk of missing valuable ideas. Among various markets, the case company decided to select retail, public transportation, manufacturing and construction markets as key focuses in the first weekly team meeting. Since the company has been concentrating on its current RFID products in these markets, it has advantages in terms of knowledge and network in these markets than others. In addition, these markets are considered to be interesting and potential from the perspective of the management team of the case company as they have been pursuing them for a long time. Therefore, the corporate's interest factor was also significant in this phase. In conclusion, the technological, market and corporate factors were considered during the data gathering and ideas generation. After two-month intensive research on different websites and newspapers, a document was created which listed some applications in different markets for this disruptive technology. The below table summarizes the findings briefly.

Table 11. *Different application ideas in the target markets.*

Market	Application ideas
Public Transportation	- Indoor navigation - Requests for support - Traffic monitoring - Real-time notification and alert
Manufacturing	- Asset loss prevention - Asset positioning - Indoor navigation - Worker's location tracking - Item location tracking - Access control
Construction	- Tool loss prevention - Tool positioning and status controlling - Indoor navigation - Vehicle management - Worker's location tracking - Construction progress update - Access control
Retail	- Proximity marketing - Contactless payment - Indoor navigation - Real-time notification and alert - Item display

It is noted that almost listed ideas are very rudimentary with very limited supported evidence. Except retail and public transportation markets, others were just assumptions and thoughts. However, since the main objective of this phase is to generate ideas as many as possible, those proposals were still helpful. All above ideas fit well with the feasibility of the BLE technology in terms of technical specification and features. Moreover, the market demand was taken into consideration as well. The above applications were based on the real need of the market which is having a better or a novel technology to address unsolved or incompletely solved problems.

Other than seeking for applications in different markets, value network of BLE technology business was also explored. The interview with the Product Director of the case company revealed many interesting insights. The value network of BLE technology was exactly the same as the one of RFID, which is previously shown in the Figure 14 - Value network of RFID business. This is explained by the fact that there is no difference between these technologies from the market and project point of views. The relationship between buyers and suppliers and the main roles of each actor are remained the same in both technologies. Moreover, the BLE value network still includes three actors: suppliers, integrators and solution providers to delivery products or services to the end customers. Even though the case company currently defines itself as a hardware supplier in the value network of RFID technology business, the possibilities of changing role are considered in the BLE technology business. In other words, the idea of switching from hardware supplier to integrator or even solution provider was generated.

It is seen that since founded in 2005, the case company has been staying in its comfort zone as a hardware supplier, making its knowledge and experience about other roles limited. Hence, the author decided to study in-depth the activities and responsibilities of each actor in the value network of BLE technology business. Given updates from deployed projects of the BLE technology in retail and public transportation industries together with understandings in RFID business, roles of different actors were then clarified. In addition, the insights from previous working experience of the author when working for integrator and solution provider companies also contributed significantly to the research. To keep track and store information, the author documented the findings during the ideas generation phase.

Up until this point, all findings regarding the markets, their applications and the possibilities of changing role of the case company in the BLE value network were collected. To serve the purpose of presenting and sharing the ideas to the project members, one official meeting was organized by the author at the end of July 2016. Given that BLE technology can be used in various markets with different applications, it seems to be a very positive signal for the innovation project of the case company. In addition, the discussion about changing the position in the value network opened up many new thoughts among the team. Overall, the expectations from this phase were met. However, the preliminary findings were still vague, thus it is necessary to dig deeper into the subject. Referring to the proposed model, it seems that the activities happened during this phase matched the description of the model. The below figure illustrates the framework with key points in this phase of the case company's innovation project.

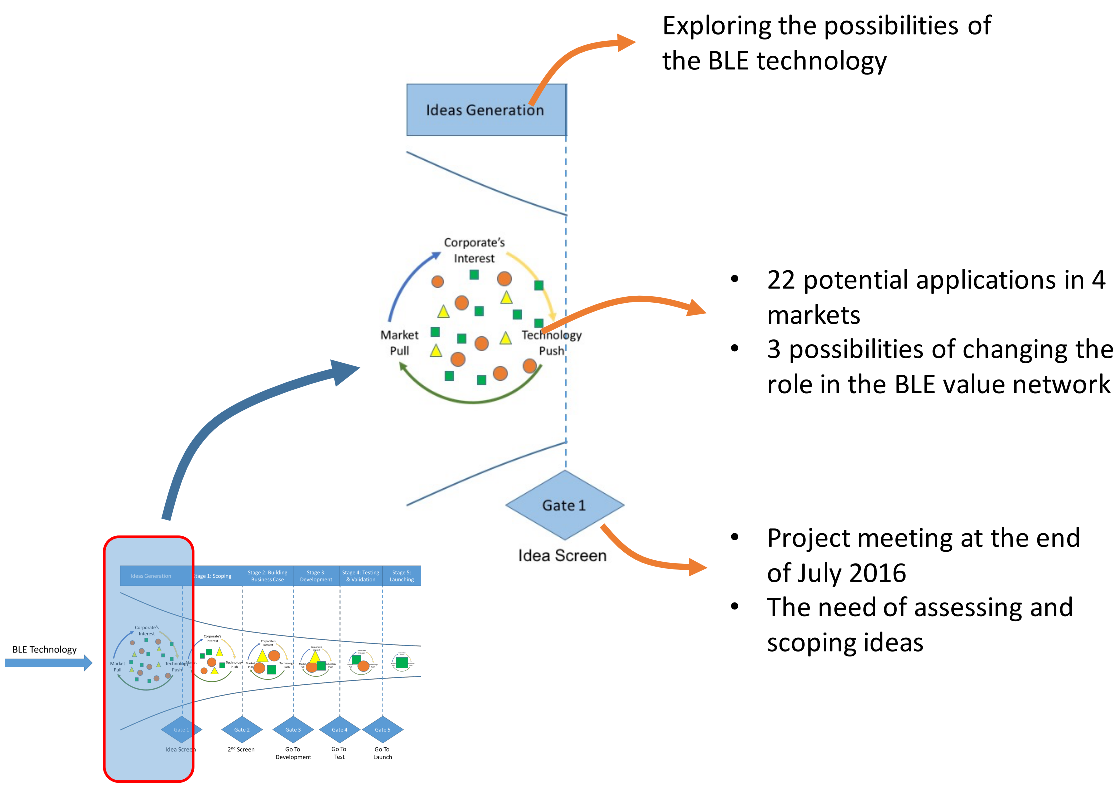

Figure 17. *The proposed framework matches the key activities of the innovation project in ideas generation phase.*

The objective of the ideas generation phase in the proposed framework is to create as many ideas as possible which matches perfectly activities happened in the case project. Moreover, the framework also describes that the ideas in this phase could be gut feelings only which also suits the outcomes of this stage in the innovation project as discussed above. In addition, the Gate 1 of the framework can be considered as the official project meeting at the end of July when the outcomes from the previous steps were reviewed. Hence, once again, the activities happened in the innovation project of the case company complemented the proposed framework and they perfectly match each other.

7.3 Scoping – Narrowing Down the Innovation Activities

The findings of the previous phase – idea generation once again proved the potential of BLE technology. It seems this technology can be used in many markets and various applications. However, as discussed above, the need of scoping the activities was raised during the official checking point meeting in July 2016 with all project members. Given the resource limitation, the company could not carry out researching activities for all ideas. In addition, during the previous phase, the technology feasibility, market demand and corporate's interest factors were taken into consideration when generating the ideas.

Similar to the ideas generation phase, these factors were considered as well but in different and more detailed aspects. These factors would be used again as powerful tools to narrow down the scope of the researching activities.

The final result of the innovation process is to create a product or service that could earn the money for the company as much as possible. Moreover, after many years working in the business world, the company has been aware that tailor-made offering is a critical factor. In detail, different markets and different applications require different products and services. Thus, there is no single solution or offering could fit all demands. As discussed above, the case company decided to select retail, public transportation, manufacturing and construction markets for its innovation of BLE technology. However, it would take many months or even years to gather requirements and then develop offerings according the market's expectations for each of these markets. In addition, many potential competitors were also exploring the potential of BLE technology. Hence, the case company could not wait long to study all these four markets. Then, the management team decided to select one market as the starting point and move to others after that. However, choosing one market out of four was a challenging job which requires intensive research on each option. While all markets were very promising given the previous findings, there should be one market which is more potential than others. Thus, each market was examined in detail. First, retail market was explored to see how potential it is. After a short period of time since invented, BLE technology already grasped a lot attention of retail companies around the world. In 2015, Heineken – a giant food and beverage company implemented BLE technology to increase the brand awareness and sales with its customers in the USA (Boden, 2016). There were 120 Heineken's selling locations across USA equipped with BLE hardware (Boden, 2016). Amberly Hilinski, the Commercial Marketing Manager of Dutch Brands of Heineken USA concluded the result of the implementation: "*We saw significant improvement in purchase intent after consumer were exposed to our BLE beacon engagement*" (Boden, 2016). To be more specific, Heineken estimated around $320,000 earned from campaigns using this disruptive technology (Proximity Magazine, 2016). Moreover, Elle, a well-established fashion brand can be also taken as another example for the success of BLE technology. According to Milnes (2015), this new technology has driven more than 500,000 retail store visits until November 2015 since deployment. He also pointed out that the combination of push-notification promotions and mobile advertisings drove the results (Milnes, 2015).

According to Smith (2015), the number of retail locations equipped with BLE tags increased significantly in recent years, especially top retailers in the U.S. On the one hand, it proved the potential of BLE technology in retail market. On the other hand, it shows that the BLE technology in retail market seems to be saturated soon. In addition, there were a lot of strong and well-established companies currently offer this kind of solution in this market. They already had strong relationships with existing customers and good reputation through previously implemented projects. Thus, it would be very challenging for the case company to jump into the retail market. In addition, since the company is in early stage of the innovation process, it would take time to have final products that can be sold to end customers. For all the above arguments, the author decided to remove retail market out of the list.

Second, the public transportation market is the next consideration. Having the same situation as the retail market, public transportation has experienced a large number of deployments in recent years. According to Babu from Beaconstac (2016), the introduction of BLE technology shaped the future of transportation industry. Moreover, many BLE projects in this market have been recorded in recent years (Boden, 2015). This BLE technology has helped companies in transportation industry around the world to enhance the end-to-end experiences for their passengers by providing many functions such as indoor navigation, travelling information or loyalty services. Thus, BLE technology has been used in many airport, bus and train centers around the world. The below table shows typical cases and brief information about projects.

Table 12. *Some public transportation projects using BLE Technology (Babu, 2016; Boden, 2015).*

Project	Description
Miami International Airport	Provide personalized updates regarding the flight information Help passengers navigate in the airport premises
Hong Kong International Airport	Trigger location based advertisements Provide interactive navigation maps
Tokyo Haneda Airport	Trigger location based advertisements Equip staff with smartwatches to locate passenger's location in case of emergency support
John F. Kennedy Airport	Deliver estimated waiting time in queues based on the location of passengers Locate staff at the terminals when seeking for help
Bucharest Bus	Guide people with visual disabilities Provide real-time travel updates when sitting on the bus
London Bus	Provide real-time travel updates when sitting on the bus Recieve relevant location-based promotions and ads

While the public transportation market is very potential, it would be difficult for the company to compete with existing competitors which already provided the solutions. In short, the market of public transportation is quite the same as the retail market. Thus, it would be not worth spending resources for studying this market. In addition, the requirements and product specifications in the public transportation market for BLE technology are already clear. Hence, it is only the matter of sales and marketing activities to engage in potential customers to get the deal. Consequently, the author decided to skip this market, however, that the company should still be well-prepared in case customers ask for solutions.

Construction and manufacturing are the two remaining markets in the list. As shown in the Table 13 about potential applications of BLE technology, these two markets have different applications in comparison with retail and public transportation ones. The difference is not only presented in terms of applications but also projects implemented. After spending more than one month to find the real projects of BLE technology in these two markets on the internet, the author realized that there has not been any real cases yet. By contrast, it was quite easy to find articles discussing the disruptive technology in these markets. While the potential of this technology in construction and manufacturing market is awared by the market, discussions about this topic was still vague without any concrete statements in relation to the specific requirements and customer's expectation towards the future products or services. It seems that the BLE technology based solutions for these two markets were still in the embryonic phase with many uncertainties. In addition, the publishers of those articles are mainly companies which have been offering the BLE technology based products and services in retail and public transportation markets. Thus those articles are mainly based on their guesses on the ground of retail and public transportation, which may be inapplicable in other markets.

Apart from differences in applications, the implementation in construction and manufacturing markets requires much more resources than in retail and public transportation ones. Despite the fact that there are a large number of projects in retail and public transportation markets for well-known companies like Heineken and London Bus, BLE solution providers are small companies with limited number of human resources. The biggest one is Kontakt which has only around 60 employees in all departments (Jurejevcic, 2015). With limited capabilities, it is very challenging for existing BLE solution providers for retail and public transportation markets to deliver projects in construction and manufacturing markets due to the high expectation and requirements from clients. This creates promising opportunities for medium and big sized companies like the case company. As a result, the author decided to continue studying construction and manufacturing markets.

In this scoping phase, it is also necessary to consider which role the case company should play in BLE business. Moreover, innovation actitivies would be different depending on the role. As discussed in the previous section, there are three roles in the BLE value network which are supplier, integrator and solution provider. The case company is currently categorized as a hardware supplier in RFID business. However, it does not mean the company would stay in the same role in the BLE technology business. Apparently, keeping the same role would bring a lot of benefits to the company in this new business. However, other roles should be considered, especially when the management was under the pressure of the aggressive revenue target. Interestingly, according to the Product Director of the case company, RFID and BLE share the same value network. Therefore, knowledge and insights in RFID value network can be applied in BLE business as well. Based on inputs from the interview with the Product Director of the case company and recent findings regarding BLE business, the earning model of BLE value network was created as shown in the below figure.

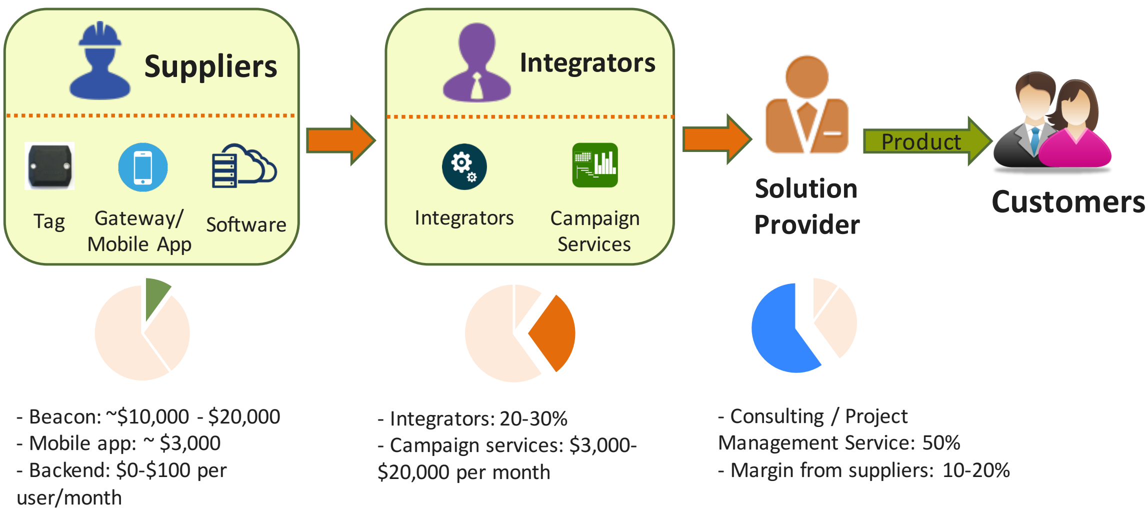

Figure 18. *Earning model in BLE value network.*

In BLE business, suppliers usually earn around 10%, integrators 20-30% and solution provider around 60-70% of the total project revenue. Suppliers provide hardware including tags, gateway/mobile app and software package for the back-end systems. On the basis of facts and figures of implemented projects, they can earn a maximum revenue of around $25,000 per project as shown in the Figure 18. Meanwhile, integrators take the responsibilities of putting separated pieces from different suppliers together. On the one hand, they can earn high profit margin from suppliers as they have strong power over suppliers. On the other hand, they also get money from customers by providing integration and related services. These add up to more than 20-30% of the whole project revenue. Last, the largest portion of revenue usually comes to solution providers who bear the main responsibility in implementing projects. To be more specific, they have the most power in the whole value network, since they are the ones who sign the contract with customers and have the ability to manipulate the price in order to get a bigger piece. As mentioned earlier, the case company has the pressure of aggressive growth expectation from recent joined investors. On the one hand, staying in the same positon which is hardware supplier would bring advantages in this new business for BLE technology. On the other hand, it is a big risk that the case company would not meet the revenue target. Hence, there is a strong need to make a move, either becoming integrator or solution provider. Given that acknowledging the pros and cons of the move is very essential for the company before making any decision, a SWOT (Strong – Weak – Opportunity – Threat) analysis was used to analyze those options.

STRONG	WEAK
- Safe move - Less investment - Less environment complexity - Potential of high revenue	- Many competitors - Less room for differentiation - Cost of implementation - Recruitment of people - Reference to the new market
OPPORTUNITY	**THREAT**
- Merge and acquisition hardware and software suppliers - Utilize existing know-how - Enter market faster	- New entrance from other verticals - Change reaction - Compete with existing customers - Take the roles in software provider and/or Integrator

Figure 19. *The first option: Switching from hardware supplier to integrator.*

The first option is to switch the role of the company in BLE business from a hardware supplier to an integrator. The Figure 19 shows that this option is safer for the case company as it involves less risks and changes with the current business in RFID. However, it also poses challenges and threats. In detail, meeting the revenue expectation of new investors would be still hard to reach.

STRONG	WEAK
- Potential of high revenue - Growth faster - Differentiation - High entry barrier	- Cost of implementation - Knowhow in organization - Recruitment of people - Complex system: support needs - Convince Integrator (Reference to market)
OPPORTUNITY	**THREAT**
- Market share - Fewer competitors - Technology push to market - Direct access to end customers - Merge and acquisition existing prime contractor	- Change reaction - Old customer, new competitors - Company buyout - Play the integrator's role - Partnership with suppliers

Figure 20. *The second option: Switching from hardware supplier to solution provider.*

The second choice which is becoming solution provider seems to be riskier than the first one. It will force the company to make many changes inside the organization in order to adapt to the new business model for the BLE technology. For instance, the process of recruitment, support and maintenance will be more complex. Conversely, it may enable the company to reach the target for the growth expectation of new investors. The chance to growth faster, increase market share are key points to attract the case company towards this option.

The scoping phase started from the beginning of August 2016 until the end of September 2016 brought many interesting findings related to the BLE markets and value network. After this 2-month period, the author came up with a proposal for the project team of the case company. All analysis and findings about those topics were documented in slides to easily present and share among the team. At the end of September 2016, during the Strategy Week of the case company, the proposal was presented to the management team of the company to make the go or no-go decision for each option. First, regarding the market, all agreed that construction and manufacturing markets are more potential than retail and public transportation. Moreover, although the preliminary applications of construction and manufacturing market are quite similar, it is certain that the offerings to these markets will be different. This difference will gradually become bigger in the later stages of the innovation process. Thus, it is necessary to select one market to move forward in order to save more resources. The CEO of the case company decided to choose construction market as he has a particular interest and existing customer relationships in this market. Second, regarding the role in the value network, the management team selected the solution provider option as the strategic move for the company in this new business. The decision was made after considering both advantages and disadvantages of this move based on the SWOT analysis.

In addition, objectives for the next phase were also raised during the meeting. It was seen from the market research that competitors started to look into the BLE business in construction. Hence, the company needed to take the action as soon as possible to have the product for launching. However, there was still no detailed requirements for the future product. During the meeting, it was suggested by the author that the most critical activity at that time was finding the business case that could apply the BLE technology. Basing on business issues that the BLE technology can solve, the features and specifications of the future product or solution will be defined accordingly. In other words, the future product is the balance of the BLE technology feasibility, market needs and company's interest. The suggestion was agreed by the management team. All agreements and decisions were documented and shared among the project team at the end of the Strategy Week. In addition, from the high level perspective, activities in this phase match the proposed model. The below figure shows the connection between the scoping stage of the framework and the activities happened in the innovation project of the case company.

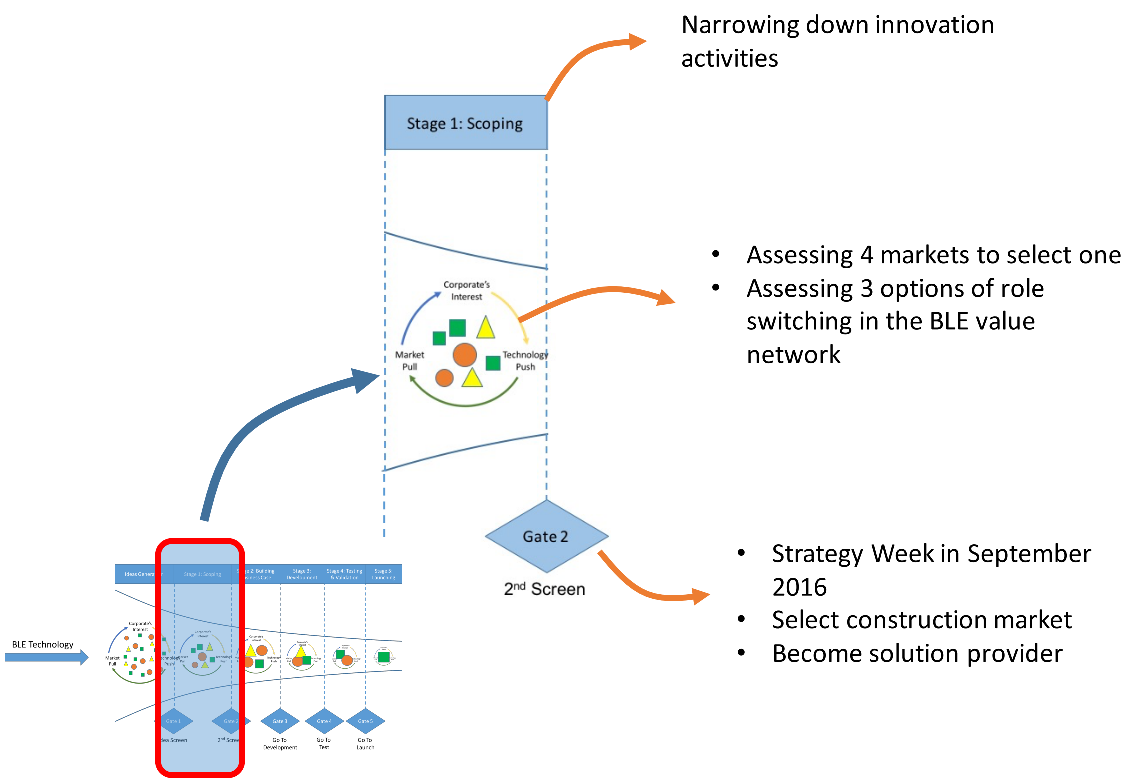

Figure 21. *Connection between the scoping phase of the proposed framework and key activities in the innovation project of the case company.*

From the above figure, the objectives of those activities could be called as scoping for short which is the same as the name of the Stage 1 in the Innovation Stage Gate Process. Moreover, it is noted that the gate in the framework takes the role of filtering the ideas for the next move, which is represented by the Strategy Week in September 2016 of the case company.

7.4 Searching the Business Case for the BLE Technology

The previous activities in the scoping phase along with the decisions made during the Strategy Week in September 2016 were significant for the next step in the innovation process. By narrowing down the scope to be a solution provider in construction market, the author could have more time and effort to do research on this market. In addition, the objectives were also agreed by the management team which increases the support from the company. The Strategy Week in September 2016 also set the target for the next phase, which was identifying the detailed business case for the BLE technology in the construction industry. However, this objective was quite ambiguous without any clear destination for the research.

To tackle with the issue, this phase started with desk research activities. The author spent his time mainly at his desk and looked for information available on the internet. Since there was no real business case in construction market for the BLE technology, the author had to find a different approach which was looking into business pain points in construction market. An intensive study based on existing materials on the internet was carried out at the company's office by the author. After few days, a list of current business pain points in construction market were identified. However, not all of them were relevant to the features of the BLE technology. Only the suitable points were kept to form the first proposal as shown in the below figure.

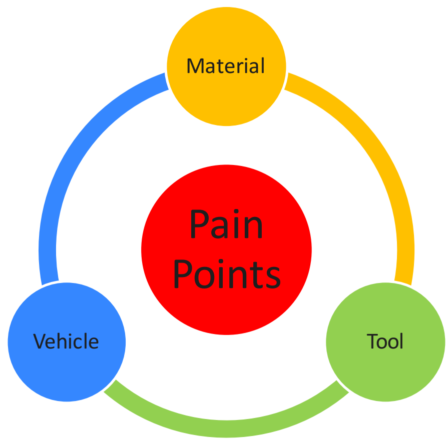

Figure 22. *Relevant business pain points in construction market in terms of BLE Technology.*

Tool management is one of the biggest problems of construction companies. There are a large number of tools and equipment in construction sites such as drillers and cutting machines. Managing the usage and location of those tools are challenging for site managers. According to a report of Hilti Company (2016), one contractor spends on average 90 man hours per month on searching for assets in its construction sites. If this number is multiplied by the average hourly salary of a construction worker in the United States which is around \$15 (Sokanu Company, 2014), the average cost for finding assets will be around 90(hours) x \$15 x 12(months) equal to \$16,200 per contractor per year. In addition, asset loss is another big pain point in construction industry in terms of tool management. On average, more than \$1 billion was lost in tools and equipment by contractors in the U.S. (Trimble Company, 2009). Furthermore, material management is another big problem of construction companies. How to manage the flow of materials in and out the construction sites in order to make the work more efficiently and effectively is the question every site manager asks every day. If the materials are delivered before needed, it will cost a lot of space and cause many inventory issues (Alarisku and Karkkainen, 2006).

However, the delay in building activities will happen in case the materials do not arrive in time (Alarisku and Karkkainen, 2006). Finally, vehicle management also causes headache for construction managers. Aggressive drive is one of the most common issues in this category (Toth and Vigo, 2014). Given the safety requirement, one vehicle is allowed to drive in a particular number of hours within a day (Toth and Vigo, 2014). Going beyond that limit can reduce the life-time of the machine or even cause accidents. Furthermore, having the same issue as finding tools and materials, locating the vehicles in big construction yards also poses burden for drivers as well (Toth and Vigo, 2014).

After having the first proposal of business pain points of construction companies, the author went to some building sites for the observation and interviews to verify the recently discovered findings. These activities led to many interesting points related to the proposal. First, vehicle locating is not a big problem in construction sites. There were not so many big construction yards consisting of more than 5 vehicles concurrently in the areas of Tampere and Helsinki. In most of the cases, the sites were rather small and medium. As a result, the need to locate the vehicles is not critical. Second, the author also observed that tools were often stored in containers in the construction sites. According to face to face interviews, construction workers of YIT company revealed that they had a procedure of using tools during working days. At the beginning of the day, when receiving the tools, workers have to sign on a checking paper with the taken date and time. During the day, they usually use the borrowed tools in the same place. At the end of the day, they return the equipment to the warehouse which is the container. However, there are some cases they exchange or borrow the tools with their co-workers causing the loss. In addition, since the system is managed manually on papers, mistakes are often happened. On 10th October 2016, the FinnBuild in Helsinki, Finland gave the author chances to discuss with some representatives of construction companies such as Skanka, and Styrud. After presenting the proposal related to pain points in material, vehicle and tool management, managers of those companies showed their particular interest in asset management over the others. One manager of a construction company stated that:

> *"In construction sites, we already have GPS to track the location of vehicles in the yards. In addition, passive RFID tags are used for short range tracking purposes such as materials flow management. However, we are still lacking a technology which is in the middle between GPS and passive RFID. That technology could enable us to track items, especially power tools in medium range, from 10 meters to 100 meters."*

There were also a number of software companies providing asset management software for construction industry such as eRent, Adalia which were also found in the FinnBuild event. These software applications can help companies in managing the flow of material in and out the site and tool borrowing procedure. However, they still do not fulfill all needs of construction companies. Inability to provide the real-time location of assets in the construction yards is a typical example. A manager of a building contractor clarified:

> *"We have our asset management system in place. We can manage our assets such as materials or tools through smart phones, tablets and computers or laptops. However, they are still static data. We have a technical engineer who has to input the data at the end of the day into the system. So, we have no eyes on our tools during the day and in real-time. There are many cases that our workers report they forgot the location of the tools and our current asset management system can not help with this. So, it leads to the delay in the working progress because we need to find the lost tools. Furthermore, manual input sometimes causes mistakes in the system."*

He continues…

> *"Besides, it is critical to manage the condition of the operating tools. On monthly basis, we have to spend a lot of money to repair the tools because of inappropriate operation. For some tools, they need a short break to cool down after a long period of operating. Some workers are not aware of this or they even forget this rule, they heat the tools up leading to the damage and increasing the maintenance cost. With the current asset management system, we are unable to solve that issue."*

The author also had chances to discuss with some equipment rental companies such as Betonikoneet, and Kallioinen Yhtiot. Their business is to lease tools to construction companies. Although the risk of asset management is not on their hands, they still share some issues with construction companies. One salesperson from Betonokoneet shared a story about the problem of a construction company that:

> *"Our tools, especially handy power tools are quite expensive, from hundreds to thousands of dollars. At night, they are kept in safe place which is warehouses in construction sites of our customers. However, during the day, we lose a lot of tools. This is because of thieves. Sometimes, they wear the same suits as construction workers, come to take the tool out of the construction yards. This happens not only to our customers but also almost building contractors."*

The findings from observation in construction sites and interviews with workers and managers of companies in this field opened up many thoughts for the author. The author realized that not all insights gathered from the internet matches the real business world. Consequently, the finalization of business paint points was taken as the next step. Given facts and statements from existing materials on the internet, vehicle management is an issue in construction industry. However, this problem is still under the control of companies. Similar to vehicle management, current technologies in the market such as GPS or RFID have provided features that meet the demand of the market. In terms of asset management, it is the biggest issue and grasps much attention from construction companies. To be more specific, real-time location tracking and condition of tools in construction sites are the most interesting topics in this category. As a result, a revised model of business pain points was formed.

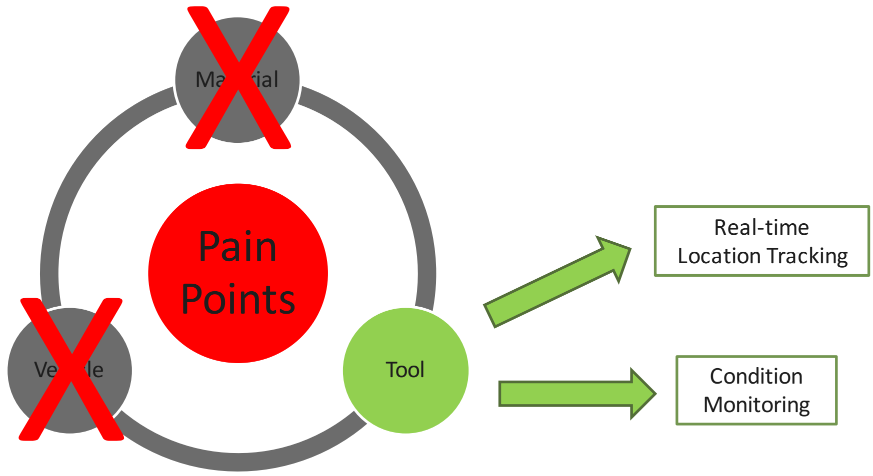

Figure 23. *The revised model of business pain points in construction market.*

As shown in the above figure, the first proposal was modified. First, assumptions about material and vehicle management were removed after the observation and interviews. Second, tool management was confirmed as the biggest issue in construction market. Furthermore, the observation and interviews took the research into a more detailed level, leading to two biggest problems in this industry which are real-time location tracking and condition monitoring. The need of solving these two problems increases noticeably among construction companies in recent years. Furthermore, there are valuable tools in each construction, losing one could cost company hundreds to thousands of dollars. As a result, the level of robustness, security and accuracy of the solution are expected to be very high. With these strict requirements, the construction industry can be considered as a high-end market. Consequently, the solution for real-time location tracking and condition monitoring should be quality enough to meet the high demand of the construction market.

Regarding features of the BLE technology, this disruptive technology has the ability to track items indoor or short range outdoor. Moreover, the power consumption of wireless data transferring of BLE technology is considered super-lower than other technologies in the same application. The improvement of BLE version 5.0 has empowered this feature of BLE technology which increases the broadcasting range from 80 meters to 350 meters (Bluetooth SIG, 206). It means that one BLE device can cover the whole area of big construction sites. It is noted that this broadcasting range can be influenced by the surrounding environment. After being shared about these superior features of BLE technology by the author, the managing director of Styrud stated that:

> *"We usually have large construction sites but with the broadcasting range up to 350 meters, BLE technology meets and even exceeds our expectation in many cases. First, we want to track our tools which are located somewhere in the site. Second, the range can also help us track the movement of the tools in case they are being taken out of the site by thieves."*

In addition, one BLE tag with a CR2032 coin battery can last up to 5 years depending on the configuration (Tarr, 2016). This feature is considered as an advantage of BLE over other technologies when they can last around 1 to 2 years on average. In order to solve the problems of tool location tracking and condition monitoring, one BLE tag will be attached to the tool. Its responsibility is to capture the information and send it to the system in real time. This information was also shared in the interviews with managers of construction companies. One salesperson of an equipment rental company the author met in FinnBuild event commented:

> *"Technically speaking, the average life time of a power tool is more than 15 years. So, it seems this technology is insufficient to be used in this application. However, on average, one tool is usually used in one site around 2 years before returning to us for maintenance activities before moving to another site. So, replacing new one can be done at our maintenance offices in the same time. If the costs of buying new BLE tag and replacing the old one are cheap, then, it is not a problem at all."*

The introduction of BLE version 5.0 is crucial for the application of this technology in high-end market. According to Bluetooth SIG (2016), this new version can increase 8 times the broadcasting message capability with the same power consumption compared to the previous version. In other words, it can transfer more data with the same amount of power usage. The BLE version 5.0 also speeds up the message transferring. It takes haft of the message transferring time compared to the previous version BLE 4.0. As a result, the battery life can be doubled or even quadrupled. With the above mentioned advantages and improvements, it seems BLE technology is gradually fitting the requirements of construction industry. In the next few years when new versions arrive, this technology will be likely to disrupt this high end market and replace current technologies.

Observations and interviews showed that real-time location tracking and condition monitoring of tools in construction industry are current business pain points. Given features of the BLE technology, these issues can be solved. The improvement from BLE version 5.0 again confirms the potential of this technology in the future for the high-end markets such as construction. Hence, it is seen that real-time location tracking and condition monitoring are two potential business cases of this technology. Being satisfied with the finding, the author decided to share them with project team. At the end of December 2016, a presentation was delivered by the author during an official team meeting. Generally, the management team agreed with the findings as it made a lot of senses. However, they feel that there are not so many companies and tools requiring the condition monitoring. Even though some companies may need that, it is not potential enough to be invested in. As a result, this business case is put aside to save more resources for the innovation of real-time location tracking business case of BLE technology.

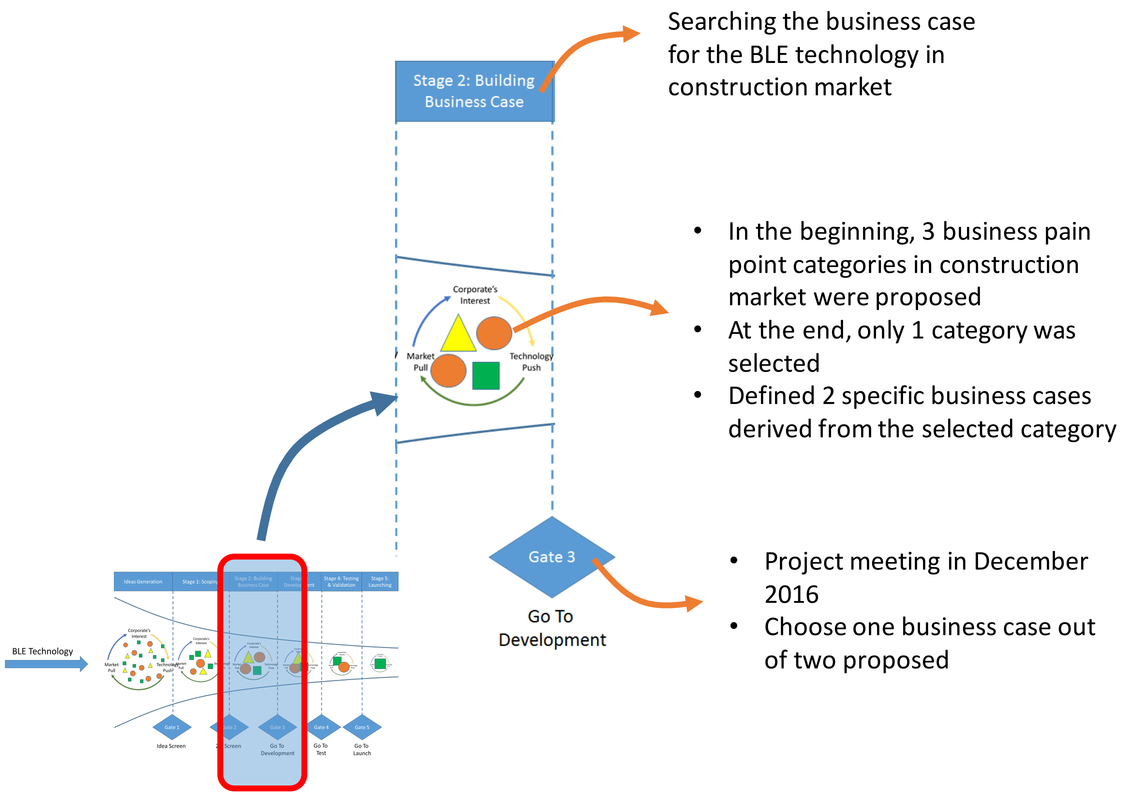

Figure 24. *The linkages between the proposed model and the key activities in searching business case.*

As shown in the Figure 24, once again, the activities happened in the case project complemented the idea of the proposed framework in the Stage 2- Building Business Cases. The above figure shows the linkages between the proposed model and the key activities in this phase. They match each other in every aspect from the objectives, carried out activities and the gate or checking point.

7.5 Developing The Solution Following the Findings from Business Case

The outcomes of the finding business case phase contribute significantly to the next phase of the process for innovation. Real-time location tracking is the real need in construction market that BLE technology can help with. In addition, this idea was also supported by the management team. While the objective of the previous phase was to find the most suitable business case that can apply the BLE technology to solve problem, what are the components that make the solution works are still a big question. To some extent, the previous phase led to some hints to answer that question. Generally, what customers expect is a solution that can locate tools in construction yards in real time. Moreover, each tool will be attached by a tag to send the signal to the software system. These findings could be considered as starting points to define the specifications for the final offering. Hence, a high level solution model which includes all related components is the first objective of this phase. This is a critical step which provides a big picture of the whole solution. After that, detailed requirements about each component in the solution is the next objective in the development phase.

Concerning the first objective, the author decided to study existing materials related to real-time location tracking solution. One of the most valuable sources of information was websites of solution providers such as Trimble and Cisco. It is noted that these companies currently use RFID and Wi-Fi not BLE as the based technologies. In addition, the author also contributed actively to the research with his own experience of many years working for solution providers for similar solutions. Moreover, in order to gather more insights and knowledge for the solution, some internal interviews with the Product Director of the case company were also carried out. The outcomes from the above activities shaped a high-level solution model for the real-time location tracking for construction industry. This model is a typical model which is used in many technologies not only BLE technology. The below figure illustrates the model.

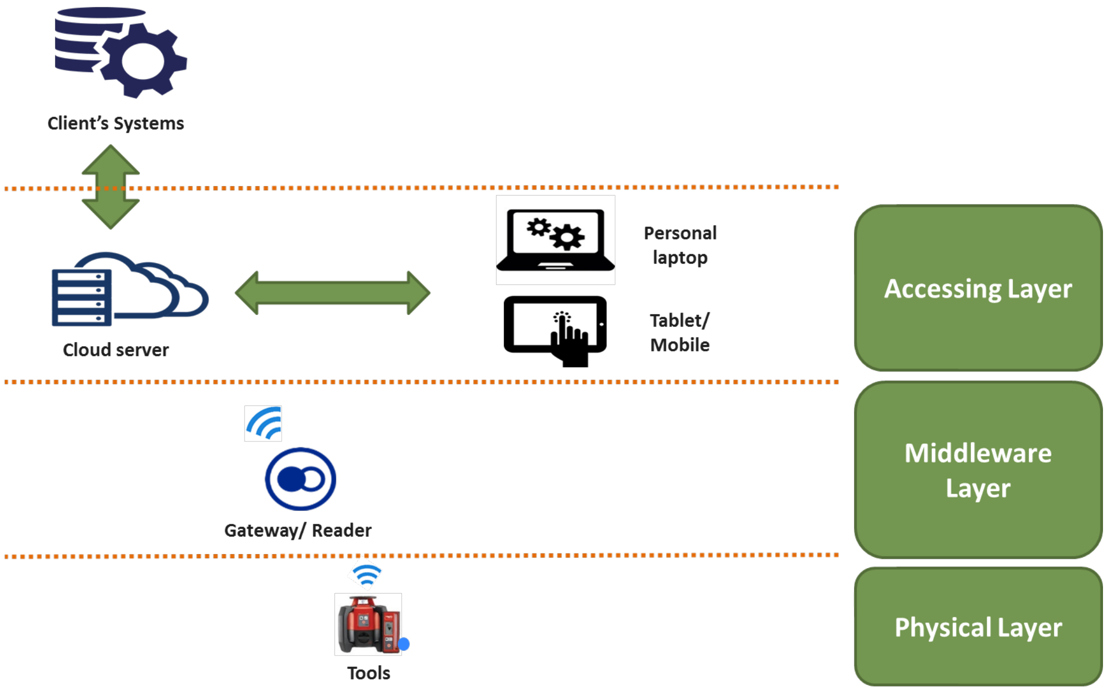

***Figure 25.** The high-level solution model of real-time location tracking solution in industrial market.*

Typically, a real-time location tracking solution has three layers of components which are physical layer, middle ware layer and accessing layer. First, physical layer consists of hard tags which are attached to tools used in construction industry. These tags will broadcast signals repeatedly after a fix period of time. The broadcasted messages typically contain information related to the identity of the tool and other system parameters and sensing information. The signal and parameters are different depending on the used technology, however; the identity information is always the same. For example, RFID tags will broadcast radio frequency signals while BLE tags send Bluetooth signals. In addition, the technology used also impact other factors. For instance, BLE has wider range and very low power consumption than other technologies like Wi-Fi or RFID. Second, middleware layer contains gateways or readers. These devices have the responsibility to receive the signals from the physical layer and calculate the distance from the gateway to the tools/tags. There are two critical requirements for gateways which are being able to read the signals from tags and being located in a fixed position. As discussed above in Chapter 7.1, locating a moving object requires at least three fixed points (Collins and Schatt, 2014). The same rule is applied in this case for gateways. In some cases, gateways also have the possibility to read different signal types with just one device. For example, some can communicate with both BLE and RFID tags. Internet connection is required for gateways to send the gathered data back to the cloud server which is one of the most important components in accessing layer. Other than receiving data from these gateways, cloud server also handles data processing and analyzing activities. It acts not only as the center point of the whole system but also as the hub for connection. As shown in the Figure 25, laptops or personal smart devices such as mobiles or tablets access data related to the location through cloud server. In the majority of cases, customers were already equipped with existing software systems in their premises like financial or human resource applications. Hence, it is critical to integrate all data from different sources to have a holistic view about the whole organization business. Therefore, the cloud service of this solution must support the integration feature.

After understanding the high-level solution model, the next step is defining the detailed specifications for each component in the model. Starting with the lowest level, defining specifications for the tags is the first target. From the meetings with construction and equipment rental companies in FinnBuild event, some basic and fundamental requirements which are broadcasting range and battery life time were identified. However, detailed information about the shape, material and other technical parameters were still missing. As the result of established relationships with some companies during the event, the author had some follow up activities to gather further information. Consequently, interviews through phone calls and emails with those companies were carried out. The interviews consist of open-ended questions to open up new ideas for the discussion. Given significant contributions of interviewees, the requirements about configuration parameters for the BLE tag were gradually identified. Hence, the findings were then discussed with BLE engineers of the case company to verify the feasibility and adjust whichever needed. Regarding the broadcasting range, as discussed above, customers stated that 350 meters is enough for the tool tracking solution as it can cover even very big construction sites. In addition, after some real tests, the BLE engineers of the case company confirmed that broadcasting range can read up to 500 meters. Moreover, that there are few cases that construction sites could be bigger than 500 meters. However, this issue can be resolved easily by equipping denser tag network in the area. Concerning broadcasting frequency, 1 to 3 seconds per message configuration is widely accepted. The objective of the solution is to track the movement of tools in construction sites and alert in case of thieves. Within 3 seconds the maximum distance a tool carried by a worker or thief can move is just few meters which does not impact much tracking and monitoring. In terms of technology, lower broadcasting frequency can help saving energy which leads to the increase in the battery life of the tag. The BLE engineer shared that the tag with this configuration can last up to 5 years or even more depending on the surrounding environment. This number exceeded the expectation of around 2 years of construction companies. As a result, this could help both solution providers and customers save maintenance cost for replacing new tags when running out of battery. Furthermore, another concern raised by the author during the interviews is that whether the tag should be able to sense the environmental information such as temperature or humidity. While this feature could be done easily from the technical point of view, the interviewees shared that it is not a market need. The below table summarizes key parameters of BLE tags and their brief justifications.

Table 13. *Key technical parameters of BLE tags.*

Parameter	Description	Justification
Broadcasting range	Up to 350 meters	- As wide coverage as possible - Meet the standard specification - Retain the location tracking accuracy level
Broadcasting frequency	1 to 3 seconds per message	- Adequate for tracking tool's movement - Save battery
Battery life time	Around 2 to 3 years	- One tool usually is used at one site for maximum 2 years - In terms of technology feasibility, it can be up to 5 years
Sensing data	No	- No real business need

Once the configuration was identified, the physical appearance of the tag were then studied. Initially, the shape of the tag was considered as the most important one. The majority of the tools are handy which are quite small with limited space on their body. Hence, the tag has to be small enough to not affect the usability of workers. Interestingly, the case company previously designed a RFID label which are used to attach to power tools such as hammer drills and cordless electric for logistics identification purpose. The design for the RFID label was based on intensive discussions with customers in construction industry. In addition, since this kind of RFID labels have been used in construction sites for many years, its design is proved by the market. Basing on the information gathered from the company's product brochure, it is a 28 mm width and 48 mm length label. This information is very valuable in designing the shape of the BLE tag, especially the width and length. It evidences that the market has this size of space in tools to attach tags. However, since the label is very thin with no battery while the BLE has, the height was still a question mark. In addition, the tag should be as thin as possible in order to minimize the impact on the worker's operation. Consequently, the author decided to conduct an interview with BLE engineer to see what will be the thinnest size of the tag with a battery. In consequence of the slim size of the CR2032 coin battery, the height would be around 10 mm with the cover. As a result, a draft design of BLE tag was created as shown in the below figures.

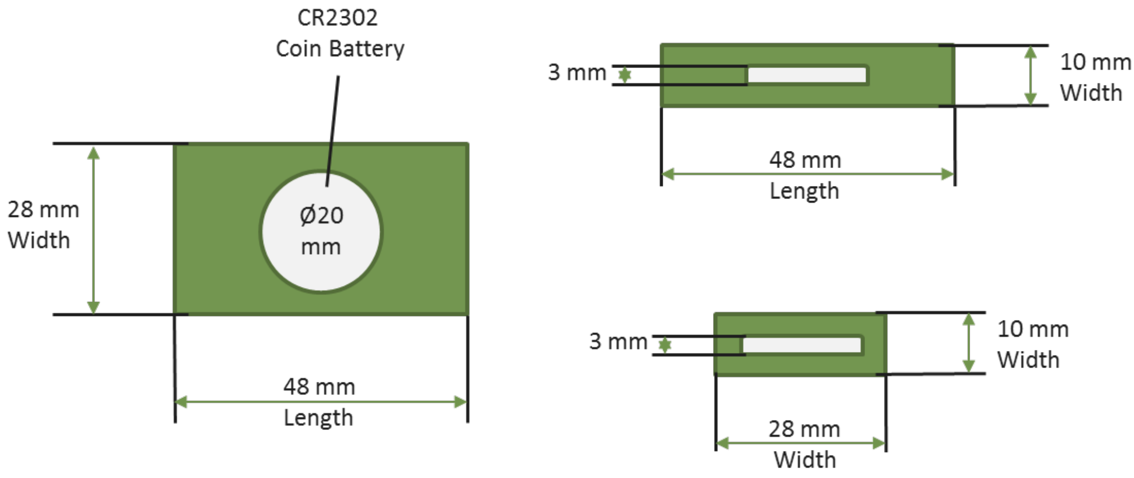

Figure 26. *First prototype of BLE tag.*

This design was shared with some companies in construction industry like NCC and Kallioinen Yhtiot. The first impression was that the height, length and width of the BLE tag seems to fit to the expectation. However, there is still an issue with the shape. An engineer of NCC commented that:

> *"I am OK with the dimensions of the design. However, it seems the tag is quite thick and sharp at edges on the surface. Therefore, it may hurt workers when they are doing the job. In addition, as shared before, we have issue with thieves. The introduction of the tag is to locate the tool but it will make no use when thieves remove the tag out of the tool. Hence, we need to minimize this risk as much as possible. However, these high edges are making it easier to remove the tag out of the tool for thieves."*

The feedbacks from the engineer of NCC were indeed useful. The battery is located in the middle of the tag, however; the author noted that there is some empty space around the battery in the upper part of the tag. After discussing with BLE engineer, a new prototype was created which eliminated those spaces. The below picture shows the new design of the BLE tag where the main difference is in the upper layer (as shown on the right). This improvement was then checked again with the NCC engineer to see how it fits the requirement. Happily, he showed his interest in this version as this design can make the tag detachment out of tools by hands very difficult or even impossible for thieves.

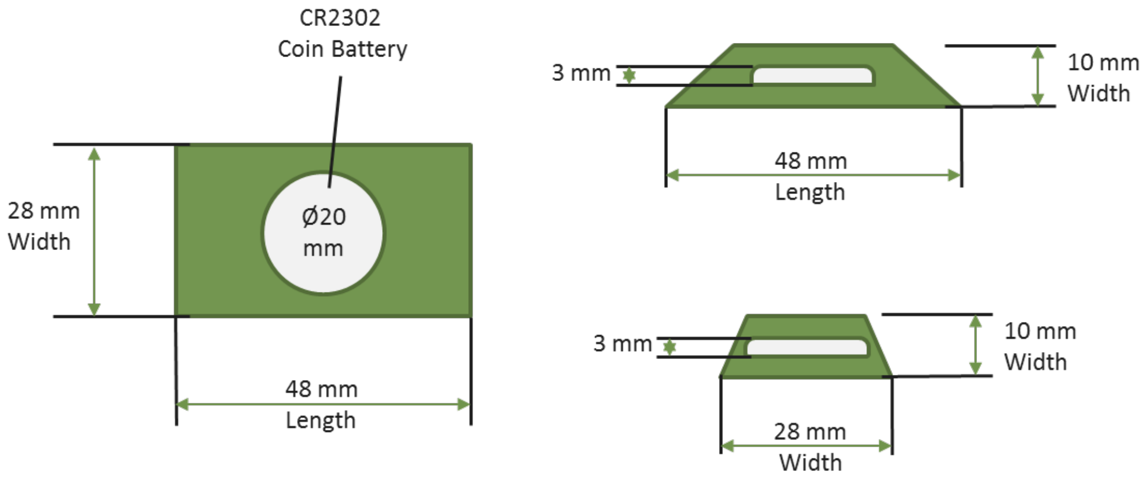

Figure 27. *Second prototype of BLE tag.*

Apart from the design, housing material and protection standard were also critical factors. When having observations in construction sites, the author noted that workers sometimes drop power tools on the ground. Hence, BLE tags are likely to shock and get scratches. Therefore, one critical requirement for the BLE tag is that its housing material should be strong enough to protect the board and battery inside. In addition, the housing material may interfere with signal. For example, metal cover significantly affects the tags by reducing the power signal which leads to shorter range or even blocking sending or receiving signals. Interestingly, the interference with material of RFID technology and Bluetooth technology are quite the same, according to the BLE engineer of the case company. Thus, the knowledge and experience in building robust and hard RFID tags of the case company can be utilized for BLE technology development. Consequently, the case company's brochures about industrial hard tags were studied by the author. After analyzing the different use cases, the author decided to use thermoplastic elastomer for the surface of the BLE tag. This kind of material is also called thermoplastic rubbers – a class of polymers. Thermoplastic elastomer is widely used in hard tags which can survive in very challenging environments and conditions such as being dropped or being sink in chemicals (Chen, 1983). Furthermore, the company's tags with this kind of material passed very demanding testing requirements of Aerospace Standard AS5678 specification which is a very well-known worldwide standard (Company's brochure, 2016). By using this material for the housing, the tags also meet IP68 water resistant standard. To be more specific, the tags covered with this material is dust tight and being immersed more than one meters for many hours (Company's brochure, 2016). For these reasons, it seems thermoplastic elastomer is a very good choice for BLE tags in construction industry. Up until this point, all requirements for BLE tags - the lowest layer of the whole solution which are technical specification, design and housing material were identified.

After having the first success in defining the detailed requirements for BLE tag, the author continued with the second layer of the solution model which is middle ware. Interestingly, there are many RFID or Wi-Fi gateways available in the market. The only one difference between these technologies and BLE gateways is the type of transferring signal. Other aspects such as shape and power source are quite the same. Acknowledging the similarities, the author studied datasheets available on the internet about RFID and Wi-Fi gateways. It turned out that there are a variety of versions and designs for the gateways in construction industry. For example, while some gateways are equipped with solar-panels to harvest the solar energy for its operation, some use normal power source which is electronic. As the result of the observations in construction sites and interviews with construction workers and managers previously, the author could select the most suitable choices for the BLE gateway. After a few weeks, a first proposal of BLE gateway for construction industry was formed and approved by the BLE engineer of the case company. The below figure illustrates the proposed gateway.

Feature	Specification
Connectivity	3G
Read range	350 meter
Power source	Electronic cable
Protection	Waterproof, Outdoor use
Others	Antenna Alarm

Figure 28. *Specifications of BLE gateway.*

Concerning the connectivity from the gateway to the cloud server, there are a number of options such as Wi-Fi, 3G and internet cable. However, it is noted that the majority of construction sites are not equipped with Wi-Fi connection. In addition, since internet cable implementation will increase the complexity of the deployment and maintenance in the future for solution providers, 3G connection is the best option for BLE gateway. Furthermore, as discussed earlier, the BLE technology can read the signals up to 350 meters far or even more. This feature can be considered as an advantage of BLE over other technologies. Since the gateway will be used outdoor and exposed to the weather, it should be protected properly. Therefore, waterproof and being covered by robust and hard metal are critical criteria for this kind of gateway. Regarding the power source, it was an interesting finding for the author. Because the gateway needs to gather the signals from many tags and forward the collected data to the cloud server, it requires a generous power source in order to operate which means solar-powered is not sufficient. As a result, electronic cable is the only option. The author previously assumed that there were just few power stations in the construction sites such as offices and corners of the sites. However, after the observations in the real sites, it turned out that apart from those mentioned power stations, contractors usually have other power points in the middle of the yards to supply electricity for building machines such as levelers and drillers. This finding complemented the idea of using electronic cables to power up the gateway. Subsequently, the author suggested to design the gateway with the antenna to increase the signal receiving capability. Given that the main objective of the whole solution is tracking the location of the tools, the more precise the gateway can capture, the more accurate the calculation is. Another interesting feature of this prototype is the alarm which will trigger sound alert in real-time whenever someone takes tools out of pre-defined zones without a given permission. This feature is suggested by the author when having the interviews with construction workers.

The research activities for the next layer of the solution which is accessing layer were done easily. From the software point of view, the applications in cloud server, laptop and smartphones are not impacted by the choice of the technology in physical and middleware layers. In other words, the features and requirements for the components in accessing layer for the real-time location tracking business case are the same for any technology including BLE. Thus, brochures for this application from software providers available on the internet were studied. In addition, the contribution of the author was also significant as he used to work with many similar applications in his previous companies. The below table lists down key features of different components in accessing layer.

Table 14. *Key features of the components in accessing layer.*

Component	Feature
Cloud Server	- Receiving data from gateways - Sending requests to gateways - Processing and analyzing collected data into business insights and reports - Providing integration services for external systems - User and role management - Tags and gateway management - Construction working zone management - Policy management

Applications in personal computer/ tablet/ mobile phone	- Viewing tool information - Receiving alerts in case of thief - Positioning location of tools - Typical asset management features: user manual, asset creation and transferring

After putting all findings together, the author decided to conduct an interview with the CEO of eRent who has much experience in construction industry to verify the solution. Before the interview, the author shared some slides about the solution together with components' features. Overall, the interviewee agreed that the solution addressed main issues in construction industry. He concluded that:

> *"BLE technology with its solution provides novel and superior features that I have not heard before. I believe this technology will fit very well in the business and operation of construction companies like YIT, Skanska."*

In the first week of January 2017, one official meeting with the project team in the case company was held. During the meeting, findings were shared among the team. It was all agreed that the solution model together with detailed requirements on each component would be very valuable for next steps of developing the real product for testing and validating. Regarding the BLE tags, since the case company had competences in building industrial and robust tags, management team decided to build it in-house. Moreover, the findings of the author contributed significantly to building the final physical BLE gateways. However, since the company lacked of knowledge in BLE gateway manufacturing, out-sourcing with strict control is most suitable solution. Similarly, components in accessing layer which are cloud server and applications would also be outsourced. Some potential partners were suggested based on their creditability, existing product quality and relationship with the case company. In addition, from the viewpoint of market research, the objectives of the innovation project were met. Then, the next phases will be carried out by the engineer team. In the meeting, the CEO of the company also shared that the company has just won a new project which will require efforts of the development team. Hence, the CEO decided to postpone the next steps for BLE solution in construction industry.

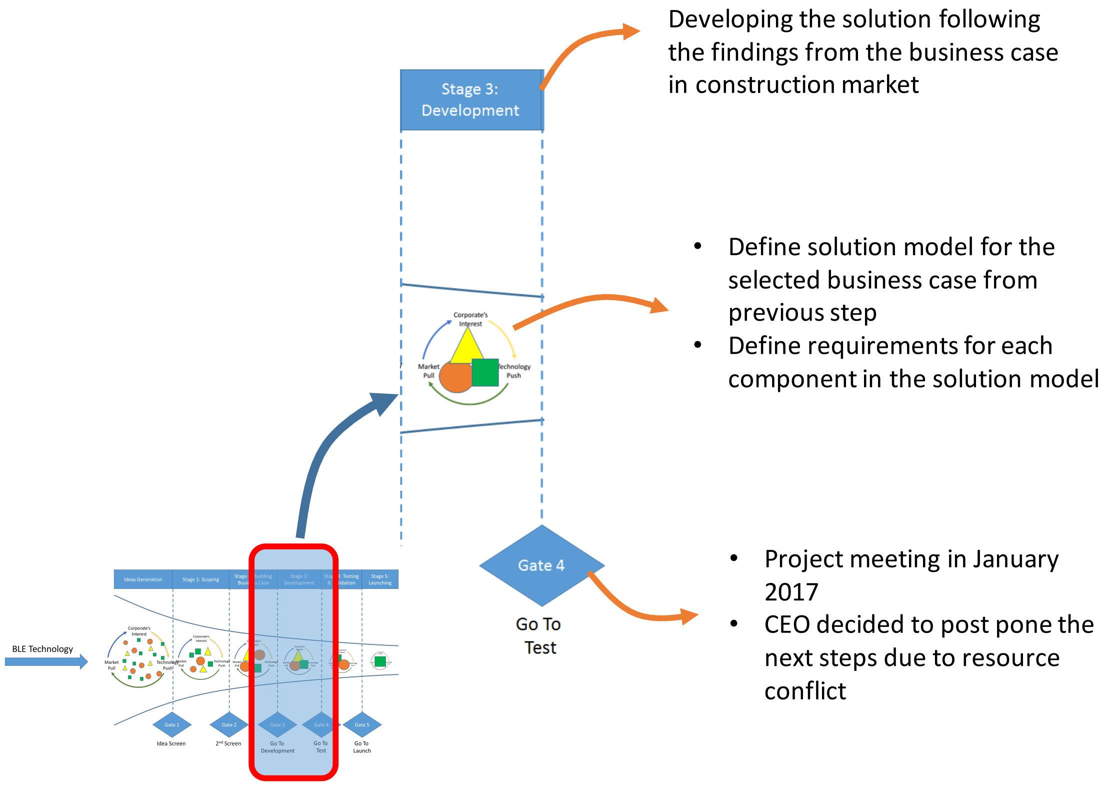

Figure 29. *Connection between development phase and key activities in this stage.*

The ultimate objective of the development phase in the proposed framework is to build a real prototype. This phase consists of various activities from transferring business requirements to technical specification and then producing physical prototype. When mapping the activities carried out in this phase of the BLE innovation project onto the proposed framework, it is seen that the project was still in the middle of the development phase. To be more specific, the detailed specifications for all components have been defined but there has been no physical prototype or actual product. However, when viewing from a different perspective, the visual prototype is also considered as a product which can be tested and shown to the customer (Pour, 2015). As discussed earlier, the shape, the configuration of the BLE tags, gateways and applications in the computers were shown to eRent for testing. Therefore, to some extent, the visual prototype of the solution is considered as the preliminary product in the development phase of the framework. In general, activities happened during this phase in the case company almost matched the description in the development phase of the proposed framework as shown in the above figure. Once again, the framework is proved by the case study.

8. DISCUSSION AND LESSON LEARNED

8.1 Reflection of the Case in the Proposed Framework

Innovation takes a significant role in the survival of companies in such a rival business environment. There are many areas that companies could apply innovative ideas. While some companies try to minimize the operation cost or improve the effectiveness of the performance with innovation, others use innovation in increasing sales and getting more profit. Among different sources of innovation, disruptive technology has been attracting a lot of attention from managers in many decades (Utterback and Acee, 2003). Regarding the combination of innovation and disruptive technology, it could bring huge benefits for companies such as penetrating the market and surpassing competitors. Despite advantages, the development of this kind of technology is very complicated given a large amount of uncertainties. Thus, there should be a systematic approach to minimize potential risks and at the same time get the most out of it.

In terms of innovation management, the Innovation Stage Gate model of Cooper (1993) has been recognized as one of the most common and generic ways in this domain. It defines different stages that an innovative idea should follow from beginning to the end. Hence, companies can apply these sequential steps to manage the innovation projects. In addition, this model is built to use in generic situation which means it has not been tailor-made for any kind of specific context such as disruptive technologies. Therefore, customization or adjustment would be required. Furthermore, the innovation is impacted by many factors from both inside and outside of the company. First, because disruptive technology is the source of innovation, the technological aspects such as specifications, features certainly affect the innovation (Brem and Voigt, 2009). Another aspect is market demand. In detail, managers should be aware that the target of innovation is bringing more money to their companies. One critical criterion that a product should meet is the expectation from customers or demand of the market in order to be sold successfully (Brem and Voigt, 2009). Last, the main actor in the innovation process is the company itself. As every move of the company is on the hand of the management team, innovation, which is a part of that, is also affected by the decisions and interests of the management team (Schumpeter, 1947). Burgelman and Sayles (2004) propose a term which is corporate's interest is to describe this internal aspect. When putting these concepts together, one conceptual framework was proposed by the author as presented in Chapter 4.3. The below figure illustrates the model once again with BLE is the source for the innovation process.

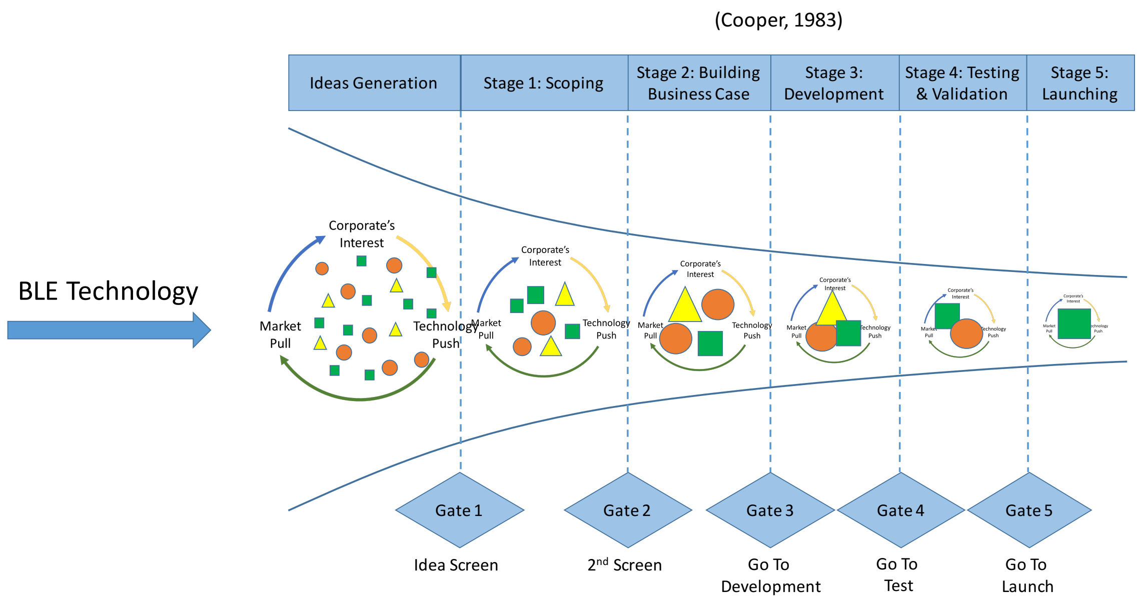

Figure 30. *Innovation process in the case company mapped with the proposed framework.*

Interestingly, activities in the innovation project of the case company perfectly matches the descriptions in the proposed framework as discussed in Chapter 7. In addition, there are also insights from the case project that complement the proposed model from the high level perspective. The first interesting point comes from ideas filtering and developing. From the beginning of May 2016 until January 2017 when the project was postponed, there were a lot of ideas being removed out of the innovation project. Moreover, the selected ones are developed gradually over the time. The longer they last during the whole process, the more detailed and clearer they are. For instance, in the ideas generation phase, the construction market is one of four different markets to study. This market was then selected to be explored further which led to three business pain point categories. Consequently, one business case out of two from the chosen category was studied carefully. After that, a solution model with detailed requirements and designs for each component based on the selected business case was defined thoroughly.

Furthermore, it is seen that every activity and step during the innovation project were impacted by three different aspects which are company's interests, features of the BLE technology and the needs from market. For instance, selecting the construction market over manufacturing was based on the interest of the management team. In addition, it can be seen from the case that the decision to become the solution provider is quite risky for the company after considering technology and business aspects. However, in order to meet the aggressive growth expectation of the new investors, that is the only option. Regarding the market demand, it is considered as a very important aspect in every activity of the innovation process. Data from the market research and implemented projects in retail and public transportation markets helped in narrowing down the scope of the market study. Especially, the most significant step in designing the future product is identifying the real business case which also focuses on the unsolved pain points of the customers. Moreover, the market demands were also gathered from discussions with workers and managers in construction industry companies. Those insights gave clear requirements and expectations towards the future solution. In addition, the features of the BLE technology were seriously taken into consideration which helped the project team in not only narrowing down the scope of the project but also adjusting the prototype of the solution. By understanding the advantages and disadvantages of the BLE in the pre-activities phase, the direction of the research was guided in a right way which led to defining different applications in four markets: retail, public transportation, manufacturing and construction. Interestingly, the above descriptions about three aspects impacting the innovation activities are linked to the concepts from the proposed framework. Hence, this again complemented and supported the proposed model of the author.

Even though the project was not carried out until the end of the Innovation Stage Gate model but stopped in the middle of the development phase, to some extent, it can be justified that the proposed framework mostly matches real activities happened during the innovation process of the case company for the BLE technology. The flow of the activities and phases in the project followed the same way as described in the model. Furthermore, the integration model of technology push, market pull and corporate's interest into the Innovation Stage Gate model is also justified through this real project as discussed.

8.2 New Findings on the Framework Based on the Case Study

Apart from playing the role of justifying the proposed model, the case study also led to many interesting findings regarding to this proposal. In the scope of the framework, disruptive technologies are considered as the source for innovation. With their remarkable advantages, they have grasped a lot of attention from managers in companies around the world. Originally, in the Innovation Stage Gate model, Cooper (1999) proposes six sequential steps an innovation should go through which are ideas generation, scoping, building business case, development, testing and validation then launching. From the case study, it is suggested that *"there should be a new step in the beginning of the Innovation Stage Gate Model which is so-called pre-phase"*. This phase is before the ideas generation phase of the proposed model. Based on experience the author had during the time working in the case company, it is noted that there is usually an issue of lacking technical knowledge in companies towards new technologies, especially emerging ones. Hence, there should be an approach to address that problem. The new suggested phase is introduced with the aim to provide background knowledge and insights about the disruptive technology. This step is a very critical as the whole innovation project will not make any sense without it. Thus, it is suggested that managers in companies when dealing with disruptive technology innovation project need to understand in-depth about features as well as advantages and disadvantages of the selected technologies before moving to next steps. The below figure illustrates this pre-phase.

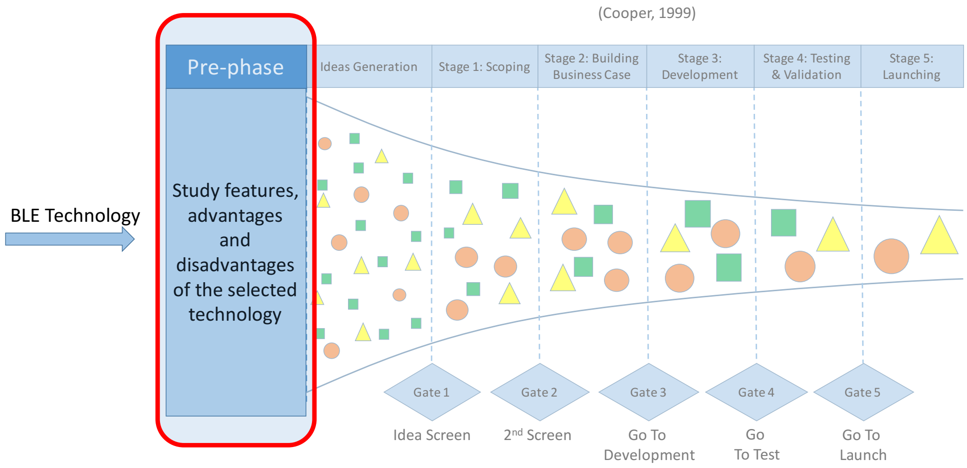

Figure 31. *The suggested phase in the Innovation Stage Gate model in the context of disruptive technology.*

In order to gain more competitive advantages, companies usually look for disruptive technologies in initial phases such as embryonic or in the early stage of growth rather than maturity phase (Utterback and Acee, 2003). However, as discussed above, these phases contain a lot of risks and uncertainties (Hevner et. al., 2004). Therefore, it poses a burden for companies in terms of market research, especially in gathering current development projects and market forecasts. In addition, given the uncertainty, it may require unexpected heavy efforts and investments from companies in the future. Hence, it is recommended that "*Company should just focus on one or maximum two disruptive technologies in order to maximize the effectiveness of the innovation project*". In the case study, the company selected BLE technology as the only disruptive technology to study. In the later phases, the study led to many new findings which forced the company to reduce the scope of the innovation project due to the resource limit. Consequently, a lot of potential ideas were put aside for this reason.

The framework proposes that innovation activities are affected by three aspects: technology, market demand and corporate's interest (Schumpeter, 1947; Burgelman and Sayles, 2004). Each of these aspects impacts different perspective of activities and guides the whole innovation project to proceed in a right direction. Interestingly, when applying this integration model to the case study, it turned out an interesting finding: *"These three aspects affect every activities of the project during the innovation process but in different phases, the pressure of each one is different from others"*. In other words, in some phases, one particular force is stronger than others. Moreover, it is rare that all forces are the same in one phase. This finding seems to complement the idea of the proposed framework about three aspects in innovation including technology push, market demand and corporate's interest. Those theories do not mention the differences in the force along the innovation process. This new finding is considered as a valuable point for managers when applying the proposed framework in the real business world. One example in the case study is that, in the scoping phase, the market aspect was considered more carefully than technology features and corporate's interest. It is noted that in this phase, some statistics and research on the BLE market played in important role in shaping innovation activities.

In the Innovation Stage Gate model, one of the most important components is gates. According to the definition, these gates have the responsibility to filter ideas for next phase (Cooper, 1999). In addition, they are considered as a check-point for the project. When linking this concept to the case study, it turned out that: "*These gates could be represented through team meetings*". This finding is considered as a new insight regarding the practicality of the proposed framework. These meetings took a significant role in the innovation project in the case company. First, they were the decision-making points to make a go or no-go decision on each idea by the management team or steering committee of the project. Second, they acted as key milestones in the project where the whole team was gathered in the same place and shared the results from previous phase. Last, objectives for next phase were also defined during these checking points. Basically, the objectives in next phase can be somehow determined in the current phase with the support of the proposed framework. However, given these meetings have the attendances of management team and project members from different departments of the company, the objectives not only are defined clearly but also meet the expectations from all project stakeholders. Furthermore, a project is a joint-effort from different personnel, as a result, synchronization among team members should be carried out during these checking points.

One of the key concepts used in this paper is technology life cycle which is the fundamental theory for every technology, including disruptive technologies. Technology life cycle theory states that there are four different development stages of a technology: embryonic, growth, maturity and decline (Foster, 1986). In additions, not every technology goes through all these steps in its life cycle. Some may experience only embryonic phase before abandoned by the market (Foster, 1986). Interestingly, when carrying out the research, it was found out that: *"One technology may have different development curves in different markets"*. From the case study, it is acknowledged that the development curve of BLE technology in retail and public transportation differs from construction and manufacturing markets. In retail and public transportation markets, BLE technology seems to reach its maturity phase when its technology features applied in these markets have been found out. By contrast, it is obvious that no one knows which features of BLE technology will fit in the construction and manufacturing markets and what to develop. In other words, BLE technology in these markets is in the embryonic phase where the development is still going on. Basically, this new finding is considered as a very surprising point which fundamental theory does not mention. Therefore, it brings the theory of technology life cycle to a new level of complexity and practicality.

Regarding the innovation which follows the Innovation Stage Gate model, it is a long process with many different steps. The previous phase provides the inputs for the next phases. Moreover, there is a close and logical connection between these sequential phases. Getting back to the data collection, existing material method proposes to use available data such as company's brochures or websites. In the case study, documented findings from previous stages can be considered as existing materials for next phase. For instance, the insights gathered from finding business case were also used in the development phase as a valuable source of information. Thus, well-documentation during the research and innovation process is highly recommended for companies and researchers.

9. CONCLUSIONS

9.1 Meeting The Objectives and Theoretical Implications

In this highly competitive market, every company is trying hard to first sustain their businesses and second gain more profit. However, the market race is very challenging which leads to a large number companies around the world still go bankrupt every day. In recent decades, a solution which has drawn attention from managers globally is innovation. Interestingly, the success of giants is now somehow measured by how innovative they are (Vaughan, 2013). Furthermore, disruptive technology can be considered as a very promising input for innovation given its potential in helping companies earn huge revenue. It is also well accepted that the combination between innovation and disruptive technology can be seen as a secret weapon for every company in the market. However, managing innovation is a challenging job which requires a lot of effort and time in dealing with complex and interrelated activities. When considering the disruptive technology as the source of innovation, managing innovation becomes even more sophisticated. Hence, there is a strong need of having a guideline for managing related activities in innovation projects.

This study was conducted to develop a new framework which companies could use as a guideline in managing innovation projects when disruptive technology is the input. For this purpose, the paper introduced the key concepts of the Innovation Stage Gate model along with disruptive technology. In addition, the theories about technology push, market pull and corporate's interest were also discussed and embodied in the framework. The proposed model was then assessed and tested through an innovation project for BLE technology in the case company. During the research process, the author involved in every activity happened in the case company as a project team member. Activities and insights from the project were captured into documents which subsequently were collated with the hypothesis of the proposed framework.

The outcome of the study points out that the ideas from the proposed framework matches the activities happened in the BLE innovation project of the case company. In other words, the application of the model is assessed and justified in the real business world. Hence, it can be used as a guideline for other innovation projects when having disruptive technologies as the source. In addition, other interesting findings were also reviewed. First, understanding the disruptive technology thoroughly before carrying out an innovation project is critical for the success of the innovation projects. Moreover, it is necessary to consider studying the selected technology as a formal and separated step in the innovation project. Second, the level of impact from three different aspects technology push, market pull and corporate's interest differs in each phase. Some aspects may be stronger than others at some points during the innovation process. Third, the role of the gate is significant for the next phases of the innovation process. It plays not only as a milestone but also a decision making point. Four, the study also reveals in-depth insights about the sub-lifecycle of one technology. In detail, one technology may have different development curves at the same time in different markets or industries. Finally, companies should bear in mind the important role of interconnection between phases as they support and complement each other.

9.2 Managerial Implications

Running a company in this rival business world is a challenging job. It is even more difficult when this world is an ever-changing one. Hence, enterprises have to deal with new challenges occurring in every single day of the business. Getting back to the case company, in the beginning of 2016, it had to deal with a totally new disruptive technology which was BLE. Consequently, the company entered new market – short range and indoor positioning system in construction industry as a solution provider without any experience. Based on my research in this specific case, some managerial implications are suggested. First, it is recommended that every manager in different company sizes, from small, medium to large ones should apply theoretical frameworks to solve real business problems. By linking theories from books to practical issues, managers could have not only a broader view about the facing issue but also potential solutions. For example, the introduction of the Innovation Stage Gate model can provide managers a comprehensive view about activities would happen in the near future. Therefore, resource preparation will be much more accurate and efficient.

The second managerial implication is the collaboration of managers from different department during innovation. It is well-accepted that innovation is a complex process which could last many months or years. Given company's investment in innovation is huge, every decision must be considered carefully in order to avoid potential mistakes. Collaboration among managers in companies stands out as one of the most effective ways to deal with this matter. Activities happened in the case study can be taken as an example. Innovation management seems to be the responsibility of the product manager in the case company as its ultimate objective is to build a product for launching. However, apart from the contribution of product manager, the sales manager's involvement was also important. Given the sales manager is the one who knows customers and markets well, his contribution in the Strategy Week meeting in the case company contributed to shape the innovation project into the right direction.

The final suggestion is for CEOs or directors of companies in innovation projects. It is recommended that CEOs and directors should not involve in every single activity during innovation projects. It would take them a lot of time and effort since innovation project contains a large number of different activities in a long period of time. Instead, they should participate in key milestones during the process which are gates – as defined in the Innovation Stage Gate model. As the result of defining checkpoints properly, CEOs and directors could save more time for other important tasks and still ensure the working progress as well as being able to make the decisions at the right time.

9.3 Limitation of the Study and Future Research

The outcomes of the case study mostly justify the proposed framework. However, the quality of the study needs to be assessed carefully. Regarding the quality and limitation of a qualitative study, Bryman and Bell (2003) state two key aspects which scholars need to pay attention are validity and reliability. First, validity concerns the research from the perspective of quality evaluation. In other words, it is used to assess whether the outcomes of the study are well-accepted or not. Bryman and Bell (2003) divide validity into two sub-aspects which are internal validity and external validity. Internal validity is used to evaluate whether the study was based on strong theories from previous literatures and how they are linked to the researcher's analysis (Bryman and Bell, 2003). In this study, the proposed framework, which plays the role as the heart for the whole study, was formed by concrete literatures including disruptive technology, the Innovation Stage Gate model and three factors of innovation: technology push, market pull and corporate's interest. In order to complement the model, each theory mentioned above is also backed by fundamental concepts. Particularly, technology life cycle and product life cycle are introduced to support the disruptive technology theory. Furthermore, the data gathering methods and analysis during the study also support the validity of the study. Different sources of data such as existing material, interview, observation were used to formulize the results of the research. Moreover, the validity of the data is also improved when one analysis is supported by many different data. Therefore, this study seems to meet the internal validity criteria. Meanwhile, external validity is described as how the findings of a study can be generalized in a wide setting (Bryman and Bell, 2003). It is problematic for many researchers when doing the qualitative research. The core framework of the paper was strong as it was built based on concrete theories. However, there is no guarantee for the validity of the findings in the real business world since those findings are based on one case study which is the innovation project in the case company in Finland. Hence, the outcomes of one case study may not be sufficient for scientific generalization for every company in the business world (Tellis, 1997). In addition, as mentioned before, the final phase of the proposed framework was not conducted in the case company, which is also considered as a limitation of this study since the validation of the proposed framework in the remaining phases have not been assessed. Furthermore, some may claim that the findings are just based on data gathered inside Finland which leads to a situation that these outcomes may not be applicable to other nations or regions. However, some data sources are not gathered in Finland only. For instance, in the existing material method, data collected are the documents, websites of international companies and organizations around the world. Other than that, interviewees are mainly managers who had a lot of experience in doing international business, which is considered as an advantage of the study in terms of generalizing the idea. Nevertheless, findings from this study may not be strong enough to be generalized in a wide scale, it is rather a fruitful thought to managers in the world to manage innovation process in the context of disruptive technology.

Second, the idea behind the reliability criteria is whether other researchers are able to obtain the same results in exactly the same experiment (Bryman and Bell, 2003). One of most difficulties in qualitative research is the credibility of data which heavily depends on various factors during the data gathering or analyzing process (Saunders et al., 2009). There are four data gathering methods applied in this study consisting of existing material, questionnaire interview, observation and action research. Among them, the questionnaire interview method can be taken to examine the reliability of the study. Despite advantages, this kind of data gathering method is considered as the riskiest method since it is heavily influenced by different aspects such as interpretation or biases of the author (Saunders et al., 2009). Bryman and Bell (2003) state that the interpretation of the author towards the research subject is a high risk for its reliability. Moreover, Saunders et al. (2009) point out that interaction between interviewers and interviewees during the interview such as commenting and other non-verbal behaviors could be a source of error. In addition, interviewer's and interviewee's biases are also a big problem (Saunders et al., 2009). For example, since the author already came up with a proposed framework, intentionally or unintentionally, he may influence the interviews' outcomes to favor his own expectations. Furthermore, the interviewees' answers may be impacted by their feelings. Another aspect in terms of reliability which is worth to mention is the author's contribution during the innovation project of the case company. On the one hand, many years working experience in this field of the author generated a lot of valuable insights towards to the researching topic. On the other hand, it may cause some issues related to reliability. There is a risk that the author unintentionally forces the outcomes in line with his own ideas or experience. Acknowledging these risks, the author tried to gather data from different sources such as existing material, observation and interviews in order to minimize the deviation and maximize the reliability of the study. In addition, all findings from these data gathering methods did not contradict but complement with each other consistently.

While the outcomes of the paper created fruitful thoughts towards the study of innovation management in terms of disruptive technology, there are still some limitations as discussed above. However, those shortcomings may create some spaces for future research on the subject. For instance, research on the same topic could be carried out with different technologies as sources rather than BLE or in different countries would complement the outcomes of this study. Furthermore, conducting the study until the end of the innovation project is also recommended to justify whether the whole proposed framework still fits the real world or not. To conclude, hopefully, in the future there will be more studies done to enhance the reliability and validity of the research topic, which would provide more insights for companies, especially for managers to apply the proposed framework in the real business world.

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