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Impact of Internet of Things on Software Business Model and Software Industry

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Abstract

Context. Internet of things (IoT) technology is rapidly increasing and changes the business environment for a software organization. There is a need to understand what are important factors of business model should a software company focus on obtaining benefits from the potential that IoT offers. This thesis also focuses on finding the impact of IoT on software business model and software industry especially on software development.
Objectives. In this thesis, we do research on IoT software business model and also software industry. The objectives of this research are included as follows:
1. Summarize the current business models for IoT and to identify the important factor for IoT business models.
2. Analyze the impact of IoT on software business models.
3. Analyze the impact of IoT on Software development especially on requirement engineering.
4. Provide recommendations how requirements engineering are connected to provide better support business modeling for IoT.
Methods. We conducted a systematic literature review based on the guidelines suggested by Wohlin [1], to find the current business model for the IoT. Next, we designed and executed an industrial survey to explore the impact of IoT on a software business model and software development.The results of survey were statistically analyzed using descriptive statistics, chi-square test of significance and Friedman test.
Results 21 peer reviewed papers were identified which were analyzed in relation to their rigor and relevance. From the literature reviews, results indicate 9 business model elements are being focused on the IoT business models. In addition to this 4 most important business model factors were identified. On the other hand, the industrial survey resulted from 56 survey responses, identified that value proposition is the most important element for the IoT business model. It was also observed that even the impact is high for the value proposition. Regarding the software development, customer demands is highly impactful and moreover, the results suggest that requirement management is highly impactful.
Conclusions. The current software business models were found for the IoT industries. In additional the software business model elements which were majorly focused in the IoT industries were also identified and the most important factor which brings the value for IoT business models were also discussed. Furthermore the impact of IoT on software business model element and software development, especially on the requirement phase, was analyzed and discussed. This helps the practitioners to understand the impact of IoT on software business models and software industry and helps the organization to improve IoT business to its full potential.

Keywords: Internet of Things, Software business models, Software development.

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Chapter 1

Introduction

This thesis specifies an exploratory research on the impact of Internet of Things on software business models and software industry . It pursues the goal of determining what is the impact of Internet of Things on software development, software business models, requirement engineering. This section describes motivation about this research.

Consider the world where the physical object are connected with each other using a network, which interacts with the people or systems or other objects this is referred as Internet of Things(IoT). Internet of Things is defined as a service which benefits humans, where in the world things are connected with each other and they communicate with each other using a network [7].

IoT is on the edge of a huge rise in the market, where the number of machines that are connected to the internet has increased by three times and present day over 12 billion of devices are connected to the internet according to Cisco [8]. Furthermore, Cisco predicted that international market for the internet of things would achieve $15 trillion of profit over the next decade [9]. Today, the number of application that is using IoT technology are being used by the customers and the market is having a good business [10]. Due to a sudden change in the using, the IoT technologies in both home and office leads to the impact in the global market, suppose if the price of the device is reduced and performance is increased then the IoT adoption increases.

According to the survey conducted by the Economist Intelligence unit [11], for conducting the business based on the IoT. They found that 46% of respondents told the existing business model will change due to IoT, 30% respondents told IoT will unlock new revenue opportunities from the existing product or services and 29% told that IoT will inspire new business process. Therefore many business models [12, 13, 14, 15, 16, 17, 18] are created for the IoT. Moreover they also gave a feedback that IoT will unravel the new revenues for the current products that will change the existing business model. Zhuming Bi [19] had investigated the impact of IoT on enterprise context , but none of them had investigated the impact of

IoT on the software industry and software business model. Therefore, the impact of IoT on business models and software industry remains greatly unexplored .

Concluding, it unravels the IoT improvement to its full potential therefore it unlocks new opportunities. Furthermore this master's thesis focuses in finding the impact of IoT on the software development especially on requirement engineering, it helps the organization to improve their IoT development to its full potential. In order to achieve the objectives, the systematic literature review was done, to identify the most important factors and element used in the software business model that were focused on the IoT industry. Furthermore, a survey was conducted based on the elements that were found in the literature, these elements are validated by the software practitioners. In additional the impact of IoT on software business models and software development was identified in the survey.

This thesis is structured as the following sections. Section 2 will describe the theoretical background of the study, in this section the definition of IoT and background of IoT technology is explained. Section 3 describes about the research design along with the aims and objectives of the study and also research question are described. Section 4 provides the details about the research methodology. Section 5 illustrates the process of conducting the systematic literature review and survey. Section 6 describes about the analysis and results of literature review. Section 7 illustrates the analysis and results of the survey. Section 8 provides the final conclusion of the thesis.

Chapter 2

Background

In this section, the theoretical background is described for this research. Here, firstly IoT definitions and concepts are described. Later in this section the concept of business model is defined along with it business model canvas is also described.

2.1 Internet of Things(IoT)

Here , the definition of Internet of Things, evolution of IoT and application , sectors of IoT are described.

Definitions of Internet of Things(IoT)

There are numerous definitions for Internet of things. Fleish [20] stated that things are turned into tiny computers. Vermesan [21] detailed as the physical objects that are connected to the network everywhere around us, it consists of sensors which are integrated into the devices that are connected to the internet and wireless network. Uckelmann [22] defined IoT as linking the things to their virtual image in the internet and wireless networks, in other ways linking the information based on their identification, location, and business to an individual who is using that particular thing. The particular things can access at the right condition, time and place in order to get the accurate information. Valhouli [23] stated that the technology which deals with the digital information in the physical world, where the objects and location are part of IoT in both ways. Information is combined with the location using a global positioning system coordinates. In other words, sensors in an object are set up, to send IP and to acknowledge their surroundings as well as to communicate with each other and with other objects. Closing, Internet of Things is termed as a technology that connects the objects with the digital and physical world with the help of internet and wireless networks.

In detail the view of IoT is explained in the following example: a car which is equipped with sensors, these sensors enables an automatic update when the car needed repair or maintenance, it also autonomously files a valet to pick the vehicle

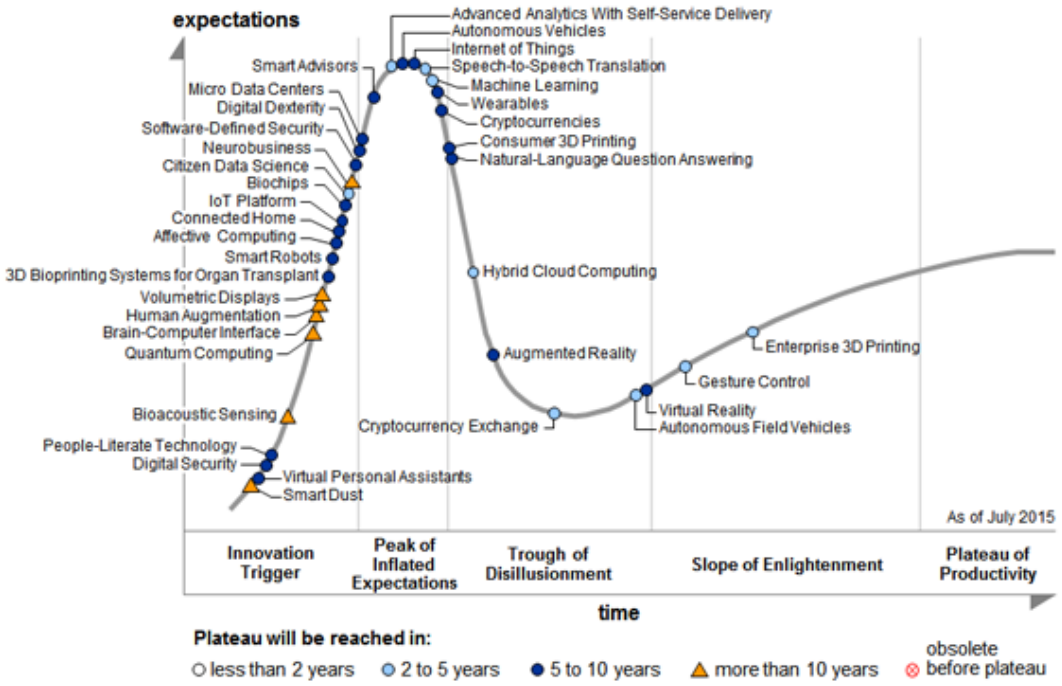

Figure 2.1: Gartner's 2015 Hype Cycle [2]

and get it to the nearest service center. Suppose if an accident is about to occur the sensor get activated and they are connected to the nearby hospital, it also informs the whereabouts to the local hospital. Everything's happens before the driver unbuckles the seat belt. Therefore, a value is created in the time contrast between the event and response which is brought down to zero.

Evolution of IoT and applications

Kevin Ashton, in 2002 was the first to use the word Internet of Things(IoT). Later, in 2005 IoT is found in books and the first conference was held [24]. At present time, these are affordable to the customers. The IoT devices are inversely proportional to the size, price to the performance that is the size and price are decreased, and the performance is increased. According to Cisco the connected devices today are estimated to be around 10 billion and by 2020 the devices will increases to 50 billion [25]. The figure 2.1, the Gartner's hype cycle indicated that IoT for emerging technologies is at the peak position. Chui described the IoT applications into two broad categories that are information and analytic, automation and control [26]. These categories are further divided into three types of IoT application in each category, they are tracking, enhanced situation, sensor-driven decision analytic, process optimization, optimized resource consumption,

Figure 2.2: Evolution of IoT and Applications [3]

complex autonomous systems. Atzori [7] described that the IoT applications are distinguishable as both domestic field and business field. The few examples of IoT application are e-health, enhanced learning, industrial control, smart cities, and logistics. Figure 2.2 describes the IoT application used in various sectors or industries.

2.2 Business Models

The concept of the business model is originated from the concept of business strategy this is the first systematic report growth and change in the industry [27]. Zott [28] described the business model is not originated from business strategy, both business model and strategy are different. Zott, Amit and Massa illustrated, business models objective is to create value, focus on the value proposition and prioritize the role of customers whereas strategy objective is to capture the value of the firm.

Since mid - 1990 with the use of the internet the concepts business model

became popular. Zott [28] in their literature review gave a synopsis of definitions of business models in which the recent one was Teece [29] defined business model as the model that express the logic, data and other information that supports the value proposition for the customer and usable structure of revenue and expenditure for the enterprise that delivers the value. Osterwalder [30] defines the business model as a conceptual tool that has a set of elements and relationships, which allows explicit the business logic of an organization. the tools describes the value that an organization gives to the one or many segments of customers and architecture of an organization and its network of partners for creating, marketing and delivering the value and its relationship capital in order to generate a profitable and sustainable revenue streams [6]

osterwalder [30] described the business model literature in three different levels:

- Level 1: Throughout the business model concept the authors described the model as an abstract overarching concept that can detail the real world businesses.
- Level 2: Taxonomies, the author described that different types of abstracts of business models, describes each set of businesses with a common attribute.
- Level 3: Instance level, authors describe the factors of real world business model.

Moreover, Osterwalder [30] proposed five phases in the evolution of business model literature. In the first phase, business model definitions and classifications are proposed. In the second phase, elements in the business model are described. In the third phase details of elements of software business models are described. In the forth phase the components of the model are described, in this phase the framework is formed. In the final phase the author have implemented the model. Throughout the software business model concept the main focus is on ontology levels that is the software business model canvas[31], it is a conceptual tool to describe , analyze, and design the software business models. According to Fielt [32] , the advantage of business model canvas is their usability high, model use visualization template therefore designing and communicating business models becomes easy. According to Osterwalder [6] The business model consists of nine blocks they are, customer segmentation, value proposition, channels, customer relationships, revenue stream, key resources, key partnerships and cost structure. In this thesis these blocks are referred as 'elements'.

A business model consists of several important entities, they are "Who, what, how and why" [4]. To describe the entities 'who' which refers to the customers,

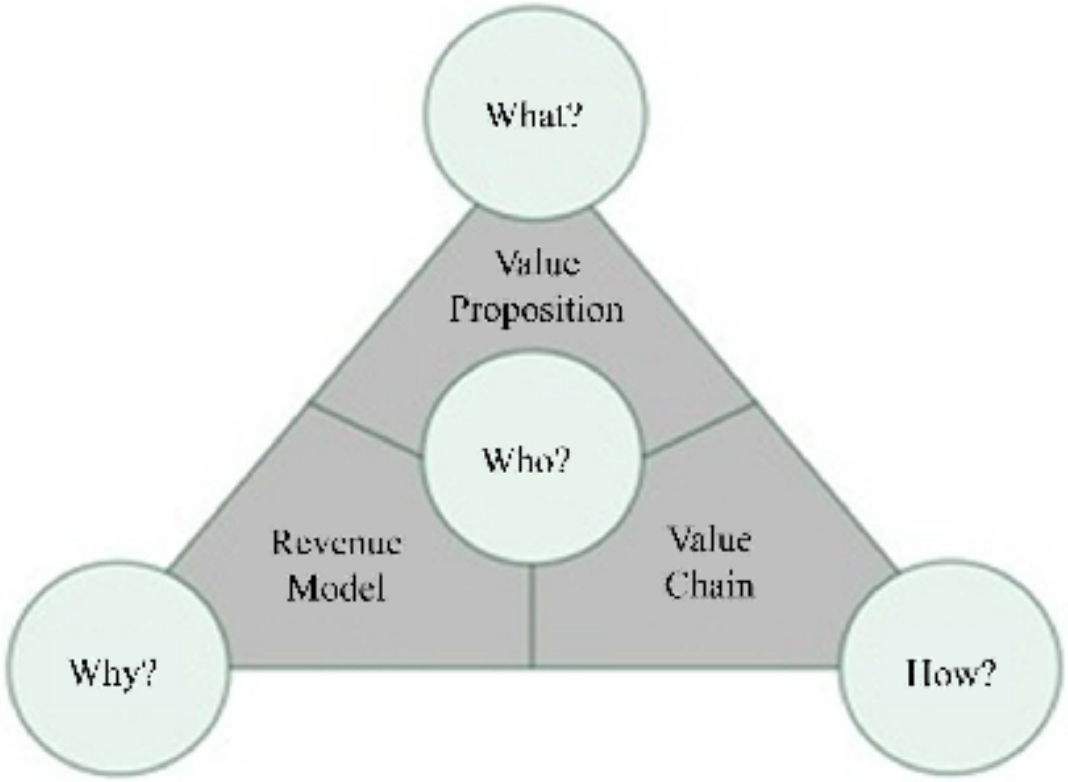

Figure 2.3: Archetypal business model[4]

'what' is the value proposition which is offered to the customer, 'how ' is the value delivered the value proposition to the customer and 'why' refers to the essential model for capturing the value [33]. These entities are used as basic requirements to build a business model. The figure describes the functions that a business model needs to concentrate. Furthermore, in the context IoT the software business models were described in the related work.

In the context of IoT, software business model is defined as to create the value for IoT, the basic entities like who are the target customer for IoT products, what is the value proposition that will be offered to the customer, how the value for IoT products delivery the value proposition to the customer and why a IoT product require a model to capture the value. For our study the IoT business model is defined from Osterwalder business model(canvas) elements [6], Since the business model is evolving,therefore to create value for the business the new elements must be considered. Osterwalder business model(canvas) elements [6] describes the all entities and most of our literature studies also follows these business model elements for IoT.

2.3 Software Development

Software development for IoT is a challenging task since, IoT products are developed according to the connectivity, interoperability and security of the applications. Therefore, the developers who are developing the IoT products must be customer driven where software is built with a simple interface, for example, the software must be developed for a light which will respond to the sense of moving objects [34]. The management strategies play a crucial role in developing the IoT product throughout the different phase of the software development. According to the Chirtopher [34], to assure success the requirement phase of the software development in IoT must address the issues of the IoT applications like trace ability, maintainability, security.

Over years requirement engineering (RE) has been recognized as the most important process in software development [35]. Abran et al [36] divided RE into four areas, they are described below.

Requirement Elicitation: This is a process where the key stake holders for the IoT applications are recognized.

Requirement Modeling and Analysis: The modeling based on the classification of the functional and non-functional requirements of the IoT application while requirement analysis was focused on the deriving software requirement and setting boundaries for the software.

Requirement specification: This is a process where the documents are produced for the software.

Requirement validation: This is a process of validating the documented requirements for IoT.

2.4 Related Work

There are few studies focused on the business models associated with IoT [12, 13, 14, 15, 16, 17, 18, 37, 38, 39, 40] .These papers mostly describes about the designing the business model where the new IoT business models were proposed, some business models were proposed and also implemented in the industry and a few describe about the empirical studies for business model in IoT.

Stefanie Turber [12], the business model for IoT. Which helps to visualize, analyze and design the business model for IoT in a structured and actionable way.

This business model includes the value network, value creation and benefits. They also conducted several case studies(34) which concluded that this framework is able to represent the business model in IoT.

Liran Liu [13], in their research they applied a traditional value based business model is applied for IoT application to identify how the value is created and that exchanges between actors. The business model element used for the IoT application are value proposition and revenue streams.

Peng-fei FAN [14] in this paper , e3- value methodology is applied to the traditional business model for IoT application. Later the authors designed a business model on value base.That main focus of the business model elements is on value proposition and target customers.

F Berkers [15] in this paper the researchers implemented the business model in IoT by using the value net analysis , they also conducted a case study on the real-world vehicle traffic concept. In the real-world scenario the authors have considered the live data originating from the IoT services which is a serious problem for the IoT business potential. Hence, they used a business model, which provides a platform to grow efficiently and also utilize the resources productively.

Jozef Glova [16] this papers describes about the applying a value based approach to business modeling in IoT. They applied e3-value for a sustainable business model for the IoT application. This business model which is in IoT application analyzes the value and also brings new value objects for the business system.

Xin shi [37] this paper analyzed the existing business models and proposed a strategy for using the business model in development of IoT for China mobiles.The strategy includes four aspects, firstly they they have concentrated on improvement of high-quality network for IoT, secondly they established the value proposition, thirdly they build the key partnerships, finally key activities for launching the IoT product were discovered. The authors have selected the best suitable business model based on business growth point and realizing the continues new increment of value to modify the development in IoT. The selection of the business model for IoT is based on the value proposition, key activities and key partnerships.

Bucherer [38] in this paper the authors have proposed a business model for the value and revenue creation in the IoT. According to authors, the main source of the value and revenue creation is value proposition. The proposed business model is visualized using a framework by Osterwalder [31]. This framework creates the value and revenue for IoT. This business model will serve a tool for practitioners for analyzing their business model while implementing the IoT.

S Leminen [40] categorized the business models for IoT in the manufacturing industries. They have described the challenges like unprofitable environment, exploded market and need to extract more value in the existing business models for IoT and established a framework to identify different IoT business models. Here the main focus is on finding the challenges in the existing IoT business models for the industry.

Maio He [39] have proposed a model to describe the impact of IoT on materials, information and capital flow for the supply chain innovation. The material flow is satisfying the customer demands, informational flow is capturing the demand and capital flow is participating in the financial activities for a better supply chain capital. Along side they also supported their model with the business scenarios, where they created and supported new business that were unavailable in the past. They have also raised few issues and opportunities for IoT on business models.

Regarding IoT on business models few studies reported certain methods and techniques like value based requirement technique, e3- value, etc [16] [14]. Most of the studies focused on implementing the business models on IoT for better business in IoT. For example, value by production of the goods or providing a service has received more attention [16]. But few studies have also focused on designing the business models for IoT to strengthen the business models [18] [17].

Most of the related work focused on the designing software business models and implementing them on IoT application but no study mentioned which software business model is suitable for IoT industry and no study focused on the impact of the IoT on software business models. There is a need for exploring the impact of the IoT on business models software industry. The research aims to support software practitioners and researcher who are implementing the business models for IoT and provides a knowledge on software business models for IoT.

Chapter 3

Research Design

3.1 Aims and Objectives

The main aim is to identify the existing business models for IoT and impact of IOT on Software business models, software development and requirement engineering. In addition, the improvements for IoT business models and IoT requirement engineering are also investigated. The key objectives to attain the goal are:

O1: Summarize the current business models for IoT and identify the most important factor for IoT software business models.

O2: Analyze the impact of IoT on software business models.

O3: Analyze the impact of IOT on Software development especially on requirement engineering

O4: Provide recommendations how requirements engineering are connected to provide better support business modeling for IoT.

3.2 Research Questions

RQ1: What are the current business models for IoT in the literature and in practice?

The current software business model for IoT in the literature was identified through systematic literature review (SLR). The first objective was addressed in the research question. There is a lack of systematic summary of what had been published in the literature regarding IoT business models. RQ1 is the base for the software organizations in understanding how the business model for IoT was used in the industry.

RQ1.1: What are the most important factors for IoT on Software business models?

The most important factors for IoT on software business model were identified through the systematic literature review (SLR). The first object is addressed in this

research question. There is a need for identifying the most important factors for software business models. RQ1.1 is a base for the organization in understanding the what and how the factor generates value for the business model in IoT.

RQ2: What is the impact of IoT on software business models, Software development and requirement engineering?

The impact of IoT on business model and software development is identified through the survey. In the survey business model elements that are extracted from the literature are used. Moreover, the impact of software development especially on requirement engineering is identified. This RQ2 addresses the second and third objectives and forms a base for the organizations in prioritizing the business model elements and RE activities.

RQ3: How requirements engineering can be connected to better support business modeling for IoT?

This RQ3 is used to address the fourth objective through the survey. Since, there is a problem of requirement engineering that connects to the business needs [41]. Here the business model elements are connected to the RE activities which help the practitioners to identify the how the value is generated by the requirements.

Chapter 4

Research Methodology

This chapter explains about the methods used in this thesis. Here, both qualitative and quantitative methods were applied to get the final results.

4.1 Systematic Literature Review

A systematic literature review was performed to find an available related research for a research question through a well-organized process of identifying, evaluating and interpreting available articles [42]. In this research snowballing method is used for searching relevant literature rather than database search.

4.1.1 Why not database search approach?

The reason for not choosing database search was because it is both complex and challenging, where the problems in this research are related to search terms which are suitable for titles and variable quality of abstract and different indexing practices utilized across databases[1] [43]. Furthermore, there is a lot of manual work which also results error-prone [1]. The challenges faced with database selection are creating different search strings, selecting a database, using different search string with help of synonyms for search terms. Therefore, these all challenges lead to missing of literature [1] [44]. According to Wohlin, the database search approach has difficulties with different terms, he also listed few examples where he couldn't find some relevant papers. Hence, by following Wohlin guidelines [1], snowballing is chosen.

4.1.2 Search approach: Snowballing as a search approach

Many authors stress the importance of the systematic approaches to building the knowledge from the literature, including evidence-based software engineering by Kitchenhem et al. [45] information system research e.g. by Webster and Watson [46] and the concept of synthesis of research by Hayes [47] or Wohlin [1]. Wohlin outlined the ways of applying the snowballing process as a search approach for literature review by enhancing the previous literature review in

software engineering [1]. The systematic research was used as a common term for both systematic mappings and SLR [1]. Snowballing is used to highlight the papers which are referenced or cited to identify new papers. Therefore, there is less crash than using a database approach. Likewise, it has been proven that systematic literature study is in practice because on-going new studies should cite at least a single paper based on the existing literature in the particular domain area.

4.1.3 Why Google Scholar was not chosen for selecting start set?

Wohlin advised to use Google scholar to get the start set of papers, that is the basic set of papers for snowballing procedure [43]. To avoid the publisher bias Google Scholar was used, but in Google scholar articles which are not peer reviewed and gray literature were found [48]. Using Google scholar, the scope in extension to literature also lacks regarding providing inevitability for scholarly value and also to get few records [48]. The major disadvantage in Google scholar is experts can easily pick a good set of start papers, but it will be difficult for everyone to find the start set. According to experimental study, outcomes shows that the start set of papers are far perfect from the start set of papers which had same authors for all papers [1]. In our study to meet the end goal, a careful observation of the studies is taken into consideration for mitigating the risk. Regarding ability and capacity, the experimentation by Wohlin resulted that use of snowballing is better than multiple database search [49]. Therefore considering these all factors led us to do snowballing for our Systematic literature review. review.

4.1.4 To find the start set Engineering village is used

As per Knisley "Engineering Village" is the best place to start a search for software engineering research start set of papers then other databases [50]. Therefore, we choose Engineering Village database for selecting the start set of papers. In this study database was compared and search engines for information concerning the various results contributed by different researchers on this topic [50]. In comparison between Engineering Village with Google Scholar for finding the start set of papers, the advantage of Google Scholar is it sorts the papers according to the importance, susceptibility to the academic values. The major disadvantage of Google Scholar is the scope, it returns many articles that are not peer reviewed and gray literature [50]. In our research Google Scholar is not used to finding the start set as our study implies one term, that should be narrowed such as Internet of Things -> Web of things ->Internet for everything and business models. This indicates that our study requires flexibility and findings relevant papers that required more hence we didn't use Google scholar.

4.2 Industrial Survey

There are various methods for an empirical method such as experiment, case study and survey but for our study we selected survey. Since experiment has controlled environment which will not be suitable for our study as our research objective is to identify the impact of IoT on software business model and software development, this reduces our scope of results to the confined environment [51]. For case study it difficult to identify the impact of IoT on software business model elements since few companies may use some of the elements, therefore, results cannot be generalized [52].

Wohlin et al. [53] described various reasons for selecting the survey, since the survey is used to identify both quantitative and qualitative research. Survey is also used to collect the data in a large quantity from various locations globally [54]. Therefore, the survey was selected for our study which helps us to get different opinions from different places globally. The survey questions were designed based on the SLR and background study of our research. The main reason for designing the investigation questionnaires was that they are time and cost effective [54]. The survey questionnaire was distributed electronically since Sproull [55] identified that the average duration for collecting the data is half when it is compared to the conventional methods. The questionnaire was designed using an online tool 'Survio'.

4.2.1 Data analysis

Qualitative data analysis deals with various types of non-numeric data, like the descriptive type of data that cannot be measured [56]. This kind of data analysis is used to convert the data into rational findings, it depends on reasoning and decision making of the analyst because there is no explicit formula for the qualitative data analysis hence it can be sometimes problematic [57]. However, there are few guidelines available for this data analysis, and first the SLR was analyzed then Survey was analyzed separately then analyzed together.

Narrative analysis

We have conducted a narrative analysis of the data extracted through snowballing. Considering the guidelines suggested by Cruzes et al. [58] this analysis is done, since it is the most appropriate analysis method for collecting the information along with the section, ordering and reporting the data extracted from the literature reviews. The particular characteristic of this analysis is the selection and inclusion of studies [59]. The data obtained from the SLR was analyzed through the narrative analysis(for RQ1).

Statistical analysis

This analysis is done after getting the results of the survey, the statistical analysis is based on the variables and statistical methods [60].

Likert scale:

This scale is regularly used for survey questions. There are many different levels(measures from three to nine) to measure the participants responses. Depending on the survey questions the level is selected, for our research five points scale and 3 point scale is used. Here these levels can be dealt with either ordinal or nominal scales, for our thesis ordinal scale is used. For statistical analysis, descriptive and interference methods are used for analyzing the data. Since the samples of our thesis are non-probabilistic, we choose descriptive analysis which is used to analyze the sample size survey based on the ratio such as mean, deviance, variance. For our survey close ended question were examined and analyzed, using descriptive analyzes we get the sample and measures [59]. We also used Chi -square test to find a statistical difference between the obtained value and expected value and also to find the difference that occurred due to the sampling error [5]. The chi-square test is related to two hypothesis, null(H0) and alternate hypothesis(h1). Null hypothesis assumes that there is no variation between two variables when they are compared while alternative hypothesis implies that there are some change and difference between two variables when compared.

Chi-square test calculated using the formula:

$$\chi^2 = \sum \frac{(f_0 \quad f_e)^2}{f_e} \tag{4.1}$$

Where, f_0 = Observed frequency and f_e = Expected frequency.

The value obtained from the chi-square test is used to accept or reject the hypothesis (null or alternative). If the value obtained is more then the hypothesis is accepted, if its less then hypothesis is rejected. The chi-square values also need the information regarding the level of confidence and degree of freedom.

Degree of freedom is calculated using the formula:

$$df = (c \quad 1)(r \quad 1) \tag{4.2}$$

c= Number of categories in the column.
r= Number of categories in the row.

To validate the chi-square test values depends on the multiple considerations of the researcher while predicting and analyzing the results. The considerations

the research must consider for each category must be at least 1, moreover not greater than 20% of the group must be less than five [5]. If these conditions don't meet, then the chi-square values are not valid [5].

The relationship between two variables is decided by Chi-square test while Cramer's V predicts the strength of the relationship between two variables [5]. V measures the range from 0 to 1 where if V=0 the there is no association and if V=1 then there is strong association [5].
Cramer's V is calculated using the formula:

$$Cramer' \quad V = \sqrt{\frac{\chi^2}{n(M \quad 1)}} \tag{4.3}$$

Where, χ^2= Calculated Chi-Square, n=Sample Size and M= Minimum number of row or columns.

If the variables contain only 2 categories then Phi(Φ) value is used.
Phi is calculated using the formula:

$$PHI(\Phi) = \sqrt{\frac{\chi^2}{n}} \tag{4.4}$$

Where, χ^2= Calculated Chi-Square, n=Sample Size

Table 4.1 describes the measures and their perception of Cramer's V and PHI values.

Table 4.1: Perception of calculated Cramer's V, PHI and Measures of association [5]

Measures	**Perception**
.00 and under .10	Negligible association
.10 and under .20	Weak association
.20 and under .40	Moderate association
.40 and under .60	Relatively strong association
.60 and under .80	Strong association
.80 and under 1.00	Very strong association

Friedman test

The primary reason for using the Friedman test is, when there is no relationship between the demographic parameters, then the non-parametric test like Friedman

test is used [61]. To identify the variance between the impact of IoT on software business model and software development descriptive statistics was performed with the help of Friedman test. By performing the Friedman test the standard deviation variation along with significance with respect to each values can be represented using the mean rank.

Chapter 5

Description of research methodology

5.1 Snowballing procedure

The snowballing procedure contains two steps: (1) Acquiring the start set papers and (2) Performing iteration in backward and forward snowballing.

5.1.1 Acquiring and designing start set papers

According to Wohlin [1], for a better start set we have to follow the following qualities:

1. must be on different kind of papers which covers different years, authors, publishers, and communities.
2. The number of papers or quantity of start set depend only on the area which is being concentrated. For example, if the topic is specific then the required papers are few or else number of papers for a broad area.
3. If the results are too many papers because of the search string, then the alternative to get a good start set is to identify the highly cited paper and relevant references.
4. To mollify the risk of missing proper papers we have to use different synonyms and vocabulary with the keywords from research question.

Step 1:For the start set identification, the initial keywords are used from the research questions. Vocabulary or synonyms are also used as keywords. Operators like AND and OR were used. The following is the search string used to get the start set:

(Internet of Things" OR "IoT" OR "Web of Things" OR "Industrial Internet" OR " Internet of Everything") AND (Business Models)- 191 Articles

Finding a good start set is similar to the challenges in finding the search string in the database search. As mentioned earlier, this research encounters the

problems with vague terminology. Therefore, our aim is to focus on getting a good start set than concentrating more on the search string. A simple search string and Engineering Village database used to get the start set

Before the systematic literature was done, we conducted a test for our search string. This test was done to know the competence and usefulness of the selected studies. The author conducted the review, and the supervisor evaluated that.

Step 2: Tentative Start set of papers.
With the search string, we started to search in Engineering Village and included the studies which are published in English only. The papers which are included are in the study are based on the title and abstract. To decide the inclusion / exclusion criteria the preference order goes as, the tittle of the article followed by abstract and then full-text if needed. The paper which the full text is not available is not considered in our studies. In the below the inclusion/ exclusion criteria is explained in detail.

Inclusion Criteria:

- IC1: Paper that are published from 2010-2015.
- IC2: Paper that are only published conference, journals or other peer-reviewed e.g. workshops.
- IC3: Papers that are only related to internet of things, internet and business models.
- IC4: Articles that are available in only full text.

Exclusion Criteria:

- EC1: Papers which are not written in English.
- EC2: Papers that are partly available are excluded.
- EC3: Studies that are not related to Software Engineering for example the studies that are related to hardware, system programming etc. are excluded.
- EC4: Research articles that are not peer reviewed are excluded.

Inclusion and exclusion criteria were applied during the set start extraction. The search string results from 191 articles by using the IC1 and EC1 it gives 171 items. The reason for choosing the articles from 2010 is due to the research which is started from 2010, since 2012 the research is stable. By using IC2 and IC3 only

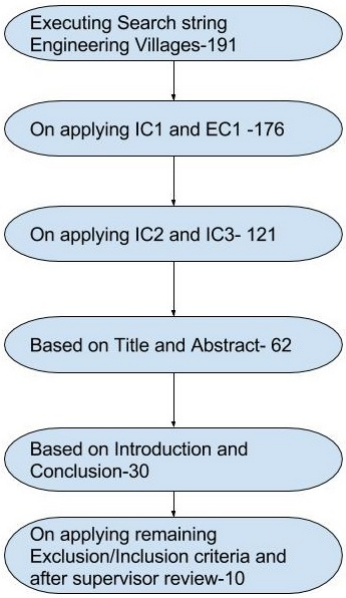

Figure 5.1: Inclusion/Exclusion Criteria

121 papers. After considering the titles and abstracts, only 62 papers found. Later based on the introduction and conclusion only 30 articles are found.Upon using the remaining inclusion and exclusion criteria, review by the supervisor only 18 papers are found. The papers which are discussed by the author are cross-reviewed by the supervisor to mitigate the risk of avoiding relevant papers.

Step 3 : Start set papers.

After finding the start set another filtration is done by considering the number of references and citations of each paper because there are 253 references and 60 citations for the tentative start set. Since it is a snowballing approach, the paper that is chosen must have relatively many citations and references. The candidate papers are fully read, and papers with a high citation and more references lead to giving more coverage on relevant studies [1]. After reading the full articles, only 10 were considered and selected. These articles were also reviewed by supervisor before finalizing.

5.1.2 Performing iteration in backward and forward snowballing

In the resulted start set of papers, backward and forward snowballing was performed, see figure 2. Only two iterations were conducted. Forward snowballing is looking at the citations and back snowballing is looking at references. The same inclusion and exclusion criteria are applied for each forward and backward snowballing that is used for the start set. Google scholar is used to finding out

the citation for each paper. The following explains the inclusion criteria in detail.

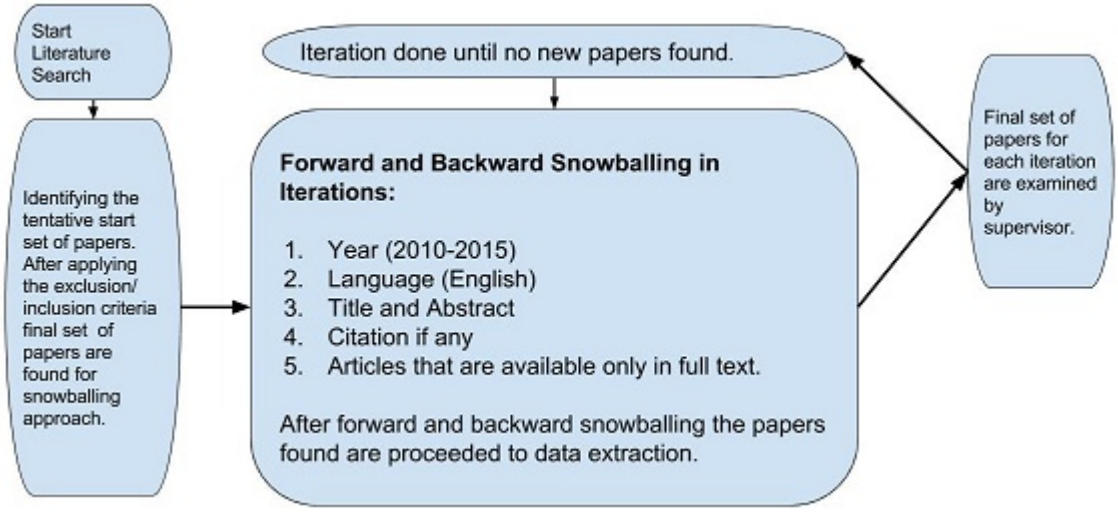

Figure 5.2: Snowballing Iterations

5.2 Quality assessment based on Rigor and Relevance

After snowballing for the final set of papers this quality assessment is conducted.We applied rigor and relevance [62] to check the truthfulness of identified studies and the business models they described. Rigor is an exact way to use the research method for the expected proposed and finalized in consonance with a suitable purpose, and relevance is the identifying the impact of study in the industry [62]. An assessment checklist is made for rigor and relevance which is recommended by Ivarsson et al. [62]. The primary reason for using this method is, it gives confirmation to synthesize the results, since this study is very apt to the industry. Finally, a rubric-based assessment is applied to this study, these rubrics are mapped to reach the objective criteria [62].

Rigor:

Context(C): The study characterizes to the extent it can be identical to another environment in general. Especially, subject types are classified to researchers, expert, and graduates. If all the factors are identified then C is estimated with a value 1, if some of the factors are missing, then C is estimated to 0.5 and if no other factor matches then C is estimated with 0.

Design (D): The research design is clear, genuine and structured enough that is understandable for the reader. Especially the variable outcomes, the number

of data sampling, measurement criteria then D is estimated with 1, if some of the factors are missing, then D is calculated with 0.5, and if the above factors are not present, then D is estimated to 0.

Validity Treats (V): In this study if the validity threats like internal, external, conclusion and construct validity are assessed then V is estimated with 1, if some of the factors are missing then V is determined with 0.5, and if there are no validity treats then V is given 0.

Relevance:

Subject or User (U): If the papers used for this study are from industry then U is estimated with 1, if graduates or masters are specified then U is expected with 0.5, and if subject's information is missing then U is given as 0.

Scale(S): If the size of the industry is utilized then S is estimated as one otherwise S is will be given 0.

Research Method (RM): If research method is applied in the real world context with the importance of practitioners that is an experiment, case study, interview, the survey then RM is estimated with one else RM is given 0. **Context(C)**: If the studies implemented in the real world or industrial environment the C is evaluated with one otherwise C is given as 0.

5.3 Validity treats to literature review

According to the Wohlin et al..[49] Petersen et al..[63] the validity threats for the snowballing phase is categories into four stages. In this section the treats are addressed and how the threats are handled to reduce their impact.

Internal validity: The principle idea of selecting the snowballing is to capture the available literature reducing the researcher preference. Hence internal validity is a primary challenge for this study. Hence to amend it, the supervisor had accessed the review protocol. Additional to this, choosing the articles which are open literature study for IoT Business Models can be treats of avoiding. This treat is addressed along with supervisor for each iteration in snowballing. Therefore, it reduces the researcher's preference. By using the guideline of Petersen et al. [63] the internal threats are minimized.

Construct validity: This validity treat targets on some potential to find the capacity to achieve the aims and objectives, it mainly depends on the formulation of the search string. In construct validity search string is a treat to our research, formulation of search string may not fetch us relevant and appropriate articles for our start set. To overcome this refining the search string with the help of supervisor is a solution to our treat.

External Validity: This validity treat is considered as a potential to generalize the results. In this study most of the research fall into case study and industrial context that is they have more rigor and relevance. Therefore the final outcomes are generalized and are appropriate to the industry.

Reliability: This depends on the extent of data and analysis related to our topic, thus to improve reliability many strategies were considered. To find the start set for snowballing "Engineering Village" rather than "Google scholar", this is done to avoid the not peer reviewed papers. Hence, there is a chance to miss few articles that are relevant to our study. Therefore again the cross check is done with Google Scholar to find the necessary studies. Additional to this, there is the chance of missing primary and secondary studies with the same search string. Therefore, ten paper were identified for the exactness of the search string and forward and backward snowballing is done to find the relevant articles related to the IoT business models.The assessment is done by the author and later assessed by the supervisor.

Quality assessment of the chosen papers was assured with the help of rigor and relevance criteria. Quality is assured with research type of studies and peer-reviewed articles. An excel sheet is created, and data equity is mapped with the research question. According to the guidelines of Ivarsoon [64], rigor and relevance are rated, and data equity for each paper is examined by both author and supervisor.

5.4 Industrial Survey

The survey question were based on the literature review. This section describes the structure, design, distribution and participants for the survey.

5.4.1 Survey structure

The first question in the survey is about the involvement of IoT on software development and selling IoT products. Based on this issue the further investigation is classified into two alternatives, where one alternative is the participants who are involved in the IoT project have few more question regarding their project. The other alternative is the participants who don't have any involvement in the IoT can directly go to the importance of Business model in Appendix C.

In the first alternative, there is few question related to the IoT project, the participants role in IoT project, the participants IoT project is targeted on which department, size and age of the organization which the participants are working for, and the final question are age of the IoT project which they are working. In

the second alternative, the participants generally can answer the question who have knowledge on IoT business models.

Both the alternatives meet at the question 7 where the first question was the importance of the business model question. Second was the impact of IoT on software business model, software development, and requirement engineering. Third, these are open ended question where the participants are requested to answer to improvements for IoT on the business model and requirement engineering. Final questions were open questions. Figure 5.3 represents the graphical representation of the two alternatives of the survey.

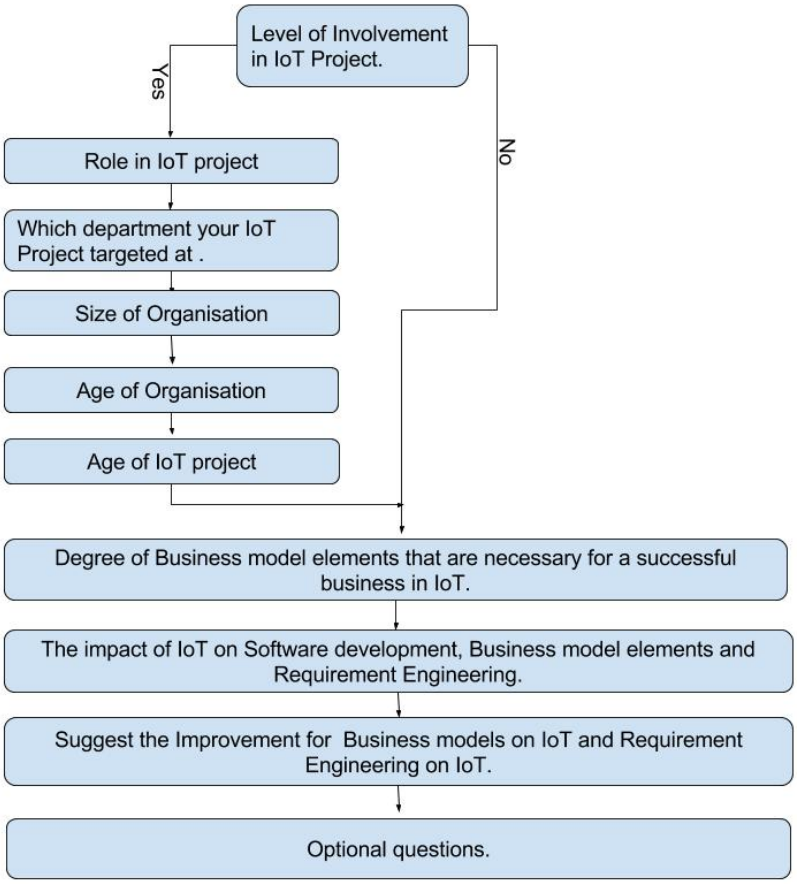

Figure 5.3: Survey Structure

5.4.2 Survey Design

In this section, each question of the surveys are described more intensively.

Question about IoT project (Section 2): In this sections, questions are answered by participants in alternative 1, the question are about the IoT projects in order to compare with the outcomes of different groups , the following components are divided for the IoT project :

1. Role of participant in IoT project.
2. Department of IoT project where the participants are working.
3. Size of the organization.
4. Age of the organization.
5. Age of IoT project.

These questions were designed using the categorical scale.

Importance of Business model (Section 3): The primary goal of this section is to explore the importance in business model canvas elements as these elements are mostly used in the IoT business model that were discussed and analyzed in the literature review. These items are rated by the participants who will be helpful to the success in business for IoT. Likert scale was used, to indicate the degree of agreement between the factor.

Impact of IoT (Section 4): This is the central part of the survey, in this section, there are three question where the impact for IoT on software development, business models, and requirement engineering is rated by the participants. Firstly the impact of IoT on the software development is rated by the participants. Secondly, the impact of a business model is rated, the factor that is used to find the impact are extracted from the literature review. Even here Likert scale is used.

Suggestion for Improvement of IoT on Business models and requirement engineering (Section 5 and section 6): These are open-ended question, where the participants are requested to suggest about the improvements of IoT on requirement engineering that supports the software business model based on their experience. There is an open ended question for the participation, where, the important issue that still needed to answer in the impact of IoT on business models was asked.

5.4.3 Survey Distribution

The survey is made in the online survey tool "survio", this online tool is used to reach participants in a short time. Before the survey distributed, a pilot study was conducted to identify threats and correct them. Later the survey is being circulated in various online groups. Survey participation takes approximately few minutes.

5.4.4 Survey participants

This survey was distributed in various IoT online groups, all the participants were assumed to have basic knowledge on IoT. Therefore, the error will be minimal. The survey is distributed online are listed below.

1. Post in IoT Linked In groups.
2. Post in IoT Meet up groups.
3. Post in IoT Facebook groups.
4. Usage of mailing list, the authors contacts who have experience in IoT projects.

Chapter 6
Results and Analysis of Literature Review

6.1 Results

6.1.1 Start Set

For the start set 10 papers i.e. from P1 [14], P2 [12], P3 [65], P4 [16], P5 [66], P6 [15], P7 [67], P8 [68], P9 [39], P10 [40] were chosen from 191 papers obtained from Engineering Village database. The table A.1 below are results obtained for start set.

6.1.2 Iteration 1

Backward Snowballing:

For the backward snowballing in the first iteration, a total of 253 references are fully examined and evaluated. After evaluation 71 are removed on basis of publication type, 13 were removed due to language, 108 were removed based on titles and 16 were duplicates, and 43 were removed based on abstract and full text. Finally 5 papers are extracted i.e. from P11 [69], P12 [70], P13 [38], P14 [71], P15 [37] as shown in table A.2.

Forward Snowballing:

For the forward snowballing in the first iteration, a total of 60 citation are considered where 10 of the papers were removed based on language, 27 were removed based on the title, 5 were duplicates, 14 were removed based on the abstract and full text. Lastly, 4 papers are included for the further studies i.e. from P16 [33], P17 [72] as shown in table A.3.

6.1.3 Iteration 2

Backward Snowballing:

In the backward snowballing for the second iteration, a total of 298 references are examined and evaluated. After the evaluation, 129 were removed based on the publication, 116 were screened based on the title and 9 were duplicates, 44

were removed after reading the abstract or full text. Therefore only one paper is extracted i.e. P20 [73] shown in the table A.4.

Forward Snowballing:

In the second iteration of forward snowballing a total of 232 references are cited. Where 101 were screened based on the title, 62 based on the publication, 23 based on the language, 10 were duplicates and finally 14 were removed based on the abstract or full text. Finally one paper was extracted i.e. P21 [74] as shown in the table A.5.

6.1.4 Iteration 3

Backward Snowballing:

For the backwards snowballing, 44 reverences were thoroughly examined and evaluated, in which 22 were removed based on the title, 17 were screened based on the title, 2 were removed based on the language, and 2 were removed based on the abstract or full text.

Forward Snowballing:

For the forward snowballing, 8 citation were examined thoroughly examined, among which 3 were found duplicates, 4 were screened based on the title and one were removed based on the abstract or full text.

6.2 Synopsis of selected studies

From the snowballing iterations, 21 papers are found during the period of 2010-2015. Internet of Things (IoT) on the software business model is a novel concept, and the research is started from 2010. Over the five years of time span between 2012-2015 most of the papers are published and organization begun to use the software business models for IoT. The figure 6.1 below shows the details of some publication in the period of 2010-2015. In figure 6.1, there is a decrease in the publication in 2015, since the author identified the start set in mid 2015 the number of publication until March was very less.

6.2.1 Classification of papers

The identified papers are classified based on the research methodology (Survey, case study, experiment, etc.) and type of study (Evaluation, proposal, solution, etc.). In figure 6.2, X-axis represents the research methodology considering framework, survey, case study and the y-axis represent the type of study represents evaluation, proposal, validation, the solution as defined by Wierlinga et al. [75]. Among the 21 papers framework proposal are seven papers [P6, P10, P11,

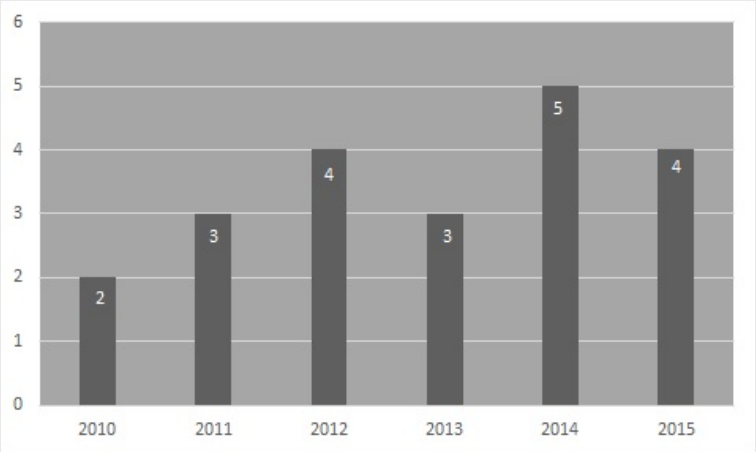

Figure 6.1: Publications Over the years

P14, P16, P17, P19] where these papers have followed the Osterwalder [6] business model elements for proposing the framework for IoT. Case study - evaluation were 6[P1, P4, P7, P8, P15] and final category of survey evaluation was 5[P3, P5, P12, P18, P21] identified in selecting the business model elements that are used for IoT business models.The following figure 6.2 summarizes the classification of papers.

From the classification, it was clear that most of the articles proposed framework but that were not implemented in the IoT industry. This implies a gap in the implementation of the business model framework. The next were case-study evaluations which imply even here there is a difference in addressing the challenges faced in the case-study. Furthermore, few studies have done empirical research on the business models which are used in the identification of the business model(canvas) elements for IoT.

6.2.2 Quality assessment based on the rigor and relevance

For the quality assessment based on rigor and relevance, the papers are categorized into four quadrants (A, B, C and D) according to the score of rigor and relevance. Classification of papers done based on the score which is listed below.

Rigor:

1. Score from (0-1.5) are classified into low rigor.
2. Score above (2) are classified into high rigor.

Relevance:

1. Score from (0-1.5) are classified into low relevance.
2. Score above (2) are classified into high relevance.

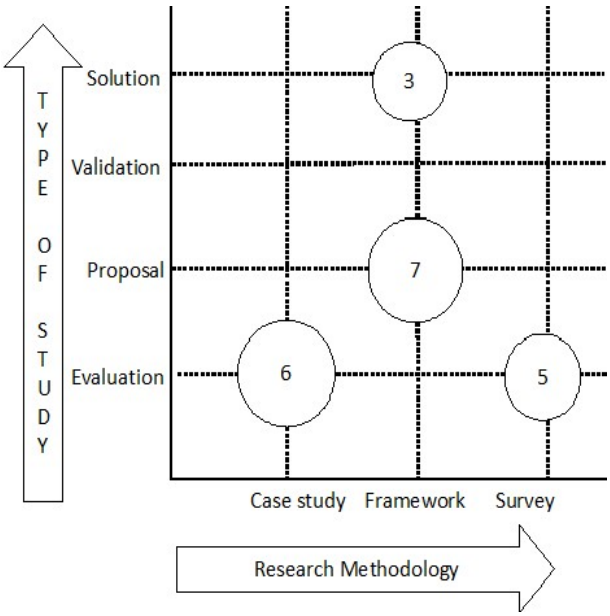

Figure 6.2: Classification of Papers

The figure 6.3 below describes the scores of the rigor and relevance, the score are categorized into the four quadrants. The papers with high rigor and relevance are considered as more good papers than other papers. Out of 21 papers, 7 papers were found with high rigor and relevance, 6 papers are found with high relevance and low rigor, 5 papers were found with high rigor and low relevance, 3 papers were found with low rigor and low relevance.

Based on the quality assessment, the authors identified that case study has high rigor and relevance than other methodologies which inferred that the experiments done in this domain are low, they might not have been implemented in the industrial setting. Even studies few are framework proposal which has high rigor and relevance, which implies that proposed might not have applied in the industrial settings.

6.3 Data Extraction and Analysis

6.3.1 The important factors of Software Business model for Internet of Things(IoT)

In this section, the papers were analyzed to identify the aspect of business models which captures the value for IoT. Amit, zott [76] defined the business model as *a model that describes the content, structure, and governance of transactions designed so as to create value through the exploitation of the business opportunities.*

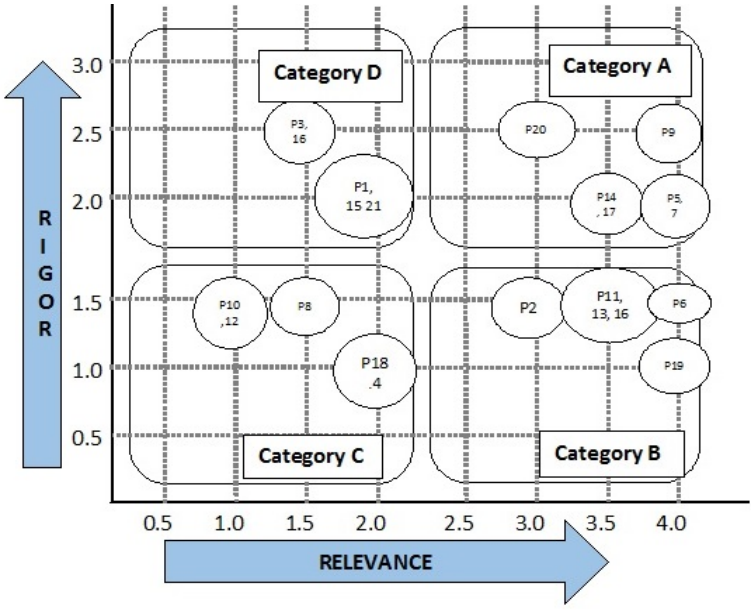

Figure 6.3: Quality assessment based on Rigor and Relevance

According to Amit [76] the business content refers to the exchange of information between the IoT resources and their efficiency that are required to enable the transfer. Business structure refers to the ways in which the participants exchange and get linked, transactions governance describes the way in which the flow of information are controlled by the participants. Amit [76] also mentioned that the definition of the business model is consistent with the significant factors of business efficiency(highlighted by the transactions cost), lock-in, novelty and complementarities which are used to create value. The business model is constructed (business model structure, content and governance) with a source of value creation (sources are factors like efficiency, complementarities, lock-in, and novelty).

Efficiency: To create value from the IoT products or services the IoT software development must be efficient. Therefore, to get efficiency the organizations must identify a way from the IoT capabilities and create new business models that add value to their products. We identified 9[P2, P5, P6, P8, P11, P14, P16, P18, P20] papers that were discussed below regarding the efficiency in IoT business models.

In P14, the authors have focused on challenges for creating the value, security in the flow of information for IoT. They provided a tool for designing the business model for the IoT. The tool was built on various aspects for creating value in the business model for IoT. This improves the transaction speed and simplicity. In P20, the authors have designed a framework for IoT business models. This framework represents the business models regarding design, needs, and aspiration

which simplifies presentation, analysis and design of a business model for IoT. For accessing a large number of products, services, and information in the physical world. As far the trustworthiness of results for theses studies based on rigor and relevance 2 (P14, P20) studies fall under category A.

In P2, the authors have discussed the decision making regarding the IoT business model in the Software industry, they also discussed various features of the business models in the industry. They proposed a business model for their case study in the IoT postal logistics, which reduced the asymmetry of information and also there is transparency in the flow of transactions for the content in the business model. This gains efficiency for the business model content and also value is created. Jozef Glova in P6 has applied the e3-value technique for handle the business modeling perspective information. Using this approach the author have reduced the information symmetric and described how the business model can be sustainably developed for the IoT. P11, P16 a business model was proposed which used to capture the value creation. Both studies concentrate on capturing the value for IoT applications. These business model, in each study reduce the information asymmetry and also increase the transparency of the flow of information in a business model for IoT. The P11 and P16 use traditional business model for proposing the new business model. As far as the efficiency is concerned the results of this studies are based on rigor and relevance, therefore, (P2, P6, P11, P16) were classified into Category B.

In P8, the authors have described the transparency in the flow of information for business model content for IoT. They have identified the value network for the collaborating partners like source value creation and benefits for collaborations. They proposed a new model where the efficiency is more in transparency in the business model for IoT. In P18 a business model was proposed which used to capture the value creation. This studies concentrate on capturing the value for IoT applications. In the business model there is a reduce in the information asymmetry and also increase the transparency of the flow of information in a business model for IoT. P18 suggests a business model based on the primary challenge of creation in value. Hence, the results of these studies P8 and P18 fall under category C.

Complementarities: Brandenburger [36] have identified that the complimentary are also the source of value creation in IoT software business, where the customer value is given more preference. Gulati [77] if the customer is satisfied they are the complementors and increase in complimentary increases the revenue. Five paper[P5, P8, P13, P19, P20] have discussed the participants in business model offers the complementarities for IoT product and services.

In P5 the authors have proposed a new business model approach which focuses

on the value proposition, that is the value based approach where the combination of both online and offline transactions are done in a case study of health care services. They used this business model approach in a tele-health care monitoring system for patients with diabetes. This approach enables cross-selling between the participants and the IoT product.From P20, the authors have explained the importance of richness in the potential market for large scale industries in the context of IoT. They have developed a business model framework for the specialized resources. The author has implemented the business model in large scale for value creation. As far as the evidence is concerned these two papers (P5, P20) paper falls into the category A.

In P13 and P19 the papers focused on the benefits for IoT products and the customers satisfaction, where the complimentary services offered by the business models participants. These papers have discussed the IoT reach in the market to generate the revenue for the large scale companies. These papers fall under the category B.

In P8, the paper described designing a new business model and analyzed the business model in the context of IoT. The authors have applied their business model in various case studies; this resulted the business model offers a strong value chain integration for IoT products. This paper lies in the category C.

Lock-in: Lock-in is a method which is used to achieve the profits and create value for the IoT business model [78]. Amit, Zott [76] lock-in creates a positive effect on efficiency and complementarities hence there is an important relationship between lock-in, efficiency and complementarities to create value. To create the lock-in for any business model the must be transaction reliable, customer preferences and must offer loyalty. 7 paper[P2, P5, P8, P14, P15, P17, P18] have described the content of lock-in for the business model.

From P5 to create lock-in the authors have designed a dominant IoT business model. This business model can bring changes to the value object and also bring new participants for a better performance of the model.In P14, the authors proposed a new tool for designing the business models. This tool is reliable when the participants depend on the business model in the IoT industry for creating value. This model is used to generated to capture the value through the value flows in the business model. The authors in P17 have compared several successful IoT business models and analyzed that they benefit the end-user in personalizing the products or services. They have also analyzed the participants lock-in and found improvement in resource utilization (Reputation, simple transactions) for the IoT goods or services. To make the above studies stonger these studies(P5, P14, P17) fall under category A

In P2 the authors to create lock-in for the IoT business models they have offered customers preference in the case study they have described. In the case study they described that the customers can compare the features of IoT and choose features according to their preferences. This study falls under the category B.

In P8 and P15 the authors have proposed a business model framework which can be customized by the participants, the features(different underlying networks) in business model for IoT context can be changed according to the participants preference. The authors have created the lock-in for the benefit of the customers and also the business model framework is very reliable to the participants since the business models frameworks allow to visualize the model for IoT. These studies P15 falls under category A, while P8 falls under category C.

Novelty: From innovation of new ways to do business, the value can be created, and this eliminates inefficiencies in a business process that capture the customer also needs creates new markets [76]. In 8 papers[P3, P4, P7, P8, P9, P10, P11, P12] the new ways for the value creation are described for the IoT business models.

In P7 and P9 the authors have described the link between the participants in the business models, they have also applied the IoT business model in the industry to find the quality and depth of the linkage. These studies fall into category A.

In P4, P8, P11 the authors have proposed a business model framework tool which enables the unique capability of the new business models, where these business models focus on innovation of IoT products and services to create the value in the market. The authors have also addressed innovative solutions through this tool which expands the business market.

6.3.2 Software Business Model elements that were considered for Survey

Osterwalder and Pigneur [6] have identified the most common blocks for the business models, and they have constructed nine blocks. Since most of the studies that we had discussed in the literature has also used Osterwalder business model(canvas) elements for IoT applications. These elements are used for the survey, since many organizations used these business model elements for describing the value they offer to the customers. Table 6.1 are various business model elements that are described by Osterwalder and Pigneur [6].

Table 6.1: Business Model element [6]

Business model elements	**Description**	**Papers**
Customer Segmentation	The value that is offered by the company to the segments of the customers.	P1,3,6,7,10, 11,13,15,20
Value Proposition	Complete view of the company's product and service	P1,2,3,4,6,7, 10,11,12,13,15 ,17,20,21
Channels	Numerous ways of company to get in touch with customers.	P3,6,10,13,20
Customer Relationship	Different types of relationships between the company and segments of the customers.	P1,3,10,13,15, 20
Revenue Streams	Details the number of ways a company can make money through revenue flows	P1,2,3,4,6,7, 10,11,12,13, 15,17,20,21
Key Resources	Adjustment of activities and resources.	P3,6,10,13,20
Key Activities	Necessary flow to execute the company's business model.	P3,6,10,13,20
Key Patnerships	Agreement with other companies to offer and degrade the value.	P3,6,10,13,20
Cost Structure	Describe the cost structure of business model.	P3,6,10,13,20

6.3.3 Discussion and Conclusion of SLR

Among the 21 papers of IoT business models, 13 articles have discussed the proposal of the business model, and the remaining papers were about the challenges faced by the IoT business models. Most of the studies are based on Osterwalder [6], where the business model elements were focused. As entitled by Jozef [16] the IoT business models will provide exceptional flexibility to generate an in-depth relationship with customers and reduce the waste processes to deliver value with less amount of resources.

Many papers have discussed the proposal of the business model, but few of the researchers have implemented the business model in the industry. For example, R.M. Dijkman [65] have just proposed a business model but have not executed due to lack of detailed research on IoT in Software industry.

Software Business model factors such as Efficiency, Complementarities, Lock-in, and Novelty are discussed in the literature. This factors was focused on creating the value for business and to generate the revenue. The efficiency is

dependent on symmetric and transparency of information in the business model. Complementarities depend on the customer preferences and business model offerings(Complementaries). Lock-in depends on the reliability of transaction in the business model and finally novelty depends on the capturing the new ways of creating the value of the IoT products or services. Utilizing all these factors in a business model can improve the quality of IoT product and also generate revenue.

Also, the business models elements that are described in the literature Table 6.1, are the building blocks for any business model to make revenue for any products. These elements are used to improve the understandability of operations in the business. In this master research, the focus is on finding which element of the business model is important for the IoT product, since there is no research is done.

To summarize, IoT business model element along with its factors will deliver value and generate revenue for the software industries. The factors are used to improve the quality and revenue for IoT products while the elements of business models are used to enhance the structure of the business.

Chapter 7

Results and Analysis of Survey

In this section the finding of the survey were reported which were posted in LinkedIn, Facebook and Google groups. where the author received 61 responses in total. The results were analyzed, while performing analysis the author identified that 5 responses have no experience in IoT, so they were removed and the remaining 56 responses were analyzed. The completion rate of the survey is 92 % as per Kitchenham et al. [79] this calculated rate will be sufficient to consider the results.

7.1 Demographic

7.1.1 Analysis of respondents information

The survey is aimed towards software personnel for those who have knowledge on IoT and Business models. Questionnaire 2 was aimed to identify the role in IoT project where 8 roles were identified during the survey preparation.From the 56 respondents there were, 9 project manager(16%), 10 Software developers(17%), 7 Product developers(12.5%), 4 Customer developers(7.1%), 7 Hardware Suppliers(12.5%), 9 Services(16%), 4 Support(7.1), 3 Logistics(5.3%) and 3 other(6.5%).

The roles of respondents presented in the figure 7.1.

The third question was aimed to identify the department which their IoT project is targeted at, 11 were identified while survey preparation. From the 56 respondents IoT project targeted at, 8 Automotive industries, 6 Education, 12 Smart Cities, 4 Supply Chain management, 2 Logistics, 10 Smart Home and smart buildings , 5 Telecommunication Industries, 5 Manufacturing Industries, 3 Security, 0 Independent living, 0 Recycling, 1 Others.

The figure 7.2 presents department of IoT project.

In the survey the first and sixth question was aimed to know the level of involvement in the IoT project development or setting up IoT infrastructure. This question was asked to know the weather the respondent are involved in project or not, if he is not involved then it would be easy to find the respondents who have no experience in IoT. The bar graph is prepared which is used to recog-

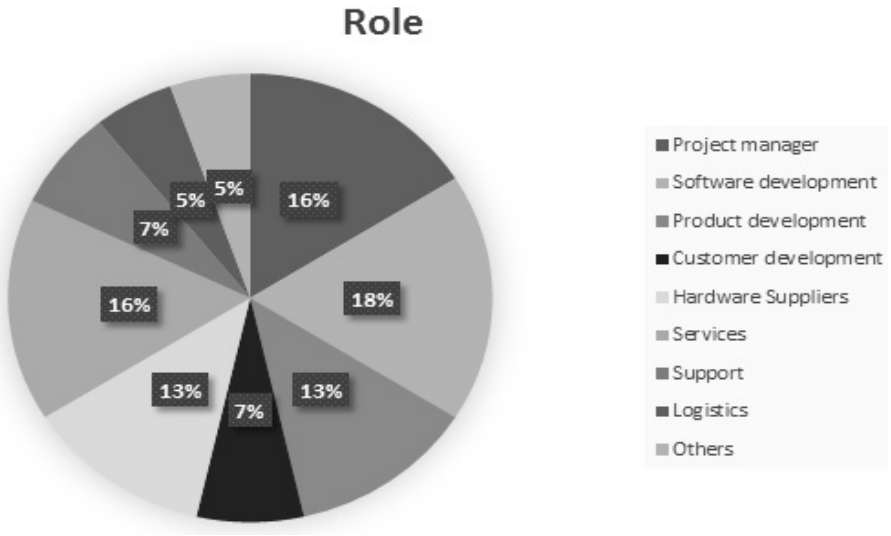

Figure 7.1: Respondents Role

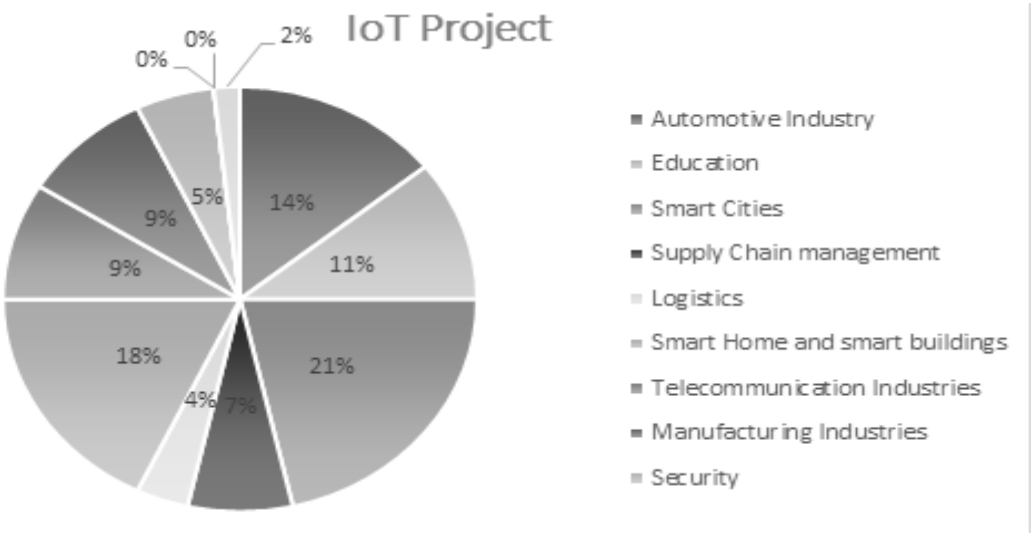

Figure 7.2: Respondent IoT project

nize the involvement of IoT project. From the analysis it was identified that the respondents involvement in the IoT project is 32% respondents have 0-1 years of involvement, 28% respondent have 1-3 years of involvement, 37.5% respondent have more than 3 years and 8.9% have no involvement hence they were removed. The figure 3 describes the involvement. Furthermore, the experience in IoT project development or setting up IoT infrastructure is 37.5% have experience between 0-1 years, 30.35% have experience between 1-3 years and 32.1% have experience more than 3years. The figure 7.3 represents the experience of respondents in IoT devlopement or setting up a infrastructure.

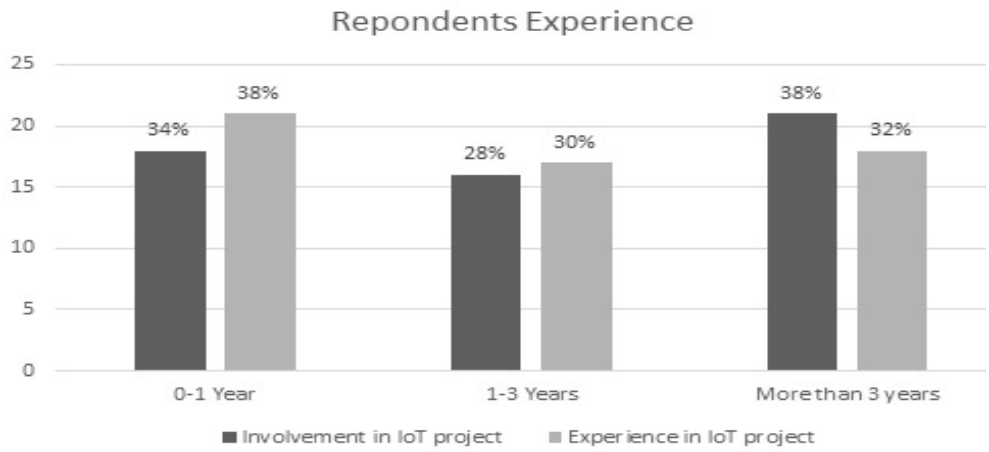

Figure 7.3: Respondents Experience

Figure 4 outlines the results for survey question 4.. From the analysis the author observed that, 18% were working for a small scale organization, 37.4% were working for a medium scale organization and 44.6% were working for a large scale organization.

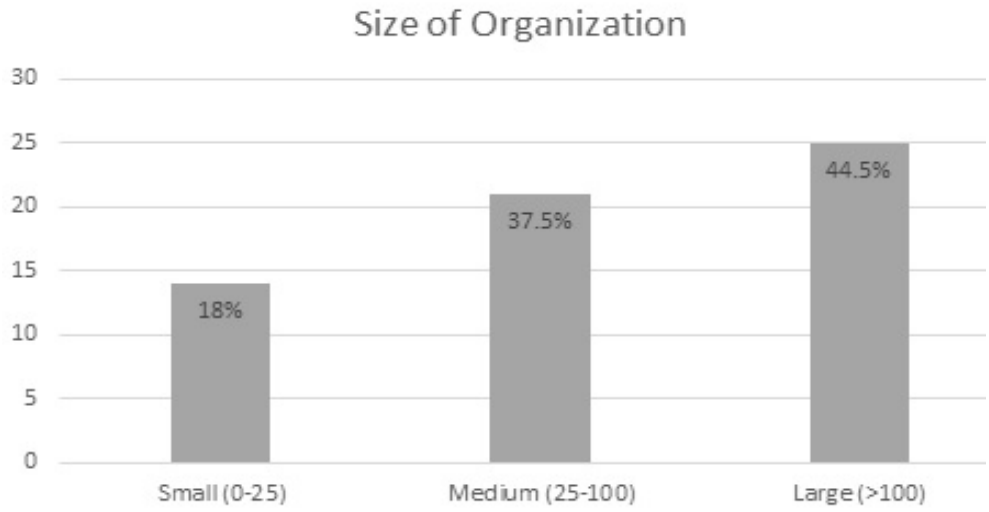

Figure 7.4: Size of Organization

7.2 Importance of Business model elements for IoT

To know the level of importance of IoT business model elements that are obtained through the literature, see section Literature review results for details, the respondents were requested to indicate the level of importance of business model elements for successful business in IoT.

The list of business model elements that are obtained from the literature review were presented to the participants and requested to mark the level of importance to business model elements for IoT business. The results are visualized as heat maps that defines the amount of responses that were obtained for each business model element on subject of the importance of business model elements for IoT business. In the heat map below the highest numbered cells more than fifteen are the strongest unit of the importance and the lowest numbered below fifteen are the lowest important. Table details the importance of the business model element for IoT business.

Table 7.1: Heat maps for Importance of business model in IoT

	Disagree Strongly	Disagree	Neutral	Agree	Strongly Agree
Customer Segmentation	0	0	0	24	32
Value proposition	0	0	6	17	33
Channels	0	0	13	43	0
Customer Relationship	0	0	3	34	19
Revenue Streams	0	0	10	19	27
Key Resources	0	0	9	28	19
Key Activities	0	0	15	24	18
Key Partnership	0	0	20	21	17
Cost Structure	0	0	22	22	12

From the table 7.1 we see a clear indication that value proposition, customer segmentation, and revenue streams are strongly agreed aspect for IoT business model element. Key resource, key partnerships and cost structure are agreed element while channel is categorized as neutral. Friedman test is conducted to know the standard deviation, mean and variance in the section.

Friedmen test was used to calculate standard deviation, mean rank and variance to the business model element for successful IoT business. The level of importance is based on the acceptance of that were provided as Strongly disagree(1) Disagree(2) Neutral(3) Agree(4) Strongly Agree(5). The values are listed in table.

On checking the mean rank values obtained from the Friedman test of the table 7.2 it is very clear that the value proposition(mean rank: 5.78) is most important

Table 7.2: Friedman Test for importance of business model in IoT

	N	Mean	Std. Deviation	Mean Rank
Customer Segmentation	56	4.3393	.47775	5.26
Value Proposition	56	4.4821	.68732	5.78
Channels	56	3.7679	.42602	3.23
Customer Relationship	56	4.3214	.57547	4.89
Revenue Stream	56	4.1071	.80178	4.94
Key Resources	56	4.2321	.66033	4.62
Key Activities	56	4.1786	.76532	4.61
Key Partnership	56	4.6071	.49281	4.60
Cost Structure	56	4.2321	.68732	4.45

element for the IoT business, followed by the customer segmentation(mean rank: 5.26), customer relationship(mean rank: 4.89) and revenue streams(mean rank: 4.94).

Discussion

In the literature, value proposition in the business model elements plays are crucial role in creating the value in the context of IoT business [16]. From the analysis the 59% of respondents mark, value proposition as important element for IoT business model then followed by customer segmentation (56%), then revenue streams (48%). In this study from the analysis of the either literature or the responses of the survey value proposition (mean rank: 5.78) is found out to be most important element for a business model canvas in the IoT business model followed by the customer segmentation (mean rank: 5.26) and next to it is revenue stream (mean rank: 4.89). According to Gloze [16] the value proposition is crucial in the business model canvas for IoT business model for e-health care domain which supports our results.

7.3 Impact of IoT

7.3.1 Impact of IoT on Software development

To know the impact of IoT on software development, we have added a question to find the impact. Most of the software development starts with identifying the customer demand and market trends. The management strategy is included because the strategy used by the organization to achieve goals. As we have discussed in the section background, IoT is trending in market, so the customer demand will be more. The impact of IoT on software development is yet to be know, as part of this research we have included software development. In

order to identify the impact of software development question 7 was added to the questionnaire, the respondents were asked to scale the impact (high, substantial, low) of IoT on Software development. The responses were analyzed and presented in the form of the heat maps as represented in the table 7.3.

Table 7.3: Heat Map for Impact of IoT on Software development

	Low	Medium	High
Customer Demands	0	17	39
Market trends	8	28	20
Management Strategy	9	30	17

From the table 7.3 it is very clear that the customer demand have higher impact of IoT followed by the market trends and management strategy

Chi-square test of significance for identifying the relationship between demographics and impact of software development

The responses obtained from the questionnaire were investigated to find if there is any relationship between the experience in IoT project and impact of IoT on software development. The reason why we are excluding other demographics is to answer the experience of respondents in IoT project can contribute ideal results and they will be aware of software development in IoT. Chi-square test is used to find the relationship significance. If there is no significant relationship then it is expressed as null hypothesis (H0) while if there exists any relationship then it is expressed as alternate hypothesis (H1).

The results for chi- square are calculated as follows:
Customer demands : (χ^2=1.813<5.991, df=2, p=2.25>0.05). 33.3% <5
Market trends: (χ^2=3.463<5.991,df =2, p=3.35>0.05). 37.5% <5
Management Strategy: (χ^2=3.259<5.991, ,df=2,p =2.00>0.05). 50.0% <5

From the above results we can distinguish that there is no relationship between the experience and software development because the chi-square value is for all the three is less than 5.991 and also the p value is greater than 0.05. Therefore null hypothesis (H0) is accepted since there is no relationship between the experience and software development.

Friedman test for impact of IoT on software development

By using the values obtained from chi-square test, standard deviation, mean and significance Friedman test was conducted and mean rank for each dependencies was calculated. Friedman test is conducted to find the variance in the IoT software development with reference to its importance.

Table 7.4: Friedman test for impact of IoT on software development

	N	Mean	Std. Deviation	Mean Rank
Customer Demand	56	2.6964	.46396	2.34
Market Trend	56	2.4107	.49642	1.91
Management Strategy	56	2.3036	.46396	1.75

From the results of the fried man test it is conformed that the customer demands are ranked first as the mean rank is 2.34 which is highest among the three, later followed by the market trends whose mean rank is 1.91, the last one is management strategy whose mean rank is 1.75.

Discussions

In the survey, mean ranks from Friedman test were used to prioritize the software development in IoT project based on the survey responses and found customer demands(Mean rank: 2.34) are ranked first followed by market trends(Mean rank: 1.91), management strategy(Mean rank:1.75). However, while applying descriptive statistics to the impact, no relation was identified between the demographics and the occurrence. This implies irrespective of the experience and roles of respondents the customer demands were highly impactful for IoT software development. Additionally, the standard deviation between the mean values is identified low. Therefore, the customer demands will always be impactful for an organization. The survey results confirm the view points in the background, e.g the customer demands are necessary for developing software since they satisfy the customer needs [34]. But, interestingly the management strategy is identified least impact on IoT, but may be the management strategy is also needed to enhance the software development to achieve efficiency and bring value to the organization [34].

7.3.2 Impact of IoT on Software business model

To identify the impact of IoT on business model elements, we have added a question to find the impact. The business model elements that were identified in the literature were presented to the respondents and requested to mark. In the above section the importance of the business model elements are known but here we identify the impact of business model elements for IoT. After obtaining the results they were analyzed and presented in the form if heat maps in high, medium and low categories.

From the heat maps, it is very clear that the value proposition is highly impactful which are numbered highest by the respondents and then followed by the customer segmentation, revenue streams, and customer relations and so on. The least element is lowest numbered that is below 10. Therefore to check the

relationship between the experience and impact on business model chi-square test of significance was done.

Table 7.5: Heat map for Impact of IoT on business models

	Low	Medium	High
Customer Segmentation	3	23	30
Value Proportion	0	16	40
Channels	6	31	19
Customer relationship	7	24	25
Revenue Streams	0	19	37
Key resources	9	24	21
Key activities	13	22	21
Key partnerships	10	24	22
Cost structure	19	22	15

Chi-square test of significance for identifying the relationship between demographics and impact of software business model

This test done to find the relationship between experience in IoT and impact of IoT on software business model elements. The main reason to find the relationship between the experience and impact is due high expert level in IoT project will give us better Responses than other. Chi-square test was done and the results that there is no relationship between the experience and impact.

The results of Chi-square test of Significance:
Customer Segmentation: (χ^2=13.0.1>9.488, df =4, p=1.75>0.05). 33.3% <5
Value Proposition: (χ^2=2.561<5.991, =2, p=2.25>0.05). 37.5% <5
Channels: (χ^2=11.83>9.488, df=4, p=1.51>0.05). 33.3% <5
Customer Relationship: (χ^2=11.07>5.991, df=2,p =3.20>0.05). 28.7% <5
Revenue Streams: (χ^2=18.39<5.991, df=2,p =2.25>0.05). 33.7% <5
Key Resources: (χ^2=13.061<9.488,df =4, p=2.5>0.05). 33.3% <5
Key activities: (χ^2=1.825<5.991,df =2,p =3.75>0.05). 25.5% <5
Key Partnerships: (χ^2=16.166<5.991, df=2, p=2.25>0.05). 33.3% <5
Cost Structure: (χ^2=1.014<5.991, df=2, p=2.25>0.05). 33.3% <5

As there is no relationship identified in the chi-square test, the alternate hypothesis(H1) is rejected and null hypothesis(H0) is accepted. Considering the chi-square values, standard deviations and variance, Friedman test was conducted to know the mean rank. After the results obtained it is clear that the value proposition is ranked as first. Hence we can conclude that the value proposition is highly impactful for IoT business models.

Friedman test for impact of IoT on software business model

Table 7.6: Friedman test for impact of IoT on software business model

	N	Mean	Std. Deviation	Mean Rank
Customer Segmentation	56	2.3571	.69879	5.71
Value Proposition	56	2.6964	.86396	5.90
Channels	56	2.2500	.33960	4.18
Customer Relationship	56	2.6786	.47125	4.67
Revenue Stream	56	2.6250	.68850	5.50
Key Resources	56	2.2143	.33148	4.17
Key Activities	56	2.7321	.44685	4.43
Key Partnership	56	2.4571	.48349	4.41
Cost Structure	56	2.4464	.50162	4.73

Discussion

As identified in the literature, various studies have found the impact in their business by using value proposition in IoT [74] [37]. Wagenaar and Shi have done case study and investigated about the impact of IoT on business models on mobile phones and supply chains. They had found that the impact of value proposition is high then the other elements through the case study they have conducted. To find the truthfulness of the studies rigor and relevance was used and these studies fall under category A. In this study the Chi-square test implies there is no relationship between the experience and impact. Hence Friedman test is conducted and found that value proposition (mean rank: 5.90) is ranked first followed by customer segmentation (mean rank: 5.71) and the least important is cost structure, one the participant stated that "As manufacturing of IoT products are in beginning stage the organization should concentrate on creating the value for the product rather than looking for the profits."

7.3.3 Impact of IoT on requirement engineering

To identify the impact of requirement engineering a question based on the impact of IoT on requirement engineering was asked to respondent. Table the responses with maximum number of responses are marked darkly in opposite the responses with least number of responses are marked with light color.

Table 7.7: Heat map for Impact of IoT on requirement engineering

	Low	Medium	High
Requirement Elicitation	9	26	21
Requirement Modeling& analysis	7	23	29
Requirement Specification	8	22	26
Requirement Validation	8	21	27
Requirement Management	6	19	31
Requirement Prioritization	10	16	30
Release planning	5	24	27

From table 7.7, 54% (31 responses) of respondents identified that the requirement management has a positive impact on organizations, 52% (30 responses) of respondents identified that requirement prioritization has high impact on the organizations, 51% (29 responses) of respondents felt that requirement modelling and analysis has high impact. Therefore from the heat table we can conclude that requirement engineering has high impact on IoT.

Chi-square test to test the relationship between demographics and impact

This test is done to find relationship between the experience in IoT project and requirement engineering. The results of the chi-square test found that there is no relationship between the experience and impact.

In this section, the author finds the relation between the respondents' experience in IoT project and impact of software engineering. As identified earlier, 32% of the respondents have more than 3 years of experience, 30% respondents have 1-3 years of experience and 47.5% respondents have 0-1 years of experience. Using the two parameters chi-square test of significance is performed. The null hypothesis (H0) indicates that there is no significant relation between experience and the impact.

Results for chi-square test of significance are as follows:
Requirement Elicitation: (χ^2=16.109>9.488, df=4, p=2.25>0.05). 33.3% <5
Requirement modeling and analysis : (χ^2=3.988<9.488, df=4, p=2>0.05). 44.4% <5
Requirement specification : (χ^2=5.670<5.991, df=2, p =2.5>0.05). 44.5% <5
Requirement validation : (χ^2=0.257<5.991, df=2, =2.25>0.05). 50% <5
Requirement management : (χ^2=1.351<5.991,df=2, p=3.50>0.05). 33.7% <5

Requirement prioritization : (χ^2=4.814<5.991, *df*=2, *p* =3.5>0.05). 33.3% <5
Release planning : (χ^2=5.022<5.991, *df*=2, *p* =2>0.05). 44.4% <5

Friedman test for impact of IoT on requirement engineering

By collecting the values from the chi-test, Friedman test is conducted and the mean rank is maximum for the requirement management.

Table 7.8: Friedman test for impact of IoT on requirement engineering

	N	Mean	Std. Deviation	Mean Rank
Requirements Elicitation	56	2.2321	.71328	3.07
Requirements Modelling & analysis	56	2.3929	.73059	4.56
Requirements Specification	56	2.5714	.49935	3.95
Requirements Validation	56	2.8214	.38646	4.71
Requirements Management	56	2.6071	.49281	4.97
Requirements Prioritization	56	2.7500	.43693	4.76
Release Planning	56	2.6964	.46396	4.29

Discussion

The results from the survey also show that requirement engineering has a positive impact on the organization. Irrespective of the experience, size and role, 53% of the respondents felt that requirement management has a positive impact. From the Friedman we can analyze that the mean rank is high for requirement management (mean rank: 4.97) followed by the requirement prioritization (mean rank: 4.76). Surprisingly requirement elicitation is least impactful but elicitation is a initial phase of the RE for an organization. This contradicting results suggest that the may be these organizations might have low impact in elicitation phase of IoT development. As these RE activities were discussed in the background section, surprisingly there are no papers that discussed the IoT on requirement engineering. But most of the industries uses RE phases in their initial stage of development [41]. This implies that there is still the gap in the literature. According to Penzenstadler [41] the requirement management is collection of activities which are needed for the software development process where the activities such as tracking of requirement, change management, risk and project management effects the process. This implies the requirement management might increase the

efficiency of IoT projects, if the requirements are properly managed and documented.

7.4 Open ended question results

This open-ended question was included in the survey to discover how the requirement engineering supports the business modeling for IoT.In detail, how the requirement phases are connected to the business model In IoT, which improves the value of an organization. After the results had obtained they were analyzed irrespective to the experience and roles. Based on the obtained results, after analysis the requirement engineering are connected to the business model for creating the value for an IoT organization are listed below.

- Requirement Elicitation- Clear understanding of the customer's requirement for IoT products are used to identify the strong relationships between the organization and customer's. This implies the customer's needs are will be satisfied if the needs are clear understood, and they will generate value for the organization.

- Requirement Analysis and Modeling- Identifying the customer needs and elaborating their needs down to IoT component requirements will generate the extra revenue for the IoT organizations. This implies the ways the organization analyzes the market to make profits and generate revenue.

- Requirement Specification- Identifying the ways to communicate with the stakeholders for IoT products or services and documenting the requirements which describe the needs through any channels improves the business. This implies the requirement specification is a process of effective communication of the requirement among IoT stakeholder through various channels.

- Requirement validation - Validating the requirement is important which is used to reduce the risk of IoT project failure by carefully adjusting the activities and resources. For validation there should be acceptance criteria where the suppliers for IoT products and the customer should agree before and after completing the IoT project. This implies validating the requirement phases improves the quality of the product and also decrease the cost of software development.

- Requirement Prioritization- This is used to identify the most valuable requirement for the customer in the IoT project.

Therefore, this process of connecting the requirement phases with the IoT business models may mitigate the problem of requirements [41] and connects to the business needs.

Chapter 8

Conclusions and Future Work

With rapid increase in the IoT technology, the business environment for software organization has become challenging. The use of business model tools (canvas) in IoT creates value for the software organization [38]. Further there are many infidelity on the importance of business model elements with respect to the IoT in the software organization. As a result many organizations use different business model elements for their IoT projects.

This thesis focuses on identifying the impact of IoT on software business models and also importance of business model elements that are used for the IoT projects. In addition to this the impact of IoT on software development and requirement engineering is also identified. The investigation is done with systematic literature review and survey.

The findings of RQ1 suggest that most the organization use the business model canvas for IoT applications. Where, the value proposition, customer relations were found to be very important in IoT business model in value creation. But surprisingly the survey results suggest that the customer segmentation is important to create the value for the IoT business.

Additionally, the RQ1.1 suggest that 4 most important factor for IoT business model were discussed for creating the value for an organization. These factors are used to define the business model structure, content and governance for IoT applications. These factors help the practitioners to construct the business model for IoT applications.

From the survey, analysis of the survey is done using descriptive statistics, chi-square test and Friedman tests. The results of survey signify that the business model elements like value proposition, customer segmentation, revenue stream customer relationship have gained much importance in the applying software business model for IoT projects. Customer relationship surprisingly have gained much attention in context of IoT business model a part from those which were discussed in the literature. Furthermore the least important is cost structure

since one of the participant in the survey stated that "As manufacturing of IoT products are in beginning stage the organization should concentrate on creating the value for the product rather than looking for the profits."

In survey, the impact for the software development, software business model elements and requirement engineering are found. The results of the impact of IoT on software development indicate that, customer demand (mean rank: 2.34) is ranked first, market trend (mean rank: 1.91) and management strategy (mean rank: 1.75). From the analysis of the survey for impact of IoT on software development it is clear that the customer demands are highly impactful.

As for the impact of IoT on business model, the results state that value proposition (mean rank: 5.90), customer segmentation (mean rank: 5.71) and revenue stream (mean rank: 5.50) are highly impactful for IoT business. Also a question in the survey also states that value proposition is highly important for the IoT. In addition the impact of IoT on requirement analysis results that requirement management (mean rank: 4.97), requirement prioritization (mean rank: 4.76) and requirement modeling and analysis (mean rank: 4.56) are highly impactful.

This thesis find the impacts of IoT on software business model and software industry. From the findings through SLR and survey it was identified that customer demands is highly impactful for software development, value proposition has high impact on the IoT software business model and requirement management is highly impactful on the IoT requirement engineering. These finding help the practitioners to prioritize the things and helps the organization to improve the IoT business to its full potential.

Future Work

This study identifies the impact of IoT on requirement engineering in software development was positive for an organization. The requirement engineering activities that were identified from the background, there is a scope for future to identify the literature regarding IoT on requirement engineering. In the survey, it was identified that most of the practitioners are concentrated on requirement management and requirement prioritization. For future research, there is a need of exploring clear requirement engineering strategies for the realization of IoT.

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Appendices

Appendix A

Appendix A

Table A.1: Start Set

IDID	PapersPapers
P1	P.Fan and G. Zhou, "Analysis of the business model innovation of the technology of internet of things in postal logistics," in Industrial Engineering and Engineering Management (IE&EM), 2011 IEEE 18Th International Conference on, 2011, pp. 532–536.
P2	S. Turber and C. Smiela, "A Business Model,Type for the Internet of Things," 2014.
P3	R. M. Dijkman, B. Sprenkels, T. Peeters, and A. Janssen, "Business models for the Internet of Things," Int. J. Inf. Manag., vol. 35, no. 6, 2015.
P4	J. Glova, T. Sabol, and V. Vajda, "Business Models for the Internet of Things Environment," Procedia Econ. Finance,vol. 15, 2014.
P5	O. Alvarez, A. Ghanbari, and J. Markendahl,, "Smart Energy: Competitive landscape and collaborative business models," 2015 18th International Conference on,,2015, pp. 114–120.
P6	F.Berkers, M. Roelands, F. Bomhof, T. Bachet, M. Van Rijn, and W. Koers,"Constructing a multi-sided business model for a smart horizontal IoT service platform," in 2013 Networks, ICIN 2013,Venice, 126-132, 2013.
P7	M. Westerlund, S. Leminen, and M. Rajahonka, "Designing Business Models for the Internet of Things," Technol. Innov. Manag. Rev., vol. 4, no. 7, 2014.
P8	T. Keskin and D. Kennedy, "Strategies in Smart Service Systems Enabled Multi-Sided Markets: Business Models for the Internet of Things," 48th Hawaii International Conference on, 2015.
P9	M. He, C. Ren, Q. Wang, B. Shao, and J. Dong, "The Internet of Things as an enabler to supply chain innovation," 2010 IEEE 7th International Conference on, 2010, pp. 326–331.
P10	S. Leminen, M. Westerlund, M. Rajahonka, and R. Siuruainen, "Towards iot ecosystems and business models," Springer, 2012, pp. 15–26.

Table A.2: Iteration 1 Forward Snowballing

ID	**Paper**
P16 P7 cite 3	H. C. Chan, "Internet of Things Business Models," J. Serv. Sci. Manag.,vol. 8, no. 04, p. 552, 2015.
P17 P10 Cite 9	S. Leminen, M. Rajahonka, M. Westerlund, and R. Siuruainen, "Ecosystem businessmodels for the Internet of things," in XXIV European Association for Research on Services Conference, Helsinki, Finland, 2014.
P18 P10 cite P8	C. Blythe, "Business Models for value generation in the Internet of Things," Data-Value-Driven Softw. Eng. Deep Cust. Insight, p. 8,2013.
P19, P10 ref 2	M.Westerlund, S. Leminen, and M. Rajahonka, "Designing Business Models for the Internet of Things," Technol. Innov. Manag. Rev., vol. 4, no. 7, 2014.

Table A.3: Iteration 1 Backward Snowballing

ID	**Paper**
P11,P7 ref 6	S. Haller, S. Karnouskos, and C. Schroth, The internet of things in an enterprise context. Springer, 2010.
P12,P7 ref 15	T. Mejtoft, "Internet of Things and Co-creation of Value," in Internet of Things (iThings/CPSCom), 2011 International Conference on and 4th International Conference on Cyber, Physical and Social Computing, 2011, pp. 672–677.
P13,P10 ref 30	E. Bucherer and D. Uckelmann, "Business models for the internet of things," in Architecting the internet of things, Springer, 2011, pp. 253–277.
P14,P6 ref 9	O. Mazhelis, E. Luoma, and H. Warma, "Defining an internet -of-things ecosystem,"n Internet of Things, Smart Spaces, and Next Generation Networking, Springer, 2012, pp. 1–14.
P15,P3 ref 16	H. Li and Z. Xu, "Research on Business Model of Internet of Things Based on MOP,"in International Asia Conference on Industrial Engineering and Management Innovation (IEMI2012) Proceedings, 2013, pp. 1131–1138.

Table A.4: Iteration 2 Backward Snowballing

IDID	**PaperPaper**
P20, P16 ref 9	Y. Sun, H. Yan, C. Lu,,R. Bie, and P. Thomas, "A holistic approach to visualizing business models,for the internet of things," Commun. Mob. Comput., vol. 1, no. 1, pp.,1–7, 2012.

Table A.5: Iteration 2 Forward Snowballing

IDID	**PaperPaper**
P21, P11 ref 102	J. Wagenaar, "The impact of the Internet of Things on revenue in supply chains," in 17th,Twente Student Conference on IT, Netherlands, 2012.

Table A.6: Quality assessment based on rigor and relevance

Study Id	**RigorRigor**			**Rigor Sum**	**RelevanceRelevance**				**Relevance sum**
	Context	Study Design	Validity		User/ Subject	Scale	RM	Context	
P1	0	1	1	2	0	1	1	0	2
P2	0.5	1	0	1.5	1	0	1	1	3
P3	0.5	1	1	2.5	0.5	0	1	0	1.5
P4	0	1	0	1	1	1	0	0	2
P5	0	1	1	2	1	1	1	1	4
P6	0.5	0.5	0.5	1.5	1	1	1	1	4
P7	0.5	0.5	1	2	1	1	1	1	4
P8	0.5	1	0	1.5	0.5	0	1	0	1.5
P9	0.5	1	1	2.5	1	1	1	1	4
P10	0.5	0.5	0.5	1.5	0	1	0	0	1
P11	0.5	0.5	0	1.5	0.5	1	1	1	3.5
P12	0.5	1	0	1.5	0	1	0	0	1
P13	0.5	0.5	0.5	1.5	0.5	1	1	1	3.5
P14	0	1	1	2	0.5	1	1	1	3.5
P15	0.5	1	1	2	0	1	1	0	2
P16	0	0.5	0	1.5	0.5	1	1	1	3.5
P17	0	0.5	0.5	2	1	1	1	1	3.5
P18	1	0.5	0	1	0	1	1	0	2
P19	0	0.5	0	1.5	1	1	1	1	4
P20	1	1	0	2.5	0	1	1	1	3
P21	1	0.5	0.5	2	0	1	0	1	2

Appendix B

B.1 Distribution channels of the survey

1. Linkedin groups

   Internet of things (62,679)
   M2M and IoT communication (2,20,145)
   The Internet of things (15,023)
   Wearable technology, IoT (9,073)
   Internet of things, Big data and Internet of people (91,426)
   IEEE Internet of Things (4,094)
   Business Intelligence, Big Data, Analytics,MIS (1,71,347)
   Informational Technology Professionals (1,42,230)

2. Post in IoT meetup groups

   IoT India (2,985)
   IoT Chicago (806)
   IoT Paris (1,824)
   IoT Bengaluru (528)
   IoT Hyderabad (354)
   IoT Malaysia (1,009)

3. Post in Facebook groups
   Internet of Things Enthusiasts (3,155)
   Internet Of Things (18,310)
   IoTBLR- (13,771)
   Internet of things sverige (1,019)
   IoT knowledge- (6,456)

4. Mailing list for the authors contacts who have experience in IoT projects.

B.2 Survey

Section 1

IoT involvement in Software development, selling software for IoT products.

1. Please indicate your level of involvement in IoT project:
   () Not Involved
   () 0-1 years
   () 1-3 years
   () More than 3 years

Section 2

IoT Project

1. Your role in IoT project:
   () Project Manager
   () Software Development
   () Product Development
   () Customer Development
   () Hardware Suppliers
   () Services
   () Support
   () Logistics
   () Others _____

2. Which of the following departments is your IoT project targeted at?
   () Automotive industry
   () Education
   () Smart cities
   () Supply chain management
   () Logistics
   () Smart homes & smart buildings
   () Telecommunications industry
   () Manufacturing industry
   () Security
   () Independent living
   () Recycling
   () Other _____

3. Size of organization:
   () Small (0-25)
   () Medium (0-100)

() Large (>100)

4. Age of the organization:
   () 0-1 years
   () 1-3 years
   () 3-7 years
   () >7 years

5. Age of IoT project:
   () 0-1 years
   () 1-3 years
   () More than 3 years

Section 3

Importance of IoT Business model elements
From your experience on IoT, please suggest to what degree the each business model elements are necessary to successfully offer an IoT application:

Table B.1: Importance of Business model Element

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Customer Segmentation	()	()	()	()	()
Value proposition	()	()	()	()	()
Channels	()	()	()	()	()
Customer Relationships	()	()	()	()	()
Revenue streams	()	()	()	()	()
Key Resources	()	()	()	()	()
Key Activities	()	()	()	()	()
Key Partnerships	()	()	()	()	()
Cost Structure	()	()	()	()	()

Section 4

Impact of IoT

(a) Software development: According to your knowledge can you please scale the impact of IoT on software development.

Table B.2: Impact of IoT on Software Development

	Low	Medium	High	Don't know
Customer Demands				
Market Trends				
Management Strategy				

(b) Software Business Models: Impact of IoT on software business models is broad concept. In my opinion the following software business model elements are very impactful, so please scale your experience.

Table B.3: Impact of IoT on Software business models

	Low	Substantial	High	Don't know
Customer Segmentation				
Value proposition				
Channels				
Customer Relationships				
Revenue streams				
Key Resources				
Key Activities				
Key Partnerships				
Cost Structure				

(c) Requirement Engineering: What is the impact of IoT on requirements engineering practice within your organization pointing out different viewpoints.

Table B.4: Impact of IoT on RE

	Low	Substantial	High	Don't know
Requirements Elicitation				
Requirements Modelling & analysis				
Requirements Specification				
Requirements Validation				
Requirements Management				
Requirements prioritization				
Release planning				

Section 5

Open Ended question
How requirements engineering can be connected to better support business modeling for IoT?

Section 6

Others
Based on your experience, what are the most important questions that still needs to be answered on impact of IoT products or services on Business model?