A Business Model Framework for the Internet of Things

by

Bassey Itam Eyo

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School of Engineering and Informatics

Department of Informatics

University of Sussex

Brighton

BN1 9QT

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Declaration

The work described in this thesis, carried out in the School of Engineering and Informatics, is that of the author and has not been submitted in any form for any other degree at this or any other university.

Signed ________________________

Bassey Itam Eyo

School of Engineering and Informatics

Department of Informatics

University of Sussex

Brighton

BN1 9QT

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Abstract

The Internet of Things (IoT) is an emerging technology with research interests transcending disciplines of computer sciences and computer engineering to agriculture, business management, civil engineering, architecture, medical sciences, social science etc. This is because of the potential expanding range of its application areas of wind mill operation and irrigation control, supply chain and logistics, manufacturing, home and office environment, healthcare, social care, etc. As it is usually the case with emerging technologies, IoT is faced with the challenge of bridging the gap between the technology development and corresponding business model design. Without a workable business model, the IoT paradigm may end up in research labs and subsequently fade away. A business model should show how lucrative it is to be in the IoT business by adding value to the customer and generating revenue for the business firm. This research is a contribution towards the goal of developing a business model for IoT, with customer/user value potential as the focal point. The comprehensive literature review carried out during this research (i) outlines the concept of business models; (ii) investigates through desk research, existing digital technology business models with focus on two (2) established digital technology firms and identified five generic components of their business models including but not limited to subscription, training, price, satisfaction, and trust, which were used for the primary investigation; (iii) investigates the IoT state-of-the-arts by elaborating on the IoT space and precursor technologies that are part of its ecosystem with the aim of describing, illustrating and developing application prototypes for three IoT scenarios of health monitoring, the use of the library and borrowing of books (a novel idea), and home environment; (iv) evaluates business model framework representation maps in current use, and specifically modified the general structure, content, and performance framework map to design an adoption framework map called a customer-focused business model framework map for IoT (CBMF4IoT). The unique approach to business model research involved conducting a user-led experiment to investigate the likelihood of IoT adoption of existing digital technology business models, as the customer value potential aspect of a business model design was the focal point of this research. Specifically, the experiment was aimed at determining if there was any significant differences in user inclinations towards the five generic components of existing digital technology business models based on smartphone context and IoT products context in a within-subjects design, with sample population drawn from University of Sussex community. The experimental design relied on participants' past experiences with smartphone for them to indicate their pre-purchase inclinations towards the five generics components. For the IoT products context, descriptions and diagrammatic illustration of the three IoT scenarios with their corresponding Just-in-Mind clickable prototypes served as educational tools to enable participants to be acquainted with IoT in order for them to indicate their potential pre-purchase inclinations towards the five generic components. A unique procedure for business model adoption likelihood was designed using the Sign test for high, low, and medium likelihood of adoption. The results of this test indicate medium likelihood of adoption for three of the generic components and low likelihood of adoption for two of the generic components. The results of this test was then fed to the CBMF4IoT. This thesis demonstrates that reusability of successful digital technology business models could potentially result in market success for an emerging digital technology in a B2C context, as users opinion formed the bases for the conclusions, instead of the conventional opinion gathering from only experts, business owners, and practitioners for a BM research.

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LIST OF ACRONYMS

AAL.. Ambient Assisted Living
BM.. Business Model
BMF.. Business Model Framework
CFBM4IoT.. Customer-focused Business Model Framework for IoT
DT.. Digital Technology
DTBM... Digital Technology Business Model
GPS.. Global Positioning System
GSCP... General Structure Content Performance
IoT... Internet of Things
IncCPP.. Inclination to Consider Product Price
IncVT... Inclination to Value Training
IncSSP.. Inclination to Set-up Subscription Plan
IncSPVO.. Inclination to be Satisfied with Product Value Offering
IncTPVO.. Inclination to Trust Product Value Offering
NFC.. Near Field Communication
RFID... Radio Frequency Identification
Sp.. Smartphone
TAM... Technology Acceptance Model

CHAPTER ONE

1 Introduction

1.1 Research background

The first wave of the Internet was email and basic websites, followed by e-commerce, and then cloud, social media and video define the third and current phase, version 4.0 is the emerging Internet of Things (Schmid, 2014). IoT, being a relatively new technology, is gradually gaining recognition in academic and industrial research circles. But, its global adoption especially by end-users will depend on a successful business model offering that focuses on value creation to the user. Research studies on IoT are limited in presenting the results of empirical research (Macik and Currie, 2017) as relevant articles are mostly reviews aimed at sensitisation towards new business opportunities and commercial applications of IoT devices markets forecasts (Chui et al., 2010; Wei, 2014). This research is an attempt at contributing to the body of empirical research works on the business model (BM) aspect of the IoT.

Individual technologies such as traditional internet, identification (Radio Frequency Identification - RFID) and tracking, wired and wireless, sensor and actuator networks, enhanced communication protocols, distributed intelligence for mobile phones, etc are the bedrock for the Internet of Things concept. It is envisaged that in the nearest future, our bodies, cloths, cars, devices of various forms with peculiar addressing formats, would represent nodes in the internet of things with the potential of creating new services in various domains such as e-health, assisted living and smart homes, emergency management services, automobile industry, transportation and logistics, environmental monitoring, etc (Guisto et al., 2010; Atzori et al., 2010).

In terms of the IoT implementation contexts, the aspect that deals with developing technology to improve object visibility with respect to its status and current location awareness is conceptualized as the 'things oriented' IoT, such as in pets tracking. The aspect that deals with taking advantage of the existing internet technology to connect numerous smart devices globally is however conceptualized as the 'internet oriented' IoT, such as in sensors detect leakages in gas pipes (Talpur, 2013). The IoT is therefore comprised of the following key components as outlined by Infosys (2015).

- **Things:** Such as wearable (shoes), electricity meters, farm land, cars, animals, humans, etc;

- **Connect:** With the help of Telecom Network and short distance communication protocol - Bluetooth, ZigBee, RFID, GPS, etc;
- **Monitor/Control:** With the help of Sensors, GPS, vehicle telematics, etc to control/monitor physical objects;
- **Insight:** With the help of Big data / Analytics to create meaningful insights that can be consumed by firms to meet End-Consumers needs.

Some of this components are expatiated upon in chapter 3 'IoT state-of-the-art'. The concept of an internet of interconnected physical objects communicating with humans and things to provide specific services is a gradual shift from the traditional internet. In traditional internet however, end-user devices were interconnected for data sharing and communication. This has influenced research on new approaches to computing, networking, service provision and management (Miorandi et al., 2012). It is also upstaging traditional business models and giving rise to questions as to how companies could capitalize on the progression in technological transformation brought about by IoT among others to develop new business models (Bughin et al., 2010).

But, the fact that a BM is traditional may not imply it is obsolete, as *"a business model describes the rationale of how an organization creates, delivers, and captures value"* (Osterwalder et al., 2005). Some of its components may still be applied on a new technology with success if it meets the purpose for which the new technology was created. This research therefore emphasizes this notion of adoption of successful BMs to advance IoT.

Macik & Currie (2017) posits that a poorly explored area of IoT applications is its acceptance by users and attempts to use the updated versions of the technology acceptance model (TAM) model to justify this assertion. However, as Chesbrough (2010) in his research on business model innovation posited, *"a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model"*. Users may not 'accept' an IoT product with a weak BM customer value offering; as TAM research should follow BM research or at most, both should be carried out simultaneously. This research is however not applying the TAM approach, but captures the opinions of users in the context of a BM research for a digital technology (IoT), resulting in an indirect acceptance of IoT by users and direct validation of the business model customer value proposition.

IoT is said to be *"the cornerstone of many organizations' digital transformations, enabling them to optimize existing operations and excel at creating and pursuing exciting new business models"* (Columbus, 2018). This is in tandem with the rise in global revenue on IoT investments, which was estimated at $613 billion in calendar year 2013 (Bradley et al., 2013), with an estimated to $772.5 billion in 2018 (Pymnts, 2017). However, industrial and academic research on development of IoT are few, even with potential revenue estimates amounting to $1.2 trillion for M2M communications alone by 2022 (Hatton, 2013) and updated growth estimates for IoT as a whole pegged at $6.5 trillion by 2024 (Pymnts, 2018). The foregoing presents massive investment opportunities for businesses such as telecom operators and software vendors, IoT application and service providers, IoT platform providers and integrators, and the academic community.

Mobile operators have initially focused on increasing their connected devices base to build scale in relation to IoT (GSMA, 2012), instead of simultaneously building a business model. However, business design ought to be carried out at the primary stage of IoT development (Limburg et al. 2011; Michahelles, 2011), and IoT business cases are becoming more compelling with the drive towards integration of machine learning, artificial intelligence, and context-sensitive, real-time data delivered by IoT sensors (Columbus, 2018). This makes it imperative to identify the value potential of the emerging IoT, especially in a business-to-consumers (B2C) context.

Bankinter (2011) suggest that IoT may take a bit longer to be widely adopted, giving business and government time to assimilate its implications and implement the measures needed to minimize the associated risks to security and privacy. They outlined the challenges to the acceptance of IoT based on their study as shown in the figure 1-1 below, with the scale above the bars indicating areas of priority requiring industry and research attention from 5 to 1.

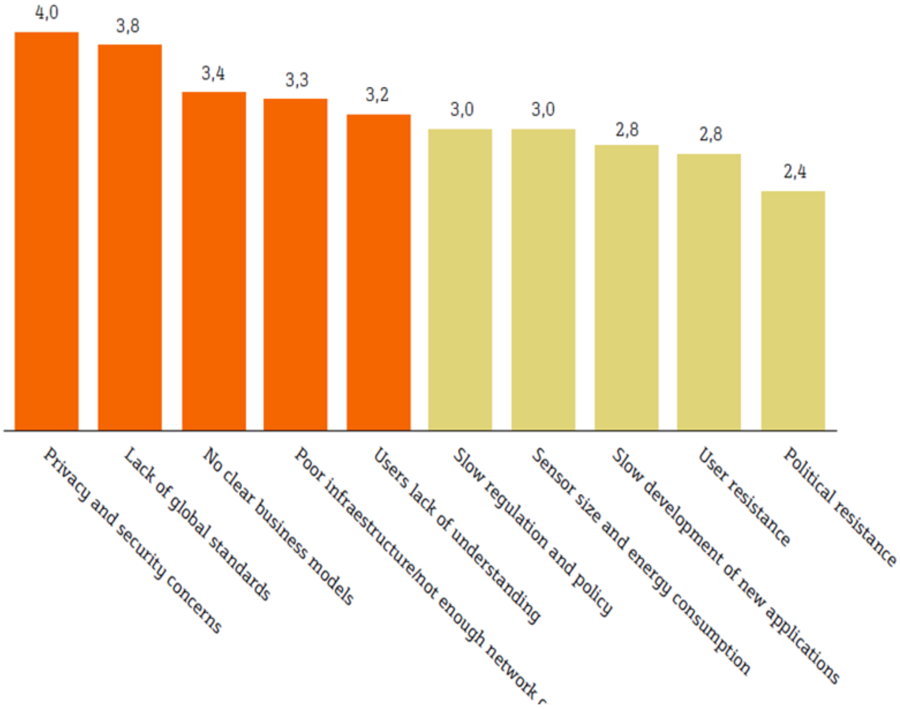

FIGURE 1-1: ASSESSMENT OF FACTORS AS CHALLENGES TO THE ADOPTION OF IOT (SOURCE: BANKINTER, 2011)

From figure 1-1 above, although privacy and security concerns, and global standards were found to be higher in the pegging order of priority for IoT adoption, it could be posited that a unified business model for IoT will be a major factor for the adoption of IoT, as clarity of BM was found to be third in the order of priority for IoT adoption. Although this research was partly a response to the findings of this survey with focus on BM clarity for IoT, it could be inferred that recent increase in revenue projections and investment in IoT by global technology firms may be as a result of increasing adoption of IoT (Pymnts, 2018).

Furthermore, few BMs are proposed for IoT in a B2C context, as more researchers and IoT solution markets have focused on BM proposal for IoT in a business-to-business (B2B) context (Leminen et al., 2012), which suggests a priority area for IoT BM research and market solution is in the B2C context. For instance, Pang (2013) developed a BM for IoT with focus on food and pharmaceutical industry supply chain, which was a B2B approach. However, Leminen et al. (2012) also posits that there is a trend towards B2C solutions.

A business model should consider a target users as a key factor for its design. The approach in this research is the B2C approach to the IoT BM design. Therefore, this research approach entails proposing and validating a BM framework for IoT by adopting the BMs applied to products of established digital technology firms in relation to the end user at the lower level (B2C). This approach is based on the assumption that a likely suitable and acceptable BM for a new technology such as IoT should apply the BM of products of established digital technology firms based on their success in the market.

Given the fact that IoT is evolving towards gaining a foothold in the digital technology world with its ambitious scope of connecting everything seamlessly to the internet, various efforts at designing its BM is what this researcher refers to as ‘here a little, there a little’. This is because currently, there is no absolute standard document for IoT BM. What we have is BMs with focus on individual or group of areas in the IoT space. The ‘here a little, there a little’ mantra of the IoT BM design propounded in this research is akin to the biblical rule for understanding divine precepts. For instance, to understand the subject of finance in the bible, one will have to go through different verses and chapters of the bible to arrive at an absolute rule for finance. Therefore, this research envisages that an acceptable BM for IoT will be a compendium of concepts espoused in IoT BM research. Thus, if other IoT BM frameworks are ‘there a little’, the framework proposed in this research is ‘here a little’; and together they will lead to a standard and absolute BM for IoT as it gains acceptance globally.

Given the foregoing, it is worthy to note that IoT has no formal technological independence of its own, but, depends on the state-of-the-arts in the development of already existing digital technologies to drive its own evolution. In fact, the IoT European Research Cluster (IERC) defines IoT as *“a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “things” have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.”* (Vermesan & Friess, 2015).

The notion of intelligent interfaces in the definition above, refer to these individual technologies that are seamlessly integrated into the information network. Thus, in delivering digital technology products and services to the user/customer, each of these may apply different business models, resulting from different set of activities and performance capabilities, and disposition of available resources either within or without the business establishment by taking clients (suppliers and customers) into consideration. And each model will influence capital expenditures, prices to be charged and average revenue per user, and most importantly, determines which customers and competitors the venture deals with.

Laudon & Traver (2017) identified value proposition and revenue model components of a business model as "*the most important and most easily identifiable aspects of a company's business model"*. Thus, a user-validated approach towards the adoption of existing digital technology business model for IoT based on the value offering component is applied to this research. This is not to neglect the importance of other business modeling components, but for resources (especially access to digital technology firms) available to this researcher, the other components would have been part of the scope of the study. Therefore, this research outlines an elicitation technique for the adoption of existing digital technology business model value offering for IoT. A desk research is undergone to identify key business model value component for existing digital technology products and services of two digital technology firms (Microsoft and Apple) and what may constitute user response towards the value offering in the purchase of digital technology products and services.

It is useful to briefly discuss imitation theory in this research because of the notion of a likelihood of adopting an existing digital technology product BM for IoT. Giachetti and Dagnino (2015) suggests that the competitive position of a firm is a signal that it has superior information regarding the introduction of innovative offerings and their potential acceptance by consumers. Consequently, if this information supremacy signal is launched by a firm with the strongest competitive position, there is a likelihood that their product strategies will be imitated. Several preceding literatures on information-based imitation theories (Lieberman & Asaba, 2006) have alluded to the notion that firms are likely to follow the behaviour of rivals perceived as having superior information. However, imitation of a superior firm's strategy will depend on the technological convergence between product categories of the imitating firm and the originating/existing firm (Giachetti and Dagnino, 2015).

Technological convergence describes the process whereby a technology-base and common ideas are shared by two or more different industrial sectors, meaning that a product is said to be convergent if it is a physical integration of two or more platform technologies (Giachetti & Dagnino, 2015; Gill, 2008; Rosenberg, 1976), and is mostly applied in high tech consumer electronics sector (Yoffie, 1997; Christensen, 2011). Therefore, this guides us to discuss mainly, those product categories with possible technological convergence with IoT. For example, a mobile phone that has the potential of becoming an IoT gadget; if it has sensors, is seamlessly internet-enabled, then it is convergent with IoT. Also, portable consoles with facility to show movies and enable internet access on a handheld gaming device, have the potential of becoming IoT devices, so these product categories are explored to ascertain the BM applied to them by Microsoft and Apple for IoT adoption of such BMs.

Nevertheless, in order to study the BMs of these two established digital technology firms, the focal products' BM of existing digital technology firms to be studied (such as Smartphone) are not restricted to those that technologically converge with the IoT product atomic ecosystem (internet enabled Sensors, actuators, RFID, Cloud applications, etc). For instance, products such as MS Office, although it may not be directly technologically convergent to the IoT atomic ecosystem-like products, it can be useful in the area of its application to the front end of IoT in the areas such as dashboards for visualization of current updates from sensors and other internet enabled devices. Thus, one of the abstract ideas behind the research approach for determining the **likelihood** of IoT adoption of existing digital technology business model (DTBM) partly stems from the notion of **imitation** and **technological convergence;** as similar constructs (question-items) derived from the value offering of existing DTBM for a smartphone (an existing DT product context) is applied for IoT (the new DT product context) in this research.

1.2 Research Questions

The objective of this research is to identify *generic* **components** of the BM value offering of two existing digital technology firms (Microsoft and Apple) in order to determine the likelihood of IoT adopting them as part of demonstrating a BM framework for IoT. These **components** are customer-focused and value centric, such that they could be evaluated by everyday users/customers. This is because the convention in most BM research, especially for B2C models rarely involve end-user evaluation, as focus is usually placed on evaluating 'expert opinions' and opinions of businesses that deliver services to the user; thus neglecting user input. This study is, among several other objectives, an attempt to fill this research gap. This study extensively explored the state-of-the-arts of IoT by describing and illustrating the IoT space with the aim of illustrating, describing, and designing clickable application prototypes for three IoT scenarios.

In particular, three scenarios of health monitoring, home environment, and the **use of the library and borrowing of books IoT (a novel IoT application idea)** were described and illustrated. Three wireframes (clickable prototypes) are developed using Just-in-mind software to simulate the frontend (application user interface) of the three IoT scenarios. The three diagrams illustrating the IoT scenarios and the three wireframes were applied as educational tools for users participating in a within-subjects experiment designed for this research.

This research compares user inclinations towards the identified **components** of the existing DTBM applied to a current DT product context (Smartphone) versus their inclinations towards similar components as applied to IoT products context. This was aim at determining their level of differences in order to suggest the likelihood of IoT adoption of the digital technology product's (Smartphone) BM. As a contribution to the larger body of research, an attempt is made to provide answers to crucial questions that are vital for this research work, based on a well defined and narrow research scope. A review of relevant literature elicited the following key questions:

RQ1) What are the major components of an IoT space?

RQ2) Is there a significant difference in the inclinations of users towards components of existing digital technology business model as compared to IoT? Are there any associations between user inclinations towards components of existing digital technology business models IoT?

RQ3) What type of relationship exist between product usage experience and user inclinations to be satisfied with the value offering of smartphone compared to IoT products?

RQ4) What is the likelihood of IoT adopting existing digital technology business models?

A range of hypotheses are developed as detailed in chapter 2 to investigate the research questions outlined above. A within-subject design is presented with questionnaires mostly in the form of likert-type or ordinal type question-items, as well as a range of single-choice or multiple-choice questions and one open-ended question for descriptive analysis. The **method of successive interval (MSI)** (Asdar & Badrullah, 2016; Waryanto & Milafati, 2006) was applied to assign numeric (interval) values to the ordinal type data to aid the quantitative analysis.

Subjective measures in the form of pre-experiment questionnaires were in the form of demographic questions and questions about user inclinations towards BM components for Smartphone, post experiment questionnaires were in the form of user experience questions for the IoT scenarios and. This approach was aimed at reducing fatigue from experiment participants responding to too many similar questions in different sections of the questionnaire in the within subject design. The research methodology and experimental design are presented in chapter 5.

1.3 Contribution to knowledge

This thesis is expected to make some key contributions to knowledge. It was expected that key components of the business model value offering (at the generic level - applicable to products) of two existing digital technology firms will be identified, which will allow for customers/users evaluation. This was followed by an elucidation of the IoT state-of-the-art for the purpose of illustrating the IoT space in order to illustrate and describe of three IoT scenarios (**one of which is a novel idea**), with corresponding application prototypes developed for the three scenarios to be used as educational tool for the experimental survey.

It is also expected that a **unique research approach** will be demonstrated for investigating the likelihood of IoT adoption of existing DTBM value offering, by determining the level of differences that may exist between user inclinations towards BM value components for smartphone versus IoT. It is expected that this unque approach will involve design of a unique procedure for determining the likelihood for IoT adoption of existing DTBM based on primary data analysis. It is also expected that a customer-focused BM framework map for IoT will be developed with validated data fed to the framework representation map to illustrate the DTBM adoption likelihood. Finally, it is expected that this unique research approach will transcend IoT BM research, as it could be applied to other aspects of BM research for other product categories and other segments of a BM canvas. These expected key contributions were comprehensively achieved as highlighted below.

1.3.1 The business-technology user-led design approach

The contribution of this research work is discussed with respect to the state-of-the-art in the area of IoT implementations for the end-user. A Business Model is meant to add value to the user and generate revenue for the business firm. The unique research approach involved identifying components of the BMs of established DT firms in order to support a user-led investigation into the likelihood of IoT adoption of existing DTBM. the five components identified in chapter two were subscription, training, price, satisfaction, and trust.

Although several DTBMs were highlighted in section 2.2, these five generic components of DTBM were relevant to this research, as they were subjective instruments that could be measured with data obtained from end-users, rather than business owners, experts, or practisioners. The approach to the literature review was a type of business-technology co-design, whereby the business model related literature enabled subjective measures to be identified, while the DT literature enabled the selection of three IoT use case scenarios for illustration description and developement of Just-in-mind wireframes. In particular, the three IoT scenarios and prototypes that were developed were in the area of health monitoring, home environment, and a novel future IoT implementation and atomic BM idea proposed by this researcher for the use of the library and borrowing of books.

1.3.2 Unique protocol for business model adoption

A within-subjects design for the experiment provided an opportunity for a challenging but innovative approach to analysing data in a BM research context. In particular, question-items developed for **the five generic components of existing DTBM** that were identified in chapter 2 were single-item question constructs applied to the **matched pairs of user inclinations**[1]. Because primary data was obtained in categorical ordinal scale for the matched pairs of user inclinations, this resulted in discovery in the literature a statistically validated method for transforming ordinal data to interval data[2]. This was then used for indepth statiscal analysis using the **Sign test** as the primary validation method. The Sign test enabled the design of a unique procedure to determine the likelihood of IoT adoption of DTBM by this researcher. The results of the test obtained from the procedure were fed into the modified general SCP framework for BM representation map (Pederson et al., 2007).This procedures could be re-usable in any BM research context especially in were new products are released by firms or invented.

1.4 The Research approach

In order to achieve our research goal of investigating the likelihood of adoption of existing digital technology business models for IoT, the research approach is outlined

[1] Refers to the user inclinations towards the five generic components of DTBM as applied to the smartphone context and the IoT products context.

[2] The method of successive interval (MSI) (Asdar and Badrullah, 2016; Waryanto and Milafati, 2006).

in the subsequent section. In the first part, desk research (Yin, 2009; Greener, 2008) was used in investigating the business models of the following digital technology giants: Microsoft, Apple. The choice of these two digital technology giants is because as existing dominant players in the digital technology industry, they have been able to innovatively develop products and services that could be considered as technological breakthroughs over time, with improvements in end user experience. This has led to their successful performance in the global market, and general acceptability/loyalty by millions of consumers worldwide. This enabled the development of hypotheses from the business model of these digital technology giants to be fed into a business model framework for the IoT.

The use of desk research (Yin, 2009), which is a qualitative method is due partly to the difficulty in accessing company data on the dynamics of their business models; hence, the accessible information are gotten from journal articles, business reviews, official reports and news articles on these firms that alludes to their business models. This secondary data collection through desk research complements and informs the primary research (Greener, 2008). Figure 1-2 shows the unique research approach.

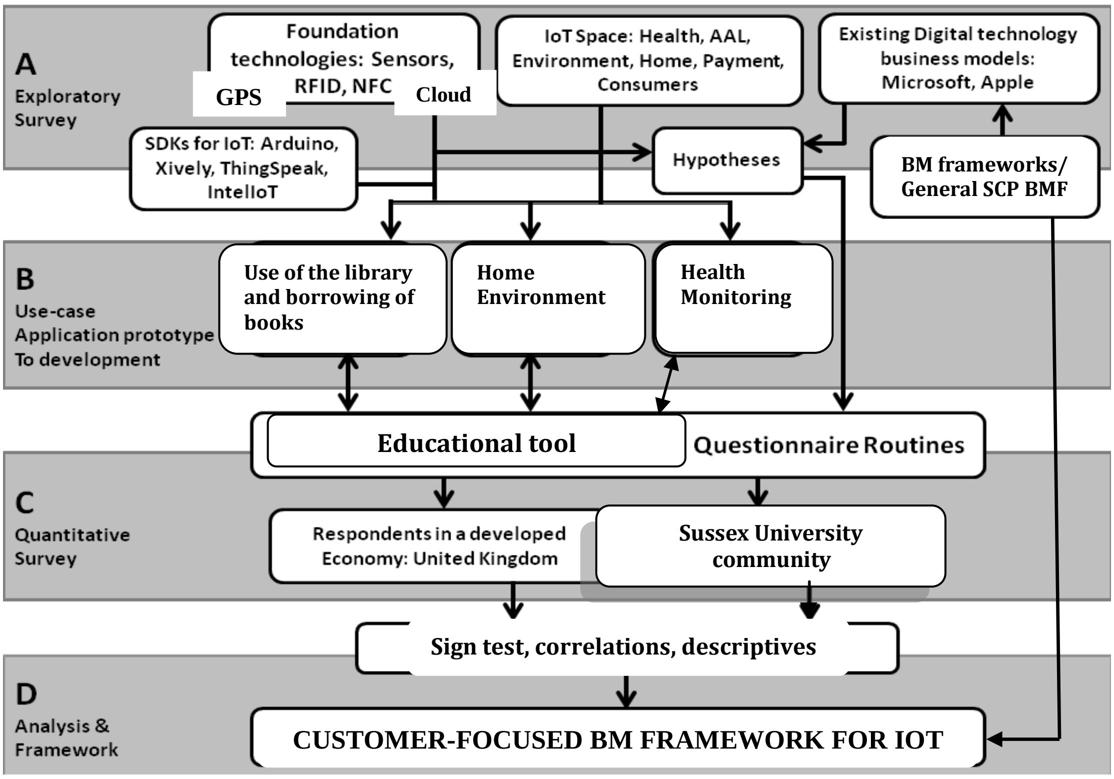

FIGURE 1-2: RESEARCH APPROACH

This approach is designed from Yin (2009) exposition on generalization from case study to theory; and results in an analytical and statistical generalization, with more emphases on analytic generalization, which uses already existing business models as a template for its adoption for use in a start-up or new technology. The second part of the research entailed carrying out an experiment on identified components of existing DTBM based on smartphone and IoT products context using the three IoT scenarios as educational tools.

Deductive approach was useful in this research as it enabled the identification of business models applied by Microsoft and Apple on relevant product categories and to what extent such models led to customer satisfaction. In essence, deductive research approach helps in construction and validation of the hypotheses and theories that had been found in the literature. Since deductive research is concerned with the development of hypotheses or theories and then subjecting them to empirical tests with a view to drawing the necessary conclusions, such an approach was deemed relevant for the current study.

1.5 Thesis Outline

Chapter 2 presents a literature review of existing digital technology business models, outlining competing definitions of BMs and description of the concept of atomic BMs, generic components of DTBM. This was followed by a description of the notion of user pre-purchase decisions as used in this research. An overview of related work on IoT BMs is discussed with a description of two digital technology (DT) firms' BMs highlighting the components of their BMs that were used in deducing hypotheses for further investigation. This was followed by a description of external variables and how they were used in this research. This chapter was then concluded with a chapter summary.

Chapter 3 presents the state-of-the-arts in the area of IoT with a comprehensive description of the IoT space outlining the use case scenarios of IoT. This was followed by a description of the health monitoring IoT and continues with the description of an IoT implementation for elderly people and people living with disabilities, that is the ambient assisted living (AAL). The literature was used to determine three IoT scenarios for description and prototype development. Precursor technologies such as sensors, RFID, cloud, GPS that are part of the IoT ecosystem were critically reviewed. Projects and applications already developed by technology firms in the area of IoT were outlined, followed by an outline of software development kits (SDK) for IoT application development. The chapter concludes with a description of the prototyping tool that is used for application prototype development for three IoT scenarios that are proposed in section 5 of this report followed by a chapter summary.

Chapter 4 presents the BM frameworks and BM framework representation maps that are already developed in the literature in order to identify a BM framework map for modification to be used in illustrating the likelihood of IoT adoption of existing DTBM. A user-based business model framework representation map for IoT caled the customer-focused business model framework for IoT (CBMF4IoT) was designed using modifications to the general SCP framework for BMs. The chapter concludes by illustrating how the validated data relating to the five identified generic components of existing DTBM will be fed into the modified framework, followed by a chapter summary.

Chapter 5 presents the methodology adopted for this research starting with an overview of the research methodology, description of experimental design describing the within-subjects design adopted for this BM research. This is followed by the description, illustration and design of prototypes for three IoT scenarios. This is followed by data collection and sampling strategy, description of experimental tasks that was designed, and a four-part mix of quantitative questionnaire of 61 question-items. This is finally followed by an introduction and description of the method of successive interval (MSI) for transformation of data from ordinal to interval scale, followed by a detailed description and justification for the choice of analysis methods used in this research. The chapter concludes with the chapter summary.

Chapter 6 presents the results and analysis of data obtained from the experimental survey. Data analysis was carried out using the Sign test, Spearman correlations, and descriptive frequencies and percentages; thus, enabling the hypotheses developed in this thesis to be tested. Also, results of MSI transformation on the primary data necessary for the conduction of the primary validation exercise were reported. The transformation of ordinal data to interval data using the MSI proved useful in a unique way to broaden the reach of analytical method used in testing the hypotheses. Chapter 7 concludes this thesis by outlining the summary of findings, conclusions, limitations and suggestions for future work.

CHAPTER TWO

2 Digital Technology Business Models (DTBM)

In this chapter, we outline competing definitions of business models (BMs), including the description of the concept of atomic BMs, including a terminology that is used throughout this research; generic components of DTBM. This is followed by a description of the notion of user pre-purchase decisions as used in this research. We then proceed to give an overview of related work on IoT BMs. This is followed by case description of two digital technology (DT) firms' BMs highliglight the components of their BMs that are useful for the investigation carried out in this research. Finally, a description of external variables and how they were used in this research are outlined.

2.1 Concepts of atomic BMs and generic components of BMs

Business models (BMs) have been defined as the illustration of the content, structure, and governance of transactions between a company and its customers to create value by exploiting the business opportunities (Amit & Zott, 2001). It is used for establishing the roles and relationships existing between the customers, partners, and suppliers of a company, in terms of product flow to the customer, and money made in the process, so as to benefit the participants (Weill & Vitale, 2002). This notion is supported by Timmers (1998), who opined that business models should include (a) an architecture for the product, service, and information flows, (b) description of the benefits for the business actors involved, (c) description of the sources of revenue.

In general, many competing theories describe BMs as tools for identifying the entities and attributes that enables a business to create value for the customer on one hand, and profit for the company on the other hand (Dubosson-Torbay et al., 2001; Weill et al., 2005; Chen 2009). This definition among other similar ones, focuses on a firm's approach to the business as whole. However, Weill and Vitale (2002) suggested that a firm's business model (BM) is made up of several sub-BMs. They demonstrated this by describing eight atomic e-business models, each of which could be applied as independent e-business model or combined to create a hybrid business model.

The concept of **atomic BMs** could be viewed as the value created from individual product and service with corresponding revenue generated from this product and service, which depicts the **core** of a digital technology business model; while the

hybrid BM are a combination of this atomic business models into one (Weill & Vitale, 2002). **Atomic BM** scenarios for IoT are described, using three IoT scenarios and clickable application prototypes. See section 5.2 and appendix B for the description of the three IoT scenarios and screenshots of the clickable prototypes. In particular, one of the atomic BMs is a novel idea[3] proposed by this researcher.

However, the BM components that are identified in section 2 of this research for use in our investigation are refered to as **'generic components'** because they are not specific to one product context. Cambridge dictionary defines the term **generic** as: *"shared by, typical of, or relating to a whole group of similar things, rather than to any particular thing."* (Cambrigde, 2018). This is because the **five generic components** identified in the next subsections of this chapter may be applied in all digital technology products context.

Thus, we investigated user inclinations towards these generic components of existing DTBM to make inferred conclusions about how successful their[4] application may be when used in a Smartphone context and IoT products context. The reason for this is that the participants recruited in gathering opinions about this generic DTBM components are the 'users' not the 'experts' or 'business owners'. For instance, revenue model is a BM component that is business-led not user-led and this components would have required inputs from the business owners.

Hence, although they are mentioned and also part of the BM framework representation architecture modified for use in this research[5] (as could be seen in section 4 and section 7), they are not part of the insvestigation scope of this research. The next section describes the terminology that is used in referring to the purchase decision of customers or users with respect to the value offering of DT products and services.

2.1.1 User digital technology product pre-purchase decisions

Purchase decisions may be linked to users' uncertainty about the product they wish to acquire in both traditional and online shopping scenarios (Cowart & Goldsmith, 2007; Dash & Saji, 2008). Khosrowtaj (2014) re-emphasized the notion that pre-purchase decision or behaviour of users towards aquisition of a product may differ with respect to online and onsite purchase. This is because onsite purchase decisions

[3] For use of the library and borrowing of books.
[4] That is, the five generic components of existing DTBM.
[5] That is, the General SCP framework for BM architecture.

may be influenced by information users gathered from friends and relatives (Guo et al., 2011; Mangleburg et al., 2004), while online purchase decisions may be influenced by information gathered online (Dash & Saji, 2008).

However, the application of users' pre-purchase decisions (**user inclination**s or behaviour towards acquisition of a product) in this research encapsulates both online and onsite purchase user inclinations, as the focus of this research is not to differentiate between both. The focus in this research was to investigate IoT adoption of existing DTBM. In order to achieve this, an investigation into user inclinations towards **generic components** of existing DTBM (value offering) based on Smartphone and IoT products context was carried out. The phrase ***'user inclinations'*** is used in subsequent sections of this report to refer to *'the encapsulated purchase decision of the user or customer'.* The next sub-section outlines related work in the literature on BMs for IoT, thus establishing the need for investigating the likelihood of IoT adoption of existing DTBM.

2.2 Overview of related work on business models for IoT

Various researchers have proposed different business models for the Internet of Things, which arises from the emerging nature of the technology with accompanying lack of unified BM policies and standards. Because this thesis is a step towards a unified BM approach for IoT, this sub-section highlights some of these BM approaches for IoT. Fan & Zhou (2011) analysed how the IoT could be profitable in the area of postal logistics and how this can impact on the construction of business models for IoT. However, their analyses were based on decision making at the management level in the industry and how this could influence the business model for IoT.

Also, Chang et al. (2014) proposed a service application model and business model for IoT in a shopping mall by integrating cloud application, open/big data, and the IoT. The article demonstrated the value created for users of the service application, but in the demonstration it lacked what type of formal business model could be applied to the IoT infrastructure. While there are several research work on IoT BMs, there are however, more work in comparison on IoT applications as would be seen in section 3.

An investigation on how a smart IoT service platform could add value to a traffic system to create a multi-sided business model was carried out by Berkers & Roeland

(2013). They suggested in their findings that real-time data management complexity and resource-efficiency are some of the constraint on the full realisation of IoT business potential. The major plank of their business model was the provision of incentives to the platform operator to effectively grow and utilize additional information for resource efficiency. However their business model failed to identify additional application domains with which the model could be implemented, which constrained scalability of their atomic BM.

In another instance, Wei & Liping (2013) carried out a study on the coupling relations between business model innovation and technology innovation in the IoT industry. Their aim was to build a cause and effect feedback loop between business and technology innovation. But, the result of the study, which was in the form of a mathematical model was more theoretical than practical and only covered a handful of application areas in the IoT industry.

Ehret & Wirtz (2017) suggested that technology firms may find it difficult to address the threats posed by the Industrial Internet of Things (IIoT), if they fail to move from applying existing BMs to IoT. But, this is in a B2B BM setting. It may prove successful for existing DTBM to be applied to IoT in terms of their atomic components. However this thesis investigates the likelihood of success in the application of generic components of existing DTBM to IoT in a B2C setting. Findings from our investigation are discussed in section 7 of this research.

At this stage in the advancement of the IoT paradigm, working for the full realisation of its potential should be the aim of researchers and stakeholders. The development of practical BMs for IoT will ensure it endures just like every other digital technology concept, such as the web. In their study, Leminen et. al (2015) argued for the creation of value-centric ecosystem BMs IoT, as there were insufficient IoT BM tools and templates. The work in this thesis is a response to this, as its unique research approach is a likely template for creation of IoT BMs.

Further to the advancement of IoT, Setzke et al. (2018) suggested that six BM components were necessary for the interoperability of IoT platform BM. The six (6) BMs they outlined after consulting with experts were: monetization of operation data, co-development of products, synchronization with end customer ecosystem, information integration, co-usage enablement, and automated procurement and vending operations. However, large volumes of theories alone will not take IoT to the promised land of global acceptability.

The need to demonstrate both a theoretical and practical application of business models for IoT is one of the objectives of this research, as Westerlund et al. (2014) opined that most of the promises of IoT have failed to materialise. Thus, the IoT BM research approach in this report comprehensively outlines the state-of the-art of IoT, which could be seen in section 3. It discusses the IoT space in order to illustrate three IoT scenarios and prototypes (see section 5.1 and appendix B) for further user-led investigation in a B2C IoT setting.

A B2C IoT BM development that does not factor in the opinion of users may be a failure waiting to happen. Consequently, in a bid to mitigate against the failure of IoT, the BM framework architecture proposed in this research was an attempt at applying a general use of existing DTBM components to specific application scenarios. This may ensure the framework's reuse in other IoT application scenarios. This is ellaborated upon in sections 4 and 5. In the next sub-subsection, the BMs of two DT firms as applied to their products and services from a user perspective are discussed, in order to identify **generic components** of their BMs.

2.3 Established digital technology firms' product business models

This section discusses the business models of established digital technology firms and identify **'generic'** and **'atomic'** components of their business model which are critical to formulating a customer-focused BM framework for IoT. A digital technology business organization could be described as an enterprise that automates most of its business processes through the use of computers and information systems (Turban & Volonino, 2010). Turban et al. (2012) also emphasized that digital business organizations deploy IT with the aim of reaching and engaging customers more effectively, boosting employee productivity and improving operating efficiency. They outlined several characteristics of a digital organization versus a traditional technology organization as presented in table 2-1.

TABLE 2-1: DT VERSUS TRADITIONAL TECHNOLOGY BUSINESS CHARACTERISTICS (TURBAN ET AL., 2012)

Digital Organization	**Traditional technology Organization**
Selling online	Selling in physical store
Selling digital goods	Selling tangible goods
Online collaborative inventory forecasting	Internal inventory/production planning
Smart electronic catalogs	Paper catalogs

Electronic market place	Physical market place
Uses computers, smartphones, Internet, and extranet	Uses telephone, fax, VANs, and traditional EDI
Online auctions, everywhere, anytime	Physical auctions, infrequently
Electronic infomediaries, value-added services	Broker-based services, transactions
Electronic billing	Paper-based billing
Electronic tendering (reverse auctions)	Paper-based tendering
Pull production, starting with an order (build-to-order)	Push production, starting with demand forecasting
Mass customization (build-to-order)	Mass production (standard products)
Affiliated virtual marketing	Physical-based commission marketing
Explosive viral marketing, especially on social networks	Word-of-mouth, slow and limited advertisement
Hub-based supply chain	Linear supply chain
Less capital needed for build-to-order; payments can be made before production is commenced	Large amount of capital needed for mass production
Customers' value proposition is perfectly matched (cost <= value)	Frequent mismatch of customers' value proposition (cost > value)

Table 2-1 presupposes that DT firms may have discarded some of the activities of the traditional technology organization, but most of the existing DT global giants (such as Microsoft, Apple, etc) are still carrying out traditional technology business activities such as selling in physical store, selling tangible goods, push production based on demand forecasting, and physical market place. This ensures their reach is extended to meet the demands of online and onsite customers albeit through partners/vendors.

The foregoing is essential for an IoT enterprise that may have to deal with both tangible and intangible products and services. It is also complementary to the IoT vision as viewed from the perspectives of the 'internet'-centric and 'thing'- centric architectures (Gubbi et al., 2012). The internet-centric aspect focuses on the Internet service (Cloud enabled) which obscures the user/customer from data analysis, data distribution, and data visualization (Komarov & Nemova, 2013), while the thing-centric aspect focuses on the object (smart object) and data obtained from the object (Lopez et al., 2012).

Thus, some aspect of the traditional technology BMs may be applied to IoT. However, more of the DTBM components will be beneficial to the advancement of the IoT paradigm. In order to expatiate on the business models of existing digital technology giants, it is pertinent to outline some digital technology business models as identified by Turban & Volonino (2010), with the view of highlighting their application by the selected digital technology giants as shown in figure 2-1.

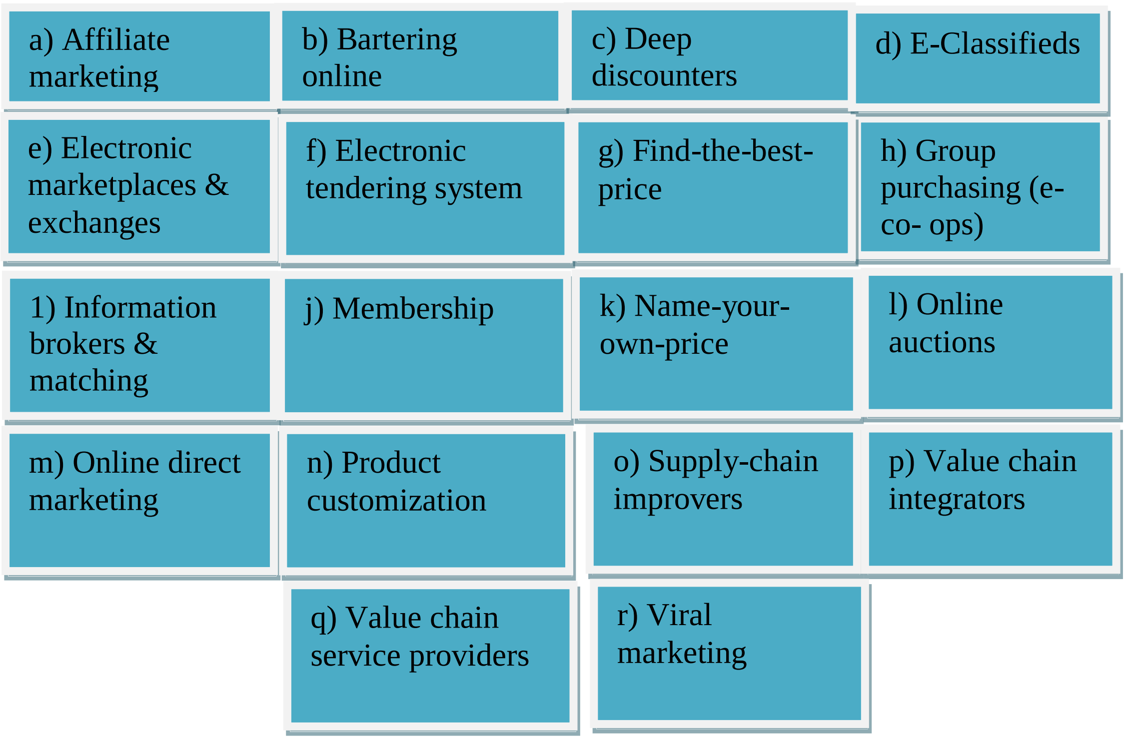

FIGURE 2-1: DIGITAL TECHNOLOGY BUSINESS MODELS (TURBAN & VOLONINO, 2010)

One of the factors that may lead to a setback in the business of DT enterprises is the disconnection between product development and service delivery to an ever technologically evolving customer-base. The above-mentioned DTBMs sought to address this issue (Turban & Volonino 2010). In order to investigate the potential adoption of most of the DTBMs outlined in figure 2-1, experts and business owners have to be recruited. This is not the approach in this research. The approach in this research recruits 'users' to validate inferences about generic components of DT firms' BMs.

However, DTBMs such as membership, name-your-price, find-the-best price, **Product customization**[6] may be investigated using opinions from business owners, experts and users. They may also play a central role in the advancement of IoT. In the next sub-section the generic BM components applicable to selected consumer products and services of two (2) DT giants: Microsoft and Apple are identified. Also, their[7] application of some of the DTBMs outlined by Turban & Volonino (2010),

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[6] IoT products can be tailored to individual user needs making the user have a real sense of ownership. For instance, the fitbit allows a user to personalise user interface of its app.

[7] That is, Microsoft and Apple.

will be highlighted. The choice of these two organizations as against smaller DT firms is because of the notion of IoT as a global technological phenomenon, which may benefit from BM tools applied by these two firms to deliver their products and services to millions of their customers/users worldwide.

2.4 Microsoft user products BM

Microsoft (MS) is one of the most successful world leading digital technology business enterprises that develops, manufactures, licenses, and supports a wide range of software products for various computing devices. It has interests in software, services, and Internet technologies for personal and business computing. With annual revenues in excess of $37 billion as at 2005/2006 (Suder & Payte, 2006), Microsoft has seen rapid revenue increase to the tune of $125.84 billion in fiscal year 2019 (Liu, 2019A). Microsoft revealed in recent results that it has about 1.5 billion users globally, which is more than the number of Apple users, which is about 1.3 billion active ioS users (Tung, 2018).

Also, with 669,000 apps in the Windows Store as at 2015, Office apps have also been downloaded over 100 million times on Android and iOS devices (Jawad, 2018). Microsoft BM, among others, involves providing **product licenses** for its users/customers, with a software assurance package that includes support, **training,** updates (Harvey, 2002). In particular MS runs a type of product-services BM (Reim et al., 2015; Suarez et al., 2013; Storey & Easingwood, 1998).

However, Suder & Payte (2006) highlighted the fact that customer satisfaction dropped because of the perception by customers that the product licensing was aimed at short-term revenue drive due to reduction in benefits on upgrades. Microsoft however opted for an issue resolution template for this consumer perception problem by implementing changes at the higher level of their BM. They divided the single product licence into seven product licences to be managed by seven business groups. These business groups interface with MS customer segments, which include enterprise partners, SME partners, customers, public sector.

Another aspect of Microsoft's BM, in terms of its consumer product line was to go into partnership with smaller tech enterprises or buy up a product line from another (Waters, 2004). However, Microsoft's offering for consumer products such as smartphones has been viewed as lacking in consumer-orientation. For instance its smartphone – Kin, which was released in April 2010 had poor reviews; some of which included lack of instant messaging, which is not compatible with YouTube, and inability of users to buy online games. This was despite an estimated $2 billion spent to develop and market the smartphone according to insiders (Gary, 2011).

However, an area where Microsoft leads is in the digital rights management for protecting online content, especially in the digital media market where they sell technology to media companies to distribute songs or movies in the Windows Media format (Waters, 2004). But, their release of another music player – Zune, also suffered from poor reviews (Gary 2011). Some of these setbacks were as a result of Microsoft's attempt to lead in all fronts of the IT and ICT market.

An analysis by Gary (2011) highlighted some areas of the Microsoft recent product offering that could be considered as a success or failure. It was found that Microsoft was more successful in the game console and database software market than the rest. Since our research scope in terms of business models for IoT is targeted at the lower end[8] of their BM, we are going to analyze Microsoft's value proposition for the Xbox that has made it a success, because Xbox is a consumer/user product (B2C) as against products that are targeted at corporate consumers (B2B).

According to Russell (2014), over 80 million units of the Xbox 360 has been sold since its release in 2005 following the successful outing of the first Xbox console which sold about 24 million units. The Xbox 360 is a response to Apple TV, Amazon Fire TV, etc. There are more than 60 services available in the Xbox 360 with tens of millions of users. Microsoft's business model was to offer **subscription** for users to access content through the available services. For instance, subscribed users can play with other gamers around the world through the Xbox Live Gold membership.

However, Microsoft hardware subscription model (the standard console retail model) for the Xbox 360 console was discontinued in 2012. This was due to long-term additional cost to the consumer for paying for both the hardware and the software components of the Xbox console. At the time the subscription scheme was introduced, the Xbox 360 sold for $200. If a user opted to subscribe for an Xbox Live Gold membership for a period of one year, the total annual cost to that user was $320. But, the subscription version of that console cost about $459 on final payment, which was a reap-off to customers (Houghton, 2014). They took advantage of users that preferred a **long-term payment plan**, which implied paying a lot more.

[8] That is, customer segment.

Microsoft later released Xbox One, which included various video applications, the Kinect interface, and Windows PC. This was an attempt by MS to convince non-gaming users to buy an Xbox console as against an Apple TV (Russell, 2014). They did not apply the previous hardware subscription model to the Xbox One (Houghton, 2014), but relied on the wide array of third party contents provided to entice consumers to subscribe. This led to many users not only buying the console, but also subscribing for additional content.

From the above discussion, it could be asserted that Microsoft's business model at the lower end - for the consumer is a form of online direct marketing and **Membership** through **subscription plans**. This is because most of their product licensing and subscription components of their BM are for their digital products and services. Also, **online direct marketing** is an efficient way MS avail these products and services to the consumer. Also, **value chain service providers** are involved in the Microsoft business model, by way of providing additional content/value for Microsoft gadgets, which in extension improves user satisfaction.

Given the foregoing, the first **generic component** of existing DTBM identified in this chapter, which may enable a user-led investigation into IoT adoption of existing DTBM is **subscription plan.** A subscription model that reduces the long-term marginal costs on the consumer may be suitable for IoT products. Thus, the following hypotheses are deduced for further investigation:

> *H_{A3}: There is a significant difference in user inclination to set-up subscription plan to acquire existing digital technology products as compared to IoT products.*
>
> *$H_{A3.1}$: There is a positive relationship between user inclinations to set-up subscription plan to acquire existing digital technology products and IoT products.*

The next sub-section outlines the product BMs of Apple and identifies two more generic components of existing DTBM.

2.5 Apple user products BM

The establishment of Apple by Steve Jobs, Steve Wozniak, and Ronald Wayne on April 1, 1976 has contributed to the advancement DT. Apple began with the sales of personal computers and then proceeded to produce new types of desktop computers, laptop computers, as well as their own operating systems in the early 90s, which led to an increase in revenue (Ning et al., 2011). Apple Inc. has cash reserves of well over $100 billion, which may be connected to their innovative bundling of products with a service or more (Reidel, 2014).

Apple's revenue in the first quarter of the 2019 fiscal year was put at between $89 billion and $93 billion with operating expenses of between $8.7 billion and $8.8 billion (Apple, 2018). Their revenue from iPhone sales alone in third quarter of 2019 financial year was $25.99 billion (Liu, 2019B). The foregoing makes it imperative to discuss the business-to-consumer model applied to these products and services that has positioned Apple as a leading light in the industry. The product BMs of Apple could further be outlined as followsiTunes is further discused below.

2.5.1 Apple iTunes Business Model

On 23rd October 2001, Apple released their first MP3 Player known as the iPod, which became popular among young kids and music professionals. Two years later, they introduced the iTunes Music Store (iTMS) as a pay-per-song service on the iPod, which was a revolution in music entertainment because of its cool design and rich features, including capacity, download speed, and ease of use, creating a new market for portable entertainment (Cheng, 2009).

Apple's BM for its iTMS and iPods sales relies on: (a) distribution deals for licensing others' content, (b) integration of proprietary hardware and software (Apple's proprietary platform, the iTMS, playable only on Apple's proprietary iPod players), and (c) its ability to tightly circumscribe users' rights based on three points of control–copyright laws, contracts, and technology measures (Reder, 2009). By integrating iTMS for use on the iPod, Apple became a market-leading distributor.

2.5.2 Apple App Store Business Model

Apple opened App Store in July 2008, which sent shockwaves across the mobile industry (Kimbler, 2010). These apps were created by a small army of 43,000 developers, with the resultant unprecedented success impacting positively on the sales of the iPhone and turning Apple to one of the front-runners of the mobile industry. Users of Smartphones and tablets are enabled to customize and personalize their mobile device with a number of key apps and preinstalled services, and downloading of other free and premium apps through the instrumentality of the App stores, which is a very attractive value proposition (Kimbler, 2010). Although it has been opined that mobile app store marketing opportunities may be overhyped (Middleton, 2010), success stories continue to abound as more developers create apps for direct billing, premium apps, in-app purchases, advertising, etc (Dieterich, 2018).

The Apple platform also include a powerful Apple iOS application platform and devices including iPhone, iPod Touch and iPad with great design, large touch screens, powerful CPUs, WiFi and 3G Internet access, and feature-rich APIs to camera, location, gyroscope, messaging, and other handset capabilities and services. Given the foregoing, Qing-Jei (2011) opines that Apple's general virtual market and digital content business model promotes business model innovation and achieves a culture of enhanced user experience.

2.5.3 Apple Experience-Based Retail Model

Apple employs various **training models** to target consumers as encapsulated in the uniquenes of combining support and community engagement to build an unparalleled retail value model that directly drives the creation of an experience-based retail model. Forbes (2012) outlined three programs that directly contribute different aspects of the Apple customer experience with respect to the traing value offer as follows;

(a) Apple One to One: the Specialist, Workshops. Apple's One to One is a program where new customers pay a fee to spend time setting up their new Apple product with an Apple One to One employee. This program sets up products to work 'for the individual' by teaching customers how to use the product that imparts a level of fluency & confidence to maximize the product experience. This may lead to customers extracting more value from the product and increasing satisfaction.

(b) Specialist: Another aspect of the Apple business model as highlighted by Forbes (2012) relates to hiring of devoted fans/experts (specialists) who utilize their deep product knowledge to apply the right combination of features that are going to be the right balance for the customer – regardless of price. This comes on the backdrop of lack of financial incentives for Apple employees to promote any particular item, as they are employed on a fixed rate and no commission. Thus, the combination of how specialists build a rapport with customers to build trust without financial incentives aligns with Apple and the customers interests, which makes the Specialist to be among the strongest aspect of the Apple retail model.

(c) Workshops: Workshops are free educational classes that offer in-depth, presentation-style walkthroughs on how to use the various applications that come with your Mac. This program focuses on educating customers with specialized product knowledge to extract more value from their Mac by empowering them to utilize more aspects of the system (Forbes, 2012).

Providing training to enable customers/users to be acquainted to that a DT product pre-purchase, may likely be perceived as valuable to the customer. Training can also be provided through user manuals and may generally be applied to every DT product. But from the users' pespective, the value place on receiving traing to use a product may vary. Therefore, training is a **generic component** of an existing DT firm's BM. Hence, the following hypotheses were deduced for further investigation in section 6:

> H_{A2}: *There is a significant difference in user inclination to value training to use IoT products as compared to existing digital technology products.*
> $H_{A2.1}$: *There is a positive relationship between user inclinations to value training to use existing digital technology products and IoT products.*

2.5.4 Apple pricing model

Neilsen (2014) outlined Apple's pricing model as follows:

(a) Apple's pricing model has been to offer a small number of products with a focus on the high end of consumers. They prioritize profits over market share, whilst creating a 'halo' effect that makes consumers yearn for next release of Apple products. They achieve this through product differentiation, thus producing unique and attractive products for their customer segment.

(b) They employ a retail model called “minimum advertised price” (or MAP), which prohibit resellers or dealers from advertising a manufacturer’s products below a certain minimum price. MAP is mainly enforced by manufacturer offering subsidies to resellers.

(c) To create premier products with corresponding premium price, as the cheapest range of Apple's products are usually priced in the mid range. But, they ensure a high-quality user experience with their features. The hardware and user interface are designed to provide a lot of value for the price, which keeps profits high.

Apple's product prices usually have a large effect on the entire smartphone industry. As long as its has the edge in the market, it can charge any amount for its product. But, this might take them to the cliff edge in the long-run, from where Android might overtake them (Brown, 2018). The price model for IoT with respect to B2C should however be such that would attract potential users to acquire it. Perdesen et al. (2007) opine that most consumers with knowledge about digital technology products and services are also aware of alternatives. So price consideration, from the user perspective, may be a pre-purchase tool.

This conclusion could make us infer that these sets of consumers will also have an insight as to the relative price for a new technology or an incremental technology in the same product category. Thus, these knowledgeable consumers will be price sensitive to IoT products and services. The same cannot be said of novice or non users. Therefore non-users or novices may likely not be price sensitive towards the IoT product. Therefore, knowledgeable users of existing DT products that are may be more price sensitive than non-users or novices (new users). Product price is therefore a generic component of a DTBM that may be both user-led and expert/business owner-led in its application to a BM research. This leads us to hypothesize as follows:

***H_{A1}*:** *There is a significant difference in user inclination to consider the price of IoT products as compared to existing digital technology products.*

***$H_{A1.1}$*:** *There is a positive relationship between user inclinations to consider the price of existing digital technology products and IoT products.*

2.6 External variables used in measurement of likelihood of IoT adoption of existing DTBM

External variables as used here, refers to the attributes external to the three generic components of existing DTBM identified and discussed earlier in this section. These three components are business-led, while external variables here are user-led. But, recall as stated earlier in section 2.1, in order to investigate likelihood of IoT adoption of DTBM, users (customers) are recruited as 'experts' in this BM research. Their inclinations towards towards the three generic components of existing DTBM are investigated for a smartphone and IoT products context.

Also, two external variables (satisfaction and trust) associated with the user are investigated in this research and included as part of generic components of existing DTBM. This is because although these two attributes are user-led, they also depend on the quality of product and services that come with the DT product. Satisfaction and trust as used here is towards the product value offering pre-purchase, not that derived post-purchase. So, a product that is not satisfaction-worthy and not trust-worthy in the perception of the user pre-purchase may not be acquired by the user.

Hence, satisfaction and trust join price, training, and subscription for acquistion as generic components of existing DTBM. Another variable that is used for measurement in this research is product usage experience, which is mainly an attribute of the user. It is not used as part of the generic components of existing DTBM because it is only available to the user from a DT product the user must have used already. But, users no matter how they may be experienced (or experts) cannot be said to be experienced in using a new related product pre-purchase. But users can derive satisfaction and trust from the product value offering pre-purchase.

Hence, product usage experience is used as an external variable in this research to measure its relationship to the five generic components of existing DTBM. While there are several other external variables that are associated with how users may make their pre-purchase decsions (such as age, gender, etc), they are only used in this research for descriptive satistics. The description of satisfaction, trust, and product usage experience as used in this research are described in the next subsection.

2.6.1 Satisfaction with product value offering

Customer satisfaction generally means customer reaction to the state of fulfilment, and customer judgment of the fulfilled state (Oliver, 1997). The Internet has proven effective for advertising, marketing, distributing goods, and providing information services (Hoffman & Novak , 1996). This implies that with the advent of the IoT, a lot can be harnessed from the Internet. Fornell (1992) opined that there are many benefits for a company from a high customer satisfaction level; as customer satisfaction with the product or service may likely lead to **recommendation** to other users. Satisfaction with product value offering can be said to be derived when the expectations of the customers are met or surpassed by the services or products of a business organization.

Dru (2000) highlighted the difference between customer satisfaction and customer services. Customer service is defined by the business organization while customer satisfaction is defined by the customers. Therefore, a business organization that wants to satisfy customers could define its services according to the wants or needs of the customers. Customer service programmes such as **loyalty rewards** and discounts may lead to satisfaction and breed loyalty. Loyalty rewards and discounts, although part of the value offering for a DT product, were measured in this research for descriptive analysis.

A key factor for the design of a BM is the target user (Komarov & Nemova, 2013). In other words, an effective DTBM design should take into consideration potential customer satisfaction with the the DT product pre-purchase and post-purchase. This implies that if a large percentage of the enterprise' customer-base is satisfied with the model of delivery of product/service, regardless of the perception of the product/service by external forces (such as competitors, legal frameworks, etc), such a BM might be sustained and become acceptable because of the two-way achievement of value creation for the customer and revenue generation for the enterprise.

For example Microsoft and Apple, and their contemporaries have developed devices, applications and service tools that could both be considered as privacy invading and competition stifling, yet the users are satisfied with such products or service/application. This could be termed as a satisfaction-based business model, whereby regardless of the negatives such as privacy encroachment in using a product or service, the user finds such satisfactory. On this same notion, IoT being a potential privacy encroaching technology due to its scope of human and non-human data gathering through tagged sensors, actuators, and RFID connect to the Internet/Cloud or a WAN, should adopt the satisfaction-based BM. This may encapsulate any of the low-level digital technology business models.

This is one of the reasons users are adopted in this research as 'experts' in a BM research context. Although it would be expected that BM research should have 'business owners' and 'experts' as the go-to authorities for materials and resources contributing to such BM research, in this research, users are recruited as 'experts' to contribute to a BM research in line with the suggestion of (Dru, 2000). Quality customer service, which is determined by the customers, should be seen as a means to an end of achieving customer satisfaction and retention. Any company that wants to achieve customer satisfaction must take real cognizance of the quality they offer to their customers in terms of services or products. It should be what the customers want rather than what the business organization wants (Gerson, 1993).

Hence, although an external variable to the the value offering of DT product by a business firm, satisfaction as used in this research refers to the pre-purchase satisfaction of the user based on the value offered (price, training for use, subscription model, discounts, quality and reliability of product, trust, etc) by the business firm to the user (customer) as applied to a DT product. As this research aims to investigate the likelihood of IoT adoption of existing DTBM, the satisfaction to be investigated is the satisfaction with product value offering of an existing DTBM (Smartphone) versus satisfaction of product value offering of the IoT products context[9]. Thus, the following hypotheses are deduced:

- H_{A4}: *There is a significant difference in user inclination to be satisfied with IoT products value offering as compared to existing digital technology products value offering.*
- $H_{A4.1}$: *There is a positive relationship between user inclination to be satisfied with IoT products value offering and existing digital technology products value offering.*

2.6.2 Trust with product value offering

Customer satisfaction with a product and service value offering may produce trust which is a breeding ground for loyalty. In the context of pre-purchase decsions, the term of 'trust' can be defined as customers' confidence in the quality and reliability of product and service (Ross, 2005). With respect to IoT, trust may be perceived from the prism of security and privacy offered by the IoT product and service provider. A company should carry out a trust evaluation exercise before a specific transaction is assumed to have a direct influence on post-purchase satisfaction (Makkhmali et al., 2010).

However, pre-purchase trust also needs to be established, and this could be determined by the information available to the user at the point of purchase. this information can be gained through the user manual and through training to use the product. According to several studies on product purchase activities (Cho et al., 2006; Han & Kim, 2017), hesitation to make an actual purchase may arise from trust

[9] Refers to the three IoT scenarios and prototypes described and developed in this research.

issues that may be identified by the customer at the point of purchase while assessing or getting to know the product he/she intends to buy. Trust is an important element that influences consumer behaviour in uncertain environments such as emerging technologies (Seeto & Ho, 2014).

Therefore, in the case of IoT, its products value offering must be perceived to be trust-worthy by the consumer as consumers' trust will have a positive or negative influence on the IoT business. It may be inferred that a user who already owns a DT product, should already possess some level of trust for that product. Hence, in the context of this research, trust that a user has for smartphone is investigated in relation to the user's likely trust for IoT product value offering. It is also necessary to determine the likely difference that may exist for the alreading existing DT product value offering and the product context of the emerging IoT. Hence, the following hypotheses are deduced to test these notion:

- H_{A5}*: There is a significant difference in user inclination to trust IoT products value offering as compared to existing digital technology products value offering.*
- $H_{A5.1}$*: There is a positive relationship between user inclination to trust IoT products value offering and existing digital technology products value offering.*

2.6.3 Digital technology product usage expertise

Product usage expertise as used in this research is a broad term that may refer to the challenges and skills a user possesses in order to operate a digital technology product, such as smartphone, web applications, e-commerce applications, etc. While several authors categorizes product usage expertise as a seperate term or attribute to product involvement, and challenges and skills a user may possess in order to use a digital technology product (Khosrowtaj, 2016), its use in this research encapsulates these three attributes as part of product usage expertise, although there may be minor differences between the three attributes.

It is suggested that there is a tendency for users who are more experienced users of a product to seek to learn less about the product compared to users who are more experienced users, when making decisions about acquiring related products (Bettman, 1979). However, it is suggested that the more a user interacts with a product overtime, the more skills are gained and interest in related products (Engel & Blackwell, 1982).

It has also been found that there is a correlation between user satisfaction with product value offering and a high degree of product usage experience (Khosrowtaj, 2016; Hoffman & Novak, 1996). It has also been suggested that because of the feelings of control, experienced product users gain more interest in the product and related products (Ellis et al., 1994; Massimini & Carli, 1988). This implies there is a tendency for more experience users to acquire updates to that product and related products than users with less usage experience. Based on the foregoing, product usage expertise is an external variable of interest in this research and its association with user inclinations to be satisfied with the product value offering of smartphone context is compared against that of the IoT products context. Hence, the following hypotheses are deduce:

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- *$H_{A6.1}$: There is a positive relationship between product usage experience and user inclination to be satisfied with the value offering of smartphones.*
- *$H_{A6.2}$: There is a positive relationship between product usage experience and user inclination to be satisfied with the value offering of IoT products.*

2.7 Chapter summary

Definitions of business models , including the description of the concept of atomic BMs and a terminology that is used throughout this research. The concepts of atomic BMs and generic components of DTBM were discussed and how they will be used in the research were also discussed in this chapter. A description of how user pre-purchase decision is applied in conducting a BM research was also given.This was followed by a description of the notion of user pre-purchase decisions as used in this research. An overview of the related work in IoT research was discussed. It was found out in the literature that IoT may not have fulfilled its potention, even though there were comparatively more research work on IoT. However, these research works were mainly theoretical in nature and actually research on IoT BMs were few when compared to the other areas of IoT. The limited number of work on IoT business models, some authors suggests, may be the reason IoT has not yet made in-roads globally.

However, in this chapter it was outlined the types of traditional and non-traditional BMs in existence. Followed by an overview of DTBMs as outlined by Turban &

Volonino (2010). It was noted that the DTBMs that are of interest in this research werew those that may support a user-led investigation into the likelihood of IoT adoption of existing DTBMs. This contrast with the usual convention in IoT research in which business owners and experts are mainly recruited for their opinions on an existing or new BMs.

Hence, the DTBMs of two DT global firms (Microsoft and Apple) were found to be useful in higlighting three generic components of existing DTBM that could be applied in our user-led BM investion. These three generic components were (subscription plan, training, and price model). In particular three pairs of similar hypotheses were deduced for each of these three components to be further investigated, The pair of similar hypotheses for each of these three components, firstly sought to determine if there was a significant difference in user inclinations towards the generic component of existing DTBM based on Smartphone and IoT products context. While the second hypotheses of the pair deduced sought the determine the relationship strenght of user inclinations towards the generic component of DTBM for Smartphone and IoT products context.

Finally, a description of external variables and how they were used in this research research was outlined. In particular we discussed and justified from the literature that satisfaction and trust could be obtained as value services from the business firm to the user. We therefore concluded that satisfaction and trsut are also generic components of existing DTBMs and thus, deduced similar pairs of hypotheses for each of them to be further investigated in our user-led BM experiment, This implied that five generic components of existing DTBMs were identified for the purpose of investigating the liklihood of IoT adoption of existing DTBM. Product usage experience as an external variable of interest was also described in this chapter as with two (2) hypotheses deduced for further investigation to measure its relationship to one of the five generic components of existing DTBM (that is satisfaction with product value offering).

In the next chapter, the IoT space is described, identifying the state-of-the-arts in different areas of IoT, for the purpose of selecting three possible IoT scenarios to be described and prototyped and used as educational tools in our BM experiment that will be later described in chapter 5. The pre-cursor technologies leading up to IoT are also described with emphasis on the notion that these technologies are part of the IoT ecosystem. An outline of various software development kits (SDK) for IoT is followed by a mention of the software used for developing application wireframes for three IoT scenarios.

CHAPTER THREE

3 IoT state-of-the-arts

This chapter introduces the state-of-the-arts in the area of IoT. It begins with a comprehensive description of the IoT space outlining the use case scenarios of IoT. This is followed by a description of the health monitoring IoT and continues with the description of an IoT implementation for elderly people and people living with disabilities, that is the ambient assisted living (AAL). Subsequently a comprehensive description of IoT application in the area of home environment is described. This is followed by a description of a novel future implementation idea for IoT application for the use of the library and borrowing of books.

The description of precursor technologies such as sensors, RFID, cloud, GPS, that incorporate the IoT ecosystem are described. Finally, this section outlines already existing projects and applications developed by technology firms in the area of IoT, followed by an outline of software development kits (SDK) for IoT application development. The chapter concludes with a description of the prototyping tool that is used for application prototype development for three IoT scenarios that are proposed in section 5, followed by a chapter summary.

3.1 The IoT Space

The IoT space could be described as a physical space that is setup with a concrete IoT solution, in which smart devices are used in collecting data that is transmitted via the Internet to other devices. Market segments consisting of three main categories can be used in characterizing IoT: monitoring and controlling the performance of homes and buildings, automotive and transportation applications, and health self-tracking and personal environment monitoring (GSMA, 2012).

The IoT enables *"hybrid solutions that merge physical products and digital services"* (Fleisch et al., 2014), which seem to indicate that IoT as a potential product-service business model will result in different application areas that may revolve round everyday activities and things. The implication is a potential diversity of target customers for IoT products and services in a B2C model, which may lead to development of different offers for IoT's diverse potential customer base.

However, this research investigates the likelihood of IoT adoption of existing DTBM. Microsoft and Apple tailor their offerings on to product-service business models principles (Reim, 2015; Storey & Easingwood, 1998). Reidel (2014) supports the notion of applying/adopting existing digital technology business models to new products or technology. Hence, this study seeks to achieve that.

The IoT vision espoused by Atzori et al. (2010) posit that the differences in IoT vision of stakeholders makes IoT be approached as an 'Internet oriented' or a 'Things oriented' perspective, depending on their specific interests. The IoT process, therefore, requires huge number of heterogeneous objects. The object unique addressing and the representation and storing of the exchanged information become the most challenging issues, bringing directly to a third, ‘‘Semantic oriented”, perspective of IoT (INSFO, 2008). The IoT paradigm results from the convergence of the three main visions addressed above. A wide-ranging Internet of Things (IOT) ecosystem is emerging to support the process of connecting real-world objects like buildings, roads, household appliances, and human bodies to the Internet via Sensors and microprocessor chips (RF) that record and transmit data such as sound waves, temperature, movement, and other variables. Figure 3-1 illustrates the use-cases of IoT in an IoT space.

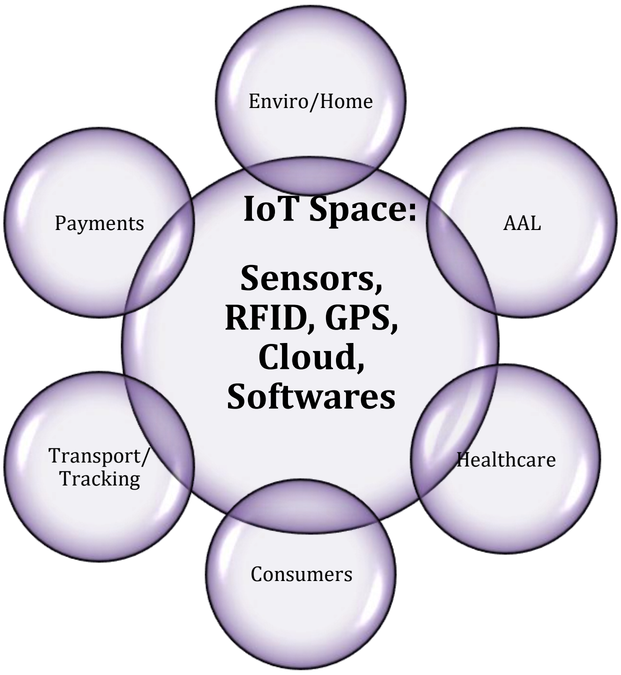


FIGURE 3-1: IOT USE-CASES

The IoT use-cases as shown in figure 3-1 covers communication between heterogeneous and homogeneous sectors such as environment, home, consumers, payment systems, healthcare, AAL, among others. One of the major enablers of IoT are sensors; and one of the areas where sensors are massively deployed is in the health sector; personal assistants are value chains in the assisted living (including healthcare), which encourages development of new business models for the IoT. O'Brien (2014) outlined three use-cases in which IoT can be applied to recurring revenue models:

1. **Location** – Being able to quickly determine the exact position of any physical thing. Lost your house key? Open an app on your phone and find it instantly.
2. **Status** – Devices that immediately report changes in their status to a system that can send a notification. You just bought the last can of Fizzy drink from the soda machine? Not to worry–it can immediately notify the soda supplier to include more in tomorrow’s delivery. Even if you are the only person in the department who actually drinks Fizzy.
3. **Consumption** – Devices that immediately report how much of them you use. If you just drained your bank account buying your dream car and you do not want to spend another £300 buying a lawnmower? Not to worry, just borrow one from a store and simply have your credit card charged £5 each time you mow.

The following sub-sections discusses the state-of-the-art with reference to the aforementioned application areas.

3.2 Health monitoring IoT

IoT applications in healthcare are still at the underpinning stage (Talpur, 2013). General Practitioners or doctors are visited when people feel ill or during their compulsory annual check-up. However, IoT can provide a means of self monitoring to alert at any negative occurrence in one's body. Few researchers have ventured into studies, design, and development of IoT health systems. Niewolny (2013) outline the significant role IoT can play in healthcare as follows:

- **Clinical care**: Hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT-driven, non-invasive monitoring. This type of solution employs sensors to collect comprehensive physiological information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review. It replaces the process of having a health professional come by at regular intervals to check the patient’s vital signs, instead providing a continuous automated flow of information. In this way, it simultaneously improves the quality of care through constant attention and lowers the cost of care by eliminating the need for a caregiver to actively engage in data collection and analysis.

- **Remote monitoring:** There are people all over the world whose health may suffer because they don't have ready access to effective health monitoring. But small, powerful wireless solutions connected through the IoT are now making it possible for monitoring to come to these patients instead of vice-versa. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyze the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations.

- **Early intervention/prevention:** Healthy, active people can also benefit from IoT-driven monitoring of their daily activities and well-being. A senior living alone, for example, may want to have a monitoring device that can detect a fall or other interruption in everyday activity and report it to emergency responders or family members. For that matter, an active athlete such as a hiker or biker could benefit from such a solution at any age, particularly if it is available as a piece of wearable technology. Figure 3-2 presents a graphic on remote health monitoring

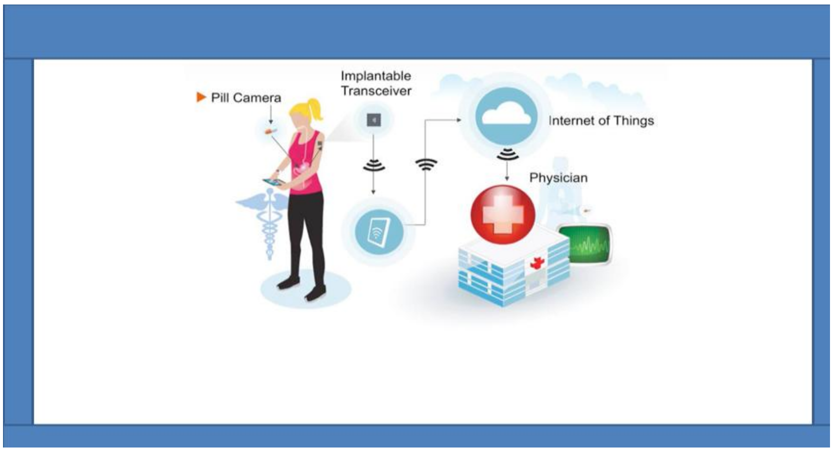


FIGURE 3-2: REMOTE HEALTH MONITORING (SOURCE: NIEWOLNY, 2013)

An example of an enabling technology for remote health monitoring is the Freescale Home Health Hub reference platform, which is built on Freescale i.MX applications processing technology and tightly integrates key capabilities—such as wireless connectivity and power management—in the telehealth gateway that enables collection and sharing of physiological information. The hub captures patient data from a variety of sensors and securely stores it in the cloud, where it can be accessed by those engaged in the patient's care. Data aggregation devices like this will soon become commonplace and will not only collect healthcare data but also manage other sensor networks within the home. Freescale’s second-generation gateway manages data from smart energy, consumer electronics, home automation and security systems—in addition to healthcare (Niewolny, 2013).

Pang (2013) developed an Health-IoT architecture that draws from the convergence of business ecosystems of traditional healthcare and mobile internet. Lessons learned from the failure of Google Health are taken into consideration in this architecture; for instance, the participation of public authority, doctors, and financial sources are enabled by technical measures including the security and authentication schemes, and the service deployment procedure based on apps repository.

Talpur (2011) discusses the significance of IoT in healthcare system with emphasis on highlighting that the extended aspect of the use of IoT is dissimilar among different healthcare components and the participation of IoT between the useful research with present realistic applications. The author's attempt at emphasizing a healthcare system for IoT aimed at realizing the illustration and traceability of healthcare actors to guarantee quality service delivery and effective control of healthcare actors was however conceptual proposition indicating deliverables as there was no illustration with workable prototypes.

Another example of health applications of IoT may include placing a sticker on one's chest to prevent heart attacks. It would monitor activity and fluid levels in your chest. This sticker could be replaced once a week to ensure continuous monitoring over a wireless connection (Bankinter, 2011). STAR Analytical Services is developing an application that will analyze a patient’s cough over their mobile phone. From the specific noise of the cough, the system can help doctors remotely diagnose anything from a common cold to pneumonia, by matching the sound to a database of 1,000 profiles (Discovery, 2013). This could bring emergency rooms into the IoT age. An IoT scenario for health monitoring is illustrated and described in section 5 as part of a within-subjects design for three IoT scenarios.

3.3 Ambient Assisted Living

The AAL environment includes any location in the home in which the user is found, but could be extended to include users walking on the road or being monitored during working hours. This form of tracking and monitoring includes technologies such as Body Area Networks (BANs) consisting of a set of sensors (usually biosensors for reading vital signs) and a transmitter, which enables the user to move around independent sensor systems at home. This has increased user participation within the AAL environment along with the proliferation of wearable devices resulting from advanced device capabilities. Consequently, personalization of services and resources in AAL environments for users are significantly enhanced by taking into consideration the user preferences, context conditions and capabilities of the device. Requirement gathering is necessary to achieve the main goals of efficiency of the corresponding systems (Costa et al., 2014).

Devices and applications such as the Fitbit, Nike Fuelband, and MapMyRun could be useful in AAL systems where the elderly persona is not totally disabled, in which case such an individual is still mobile outside the confines of the AAL environment and is doing everything possible to live healthily despite ageing. While the Emotiv BCI, NeuroSky, etc are better suited for totally or partially disabled elderly AAL persona (Casas et al., 2008). It is important to note that sensors that strictly require data transfer through USB have limited or non-existent IoT – AAL capabilities. Hence, wireless sensors are emphasized in AAL research in the context of IoT–Person–Wi-Fi and IoT–AAL space–Physical connection. Widespread adoptions of Wireless Sensor Networks (WSN) in various applications are catalyzed by improvement in wireless sensor design and energy storage.

The most important components of WSN are micro-sensors integrated with onboard processing and wireless data transfer capability, which have been in existence for some time (Kahn et al., 1999; Warneke et al., 2001), but have currently undergone more efficient design with the integration of a wide range of sensors (Aquino-Santos et al., 2013). The authors in Castillejo et al. (2014) point out that collecting various information from these entities require designing of several formal models that will help in organizing and providing some meaning to the gathered data. These formal models are applied to the various scenarios in the AAL space. The AAL space is made up of application scenarios or sub-systems that might independently be complex solutions, some of which includes indoor/outdoor guidance system, visual guidance systems, and fall-detection system. Figure 3-3 shows a non-exhaustive list of functional components of the AAL space.

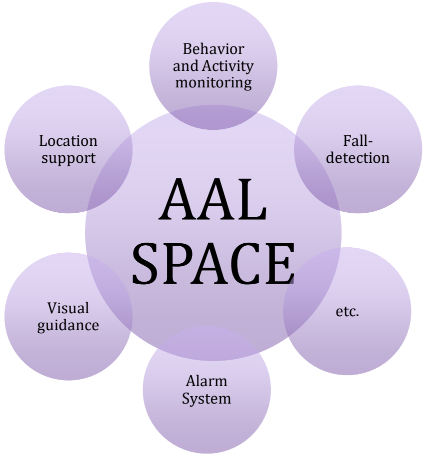


FIGURE 3-3: AAL GENERIC ECOSYSTEM

Several research works on AAL have been developed around these components of the AAL space. A high-level survey of prevailing AAL solutions for the elderly was carried out by Iliev & Dotsinsky (2011), who explored the state-of-the-art in technologies for smart homes, middleware technologies and standards, while the authors in Antonino et al. (2011) presented a review that evaluated the prevalent frameworks for the reliability, security, maintainability, efficiency, and safety properties of an AAL system to establish the quality attribute of the architecture of the AAL platform.

The above studies emphasized AAL work in countries with high GDP but with recommendations on the need for development of low-cost assistive systems for countries with lower GDP. However, if the technology is not developed to cutting edge where it was created, there will be no need selling it to the developing or under-developing nations. The following text summarizes related works in some of the areas of AAL generic ecosystem:

a) Fall detection: Several technologies and systems have been developed for fall detection, since it is one of the major features in AAL platforms, as it addresses a major concern for the aged population activity of daily living. Projects have been churned out with respect to this system over the years (Terroso et al. 2013; Chernbumroong et al. 2013; Gjoreski et al. 2011; Rodriguez-Martin et al. 2013) with an increasing fall detection accuracy of 97% achieved in a recent work by Rodriguez-Martin et al. (2013).

b) Visual guidance and location support: Wireless solutions to indoor guidance systems with a Smartphone's Wi-Fi tags were proposed in Pu et al. (2011). The authors in Losada et al. (2011) developed a similar location system enabled by ultra-wideband radio frequencies, which was novel in solving the problem of saturation-prone Wi-Fi systems, by deploying a bypass with proprietary hardware. Also, the project carried out by Fernández-Llatas et al. (2013) presented the eMotiva process mining algorithms that perform filtering, inferences and visualization of workflows from samples produced by an indoor location system, with which the location of a resident in a nursing home is stored. Their experimental results showed that the developed tool for visualization could compare and highlight patterns of behavior that facilitates expert understanding of the behavior of humans.

Also, Redondi et al. (2013) developed the LAURA system that also monitors users in a nursing home, using ZigBee wireless networks, with novelty in the use of accelerometers to detect sudden user movements, which improves accuracy of the detection system. Similar projects were developed by Liu et al. (2009) and Ramos et al. (2013), with the former designing an architecture that was limited by relying on user accustomed predefined paths with which the user is guided by landmark pictures to improve the visual memory of the user; while the latter presented novel way of restricting the user within the allow area via a smart phone's camera with a direct video feed that triggers a warning to be effected when the user bridges the boundary. One of the highpoints of these projects was the availability of permanent interface for communication between the user and caregiver.

c) Behaviour and activity monitoring: Chung & Liu (2013) designed a wireless remote tele-home care system, where ZigBee was used to set up a wireless sensor network for the users to take measurements anytime and anywhere. They used requisite measuring devices to take measurements of users' physiological signals, and monitor their daily conditions with various sensors (central to the system is a camera sensor). The ZigBee network enables the transfer of vital signs to computers that perform analyses on the data, and then triggers distinct alerts to remind the users and the family of possible emergencies. This design addressed the issue of privacy by ensuring that the video camera is turned on only when necessary.

However, Aquino-Santos (2013) described a Wireless Sensor Network for AAL as a proof of concept by developing an arrhythmia detection algorithm derived from the Pan and Tompkins algorithm, which they evaluated by developing a prototype using the TelosB platform. The architecture that was proposed took cognizance of peculiar restrictions with regard to wireless sensor network usage for relaying collected information to where the information can be registered, monitored and analyzed to support medical decisions in clinical situations. The architecture of the system was seamlessly integrated to enable network configuration and mobile node, which provides the versatility, and robustness required of real-time applications that supports medical decisions by healthcare providers. This heart rate monitoring (HRM) approach extended the hitherto isolated HRM applications to the AAL platform. The background presented above suggests the need to harness an inadequately deployed area of AAL (and in extension IOT) - being the notion of recommender systems.

An AAL infrastructure via a sensor network that enables long-term monitoring of everyday activities and physiological data in a homecare situation was developed under the European GiraffPlus project (Palumbo et al., 2014). The system developed allows a tele-operated robot (a virtual AI machine) to make a virtual visit to the cared home, during which activities that took place over a period of time including physiological data are discussed. Data is acquired from environmental sensors such as electrical usage, motion, bed/chair occupancy - and physiological sensors such as blood pressure, temperature, and usage. Alarms are triggered by the system to notify of sudden problems such as falls and deteriorated health status.

An Open Services Gateway initiative (OSGi) standard-based middleware is employed to integrate various system components such as sensors and high-level reasoning based on a context recognition application. The middleware ensures easy addition and removal of software and hardware components, thus allowing changes in configuration. It is posited that this system has been tested in six real homes in Europe to buttress its reliability (Chung & Liu, 2013). Similarly, Blasco et al. (2014) also employed the OSGi standard for designing and developing the software architecture base of a Smart kitchen for AAL, which they evaluated with sixty three (63) real users and thirty one (31) carers in two living labs in the United Kingdom and Spain. These aforementioned projects took into consideration an outstanding attribute for any application of technology developed for activity and behavior monitoring, which is the ability of the application/technology to continuously observe important vital parameters to instantaneously trigger alerts to the caregiver.

Although AAL is an important area of IoT implementation as it relates to an important sector of the UK scoiety (social care) and with several work in top gear for its advancement, it was decided that it should not be part of the scenario illustration and prototype development that were used as educational tools for the IoT user-led

BM experiment that will be described in chapter 5. This is because the study would have been circumscribed by inability of difficulty in gaining access to vulnerable people, which requires a tedious and time consuming approval process. It is also not suitable for the within-subject design in terms of the user group. For instance, a bedridden person may never visit the library building to borrow books, but may monitor his health, and acquire smart home and environment appliances.

3.4 Internet of Environment, Buildings, Homes

Smart buildings are the best example of the way the Internet can be used for environmental purposes. In the US, buildings consume 70% of all electricity, of which 50% is wasted. 50% of all water consumed is also squandered. To remedy this type of situation, many blocks are being fitted with a smart grid, a network that can optimize energy generation and consumption using a series of smart meters that choose the best time slots from amongst different power utilities and discriminate between consumption times. The result is more sensible and economic power consumption (Bankinter, 2011).

He et al. (2012) illustrated a smart outdoor plant watering implementation of IoT. When the water in the plant pot dries out, the pot generates an event notifying its owner or an actuator to water it with a suitable dose. A sensor is used to monitor the humidity of the soil in the pot, and an actuator is set up to execute the watering command. Different plants have different preferences (watering dose and frequency), so the application uses two inputs: user configuration with the plant's name, location, and life stage, and a dynamical humidity report of the soil around the plant provided by sensors. Figure 3-4 illustrates an environment IoT and a smart living room with appliances and couches connected and communicating with user applications based on user needs.

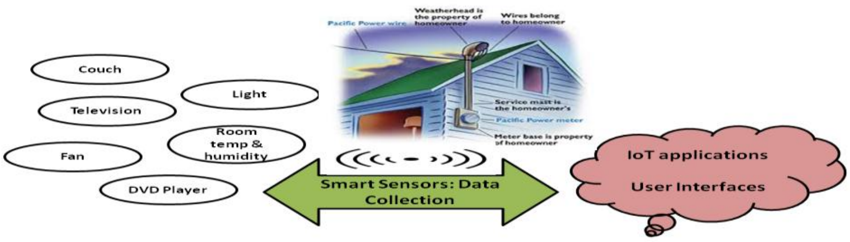


FIGURE 3-4: SMART LIVING ROOM AND ENVIRONMENT

In line with the need for consumption efficiency, “green” office spaces have been created in the GreenSpaces complex in Delhi (IBM, 2010) and the launch of the Smart IPv6 Building project with a pilot programme in Geneva (Bankinter, 2011). Bankinter (2011) also report development of the first integrated smart city in Iowa, U.S.A. In 2010 they installed monitoring systems to analyze the interaction between water and electricity supplies and transport.

Pacific Gas & Electric rolled out a massive smart grid for homes in the city of Bakersfield, in northern Los Angeles, in which the homes were fitted with “smart” meters (PG&E, 2009). Unlike traditional devices, these could be read remotely, doing away with the estimated meter readings. Also, in the event of a power cut, the utility could remotely reconnect the power faster. However, the first sets of bills had tripled in costs, which led to protest. The company claimed that the disproportionate increase was due to a heat wave and the fact that consumers had made no effort to adapt their consumption to times with lower rates (PG&E, 2009).

Whatever the reason, the incident has put a damper on the initial excitement of signing up to the smart grid and may represent an obstacle in the mind of other consumers when it comes to adopting IoT-related technologies (Bankinter, 2011). The lesson is that in order to avoid situations like Bakersfield, it is important to manage customer expectations on IoT applications. In this case, consumers should have been made aware that the change would also require an effort on their part. The ideal thing would have been to complement the grid roll-out with the installation of home control panels providing real-time information on consumption and costs (Bankinter, 2010).

As part of this research, a home and environment IoT scenario is described and illustrated in section 5 with corresponding clickable application prototype developed with Just-in-mind software. This home and environment scenario, although mostly not novel, is useful as an educational tool for participants in the broader experiment designed in this research. Also, specifications of a smart home IoT prototype is outline in appendix... The following section outlines an IoT implementation in the library which falls under a smart building implementation of IoT. The reason for the choice of these two scenarios in this research, as with the health monitoring scenario mentioned in section 3.2 is to ensure that participants can take part in the three experimental scenarios in a within-subject context.

3.4.1 An IoT implementation idea in the Library

A use case for the use of library and borrowing of books application could be implemented based on the IoT paradigm, whereby books and bookshelves are embedded with RFID chips (as active sensors) that are deployed for users to locate books on shelves for onsite reading or borrowing with status updates of current location of the IoT enabled books. The utility derived in library usage is not only obtained from the serene environment for reading, but it is also obtained from the ease of location of book shelves and required book respectively.

This is in line with two of the three possible IoT use-case revenue models mentioned in section 3.1. In particular, students, staff, members of the public, may find this useful in the case of a student borrowing such a book and misplacing it; then locating and recovering the book may be found as cost-saving for students and library users who in most cases are required to pay for lost library books. It may also be suitable to ease library assistants in shelving in the process of shelving returned books.

The issue of locating library books hinges on shelf marks that are used to identify book shelves in the library may consist of confusing sequences. A shelf mark is an identification number found within a book catalogue that indicates the location of that book in the library (Leiden, 2009). Not every library user is acquainted with or has the mastery of retaining the cataloguing system of library books. Most libraries have guides for users to locate bookshelves, which are mounted on pillars or overhead screens in the library lobby describing how users can identify shelves using shelf marks and on which floor.

Also there is the problem whereby a few number of library users have borrowed books from the library and misplaced/lost the book, and in many cases they are required to pay for the lost books to be replaced. A single shelf in the library is assigned sequences of shelf mark codes comprising letters and numbers which may pose problems for users locating a book and corresponding shelf in the library. Mark Weiser's definition of ubiquitous computing as 'the method of enhancing computer use by making many computers available throughout the physical environment making them effectively invisible' (Weiser, 1991) could be made manifest in the implementation of IoT even more than in the ubiquitous computing paradigm. This is because everyday objects could be embedded with chips (sensors and RFID, etc), thus, turning these objects to computers interconnecting in a network to the internet.

In the case of an IoT implementation in the library, bookshelves and books could be tagged with active RFID chips (invisible to the user) with the range of up to 100m which has a wider coverage area than passive RFID tags with the range of 10m (IMPINJ, 2019). Users can then access this tags as aided by location applications which includes mobile devices (embedded with RFID chips) and Servers. Also, in a future implementation notion, when embedded devices are further miniaturized, portable GPS chips could be embedded in valuable books for locating the books both within the library and outside the library.

Klepal et al., (2009) in a related work implemented a shelf location system that verifies availability of library users' required book before they proceed to locate the shelf within the library building. The system they proposed identifies the shelves internally with an RFID number, while the user interface identifies the shelves with the conventional shelf marks. Therefore, each shelf is assigned its shelf mark and corresponding internal RF identification number.

Also, several other related work developing library management and utilization systems to ease library usage and management have been in the horizon. The LibBest Shelf Management System (The BookTec Information Co, 2007A) and Patron Self Check-out/in Station (The BookTec Information Co, 2007B) are two technologies that are related to the design that is proposed for an IoT implementation in the library in this research. See section 5.2.3 and section 2 of appendix B for description of the scenario and Just-in-mind clickable prototype respectively, for the novel future implementation and atomic BM idea for the use of the library and borrowing of books IoT proposed by this researcher.

The LibBest Shelf Management System is a solution with functionality to assist librarians to search for individual books that have been tagged with Radio Frequency Identification (RFID) chips, inventory checks of library stock, and search for miss-helved books. It is made up of a base station and a portable scanner. The portable scanner is swept across the spines of the books on the shelves to identify each of them The system compares the identities of books collected with a database in an inventory check situation and generates reports if there area discrepancies found. In the case of miss-helving, a built-in beeper sound from the scanner alerts the librarian of foreign items found on the shelf (The BookTec Information Co, 2007A).

This shelf management system is only available for use by library staff only and can be extended to users for identification of books on shelves, but its concept of use can be applied to a user shelf location system. The Patron Self Check-out/in station is a computer with a touch screen user interface comprising RFID reader and special software for user identification. The self check-out station identifies a user with his library identification card then prompts him for a check-out. The user then places the book or books he collected in front of the RFID reader and the checked-out (borrowed) book title and its ID number is displayed on the screen. On finishing the process, a receipt is printed showing books that have been borrowed and return date. The user can then pass through security gates at the library exit without an alarm going off because the RFID tag in the book has been set to quiet (The BookTec Information Co, 2007B). The benefit of this system is that the there is reduction in time taken to process a book or books for borrowing from the library.

Developing a system to ease the location of book shelves would serve as a complement to the Patron Self Check-out station and the Shelf Management System. This is because the time taken to locate the shelf, identify and pick the book, and processing the book for borrowing would be effectively reduced for the user. Indoor Location Technologies There are quite a number of systems that have been developed for indoor location of objects (localization). Localization is a term in robotics engineering for the determination of physical position using uncertain sensors (Ladd et al., 2002).

The Opportunistic Localization System for Smart Phones - OLS (Klepal et al., 2009) is a system that determines the location of a mobile client (smart phone) by obtaining streamed sensory data from the smart phone's accelerometers, Wi-Fi, Bluetooth, GPS and GSM/UMTS. The OLS is coordinated by an OLS Server which handles data fusion, database, communication, management, location, and registration services. One of the advantages of OLS is its ability to interface with Google Earth to produce a map of the indoor building environment through its data fusion engine. Klepal et al. (2009) posits that *"OLS does not require a fixed dedicated infrastructure to be installed in the environment making OLS a truly ubiquitous localization service"*.

This ubiquitous functionality and set-up of the OLS is similar to the design concept proposed in this research. The Robotics-Based Location Sensing (RbLS) using Wireless Ethernet (Ladd et al., 2002) is an indoor location technology that tracks the position of a wireless mobile client. The system uses IEEE 802.11b wireless Ethernet card (embedded on the robots) that communicates with standard base stations to measure Radio Frequency (RF) signal strength thereby determining a mobile client's indoor localization. One of the advantages of RbLs is that it infers the position of the mobile robot without the computational overhead of image processing.

Another location system is the Microsoft Research's Easy Living (Krumm et al., 2000) which uses stereo vision to determine a three dimensional position in an indoor environment. But a major disadvantage (Kotz & Chen, 2000) of this location support system is the expensive hardware requirement and computational overhead of image processing. The novel future implementation and atomic BM idea for the *'use of the library and borrowing of books IoT'* scenario and Just-in-mind clickable prototypes are described and developed in sections 5.2.3 and section 2, appendix B of this report. The atomic BM for this library IoT scenario is a value-for-user and revenue-for-organisation BM idea for the location of lost borrowed library books outside of the library building, as part of a future technology implementation of IoT.

This novel idea envisages that with the future goal towards the minutest miniaturization of RFID chips, GPS chips, Wifi Sensors, etc, this chips could be so low cost that they could be embedded in the bind of every (valuable) library book for location of such books on shelves (enabled by RFID) within the library and location of such books if they are lost by a library user who borrowed it for use outside the library (enabled by GPS). The accuracy of locating an IoT enabled book as with other embedded objects will depend on the type of RFID system that is used. *"A passive RFID system indicates that a tag is in the read field, so with a passive high-frequency (HF) system, you would know a tag was within about 3 feet of a reader. With a passive ultra high-frequency (UHF) system, you would know that a tagged item was within 20 to 25 feet of the reader antenna, and perhaps no more than 10 feet to the left or right of that antenna" (Roberti, 2015).*

As part of the implementation idea, the proposal suggests an implementation of this IoT location service **within the library** should use active RFID tags as against passive RFID tags. This is because active tags can detect an item that is within 300 feet of a reader (a Smartphone with the corresponding application) and with active tags, read accuracy is usually 100% as information is broadcast by the tags like a cell phone, but passive tags are subject to interference especially if signal is blocked by a metal it will be impossible to interrogate the tags (Roberti, 2015).

For the IoT implementation in the library for locating lost borrowed library books outside the library, the solution suggest embedding portable GPS chips that will transmit location data to the cloud base of the library IoT application tailored to each library user that opts for the lost borrowed book recovery service to enable them to locate a lost borrowed library book for a token. When users return the borrowed book, access to location data is lost as authorized library staff will be saddled with the responsibility of managing borrowed books location data that are transmitted to the cloud server, which will include deletion of location data of a returned borrowed library book.

This library IoT implementation is a part of a future technology implementation idea. The atomic BM idea, which is how revenue can be generated by the library administration from this novel idea will be describes in the scenario in section 5.2.3 and will also be part of the Just-in-mind prototype design in section 3, appendix B. Particicipants in the within-subjects experiment proposed in this research responded to questions relating to this novel future IoT implementation scenario to determine how valuable this may be for them. This was after they acquainted themselves with the scenario through researcher description of the scenario using the accompanying diagram; and participants carrying out hands-on tasks with the Just-in-mind clickable wireframe. A discussion of the findings is outlined in section 6.7.

3.5 Payment Systems for IoT and Internet of Consumers

There are few published work on payment systems for the IoT, but the concept is gradually gaining attention in the technology and financial industry. However, most of the published materials for IoT are suggestions as to how IoT can revolutionaries payment systems. Parekh (2014) emphasize that IoT and M2M technology will enhance customer experience in the retail sector in relation to cash-free payment, whereby a Smartphone or another mobile device is held in front of a payment terminal. In another vein, Nicholds (2014) highlight that the opportunities for payments are boundless as triggered by technologies such as NFC. Mobile payment, NFC, and now IoT payment, are leveraging on the credit card payment. Figure 3.5 shows the credit card payment process.

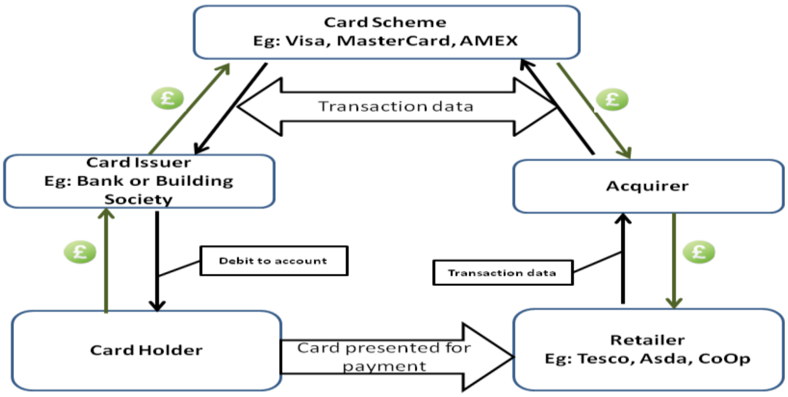


FIGURE 3-5: CREDIT CARD PAYMENT PROCESS[10]

Thus, payments, mobile and digital technologies, although developed separately, are converging at an incredible rate. One of the interesting area for IoT payment is for device subscription service. For instance, a subscription management solution for IoT markets has been designed to securely and remotely charge subscriptions in connected objects, with the ability to integrate with all the existing IoT/M2M platforms of mobile operators (Oberthur Technologies, 2014). For Original Equipment Manufacturers (OEMs), this solution, according to the designers (Oberthur Technologies), ensures reduction in cost for logistics and distribution for OEMs, and also enables easy connection to the local network s of partner operators for users. Figure 3-6 illustrates the connections between stakeholders in the payment industry. The main interest of the major stakeholders in the payment industry is outlined by Wengi (2009) as follows:

a) Merchants (Eg: Tesco, Sainsbury, Asda, CoOp, etc): Reliability of the payment system, Increased revenue, Reduced expenses, Payment convenience, security and speed, Low transaction costs, Low investments in payment infrastructure, Simple setup and operation of infrastructure.

b) Payment Networks (Eg: AMEX, Mastercard, Visa, etc): Keeping their position as a core enabler in the payment industry, Increasing global market share in the payment industry, Increasing revenues through higher transaction volumes, Making proximity payment one part of their strategy.

c) Financial Industry (Eg: Barclays, HSBC, RBS, etc): Keeping their benefits of processing payments, Keeping their revenue or having a compelling reason to share

[10] www.apacs.org.uk

it, Increasing electronic payment transaction volume from replacing cash sales, Making proximity payment one part of their strategy.

d) Mobile Network Operators (Eg: Orange, T-mobile, O_2, etc): Making mobile phones more attractive and important to the users, Increasing customer loyalty & network traffic, Getting a share of the transaction fees, Encourage consumers to upgrade to new NFC-enabled phones, Making other use of the NFC-enabled handsets (e.g. in marketing).

e) Chip/Mobile Device manufacturers (Apple, Samsung, Blackberry, HTC, etc): Increase customer loyalty, Allow as many applications as possible to attract consumers, Fronting of payment applications to attract more consumers (such as Apple Pay). Figure 3-6 shows stakeholders in the payment process.

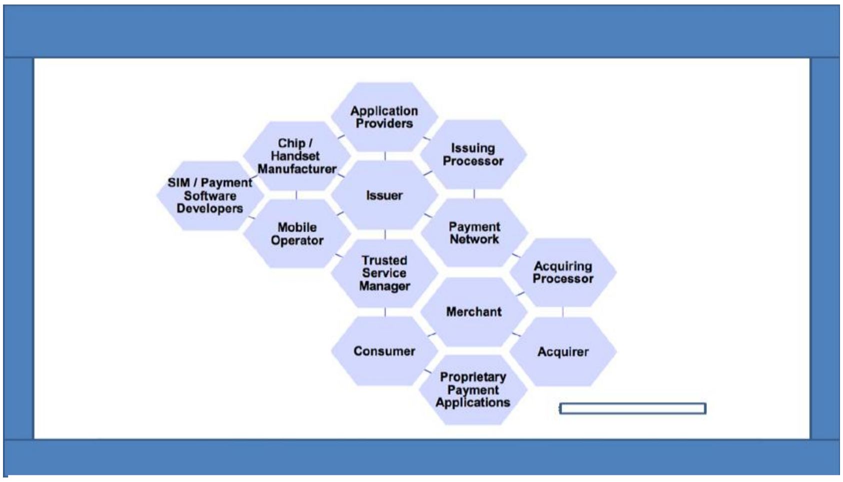


FIGURE 3-6: STAKEHOLDERS IN THE PAYMENT INDUSTRY[1]

In another report, Winston (2014) categorized companies in the payment industries and how they wil1 benefit from IoT by creating new revenue streams. This is illustrated in table 3-1.

TABLE 3-1: CATEGORIES OF BENEFITING FIRMS FOR IOT PAYMENT

Payment Industry Category	Example Firms	IoT Payment Scenarios under development
Payment Services Companies	MasterCard, Visa, American Express, etc	• Gains are being made by payment services companies through increased non-cash transactions and greater access to data. • One way in which payment processors may gain additional revenue is through a revolution in utility payment methods. Nest Labs, a household device maker recently acquired by Google, developed smart smoke alarms and thermostats that can be controlled remotely by smart devices such as iPhones. This is such that companies such as Visa and MasterCard to embed chips in these devices, which could be programmed with the user's credit card information, they would earn additional fees through automatic electronic utility payments, as opposed to traditional bill pay.

Tech Companies	Libelium, Qualcomm, etc	• Payment-tracking systems that would tailor payments through a usage-based model • Service providers such as gyms could charge fees based on how much a customer uses specific machines. • This facilitation of payment processing is enabled by RFID/NFC and ZigBee sensors based on user location or activity duration for public transport, gyms and theme parks. This entails information tracking about consumer profiles and behaviour.
In-store Payments	Shopping malls, retail and grocery stores	• automate the process of in-store payments • For instance, through chips embedded in wearables, stores could access certain shopper information upon a consumer's entrance into their shop. This would allow consumers to simply walk in a store, pick-up an item, and walk out—their cards charged automatically • Easy Pay, launched by Apple Stores, is an early entrant into automating the payment space. Easy Pay allows shoppers to pay for goods using the information attached to their iTunes account. Stop & Shop supermarkets have joined in, providing customers with intelligent carts, which calculate purchases as items are placed in the carts. As these technologies continue to develop, payment mechanisms will become more seamlessly automated. Sensors embedded in physical objects—from shopping carts to check-out counters—and linked through wireless networks stand to provide a range of new opportunities to automate and customize the payment space.

From the above table, it could be pointed that financial Institutions are always at the forefront of adopting new technology, but as highlighted by Infosys (2015), the emergence of IoT have firms scrambling to leverage on it in order not to be caught napping by the disruptive tendencies that comes with it. The consumer can be empowered by embedding payments in the many physical objects surrounding them without using card/cash/smartphone, but this should be tailored based on the consumer wish-list not on what the provider wants.

Consequently, wearable watches have been developed for the user to seamless make payments without the need to repeatedly enter his/her PIN. Therefore, financial institutions will be able to, with the aid of IoT, understand and segment consumers, for product customization, which will reduce consumer churn, increase loyalty, coupled with improved efficiency, leading to more top-line and bottom line and different brand experience (Infosys, 2015). Some of the published works on IoT payments are in the arena of suggestions as to how IoT payments can be applied.

A hypothetical business model can be developed for a smart ski lift ticket that encompasses all of the three aforementioned use-cases. It should be emphasized that IoT can be harnessed alongside pre-existing technologies such as NFC and monetization engines to accomplish the above task. However, all that is needed to make these things a reality is creativity (O'Brien, 2014). One way IoT can encourage users is by making them to be more conscious of their consumption. Sensors allow any activity to be registered continuously implying that decisions can be based on the results, which could translate into economic benefit for certain sectors of consumers. For example some automobile insurers in Europe and the United States are installing sensors in their customers’ vehicles to charge them on the basis of their driving behavior rather than by demographic criteria (McKinsey, 2010).

IoT can also throw light on some consumer patterns, which are extremely valuable for brands and stores (Bankinter, 2011). A survey by marketing professors at the Wharton School shows the shopping activities of supermarket customers (Knowledge@Wharton, 2007). Using an RFID tag attached to the shopping trolley, they could monitor and add data on speed of purchase and the physical route round a supermarket. The company that designed the technology, called PathTracker, claims that only between 20% and 30% of a buyer’s time is spent actually buying products (Knowledge@Wharton, 2007; Larson et al., 2005). These results offer valuable information on consumer behavior, which companies can use, for example, to decide how to get the most from the remaining 70% of the time. As well as improving the layout of the store and identifying the most profitable areas, knowing how customers shop creates a new dimension in marketing in which companies can try to influence the routes taken with electronic media (Bankinter, 2011).

A major challenge that IoT will face is in the area of burden for resource cost and how this could translate to high cost being presented to the consumer, which may result in rejection of the technology by a large percentage of people. Curtis (2015) makes a case for who bears the actual cost of IoT service provision. She suggest that governments should invest in the development of IoT products and services in the same way they subsidize other utilities, because billions of new devices connected to the Internet will definitely eat up the network bandwidth of Internet Service Providers and mobile operators.

This is very instructive if there should be mass adoption of IoT globally by way of government-backed standards to govern its development and usage. Failure to provide production cost palliatives by governments could have the firms that provide IoT 'things' pass the cost to the consumers. In line with this, the UK government is investing £8 million through its innovation agency, Innovate UK, to develop the

HyperCat consortium, which is working to create common standards and protocols for the IoT. The configuration of the Internet of Things will be quite different from the traditional Internet. For instance, someone who downloads an HD video might use up several gigabytes of data, whereas a vehicle that sends a message to a sensor in a car park may only use up a few bytes. The difference is that the video only needs to be sent over the network once, whereas the vehicle may need to send out hundreds of enquiries to different sensors before it finds a free parking space (Curtis, 2015).

Consequently, the communications regulator in the UK - Ofcom has proposed to free up spectrum and network address space, in order to support connections between the vast number of devices. However, mobile operators and internet service providers will ultimately need to decide how much of their own money they are willing to invest to support the IoT (Curtis, 2015). Tailoring payments based on usage of a connected device will enable delivery of annual updates to the IoT application software certificate or user license and discounts can be given based on frequency of usage of the connected device.

3.6 Precursors of IoT: Sensors as major enablers of IoT

Sensors are devices that provides a sensing channel that can be used in measuring something in the real world and representing the relevant information in terms of data in the virtual realm (Tazari et al., 2010). One of the reasons for rapid proliferation of Sensors is the ability to miniaturize sensor devices to fit into any given scenario. Device miniaturization allows for increase in mobility, while increased computing power ensures faster data processing rate, but incoming data still require the supervision of human beings, which places the burden of reviewing vast amounts of information on the shoulder of developers (Costa et al., 2014).

Also, Augusto et al. (2013) highlighted that the spontaneous growth of the Web of Things has led to the integration of advanced features in nearly all devices, thus, creating ubiquitous systems and enabling the use of high-level information, which generates complex context information of the events of the environment. Consequently, the increasing number of low-cost sensors is a major engine room of IoT. These sensors are deployed in the monitoring of a wide variety of environmental conditions that can affect health, which include barometric pressure, humidity, temperature, vibration and magnetic field intensity, light intensity, tilt, etc. Swan (2012) outlined some of the standard sensors and their area of application as shown in table 3-2.

TABLE 3-2: SENSORS AND APPLICATION AREAS

S/N	SENSOR TYPE	PURPOSE
1.	Accelerometer	Measures movement
2.	Potentiometer	Measures sound, light, electrical potential
3.	GPS	Measures temperature, moisture, location
4.	GSR (Galvanic skin response)	Measures heart rate and heart rate variability, and skin conductivity
5.	ECG/EKG (Electrocardiography)	Records the electrical activity of the heart
6.	EMG (Electromyography)	Measures the electrical activity of muscles
7.	EEG (Electroencephalography)	Reads electrical activity along the scalp
8.	PPG (Photoplethysmography)	Measures blood flow volume

Several devices and solutions employ these sensors with a current trend of multi-sensory inclined platforms consisting of various sensing elements. However, it is important to note that sensors that strictly require data transfer through USB are incompatible to IoT. Hence, wireless sensors are emphasized in the IoT paradigm. Widespread adoptions of Wireless Sensor Networks (WSN) in various applications are catalysed by improvement in wireless sensor design and energy storage. The most important components of WSN are micro-sensors integrated with onboard processing and wireless data transfer capability, which have been in existence for some time (Kahn et al., 1999; Warneke et al., 2001), but have currently undergone more efficient design with the integration of a wide range of sensors (Aquino-Santos et al., 2013).

The technologies mentioned above have been incorporated into cloths and common accessories such as bracelets, wrist watches, etc, for the purpose of measuring, registering and transmitting physiological data for body temperature, heart rate and movement (Teller, et al., 2004; Knight, et al., 2005). Schweiebert et al. (2001) gives a description of a prototype that is based on embedded implanted intelligent sensors for a retinal prosthesis, while Mamykina et al. (2006) and Gislason et al. (2012) gives a description of a prototype for monitoring of diabetic patients. Whereas, the authors in (Ganti, et al., 2006) describe SATIRE that employs accelerometer and global positioning system (GPS) reading for identification of user activity with the possibility of wireless data transmission.

Some of the available first-generation quantified personalized self-tracking devices and applications (such as Nike Fuelband, MapMyRun, Fitbit, myZeo, BodyMedia, RunKeeper, MoodPanda, The Eatery, Emotiv brain-computer interfaces (BCI), Luminosity's Brain Trainer, NeuroSky, etc) incorporate a mix of an accelerometer, GSR sensor, temperature sensor, and possibly heart rate sensor (from which heart rate variability may be calculated). The Quantified Self Community maintains a dedicated website[11] dedicated to listing current quantified tracking devices (Swan, 2012).

Out of all the aforementioned personal tracking devices, the Fitbit is most suitable for developers because it offers open access to its API development environment for third party applications to build upon. It has the capability to detect physical activity and energy expenditure, wireless syncing data when the device is within 15 feet of the base station, and consists of a micro electro-mechanical system-based triaxial accelerometer and an ultra-low powered 2.4 GHz ANT radio transceiver that operates its base station (Ceaser, 2012).

The user is able to navigate to the outputs by pressing a single button that displays an organic light-emitting diode (OLED) which indicates calories burned, steps taken, miles, time, floors climbed, and a flower that grows as a result of increase in physical activity throughout the day. An option is available for the user inclusion of optional greeting as well as user-specified 'chatter' for daily encouragement. Fitbit uses a set of protocols known as the Fitbit API (Fitbit, 2014) - at the core of which is the IoT-inclined REST API - to read and write data for a user's tracker collections, profile data, social resources, fetch status of devices and statistical data.

Also, the rapid increase in production of Smart phones with embedded Sensors is aiding the development of new mobile applications for biometric health monitoring. However, Chaudhri et al. (2012) highlight the limitations of applications programs to communicate with external sensing devices, as a result of the programming constraints of implementing communication between smartphones and external sensors, as well as energy constraints and deployment complexities; thus, preventing adoption of these applications in resource constrained environments. Their work was an effort to reduce the barriers of application creation and provide for a high level of customization and flexibility that increases the variety of external sensors that mobile applications can use.

Similar works on applications developed for manipulation of data gathered from Smart phone sensors were carried out by Che et al., 2012; Das et al., 2010; Lin et al., 2011; Lin et al., 2010; Li et al., 2012; Leijdekkers & Gay, 2006**;** Arteta et al., 2011; Lee et al., 2010. The choice of Sensor type (including manufacturer, specifications)

[11] http://quantifiedself.com/guide

for a similar system by two different developers could affect (limit or enhance) the software/application developed to manipulate measurements obtained from such a sensor. Also, the choice of programming languages and algorithms used in delivering user applications/solutions from the measurements obtained from the sensor might play a role in reducing the effect of such limitation (if any) the sensor type might have on the finished application.

3.7 Precursors of IoT: Related work in the area of NFC and RFID

RFID, sensor networks, and NFC are the foundation technologies of internet of things (Wang & Ip, 2013), as they represent key ways in which information could be collected for IoT (Atzori et al., 2010). With the wide applications of RFID, some research have been carried out as a prove of concept. Presser & Gluhak (2009) posit that RFID is at the forefront of the technologies driving the IoT vision. This results from maturity of RFID, low cost, and strong support from the business community (Atzori et al., 2010). But, a wide portfolio of device, network, and service technologies will eventually build up the IoT. However, few works have been carried out in the area of NFC as a result of slow-paced adoption (Tan et al., 2013).

The potential benefits of RFID for supply chain in three aspects: revenue, operation margin and capital efficiency were reported in the literature (Sarac et al., 2013). Villanueva et al. (2012) developed architecture for massive RFID product tracking with the notion that active user involvement in RFID development will lead to more companies being involved in the IoT ecosystem. This is very insightful for this research, as the approach adopted for this research focuses on consumers contributing to how the IoT business model is develop. Oztaysi et al. (2009) discussed the potential benefit of RFID applications in hospitality industry in literature. Oztekin et al. (2010) discussed the tracking of medical assets by RFID. Also, several literatures have researched how temperature could be monitored in perishable food transportation with the aid of RFID and sensor network (Jedermann et al., 2009; Wang et al., 2010) in order to efficiently reduce the losses that go with food/grocery transportation.

It is posited that mobile payment is the fastest-growing application of NFC (Phneah, 2012). Pham & Ho (2014) highlight a broad set of NFC applications that are currently in use, which include identification, proximity payments, smart posters and e-tickets. Amoroso & Magnier-Watanabe (2012) emphasize that NFC mobile payment's realistic take-off is tied to enthusiastic consumer adoption. MasterCard is collaborating with banks and telecom firms to issue transactions seamlessly to customers' NFC enabled phones (NFCworld, 2013). In order to contribute to the few researches providing guideline for NFC adoption, Pham & Ho (2014) in their study outlined several parameters that could be used to measure consumer adoption of NFC mobile payments deduced from various literature on consumer behavior.

Some digital technology firms have ventured into production of NFC applications. For instance, Apple Pay, which is facilitated by NFC represents among others, a major advancement in iPhone history, although it was developed eight years after the Nokia 6131 became the first NFC-equipped handset (Merriman, 2014). However, because of Apple's success in its earlier platforms, it is possible that their entry into the NFC market may catalyze wide spread/global adoption of NFC. Apple's NFC design uses virtualizes transaction data, which indicates an increased focus on security to guard against hackers reaping rewards off these transactions. This is because NFC has the potential of attracting many cyber criminals. Thus, it is suggested that security is a major reason for the slow-paced global adoption of NFC (Merriman, 2014).

As highlighted by Payment Cards (2018), the market success of contactless payments could be seen by the numbers of transactions done through the medium. For instance they highlight that the number of retail locations accepting contactless payments accross Europe is put at 42%, with 36% of all in-store transactions in the UK made through contactless. Also 80% of terminals in the Netherlands accept contactless payments, with more than 50% of payments being made with contactless.

Several constructs to measure user acceptance of new technologies such as NFC are usually derived from theories of technology acceptance model (TAM) literature - TAM (Davis, 1986; Davis, 1989; Davis et al., 1989), TAM2 (Venkatesh & Davis, 2000) and TAM3 (Venkatesh & Bala, 2008). These constructs are also useful in a broader scope of considering IoT acceptance, as there are few research work on IoT acceptance (Gao & Bai, 2014; Park et al., 2017).

However, as highlighted in section 1.1, especially the illustration in figure 1-1, in order for IoT to be accepted ubiquitously accepted by users, research and industry-led work on IoT business models should be prioritized. So, this research focuses on developing a business model framework for IoT to achieve the primary aim of broader IoT acceptance by users. In particular, the focus is on investigating those business model components that will drive adoption of existing digital technology business model for IoT from the user perspective.

3.8 Precursors to IoT: Cloud

Cloud computing has emerged as an important computing paradigm, enabling ubiquitous convenient on-demand access through Internet to a shared pool of configurable computing resources (Armbrust et al., 2010; Chang et al., 2018). In this paradigm, software (applications, databases, or other data), infrastructure and computing platforms are widely used as services for data storage, management and processing. They provide a number of benefits, including reduced IT costs, flexibility, as well as space and time complexity. In order to benefit, however, from numerous promises that cloud computing offers, many issues have to be resolved, including architectural solutions, performance optimization, resource virtualization, providing reliability and security, ensuring privacy, etc (Sohal et al., 2018; Al-Dhuraibi et al., 2018; Liu et al., 2018).

Various implementations of IoT are already part of our daily lives, their adoption and use are expected to be more and more pervasive as advances in enabling technologies such as RFID, Sensors, Cloud computing and big data are consolidated upon with the inherent potential of disrupting both current and future internet. IoT can tap from the virtually unlimited capabilities and resources of Cloud to make up for its technological constraints such as storage, processing, communication (Botta et al., 2016). For instance, Cloud can offer an effective solution for IoT service management and composition as well as implementing applications and services that exploits the things and data produced by them (Lee et al., 2010).

Cloud computing is a disruptive technology with profound implications for the delivery of internet services as well as the IT sector as a whole. However there are specific business related and technical issues with the potential of stifling user adoption and poses a constraint on advancement in Cloud applications provisioning to users such as security (data security and integrity, network security), privacy (data confidentiality), service level agreements, lack of standard APIs that prevents users from extracting code and data from one site to run on another. Moreover, outsourcing infrastructure to Cloud providers, public customers may be exposed to price increases, reliability problems or even the Cloud provider going out of business (Armbrust et al., 2010).

The architecture of Cloud can be divided into four layers (Zhang et al., 2010); datacenter (hardware), infrastructure, platform, and application. Each of them is viewed as a service for the layer above and a consumer for the layer below. Cloud services can be grouped in three main categories namely; (a) Software as a service (SaaS): refers to the provision of applications running in the Cloud environment (b) Infrastructure as a service (IaaS): refers to providing processing, storage and network resources allowing the customer to control the operating system, storage and application. (b) Platform as a Service (PaaS): refers to platform-layer resources such as operating system support, software development frameworks, etc. Cloud computing model is attractive since it frees the business owner of the burden of investing in infrastructure rather renting resources on an as needed basis and pay per use (Botta et al., 2016).

3.8.1 Types of Cloud

Considering the different issues related to Cloud environments such as lowering cost and increasing reliability among others, each type of Cloud has its own benefits and drawbacks. Thus selecting a proper Cloud model for use in IoT will depend in the specific business scenario. The following are the types of Cloud implementations available as reported in the literature (Mell & Grance, 2010; Zhang et al., 2010):

(a) Private Cloud: Exclusively implemented for use by a private organisation, as it is typically owned, managed, and operated by the organization itself.

(b) Community Cloud: Exclusively implemented for use by a specific community of users that have shared concerns.

(c) Public Cloud: Implemented for open use by the general public.

(d) Hybrid Cloud: This is a combination of two or more Cloud infrastructures (private, public, community).

(e) Virtual Private Cloud: Implemented to address issues related to public and private Clouds by taking advantage of virtual private networks (VPN) technologies to allow businesses to setup required network settings such as security, topologies, etc.

The future development of cloud computing systems is more and more influenced by Big Data and IoT (Xia et al., 2017) and there are research and industrial works showing applications, services, experiments and simulations in Clouds that support the cases related to IoT and Big Data (Ni et al., 2018). The cloud is useful in IoT, becasue it is actually the repository for user visualization of the data received from embedded device such as sensors, actuators, RFID, etc; as it is in the case of the Fitbit. The cloud is therefore an essential part of the IoT ecosystem.

3.9 Precursors to IoT: Global Positioning System (GPS)

The history of GPS is an account of how basic research first made possible a vital defense technology and then a variety of important commercial applications. Many other technological advances also contributed to the development of GPS, among them satellite launching and control technologies, solid state devices, microchips, correlation circuitry, time-difference-of-arrival technology, microwave communication, and radio navigation (NAS, 1997).

The precise location and timing ability of GPS is a critical enabler of many IoT applications. From precision agriculture, to automated vehicles, to fleet tracking, to smart mining, and many many more (McClelland, 2017). It supplies the user with Location Based information that can be used for mapping(cars), location (geocaching), performance analysis (sport), GIS (Geographic Information Services – Google Earth as an example – pick a street and the technology can link to a database showing what retail outlets are in that vicinity).[12] NAS (1997) outlined more application areas in which GPS already have been gainfully applied:

• Emergency vehicles use GPS to pinpoint destinations and map their routes.
• GPS is used to locate vessels lost at sea.
• Trucking and transportation services use GPS to keep track of their fleets and to speed deliveries.
• Shipping companies equip their tankers and freighters with GPS for navigation and to record and
control the movement of their vessels.
•Pleasure boaters and owners of small commercial vehicles rely on GPS for navigation.
• Civilian pilots use GPS for navigation, crop-dusting, aerial photography, and surveying.
• Airlines have saved millions of dollars by using GPS to hone their flight plans; GPS can be used for instrument landing at small, as well as large, airports and is making new air-avoidance systems possible.

[12] http://www.gpsports.com/gpsports_website/articles/GPS%20-%20What%20is%20it.pdf

• GPS is used regularly for mapping, measuring the earth, and surveying. GPS has been used to map roads, to track forest fires, and to guide the blades of bulldozers in construction processes, making grading accurate to within a few inches.
• Earth scientists use GPS to monitor earthquakes and the shifting of the earth's tectonic plates.
• Telecommunications companies increasingly rely on GPS to synchronize their land-based digital networks, comparing their reference clocks directly with GPS time.
• Satellite builders use GPS receivers to track the positions of their satellites.
• GPS is being installed in automobiles so that drivers not only can find out where they are but also can be given directions. In Japan, 500,000 automobiles have already been equipped with a GPS-based navigation system.

A successful application of GPS to IoT especially in a B2C context in contrast to B2B context, will be more likely when GPS chips are gainfully miniaturized for user applications. This is because current GPS sensors sizes although portable, are still sizeable and will not to fit many things of benefit to the user directly, and they are also expensive. For instance in our library IoT scenario, the major embedded component that could enable tracking the location of lost books outside the library is the GPS. But until it is so portable and low-cost, such that it could fit into the bind of a book, the application scenario here may not materialize. That is why, the research views this idea as a future implementation idea.

However, advancement are being made towards the developement of very powerful low-cost miniaturized GPS chips, the size of a shirt button[13]. The further GPS chips are miniaturize with corresponding low-cost, the more likely they will prove useful for B2C applications.

3.10 Projects and Development tools for IoT

Much of the early work on IoT technology and standards has taken place within the open source community. However, Toll (2014) outlines some of the more interesting IoT projects that have been developed. Table 3-3 presents various IoT projects and tools.

TABLE 3-3: IOT PROJECTS AND TOOLS (SOURCE: TOLL, 2014)

S/N	IoT Project	Description
1	**Mnubo**	Mnubo is an SaaS solution providing a comprehensive Big Data platform

[13] https://www.indiegogo.com/projects/ping-the-world-s-smallest-global-gps-locator#/

		catering to the Internet of Things via three solutions: mnubo smartobjects cloud, mnulabs and mnubo smartobjects analytics. Mnubo facilitates business logic modeling and Big Data analytics, speeding up your time to market by allowing you to focus on what you do best — building intelligent objects — with the mnubo platform providing the essential underlying technology support you need. It's the premier platform for Internet of Things developers to build, deploy and manage real world business rules and applications using machine data and derive advanced analytics and business insights for further innovation.
2	**OracleIoT**	Oracle's Java Embedded solutions aim to reign in the massive amounts of data required for and created as a result of the Internet of Things by facilitating seamless communications between all elements of the IoT architecture. Delivering an integrated, secure and comprehensive platform for the entire IoT architecture across all vertical markets, Oracle enables real-time response and data capture from millions of device endpoints. Oracle offers several solutions, including Oracle Java SE Embedded, Oracle Java ME Embedded, Oracle Java Embedded Suite and Oracle Event Processing for Oracle Java Embedded to meet your specific technology requirements. Oracle Java SE Embedded is ideal for devices with 11 MB or more allocated storage for Java, while Oracle Java ME Embedded provides a feature-rich platform on devices lacking the resources necessary to run the full Java SE Embedded environment.
3	**Swarm**	Swarm is an IoT development platform that facilitates adding new services to products easily. Swarm Dashboards serve as central, device-specific home pages, offering real-time, visual access to device features. Dashboards add value to connected products, enabling event notifications and alerts, historical data, analytics and reporting and other features for turning machine data into actionable insights. Swarm's parent company, Bug Labs, also provides Freeboard for building and deploying enterprise-class IoT applications and Dweet.io, which is fittingly self-described as "Ridiculously simple data sharing for the Internet of Things."
4	**Axeda**	Axeda provides a comprehensive cloud-based platform for managing connected products and machines and implementing IoT and M2M applications. The platform is used to transform machine data into valuable insights, build and run applications and integrate machine data with other applications and systems to optimize business processes. Axeda's platform encompasses the full spectrum of developing and deploying applications and integrating M2M learning into everyday business processes, from preventative data security measures all the way to device provisioning and configuration.
5	**OpenRemote**	An open-source middleware solution for the Internet of Things, OpenRemote allows you to integrate any device — regardless of brand or protocol — and design any user interface for iOS, Android or web browsers. Using OpenRemote's cloud-based design tools for developing completely customized solutions, upgrades are streamlined, meaning your devices are literally future-proof.
6	**Etherios**	Etherios is a comprehensive suite of products and services fully supporting connected enterprises. The Etherios Device Cloud is a PaaS solution enabling you to connect any product or device and gain real-time visibility into your assets. The Social Machine, Etherios' cloud-based SaaS solution, integrates machine data with your Salesforce.com instance, transforming it into actionable insights for deeper, more powerful CRM capabilities. With full services support for custom solutions and thousands of off-the-shelf wired and wireless solutions, Etherios bridges connectivity for the modern enterprise.
7	**ioBridge**	Connect any product to a mobile device via the web with ioBridge's RealTime.io IoT platform and RealTime.io Iota technology. Whether you need to connect a single product or more than one million products, ioBridge speeds your time to market and lowers your cost per connected product. More than 50,000 users in 40 countries are already relying on ioBridge to Internet-able their devices, gather product usage data, perform remote device maintenance and gain real-time, actionable insights to drive decision-making.
8	**SAP IoT**	SAP's IoT solutions facilitate connectivity and multi-directional

	Solutions	communication to enable users to interact with their devices in new ways. Transforming operations in field service and remote asset management, providing supply chain visibility and predicting and remedying logistics bottlenecks are just some of the challenges solved by SAP's remote maintenance and service, connected logistics and connected retail solutions for the IoT.
9	**Zatar**	A new cloud-based infrastructure that automatically detects (or "sees") your devices and connects them to the Internet, Zatar is an open platform for managing your entire device network. By connecting all your devices to the same platform and facilitating M2M communication, all connected devices and their respective users can share data and collaborate seamlessly. Build new customer experiences or completely reinvent your business with Zatar's IoT and M2M platform.
10	**ThingWorx**	ThingWorx facilitates rapid, streamlined creation of end-to-end smart applications for agriculture, cities, grid, water, building and telematics. Traditional industries are transformed and equipped with modern-day connectivity and smarter solutions through connected devices that provide comprehensive data collection and analysis for data-driven decision-making. ThingWorx reduces the time, cost and risks of building M2M and IoT applications. Users can build comprehensive mobile interfaces with zero coding, take advantage of ThingWorx Composer for application modeling, as well as real-time dashboards and collaborative workspaces — all with the scalability to support millions of devices.
11	**Arrayent**	Arrayent is an IoT platform for connected objects, enabling major brands like Whirlpool, Maytag and First Alert to bring smart, connected devices to consumers. The platform addresses both ends of the product spectrum with both enterprise and consumer apps, coupled with data analytics and a mobile framework for a complete plug-and-play installation at a reasonable cost. The platform scales to support millions of devices.
12	**Sine-Wave Technologies**	Sine-Wave Technologies is a premier Internet of Things platform enabling rapid development and deployment of high-performance, branded remote asset management solutions for enterprise companies. With a hosted set of APIs, the Sine-Wave Platform provides the support required to build, deploy and manage IoT applications. Hardware and network agnostic, Sine-Wave's open platform supports smart devices from any vendor as well as custom-built devices. You can even integrate with your legacy back-office systems using Sine-Wave's Business Adapter Framework.
13	**Ayla Networks**	A cloud-based application enablement platform, Ayla Networks is a simple and cost-effective solution for OEMs to connect any device to the Internet. With an adaptive fabric for building innovative applications that bridge communications between device, cloud and application, Ayla Networks provides powerful software agents embedded in both connected devices and mobile device applications for end-to-end support. With Ayla Networks, you can integrate secure connectivity and data intelligence into any product without significant design or business model modifications.
14	**Echelon**	Echelon is an Industrial Internet of Things (IIoT) platform with a full suite of chips, stacks, modules, interfaces and management software for developing devices, peer-to-peer communities and applications delivered via the IzoT Device Stack, IzoT Server Stack and FT 6000 EVK. Echelon is distinct from a consumer IoT platform by addressing the core requirements for the IIoT, including autonomous control, industrial-strength reliability, support for legacy evolution and exceptional security.
15	**EVRYTHING**	Give any product or object its own Active Digital Identity with the EVRYTHNG Engine, offering rich APIs, secure access and a persistent online presence. With EVRYTHNG, customers can personalize products with unique, user-generated digital content, brands can reward customers for actions or purchases, turn products into virtual objects to enable social sharing to drive sales, and access real-time analytics to capitalize on and improve upon the features and capabilities consumers demand. An end-to-end platform, EVRYTHNG provides everything you need for making products smart, interactive and trackable.
16	**Exosite**	Exosite enables developers to unlock the potential of Internet of Things

		applications with real-time, visual analytics and and scalable cloud device technologies. An end-to-end platform for building and deploying custom IoT applications, Exosite facilitates gaining valuable insights from everyday devices, empowering brands by putting their existing data at their fingertips in actionable form.
17	**Xively**	Xively, a LogMeIn product built on the Gravity Cloud, enables companies to leverage the Internet of Things to gain business insights from the physical world. Discover and deploy complete IoT solutions with the Xively IoT Platform, leverage innovations from Xively's world-class partner ecosystem and integrate your physical devices and associated data with your existing CRM, ERP or other business systems. Xively streamlines development with a PaaS model with searchable libraries of objects and permissions for dozens of languages and platforms, and Xively's RESTful API supports multiple data formats, including JSON, XML and CSV.
18	**Marvell**	Marvell streamlines the process of bringing connected devices to the market with flexible and cost-effective solutions for OEMs and ODMs with both hardware and software solutions. Marvell's Wi-Fi Microcontroller Internet of Things Platform is a hardware/software platform enabling seamless connectivity with mobile clients, cloud services and other devices. Marvell's Avastar Wi-Fi SoCs feature firmware that performs much of the required Wi-Fi protocol handling, and the Easy-Connect Software is a feature-rich software stack for rapid development at a lower cost.
19	**Carriots**	Carriots is an IoT platform enabling companies to easily connect devices to the Internet and develop intelligent applications in just five steps. With two-way communication protocols, rule-based capabilities, and support for any device type, any hardware and Arduino, Raspberry Pi, Nanode and more, Carriots is a complete solution for quickly joining the IoT revolution.
20	**Arkessa**	Providing connectivity and management solutions for the IoT, Arkessa enables monitoring, management and control of connected devices with the same level of streamlined functionality as though your devices were connected directly to your desktop through its Mosaic IoT platform. Arkessa's Enterprise solutions empower companies to tap into the IoT to develop new revenue streams, improve customer satisfaction and deliver enhanced value from remote devices. Arkessa's platform is proven across more than 500 mobile networks spanning more than 200 countries around the globe.
21	**GroveStreams**	From energy to health care to business, GroveStreams offers IoT solutions for a multitude of industries, including sensor technology for environmental monitoring. GroveStreams' patent-pending data streaming analytics platform enables you to collect massive amounts of data and analyze in real-time to drive smarter decision-making.
22	**CeNSE by HP**	HP is revolutionizing the way data is gathered and analyzed with CeNSE (Central Nervous System for the Earth). It's a highly-intelligent network consisting of billions of nanoscale sensors capable of taste, smell, vision, touch and hearing. Providing real-time data on the physical environment, CeNSE enables businesses and organizations to detect and respond better to environmental, biological and physical or structural changes. The first commercial application of CeNSE technology is being conducted with Shell, which will entail a wireless sensing system to acquire high-resolution seismic data for a clear picture of oil and gas reservoirs
23	**ARM**	ARM creates sensors, controllers, microprocessors and other types of embedded intelligence for the IoT, enabling ordinary objects to automatically sense variables in the environment, communicate with other devices and objects and interact with cloud-based applications and other networks. ARM licenses technology to various partners, enabling organizations to add value and differentiate themselves from competitors.
24	**Open Sen.se**	Open Sen.se doesn't address the Internet of Things, but the Internet of Everything — a world in which humans, nature, machines, information, objects and environments all interact and communicate in different ways. Open Sen.se provides a platform for imagining, prototyping and testing

		new devices, installations, scenarios and applications for this new interconnected world. It's both free and easy to use, enabling both professionals and amateur hobbyists to experiment with ease
25	**Paraimpu**	Paraimpu is a social tool for connecting physical and virtual devices, composing and interconnecting them and sharing data and published objects on the social web. Using Paraimpu, you can create customized applications for the Internet of Things, enabling your devices and objects to react to environmental changes, activities or events. Ultimately, the result is a physical-virtual web mashup in which users can tap into shared data and virtual objects to further their own applications and devices
26	**Sociot.al**	Sociot.al is a project focused on creating a socially aware, citizen-centric Internet of Things. Today, the IoT is heavily business-centric, with enterprise applications being used to optimize business processes and extract real-world knowledge from environments. In these systems, the data is available only within a pre-defined network or space. Sociot.al aims to bridge the gap between these enterprise, business-centric IoT systems and citizen provided infrastructure, facilitating open eco-systems in which data and information are shared freely and securely. An ongoing, in-the-works project, Sociot.al has a clear workplan and vision for enabling a citizen-centric IoT.
27	**NewAer**	NewAer's proximity platform SDK is a lightweight, low-power client for making apps contextually-aware without beacons. It works across all types of devices and platforms, works equally well both inside and outside, and is capable of triggering actions both in-device or in-cloud. NewAer also offers three applications: Share, for exchanging files between nearby devices, Kiosk, enabling proximity advertising without the use of beacons, and ToothTag, for setting actions and customizations without pairing by simply tagging devices.
28	**SensorCloud**	SensorCloud is a solution from LORD MicroStrain, a company that produces smart, embedded transducers, sensors and sensor networks. SensorCloud provides integrated Big Data analytics, automated alerts and actionable reports for predictive maintenance and streamlined monitoring of connected devices. A unique data storage, virtualization and remote management platform, SensorCloud supports any device, sensor or sensor network through an OpenData API.
29	**Yaler**	Yaler provides a relay infrastructure providing secure Web and SSH access to embedded systems, even if they're located behind a firewall, NAT or mobile network router, and it works with any device with a TCP socket. A pay-per-use platform, Yaler is a cost-effective solution offering premium enterprise support. Examples are provided in C, C#, Java and Python for use with Raspberry Pi, Arduino, Netduino, BeagleBone and similar devices
30	**Jasper**	Jasper is used by some of the world's largest corporations to launch, manage and monetize connected devices and powerful IoT applications. The highly-configurable Jasper Control Board Platform is customizable to suit your specific operational needs, business models and requirements across all industries and around the world. Jasper serves IoT needs such as connected cars and enterprise mobility, offering full network visibility across all devices and real-time monitoring for precise control and deeper insights to drive decision-making
31	**XobXop**	Add any project to the IoT with XobXob's simple cloud service. Connected devices can send and receive messages from Xobs, which function as small mailboxes. By sharing Xobs, devices can communicate and interact with each other, enabling actions such as the remote control of a garage door using a smartphone. Designed to be simple with minimal programming required, XobXob provides a range of sample projects and tools to streamline the process
32	**Linkafy**	Linkafy empowers the smart home with a PaaS for appliance manufacturers to easily introduce connected appliances to the market. Linkafy serves as a single application that can control all appliances in the end user's home or environment, rather than the complex myriad of apps generally required to operate multiple devices from different manufacturers. Manufacturers use Linkafy's API or SDK to integrate with IoT-ready devices, enabling customers to control, monitor and

		schedule tasks on multiple home appliances from a central interface.
33	**Revolv**	Unify, control and automate all of your smart home appliances and connected devices with Revolv. A future-proofed system with 7 radios and compatibility with hundreds of devices, Revolv is a simple and seamless solution for end consumers to make sense and take control over the IoT.
34	**Wind River**	Wind River has been providing connected intelligence of the IoT-caliber for decades. Wind River provides a foundation for the reliable and efficient operation of IoT networks and connected devices for highly-regulated industries and mission-critical applications.
35	**Wovyn**	An open, distributed architecture for delving into new opportunities and business models with the IoT, Wovyn is capable of connecting any sensor to any app using any protocol. Used for personal, commercial, industrial and military applications, Wovyn is a powerful middleware platform for the Internet of Things.
36	**Microsoft Research Lab of Things**	A platform for experimental research, Microsoft Research's Lab of Things is an innovative solution enabling the interconnection of devices and implementation of application scenarios. Enterprises can deploy and monitor field studies and analyze experimental data, as well as share data, code and participants among a connected, cooperative community. Projects span healthcare, energy management, home automation and other sectors, supporting large numbers of sensors and devices at scale.
37	**InfoBright**	InfoBright helps enterprises to compete based on analytical maturity with its Knowledge Grid architecture that serves as an analytical database platform for the Internet of Things, empowering businesses to store, analyze and act upon vast amounts of machine-generated data. With a free community edition and an enterprise-class version for companies requiring robust performance and capabilities, InfoBright is compatible with leading Business Intelligence platforms such as Cognos and Microstrategy, facilitating fully interconnected business systems
38	**2lemetry**	2lemetry powers the connected enterprise, transforming raw data into real-time actionable intelligence by interconnecting people, devices and data. Functioning similar to an Enterprise Application Integration (EAI) middleware solution, the 2lemetry ThingFabric platform provides scaled device connectivity, cross communication and data brokerage and storage. But 2lemetry doesn't stop with data collection, providing predictive computational models and a configurable rules engine for enabling automation and gaining actionable intelligence
39	**InterDigital**	Developing fundamental enabling technologies for M2M communications and facilitating a common framework and roadmap for cellular operators, service providers and device manufacturers, InterDigtial is centered around a standard service layer and API. Both are independent, network- and application-aware, fully enabling manufacturers and developers to harness the potential of M2M communications. InterDigital has been contributing to the IoT standardization process since 2009, building pioneering prototypes and demonstrations to support the emerging oneM2M global standard
40	**Superflux Internet of Things Academy (IoTA)**	Design and research lab Superflux is working on an ongoing project commissioned by Sony to experiment with building IoTA, an open, educational Internet-of-Things platform to encourage innovation and creativity and enhance technological literacy. It's a part of Sony's Futurescapes project in collaboration with Forum for the Future, first a proposed concept that has now evolved to the investigation of actually developing the proposed model. A film documents the experience to date, conducted in conjunction with Forum for the Future and Technology Will Save Us. The project is currently in talks with potential partners with the goal of developing experience prototypes
41	**HarvestGeek**	HarvestGeek is an excellent example of an innovative IoT application in real-world use. HarvestGeek enables sustainable agriculture with smart technology that builds sensors into gardens and crops, providing essential data on temperature, light, moisture and other conditions that impact plant growth. Data can be used to trigger automated actions, meaning users can control equipment to rectify environmental conditions to maximize yield.

42	**MediaTek Labs**	MediaTek Labs is a developer-centric ecosystem supporting device creation, application development and services surrounding MediaTek's other products and services. A provider of system-on-chip (SoC) solutions, MediaTek Labs is a central hub for all MediaTek developer and creator offerings, including SDKs, HDKs, technical documentation and support. Recently, the company introduced MediaTek LinkIt, a platform enabling the development of wearable devices and IoT applications.
43	**Streamlite LTE**	Sequan's product line for the connected devices market, Streamlite LTE provides both functionality and throughput to empower cost-effective IoT devices. The Colibri LTE platform is the core Streamlite LTE offering, delivering an ideal set of IoT-compatible features for high efficiency and cost-effective solutions. Suitable for adding connectivity to to M2M and IoT modules, Colibri LTE provides a comprehensive software package for over-the-air device management
44	**Bosch Software Innovations Suite**	The Bosch Software Innovations Suite is modular for advanced flexibility, enabling device management, business process management, and business rules management for the IoT. It integrates seamlessly with existing IT infrastructures for streamlined connectivity and enhanced data analytics. The Bosch Software Innovations Suite is powering the IoT by connecting the four key elements of the ecosystem: People (Users) , Things, Enterprises and Partners
45	**RIoTboard**	RIoTboard is revolutionizing the Internet of Things with its open-source platform serving demanding applications that require high levels of processing power. It's an open-source board with detailed schematics downloadable for use in any design, and it offers an Android OS distribution for applications requiring tablet or mobile experiences, as well as a Linux download
46	**INTEL**	Intel IoT Developer Kit (beta) is a complete set of hardware and software resources for creating innovative IoT solutions. IoT dev kit is part of a larger Intel IoT developer program targeted at hobbyists, students and entrepreneurial developers. In addition to the IoT dev Kit, the program includes IoT developer zone for downloads, latest content and support, local Hackathons & meet-ups to showcase and share ideas, and IoT Academic courseware program that will assist leading universities in building curriculum for the Internet of Things. It supports various IDEs allowing you to program in your favorite language (Eclipse, Intel XDK IoT Edition, Arduino & Wyliodrin)

In order to understand the tools that are used in developing IoT applications, attention is given to a lists of open source tools, which includes open source software development kits (SDK) and open source hardware that could be purchased at low prices. Harvey (2014) categorized these tools into Software development tools, middleware, operating system, hardware, and platform and integration tools as outlined below:

3.10.1 Software Development Tools

a) Arduino: Arduino is both a hardware specification for interactive electronics and a set of software that includes an IDE and the Arduino programming language. The website explains that Arduino is "a tool for making computers than can sense and control more of the physical world than your desktop computer." The organization behind it offers a variety of boards, starter kits, robots and related products for sale, and many other groups have used Arduino to build IoT-related hardware and software products of their own.

b) Eclipse IoT Project: Eclipse is sponsoring several different projects surrounding IoT. They include application frameworks and services; open source implementations of IoT protocols, including MQTT CoAP, OMA-DM and OMA LWM2M; and tools for working with Lua, which Eclipse is promoting as an ideal IoT programming language. Eclipse-related projects include Mihini, Koneki and Paho. The website also includes sandbox environments for experimenting with the tools and a live demo.

c) Kinoma: Owned by Marvell, the Kinoma software platform encompasses three different open source projects. Kimona Create is a DIY construction kit for prototyping electronic devices. Kimona Studio is the development environment that works with Create and the Kinoma Platform Runtime. Kimona Connect is a free iOS and Android app that links smartphones and tables with IoT devices.

d) M2MLabs Mainspring: Designed for building remote monitoring, fleet management and smart grid applications, Mainspring is an open source framework for developing M2M applications. It capabilities include flexible modeling of devices, device configuration, communication between devices and applications, validation and normalization of data, long-term data storage, and data retrieval functions. It's based on Java and the Apache Cassandra NoSQL database.

e) Node-RED: Built on Node.js, Node-RED describes itself as "a visual tool for wiring the Internet of Things." It allows developers to connect devices, services and APIs together using a browser-based flow editor. It can run on Raspberry Pi, and more than 60,000 modules are available to extend its capabilities.

f) OpenHab: OpenHAB lets the smart devices you already have in your home talk to one another. It's vendor- and hardware-neutral, running on any Java-enabled system. One of its goals is to allow users to add new features to their devices and combine them in new ways. It's won several awards, and it has a companion cloud computing service called my.openHAB.

g) The Thing System: This project includes both software components and network protocols. It promises to find all the Internet-connected things at home and bring them together so that the individual can control them. It supports a long list of devices, including Nest thermostats, Samsung Smart Air Conditioners, Insteon LED Bulbs, Roku, Google Chromecast, Pebble smartwatches, Goji smart locks and much more. It's written in Node.js and can fit on a Raspberry Pi.

3.10.2 Middleware tools

a) IoTSyS: This IoT middleware provides a communication stack for smart devices. It supports multiple standards and protocols, including IPv6, oBIX, 6LoWPAN, Constrained Application Protocol and Efficient XML Interchange. Several videos on the website show how it works in action.

b) OpenIoT: The OpenIoT website explains that the project is "an open source middleware for getting information from sensor clouds, without worrying what exact sensors are used." It aims to enable cloud-based "sensing as a service," and has developed use cases for smart agriculture, intelligent manufacturing, urban crowdsensing, smart living and smart campuses. Its backers include Athens Information Technology (AIT), École Polytechnique Fédérale de Lausanne (EPFL), the Fraunhofer Institute for Optronics, System Technology and Image Exploitation IOSB, SENSAP Microsystems AE, AcrossLimits, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of Zagreb Faculty of Electrical Engineering and Computing, and the National University of Ireland, Galway.

3.10.3 Operating Systems

a) AllJoyn: Originally created by Qualcomm, this open source operating system for the Internet of Things is now sponsored by one of the most prominent IoT organizations—The AllSeen Alliance, whose members include the Linux Foundation, Microsoft, LG, Qualcomm, Sharp, Panasonic, Cisco, Symantec and many others, providing a common central language to support the Internet of Things and empowering developers and manufacturers with the tools and technologies they need for forward-thinking IoT innovation. It includes a framework and a set of services that will allow manufacturers to create compatible devices. It is cross-platform with APIs available for Android, iOS, OS X, Linux and Windows 7. AllJoyn enables compatible smart devices within proximity to recognize one another, communicate and share data across brands, networks and operating systems.

b) Contiki: Contiki describes itself as "the open source OS for the Internet of Things." It connects low-power microcontrollers to the internet and supports standards like IPv6, 6lowpan, RPL and CoAP. Other key features include highly efficient memory allocation, full IP networking, very low power consumption, dynamic module loading and more. Instant Contiki provides an entire development environment in a single download, and applications are written in standard C. The Cooja simulator Contiki networks can be emulated before burned into hardware; Contiki runs on a range of low-power wireless devices — most of which can be purchased easily via the Internet. Supported hardware platforms include Redwire Econotags, Zolertia z1 motes, ST Microelectronics development kits and Texas Instruments chips and boards. Paid commercial support is available.

c) Raspbian: While the Raspberry Pi was intended as an educational device, many developers have begun using this credit-card-sized computer for IoT projects. The complete hardware specification is not open source, but much of the software and documentation is. Raspbian is a popular Raspberry Pi operating system that is based on the Debian distribution of Linux.

d) RIOT: RIOT bills itself as "the friendly operating system for the Internet of Things." Forked from the FeuerWhere project, RIOT debuted in 2013. It aims to be both developer- and resource-friendly. It supports multiple architectures, including MSP430, ARM7, Cortex-M0, Cortex-M3, Cortex-M4, and standard x86 PCs.

e) Spark: Spark is a distributed, cloud-based IoT operating system. The same company also offers easy-to-use hardware development kits and related products that start at just $39 (and the hardware designs are also open source). It includes a Web-based IDE, a command-line interface, support for multiple languages, and libraries for working with many different IoT devices. It has a very active user community, and a lot of documentation and online help are available.

3.10.4 Hardware tools

a) Arduino Yun: This microcontroller combines the ease of an Arduino-based board with Linux. It includes two processors—the ATmega32u4 (which supports Arduino) and the Atheros AR9331 (which runs Linux). Other features include Wi-Fi, Ethenet support, a USB port, micro-SD card slot, three reset buttons and more. They are available for purchase from the Arduino website.

b) BeagleBoard: BeagleBoard offers credit-card sized computers that can run Android and Linux. Because they have very low power requirements, they're a good option for IoT devices. Both the hardware designs and the software they run are open source, and BeagleBoard hardware (often sold under the name BeagleBone) is available through a wide variety of distributors.

c) Flutter: Flutter's claim to fame is its long range. This Arduino-based board has a wireless transmitter that can reach more than a half mile. Plus, you don't need a router; flutter boards can communicate with each other directly. It includes 256-bit AES encryption, and it's easy to use. Both the hardware and the software are completely open source, and the price for a basic board is just $20.

d) Local Motors Connected Car: Local Motors is a car company that manufactures open source car designs on a small scale. They collaborated with IBM on an IoT-connected vehicle that they showed off at a conference last spring. Much of the open source software and design specifications for the prototype are available for download from the link above.

e) Microduino: As you might guess from its name, Microduino offers really small boards that are compatible with Arduino. In fact, these boards are about the size of a quarter and can be stacked together to create new things. All the hardware designs are open source, and core modules start at just $8 each. It was funded by a Kickstarter campaign that raised $134,563.

f) OpenPicus: This company offers a line of programmable modules and kits for connecting devices to the cloud and the Internet of Things. Its platform and hardware are open source, but its products can be used to create closed source commercial products. The company also offers its development services for hire.

g) Pinoccio: Arduino-compatible Pinnoccio boards (which the company calls "Scouts") connect to each other in a low-power mesh network. They include a built-in rechargeable battery that can connect to solar panels or any USB power supply. The organization also offers Pinoccio HQ, a GUI for monitoring the activities of the scouts, and ScoutScript, an easy-to-use scripting language for controlling the devices. A starter kit costs $197.

h) RasWIK: Made by a company called Ciseco, RasWIK is short for the Raspberry Pi Wireless Inventors Kit. It allows anyone with a Raspberry Pi to experiment with building their own Wi-Fi-connected devices. It includes documentation for 29 different projects or you can come up with one of your own. There is a fee for the devices, but all of the included code is open source, and you can use it to build commercial products if you choose.

i) SODAQ: Short for "Solar-Powered Data Acquistion," SADAQ offers Arduino-compatible boards with Lego-like plug-in modules. The website includes a number of tutorials, making it a suitable for beginners. And the solar panel makes it a good choice for logging environmental data in various locations where power and Internet connections might not be available. A basic board starts at $39.

j) Tessel: Tessel aims to make hardware development easier for software developers with this JavaScript-enabled microcontroller that plugs into any USB port. You can also connect it to additional modules to add accelerometer, ambient light and sound, camera, Bluetooth, GPS and/or nine other capabilities. One board and a module starts at $99 with additional modules available for $25. All the software and hardware designs are fully open source.

k) UDOO: This Arduino-compatible board can also run Android or Linux (a distribution called UDOObuntu) from its second processor. It boasts that it is four times as powerful as a Raspberry Pi. Multiple tutorials and projects are available on the website, and it also offers a "Made by UDOOers" section where people can show off their creations. Prices start at $99 for a basic board.

3.10.5 Platforms and Integration Tools

a) DeviceHive: This project offers a machine-to-machine (M2M) communication framework for connecting devices to the Internet of Things. It includes easy-to-use Web-based management software for creating networks, applying security rules and monitoring devices. The website offers sample projects built with DeviceHub, and it also has a "playground" section that allows users to use DeviceHub online to see how it works.

b) Devicehub.net: Devicehub.net describes itself as "the open source backbone for the Internet of Things." It's a cloud-based service that stores IoT-related data, provides visualizations of that data and allows users to control IoT devices from a Web page. Developers have used the service to create apps that track health information, monitor the location of children, automate household appliances, track vehicle data, monitor the weather and more.

c) IoT Toolkit: The group behind this project is working on a variety of tools for integrating multiple IoT-related sensor networks and protocols. The primary project is a Smart Object API, but the group is also working on an HTTP-to-CoAP Semantic mappin , an application framework with embedded software agents and more. They also sponsr a meetup group in Silicon Valley for people who are interested in IoT development.

d) Mango: Mango bills itself as "the world's most popular open source Machine-to-Machin (M2M) software." Web-based, it supports multiple platforms. Key features include support for multiple protocols and databases, meta points, user-defined events, import/export and more.

e) Nimbit: Nimbits can store and process a specific type of data—data that has been time- or geo-stamped. A public platform as a service is available, or you can download the software and deploy it on Google App Engine, any J2EE server on Amazon EC2 or on a Raspberry Pi. It supports multiple programming languages, including Arduino, JavaScript, HTML or the Nimbits.io Java library.

f) OpenRemote

OpenRemote offers four different integration tools for home-based hobbyists, integrators, distributors, and manufacturers. It supports dozens of different existing protocols, allowing users to create nearly any kind of smart device they can imagine and control it using any device that supports Java. The platform is open source, but the company also sells a wide variety of support, ebooks and other tools to aid in the design and product development process.

g) SiteWhere: This project provides a complete platform for managing IoT devices, gathering data and integrating that data with external systems. SiteWhere releases can be downloaded or used on Amazon's cloud. It also integrates with multiple big data tools, including MongoDB and ApacheHBase.

h) ThinkSpeak: ThingSpeak can process HTTP requests and store and process data. Key features of the open data platform include an open API, real-time data collection, geolocation data, data processing and visualizations, device status messages and plug-ins. It can integrate multiple hardware and software platforms including Arduino, Raspberry Pi, ioBridge/RealTime.io, Electric Imp, mobile and Web applications, social networks and MATLAB data analytics. In addition to the open source version, a hosted service is also available.

The IoT projects and tools outlined above mainly address IoT projects of major brands which may not be open source. While some address Business-to-Business IoT solutions that are not within the scope of this research. However, it was worthy to highlight them to emphasize the growing interest in IoT by global technology giants. Also, the SDKs that have been described, although useful for insights as to how IoT applications could be developed, were not used in this research. However, the IoT scenarios that are described and prototyped in this research were prototyped using Just-in-mind[14] software. Just-in-mind is a clickable prototype that enables mobile, tablet, and desktop applications to be prototyped with clickable menus, as it would have been the case in the real application. The Just-in-mind prototypes for the three IoT scenarios of health monitoring, home environment, and the use of the library and borrowing of books can be seen in appendix B.

3.11 Chapter summary

This chapter presented the state-of-the-art in the area of IoT. A comprehensive description of the IoT space was given, illustrating the various use case scenarios of IoT. This was followed by a description of the health monitoring IoT justifying its choice as one of the IoT scenarios to be describe and prototyped as an educational tool for the within-subjects experiment. The description of an IoT implementation for elderly people and people lliving with disabilities, that is the ambient assisted living (AAL) was comprehensively discuss, with an outline of projects that have been developed for this IoT use case. However, it was concluded that a scenario could not be described and prototyped for this use case as part of an educational tool for the experimenal tasks that is described in section 5, because of ethical concerns and the the time it may take to gain approval for such a study.

Subsequently, a comprehensive description of IoT application in the area of home environment was described. It was decided that this use case be adopted to also describe a home environment IoT scenario also as part of the educational tool that is used for the experimental task as reported in section 5.2.2 and section 2, appendix B. This was followed by a description of a novel future implementation idea for IoT application for the the use of the library and borrowing of books as proposed by this researcher as part of an educational tool for the experiment described in section 5 and appendix B. It was noted however that, although this idea may not be possible now,

[14] www.justinmind.com

an advancement in the miniaturizing and correponding reduction in the cost of GPS chips, could make the implentation of this idea possible.

A description of precursor technologies such as sensors, RFID, cloud, GPS, that incorporate the IoT ecosystem were also described. This was followed by outlines of already existing projects and applications developed by technology firms in the area of IoT. The chapter finally concludes with an outline of software development kits (SDK) for IoT application development and a description of the prototyping tool that was used for application prototype developement (Just-in-mind software) for the three IoT scenarios selected as part of experimental educational tools, which are described illustrated and protyped in section 5.2 and appendix B of this report.

The next chapter describes the business model framework representation architecture proposed for this research. It introduces the general SCP framework representation map for BMs that was modfified by this research for use for the IoT BM framework proposed in this research.

CHAPTER FOUR

4 The Proposed Customer-focused Business Model Framework for IoT (CBMF4IoT)

This chapter describes the representation for the business model framework and representation diagram that is used in illustrating the likelihod of IoT adoption of existing DTBM as part of the main objective of this research. In particular, a user-based business model framework representation map for IoT is designed by modifications to the general SCP framework for BMs. The extensive literature review in chapter 2 was used to identify the generic components of the DTBM of established DT firms. In this section, a mix of business modelling concepts are used to build a narrative that results in the design of the CBMF4IoT.

4.1 Business Modeling Frameworks

In almost two decades, several authors have come up with different perspectives on business model frameworks. The scope of this research is defined along the user/consumer-centric components or elements of business modelling. This is because of limited access to resource persons that would have broadened the scope to cover other (organisational, revenue, etc) components of the business model framework. The BM framework design involves defining the principles of i) Conceptualisation, ii) Representation/Visualisation, iii) Construction and Reconstruction. However, the literature on business model frameworks tends to cover all elements of an organisational business strategy with interchangeable use of the term. Paltalidis (2014) outlined the progressive stages of business model frameworks found in the literature in Table 4-1.

TABLE 4-1: PROGRESSIVE STAGES OF DTBM FRAMEWORKS IN THE LITERATURE

Stage	Author(s)	Description of work
Stage 1	Tapscott & Lowi 2000; Mahadevan 2000 Linder & Cantrell 2000	Proposals for selecting business model for Electronic Commerce; Rules for extension of an existing business model
Stage 2	Van Hooft & Stegwee 2001 Petrovic, Kittl, & Teksten, 2001; Papakiriakopoulos, et.al 2001	Analyses of external factors influencing business modelling; Introduction of e-business strategy formulation
Stage 3	Alt & Zimmermann, 2001 Afuah, A., & Tucci, C., 2001;	Identification of elements of a business model as a list Guidelines for identification of

	Stahler, 2002 Pateli & Giaglis, June 2003	these elements Define phases and steps for describing business model
Stage 4	Gordijn, 2002; Osterwalder A. 2004	Conceptual modelling of the components resulting in business model ontologies
Stage 5	Braet & BaIlon, 2007 Richardson, 2008; AI-Debei & Avison, 2010; Wirtz, 2011 Sandstrom & Osborne, 2010; Ludeke, 2010 EI Sawy & Pereira, 2013	Business modelling research's interest emerged in other aspects of business model like in: Organisational Operational Product/Service Technological

Alt & Zimmermann (2001) distinguish six generic business model components giving a short description for each; the first four defining vertical dimensions of a business model such as mission, structure, processes and revenues, and the rest two defining the horizontal dimensions such as the legal and technological requirements and constraints that affect all business models. Table 4-2 shows the six generic business model components highlighted by Alt & Zimmermann (2001).

TABLE 4-2: SEGMENTS OF A GENERIC BM

Components	**Description**
Mission	A critical element of the business model is developing a high-level understanding of the overall vision, strategic goals and the value proposition including the basic product or service features.
Structure	It determines the roles of the different agents (actors and government) involved and the focus on industry, customers and products.
Processes	They provide a more detailed view on the mission and the structure of the business model. It shows the elements of the value creation process.
Revenues	They are the "bottom line" of a business model. Sources of revenue and necessary investments need to be carefully analysed from a short and mid-term perspective as well.
legal issues	They influence all aspects of the business model and the general vision.
Technology	It is an enabler and a constraint for IT-based business models. Also, technological change has an impact on the business model design.

However, Pateli & Giaglis (2003) illustrated steps for business model evolution, which was an extension of Alt & Zimmermann (2001). In this case we can apply this rulebook to how digital technology business models could be adopted and enhanced to develop an IoT business model framework. Table 4-3 shows these guidelines.

TABLE 4-3: GUIDLINES FOR EVOLUTION OF A BM

Phase	**Description**	**Activities**
Phase 1: Understand	This phase is concerned with a detailed analysis and documentation of the existing business model.	**Step 1:** Document the current business model. This step aims to understand the current business environment including the

		key elements of the business model and their relationships, the business and technology stakeholders, the valid requirements for technology innovation, and possible options for changing and extending the current business model.
Phase 2: Identify Technology's Influence	This phase is concerned with assessing the impact of technology innovation on the current business model. The anticipated result is the identification of possibilities for evolution or extension of the current business model.	**Step 2:** Assess the influence of technology innovation This step aims to identify the benefits and impacts that a given technological solution brings to key elements of the business model and to specify the changes imposed on the current business model's structure. **Step 3:** This step includes an identification of the requirement for one or more new roles that accomplish new business functions, and a description of the activities and the functions of each of these roles.
Phase 3: Change	This phase is concerned with the design and description of the future business model	**Step 4:** Define Scenarios According to the outcomes of the previous step (3), a set of scenarios is defined each of which proposes a different cooperation scheme and way of distributing responsibilities between new and existing players in the business environment. **Step 5:** Describe the new business models Based on the above scenarios, this step revisits the current business situation as illustrated in the step 1. This step aims to describe one or more business models by indicating the value provided by each player in the future model, as well as defining financial and communication flows among players. **Step 6:** Evaluate the impact of changes. This step aims to estimate the impact of the transformed business model on the structure and dynamics of the market concerned.

Another work conceptualised business model by means of a set of components that corresponds to the determinants of company profitability (Afuah & Tucci, 2001). Their work defined the components answering a number of questions with the aim of describing the scope of business model as shown in Table 4-4.

TABLE 4-4: DETERMINANTS OF COMPANY PROFITABILITY

Components	**Description**
Customer value	A firm must ask it if it is offering its customers something distinctive or at a lower cost than its competitors
Target Customer	Company must define to what customers it is offering value
Products and Services	What range of products and services embody this value
Pricing	How the firm prices the value it offers and who is charged for
Revenue source	A firm must ask itself where the income comes from and who will pay for what value and when. It must also define margins in each market and find out what drives them.
Sustainability	What it is about the firm that makes it difficult for other firms to imitate. It

	must define how it can keep making money and sustain a competitive advantage.

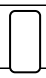
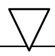
An ontology for defining how economic value is created, interpreted and exchanged within a multi-actor stakeholder network of enterprises and customers was incrementally proposed by Gordijn, et.al (2000); Gordijn & Akkermans (2001); Gordijn & Akkermans (2003). This was referred to as an e^3value business model ontology and it focuses on mainly the design of a value constellation's business model. Table 4-3 describes elements of this ontological concept.

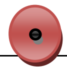
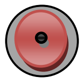
TABLE 4-5: E^3VALUE BM ONTOLOGY

Elements	Description
Actors	Actors are independent economic entities, such as enterprises and consumers which exchange value objects
Value Objects	Value Objects like services, products or even experiences to make profit or increase their utility
Market Segment	A set of actors can be grouped into market segment
Value Port	A value port is used by an actor to show to its environment that he/she wants to offer or request value objects to or from other actors. A value port has a direction: in-going (e.g., receive goods) or out-going (e.g., make a payment), indicating whether a value offering is in to or out from the actor.
Value Interface	A value interface consists of in and out ports that belong to the same actor. It shows the value object(s) an actor is willing to exchange in return for other value object(s). A value exchange is used to connect two value ports with each other.
Value Exchange	A value exchange represents one or more potential trades of value objects between these value ports.
Value Activity	A value activity is an operation that can be carried out in an economically profitable way for at least one actor

To enhance understanding of these e3value concepts, they are represented graphically. It uses notation inspired by UML class diagrams to initially present the core concepts and their relations. The result is the visualisation of the value model, providing a common, more precise understanding of the idea among stakeholders. Table 4-6 shows the notations for visualizing the value model proposed by Gordijn & Akkermans (2003) and Gordijn et al. (2001).

TABLE 4-6: CONNECTORS IN AN E3VALUE BMF MAP

Element/Connector	Symbol/Notation
Legend	
Actor	
Value interface	
Value port	

Value exchange	
Value activity	
Start stimulus	
Connect element	
End stimulus	

The graphical presentation of value model is supported by a lightweight scenario technique called Use Case Maps. UCMs show which value exchanges should occur as a result of an event, possibly caused by an actor. Scenario paths are used to explain the causality of value exchanges. This operational scenario mechanism aims to "tell" the business model as a story to the stakeholders (Gordijn, et al. 2001). On the other hand, using UCMs and following the scenario paths it is able to account the number of value exchanges for each actor. Based on that profitability, sheets can be created for each actor which show ingoing and outgoing value objects related to satisfied actor needs. The results can give an indication whether the business model is viable or not (Gordijn & Akkermans, 2003).

The e^3value ontology provides significant contribution in the field as it introduces a conceptual and graphical approach for the design of the value creation process of a business model. But, it is restricted to modelling the actors' exchanges only on the economic value view point, and no other interactions such as the exchange of control information between actors and business processes. This limited scope can have implications while requirements expressed on the one view point may influence choices to be made on another viewpoint. For instance, many solutions chosen on the business value requirements result in requirements on the business process viewpoint, and sometimes on the information system viewpoint. By modelling these relations explicitly, we can reason about choices for a particular feature and solution on each viewpoint (Gordijn et al., 2005).

4.2 IoT business model frameworks representation maps

Few authors have attempted to develop a business model framework for IoT. For individual companies, the current state and trends of the IoT business can be described by using business model frameworks (Mazhelis, 2013). Approaches to the design of business models for science and technology-inclined businesses have evolved over the years as new approaches have emerged in addition to the ones applied in the pass. Business. Limburg et al. (2011) and Michahelles (2011) suggested designing a business model at the early stage of technology development in what is referred to as Business-Technology Co-Design (BTCD). The BTCD envisages that additional value proposition that drives the whole value chain could be discovered when a whole picture of the target business use cases is drawn at the initial stage.

Pang (2013) attempted at adopting the BTCD approach to investigate the technologies and architectures of the IoT and developing a solution for the two application areas of Food-IoT and Health-IoT respectively, by resolving a series of research problems about device architectures, WSN architecture and system integration architectures. In doing this, the business aspects were taken into account at the early stage, as he rightly posited that the technologies and applications of IoT are both immature necessitating a simultaneous business design. However the framework developed here was focused on B2B BM context, which was not the primary focus of this research.

4.2.1 General SCP framework in a business model context

Given the components that have been identified from the first part desk research of digital technology business models, the relationships that will be illustrated for a proposed business model framework for IoT in this research are modifications of the General SCP framework in a business model context as proposed by Pedersen et al. (2007). The General SCP framework representation is shown in figure 4-1.

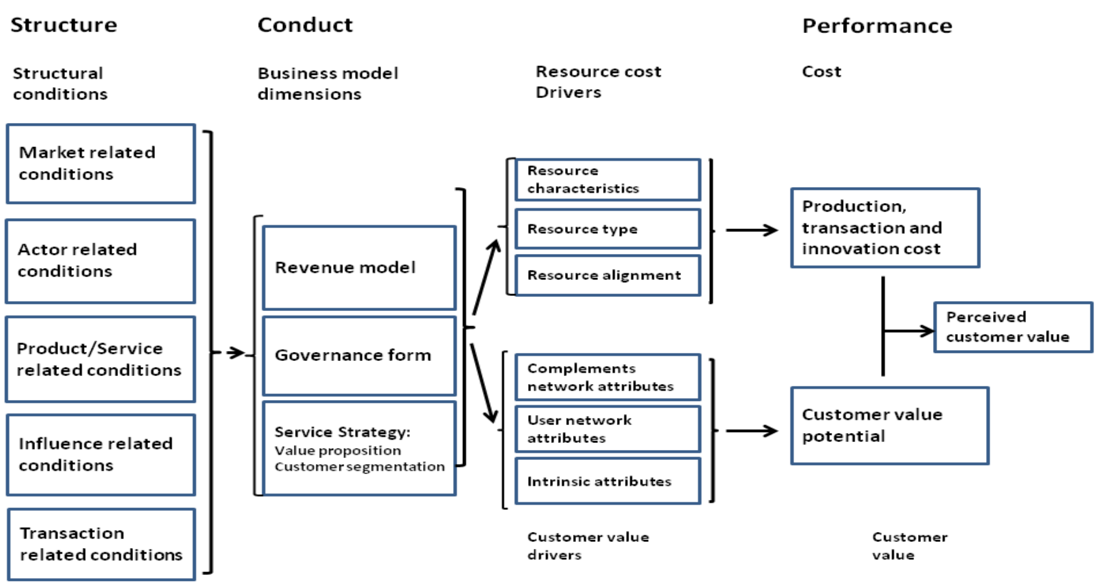


FIGURE 4-1: GENERAL SCP FRAMEWORK IN A BM CONTEXT (SOURCES: PEDERSON ET AL., 2007)

In the SCP-model, the main component models (structure, conduct, performance) have causal relationships based on theories such as diffusion of innovations theory, resource dependency theory, transaction cost theory, etc. Thus SCP models represent a conceptual framework with which **more specific operational models** can be applied.

The business model framework representation map for IoT that is illustrated in this chapter are modifications of the customer value driver and customer value of the performance segment of the general SCP framework components, while the performance component will be represented by Production cost and customer behaviour and their corresponding causal effects (Production and transaction cost, customer loyalty - perceived customer value). The relationships between existing DTBM and investigated in this research, which are based on technological convergence and imitation theory are empirically validated using primary data sources from the consumer/user are illustrated through modifications to the GSCP framework.

4.3 The Customer-focused BMF representation map for IoT (CBMF4IoT)

The CBMF4IoT involves the adoption and reconstruction of digital technology business models to IoT business model. In designing the CBMF4IoT, the business models of digital technology firms is reviewed and key components of their BM are identified. The construct of the CBMF4IoT applies these components as predictors for their inclusion in the CBMF4IoT after they have been evaluated using questionnaire survey and quantitative analysis.

The relationships between customer inclinations towards the generic components with respect to smartphone and IoT was also empirically investigated resulting in primary data sourced from the consumers/users using the three IoT use-case prototypes. In addition, empirical evidence from the primary data gathered from the user formed part of the procedure used to determine the likelihood of IoT adoption of existing DTBM.

The CBMF4IoT is designed firstly by combining (i) elements of the business model of established digital technology firms identified (as 'five generic components') in chapter 2 and (ii) the representation map of the General SCP framework for BM applied to the customer value sub elements. As a representation, the General SCP framework shown in figure 4-1 is modified to reflect each identified generic component of existing DTBM.

4.3.1 Nodes of the CBMF4IoT

This section outlines modifications Pederson et al. (2007) General SCP framework that will make up the CBMF4IoT map that was fed validated data from the primary research. The hypotheses deduced from the desk research on the digital technology firms' business models helped to identify five generic **components** which are part of the representation of the CBMF4IoT. The following are nodes that could be use in architecting a BM:

a) Structure - Structural conditions: Actor, Product/services related conditions

b) Conduct - Business Model dimensions: Revenue model, Governance form, Service strategy (value proposition, customer segmentation)
Resource cost drivers: Resource characteristics, Resource type
Customer value drivers: User network attributes

c) Performance - Customer value: Customer value potential

The CBMF4IoT representation map is a modification of the General SCP framework shown in figure 4-1, which reflect each identified generic **components** of existing DTBMs of digital technology firm identified in chapter 2. The map feeds into the Customer value node of the the PERFORMANCE segment of the general SCP framework for BMs. The reason this is because the other segments require inputs from business owners, experts, practitioners which were not part the scope of this research. The CBMF4IoT representation map is shown in figure 4-2.

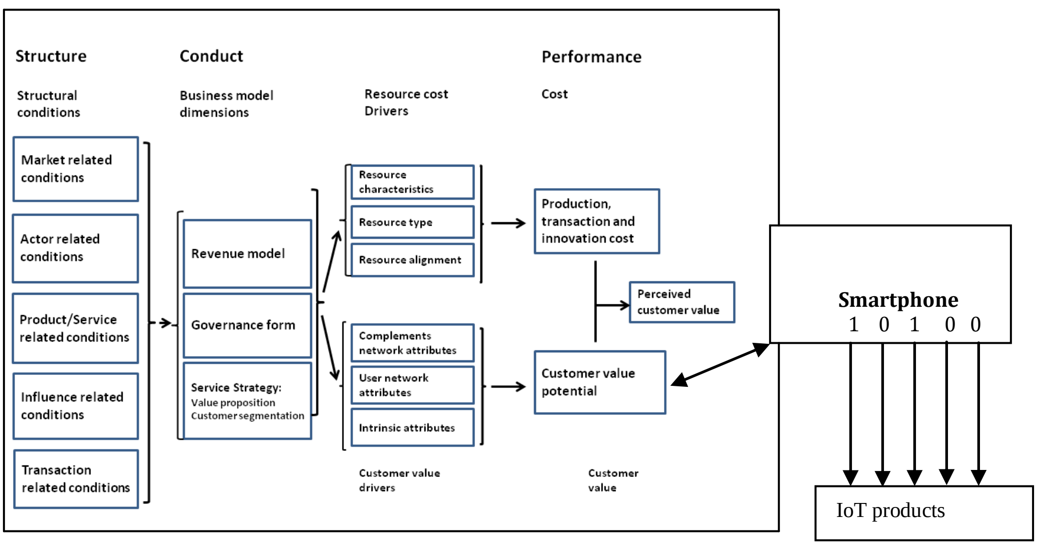


FIGURE 4-2: MODIFIED GSCP - THE CBMF4IOT

In the above business model framework representation map is represntative of IoT receiving things of value from the smartphone business model. The five arrows represent the five generic components of the DTBM. The numbers 1 and 0 represent 'adopted' and 'not adopted' respectively. It means that if the value component from the smartphone BM is accepted for implementation on the IoT product, then that value component is denote with 1, otherwise it is denoted by 0. The bi-directional arrow between the Smartphone 'Actor' node is pointed to the customer value potential node; implying that the components being adopted for use for the IoT product are customer-centric value offering. This modifications to the general SCP representation map may be re-usable for other nodes within the general SCP BM representation map and this is explained in section 7.3.

4.4 Chapter summary

This chapter presented BM frameworks and BM framework representation maps that have been developed. The purpose of which was to identify a BM framework map for modification to be used in illustrating the likelihood of IoT adoption of existing DTBM. It was identified that BM framework design involves conceptualisation, representation/visualisation, construction and reconstruction of principles that support the product business case taking the customer base into consideration.

Several business model frameworks were outlined with the aim of modifying one of the BM framework representation maps towards designing the CBMF4IoT, which is part of the main objective of this thesis. In particular, a user-based business model framework representation map for IoT was designed by modifying the general SCP framework for BMs that was proposed by Pederson et al. (2007). It was outlined that the general SCP framework has three categories of: structure, content and performance. However, the modification was mainly targeted at the performance category as it consisted of the customer value node, which was necessary for illustrating how validated data from the experimental survey in this thesis could be fed into the CBMF4IoT representation map.

The chapter concludes by illustrating how the validated data relating to the five identified generic components of existing DTBM will be fed into the modified framework. In particular, the CBMF4IoT representation map, which is the BM adoption framework for IoT presented in this thesis, was described and illustrated showing the interaction between the smartphone products context (the existing DT product) and IoT products context (the new DT product that requires a BM). The CBMF4IoT was designed in such a way that it could be reuseable in any technology product context and the adoption likelihood connectors (the arrows with their corresponding binary numbers representing 'adopted' and 'not adopted') could be applied to other segments of the general SCP framework (this is illustrated in section 7 of this thesis).

The next chapter describes the research methodology that was used in conducting the experiment and survey. It covers the experimental design, description and illustration of the three IoT scenarios and corresponding prototypes, data collection and sampling strategy, description of experimental tasks, and description of the analysis method.

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CHAPTER FIVE

5 Research Methodology

This chapter describes the methodology adopted for this research. The overall aim of a quantitative research study is to classify features, count them, and construct statistical models in an attempt to explain what is observed. Consequently, the research methodology involved: (1) an overview of the research methodology, (2) experimental design, (3) description and illustration of the three IoT scenarios, (4) design of prototypes, (5) data collection and sampling strategy, (6) design of experimental task, (7) a four-part mix of quantitative questionnaire of 61-items. The 61-item questionnaire was developed and designed in this study for a 66-person experiment participants, (8) method of successive interval transformation, and (9) the analysis method.

5.1 Overview of the research methodology

In chapter 2, five generic components of the BM model of two established DT firms (Microsoft and Apple) were identified. In particular, three (3) of the generic components were associated with product value offering as follows: price, product training, and product subscription/full purchase. Also, two (2) of the generic components were associated with user perception of product value offering (customer product satisfaction and potential for customer trust). These five generic components, although not exhaustive, form the bases for the DTBM adoption framework for IoT that is proposed in this research, and they prove valuable in enabling user-based evaluation of a BM, in contrast with the convention in BM research whereby business operators or experts are used as evaluators.

This chapter presents the research methodology that was used in investigating the likelihood of adopting existing DTBM for IoT, which is the main objective of this research. A mixed approached with a greater slant towards quantitative research methodology was adopted for this study. In particular, the research investigates the likelihood of IoT adoption of existing DTBM, by *'determining if there are significant differences (or equality) between* ***matched pairs of user inclinations*** *towards any of the* ***five generic components of DTBM*** *applied to two digital technology products context (****Smartphone context*** *an three* ***IoT products context****)'*[15] in a within-subjects design.

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[15] The phrase in this quote will be intermittently refered to as ***"matched pairs of user inclinations"*** in subsequent sections of this report.

The three IoT scenarios (health monitoring, use of the library and borrowing of books, and home environment) are illustrated with a diagram and described in section 5.2. Also, the primary data of the research gathered in these research were mostly ordinal scale data. But, because of a subsequent need for numerical-based statistical analysis, the original ordinal scale data of the **matched pairs of user inclinations** were transformed to numerical data on interval scale using the method of successive intervals (MSI) as subsequently reported in section 5.8.

Also, as part of **a novel future implementation and atomic BM idea** proposed for one of the IoT scenarios context in this research (that is, **the use of the library and borrowing of books IoT** - see sections 3.4.1 and 5.2.2), data was minimally obtained to assess its acceptance from the within-subjects participants using a problem-solution approach. The reason for not obtaining data for the other two IoT scenarios context (health monitoring and home environment) was because many implementation ideas are already in existence for these two IoT scenarios context. The concepts of generic and atomic components of BMs and how they are used in this research have been explained in sections 2 and 4 of this research.

In quantitative research, the goal is to determine the relationship between one thing (an independent variable) and another (a dependent or outcome variable) in a population. Quantitative research designs are either descriptive (subjects usually measured once) or experimental (subjects measured before and after a treatment). A descriptive study establishes only associations between variables. An experiment establishes causality and its main characteristics as outlined by Babbie (2010) are:

- The data is usually gathered using more structured research instruments.
- The results are based on larger sample sizes that are representative of the population.
- The research study can usually be replicated or repeated, given its high reliability.
- Researcher has a clearly defined research question to which objective answers are sought.
- All aspects of the study are carefully designed before data is collected.
- Data are in the form of numbers and statistics.
- Project can be used to generalize concepts more widely, predict future results, or investigate causal relationships.

- Researcher uses tools, such as questionnaires or equipment to collect numerical data.

In the next section we describe the within-subjects experimental design adopted for this research.

5.2 Experimental design

As part of the main objective of investigating the likelihood of IoT adoption of existing DTBM, an experiment was designed with the aim of using three of the aforementioned research instruments outlined in section 5 to aid data collection from participants as follows: (i) the educational tools - three user experience scenario diagrams and three Just-In-Mind (Android phone app) prototypes, and (ii) pre and post experiment questionnaires. It is important to note that the research transcends gathering data for the **matched pairs of user inclinations,** as the questionnaire construct included question items relevant to the the general research objective as reported in sections 5.7.1 and 6 respectively.

A within-subjects design was adopted for the experiment. That is, the same person is in the study in all of the set out conditions (Hall, 1998). In the case of this research, subjects' previous *inclinations* towards acquiring a Smartphone and their attitudes *inclinations* towards acquiring IoT products context[16] applicable to the five generic components of existing DTBM are investigated. This means that fewer participants are needed, which is cost effective, and also that participants are exposed to all levels[17] of a condition, so individual differences will not distort the results and each participant serves as his or her own baseline (Morgan & Case, 2013). The following examples explain the the conservative examples of within-subject design:

(a) To determine the difference in *alcohol consumption* amongst heavy drinkers after a therapy to reduce their consumption over two *time points* (consumption immediately before and after 6 months of the therapy). In this case *"alcohol consumption"* is the **dependent variable**, while *"time point"* is the **independent variable** with each of the two time points considered a related group;

(b) To determine whether there is a difference in *breaking speed in a vehicle* based on two different *windscreen tints colour* (low tint and dark tint). In this case

[16] Based on their experience with the three IoT scenarios/prototypes - represented as a single experience using an IoT product.

[17] The timepoints between pre-experiment exercise and post-experiment excercise represent levels our research.

"breaking speed in a vehicle" is the **dependent variable**, while *"windscreen tints colour"* is the ***independent variable*** with each of the two conditions considered a related group (Laerd, 2015A; Laerd, 2015B).

In the two examples above, (a) measures alcohol consumption (objective measures) over two time points, while (b) measures breaking speed (objective measures) based on colour of windscreen tints. "**Time**" and "**condition**" as within-subjects factors, are abstract attributes of an activity or object. However, Laerd, (2015A) also highlighted another within-subjects design approach known as **"matched pairs,"** whereby **individuals** or **objects** can also become within-subjects factor. For instance, two biological parts can be looked at on the same participant. Example: (c) determine the difference in the distance a ball can be kicked between participants' left and right legs. So, 'Participants leg' in this example, is the within-subjects factor (**independent variable**), while left leg and right leg are two levels (related group) of the within-subjects factor, and 'the distance a ball can be kicked,' the **dependent variables** (Laerd, 2015A).

Consequently, the within-subjects design in this research was structured to have semblance with the third example, (c) because the independent variable was an **object**, as follows: *'to determine if there is a significant difference in user inclinations towards the five generic components of existing DTBM based on two DT products (Smartphone and IoT products context).'* Therefore, 'DT product' is the within-subjects factor (**independent variable)**, while Smartphone and IoT products context are two levels (related group) of the within-subjects factor, and 'user inclinations towards each of the five generic components of existing DTBM,' **the dependent variables**. Thus, subjective measures in the form of "*user inclinations towards the five generic components of the DTBM based on two digital technology products (Smartphone and the three IoT scenarios context)"* are investigated in order **to determine the likelihood of IoT adoption of existing DTBM**. The conservative[18] approach for the within-subjects design outlined in examples (a), (b), (c) above, primary data are gathered as objective measures[19] on a continuous scale.

In contrast, for the within-subjects design approach in this research, primary data was gathered for the subjective measures[20] in categorical ordinal scale. This required primary data for each matched pair of user inclinations to be transformed from

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[18] "Conservative" as used here refers to the usual convention with within-subjects design.
[19] That is, "difference in alcohol consumption..." and "breaking speed in a vehicle..." respectively.
[20] That is, "matched pairs of user inclinations..."

ordinal to interval scale. Thus, subsequently enabling a continuous data form for indepth statistical analysis. See sections 5.8 and 6.3 for description and results of the transformation respectively, and section 1 of appendix B for the transformation operation; thus, resulting in a continuous data set for each *'matched pairs of user inclination'*.

The decision to structure the experimental design in this manner was aimed at extracting the benefits of the statistical test[21](see section 5.9.1 for the description of the sign test) that is applied in order to validate the likelihood of IoT adoption of existing DTBM in this research. Also, although Smartphone is used as part of the related group, the research relied on participants' previous experience in acquiring Smartphones in order for them to respond to the pre-experiment questionnaire to indicate their inclinations towards the five generic components of existing DTBM.

However, for the IoT products context, participants carried out prescribed tasks with the three IoT prototypes in order to educate themselves about IoT. Afterwards, they responded to a post-experiment questionnaire to indicate their inclinations towards the five generic components of existing DTBM if they were to acquire IoT products. The hypotheses deduced for each of the matched pairs of user inclinations based on the above design as were already outlined in sections 2.4, 2.5, and 2.6 are as follows:

- ***H_{A1}:*** *There is a significant difference in user inclination to consider the price of IoT products as compared to existing digital technology products.*
- ***H_{A2}:*** *There is a significant difference in user inclination to value training to use IoT products as compared to existing digital technology products.*
- ***H_{A3}:*** *There is a significant difference in user inclination to set-up subscription plan for IoT products value offering as compared to existing digital technology products value offering.*
- ***H_{A4}:*** *There is a significant difference in user inclination to be satisfied with IoT products value offering as compared to existing digital technology products value offering.*
- ***H_{A5}:*** *There is a significant difference in user inclination to trust IoT products value offering as compared to existing digital technology products value offering.*

[21] that is the **sign test**, which determines equality of median means (Laerd, 2015A).

Furthermore, the research sought to investigate the type of association between the matched pairs of user inclinations towards the five generic components of existing DTBM. The hypotheses to be validated for this purpose are as follows:

- ***$H_{A1.1}$*****:** *There is a positive relationship between user inclinations to consider the price of existing digital technology products and IoT products.*
- ***$H_{A2.1}$*****:** *There is a positive relationship between user inclinations to value training to use existing digital technology products and IoT products***.**
- ***$H_{A3.1}$*****:** *There is a positive relationship between user inclinations to set-up subscription plan to acquire existing digital technology products and IoT products.*
- ***$H_{A4.1}$*****:** *There is a positive relationship between user inclinations to be satisfied with existing digital technology products value offering and IoT products value offering.*
- ***$H_{A5.1}$*****:** *There is a positive relationship between user inclinations to trust IoT products value offering and other existing digital technology products value offering and IoT products value offering.*

Finally, the relationship between product usage experience and user inclination towards user inclination to be satisfied with product value offering applied to smartphone context was compared with results of a similar association for the IoT products context. The following hypotheses were deduced and tested using Spearman rho:

- $H_{A6.1}$: *There is a positive relationship between product usage experience and user inclination to be satisfied with the value offering of smartphones*
- $H_{A6.2}$: *There is a positive relationship between product usage experience and user inclination to be satisfied with the value offering of IoT products.*

The main advantages of using a within-subjects design is the achieved statistical power and the fact that the variance of error associated with subject differences is reduced (Hall, 1998). However, A major drawback of using a within-subject design is that the act of having participants take part in one condition can impact performance or behaviour on all other conditions; a confounding problem known as a carryover effect. Therefore, we designed the experimental procedure to mitigate carry over effects by providing a fixed time of five (5) minutes; allocated for participants to rest between completing pre-experiment exercise [22] and post-experiment exercise.[23] Also, five (5) minutes was allocated for user familiarization with each of the IoT scenarios.

Another drawback is the learning effect, which may arise from hints obtained from previous trial of the experiment run by each subject. They are products of practice effect, which are influences on test results when a test is taken more than once (Statistics Howto, 2015). That is, "the finding that learning and memory are facilitated by the inclusion of practice tests in one's learning regimen (Toppino & Gerbier, 2014)." The learning effect can be corrected using counterbalancing, which involves collecting subjects in groups, then randomizing the group to all possible orderings of the hints (Hall, 1998). However, Laerd (2015A) suggests a "linear" approach can also be used in carrying out within-subjects experiment tasks, whereby all participants are exposed to the control, and then the treatment, in consecutive succession without randomization of the order of the experiment. This is similar to how the within-subjects experiment was conducted in this research.

Nonetheless, an attempt was made to mitigate against the learning effect in this research by using the questionnaire design as a tool. This had to do with how the pre-experiment question-items (for Smartphone) and post-experiment question-items with their corresponding options were phrased as expatiated upon in sub-section 5.7.1. Finally, it should be noted that although the tasks leading up to the post-experiment questionnaire were hands-on exercises on the three IoT prototypes for partcipants to get acquainted with the workings of IoT; there was no objective measurement item for the triad. This was because the main focus of the research was to investigate user inclinations when they acquired their current or previous Smartphone on one hand, and user inclinations if they were to acquire/purchase any of the IoT products context on the other hand.

5.3 Description and illustration of three IoT scenarios

Scenarios are designed for three IoT use-cases of health monitoring, home and environment, and use of the library and borrowing of books. A wide range of potential events can be covered in a single use-case scenario with indications of user ability to use the system. The user experience scenario depicts the problems faced by

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[22] Completing a questionnaire for demographic factors and user inclination towards the components of the DTBM based on Smartphone context.

[23] Completing user education with three IoT scenarios/prototypes and post-experiment questionnaires for matched pairs of user inclinations.

the user in a graphic format and how IoT solutions are deployed to remedy the situation. The scenarios are archetypes of a real situation and may form part of a design process in actually implementing an IoT use-case. However, for this research work, the scenario diagrams will give respondents of the questionnaires an overview of the three selected IoT use-cases, shaping their perception of the IoT uses-cases to enable them respond to the corresponding questions.

5.3.1 Health Monitoring IoT Scenario

Adam Corbyn is a young entrepreneur in London who usually waits for his body's early-warning system (symptoms) before he goes to see a doctor or when he is due for a compulsory annual check-up. This 'waiting period' is aggravated by his very busy job schedule that does not allow him the opportunity for regular check-up. Corbyn has observed that on several occasions he has been experiencing difficulty breathing over the pass three (3) months, which he ignored and continued with his work schedule. However, Corbyn decides to make out time on a Saturday to go for a check-up with a general practitioner (GP). On meeting with the GP, Corbyn is informed of the danger of waiting for symptoms before visiting a GP. His check-up result indicates that the difficulty in breathing was as a result of stress, which requires rest. Nevertheless, the GP informs him that it is not always necessary to visit the GP based on how one feels as in several instances such visits might indicate that nothing is wrong with the individual. Figure 5-1 shows the illustrates the scenario.

FIGURE 5-1: HEALTH MONITORING IOT SCENARIO

As a result of this, the GP introduces Corbyn to new ways for one to constantly monitor his/her body that could indicate warnings of any anomaly, as there are ailments that have no apparent symptoms, but require biochemical analysis to arrive at a certain diagnosis. The GP further informs Corbyn that potentially fatal conditions can be identified and treated through early diagnosis. The GP recommends IoT products and services for health monitoring. He is given an electronic sticker to attach to his chest to monitor and prevent heart attacks, and a mobile cough analyzer application.

Upon purchasing this IoT health products and services, Corbyn decides to put these products to use. He places the e-sticker on his chest to monitor activity and fluid levels in his chest over a wireless connection. In the morning of the tenth day of placing the sticker on his chest, he receives a dose of medication to combat the excessive fluid levels and mitigate against breathing difficulties that may result from the excess fluid, which was analyzed on the ninth day. The chest e-sticker application has his account details to enable payment as soon as he accepts to purchase the recommended medication. Corbyn accepts the purchase and receives a payment alert to that effect.

Corbyn starts experiencing intermittent cough due to exposure to cold on the fourth day of his two weeks official trip to Reykjavik, Iceland. He makes use of the cough analyzer application on his mobile phone, which uses the specific noise of the cough over the mobile phone to analyze and diagnose anything from a common cold to pneumonia by matching the sound to a database of 1000 profiles, and then remotely sends the results of the analysis to the GP. On the sixth day, the GP spots abnormal values and contacts Corbyn via e-mail recommending medications to alleviate the situation. Corbyn proceeds to the Boots e-pharmacy, which also operates in Iceland and uploads the e-prescription of the GP, as these set of medications are in the category that can only be paid for online on submission of GP or Pharmacist e-prescription. Two hours later, he receives the medications from the Boots deliveryman in Reykjavik.

5.2.2 Use of the Library and Borrowing Books IoT User Experience Scenario

Raymond Matthew is a mature post graduate research student who visits both the University library and the local library in Brighton to read and borrow relevant books necessary for his research work. As part of the registration process with these two libraries, an 'option' of downloading a Library/Books IoT application called the Smart and Embedded Books (SnEB) app by library users is offered. Figure 5-2 illustrates this scenario pictorially.

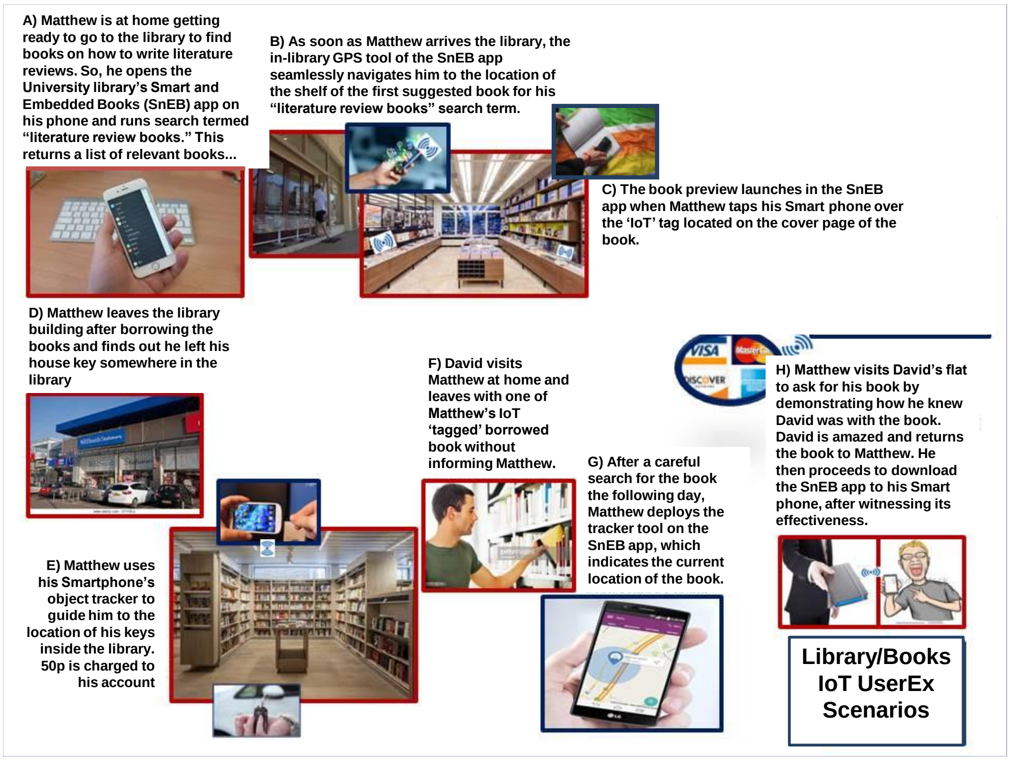

FIGURE 5-2: USE OF THE LIBRARY AND BORROWING OF BOOKS IOT SCENARIO

Matthew downloads the SnEB app to his phone. The SnEB app has indoor positioning facility to locate book shelves in the library using active tags (RFID) and seamlessly previewing relevant books that are on the library shelf using passive tags (NFC). It also has facility to locate lost or stolen borrowed book, as these books are tagged with miniaturized low RFID chips, thus making them 'Smart Books'.

Matthew is at home preparing to visit the University library to borrow a book on literature review. He opens the SnEB app and searches for availability of literature review books that are IoT-enabled. His search returns three results, so he proceeds to the library to borrow one of the books. As he steps into the library, he opens the library indoor shelf location system for the searched book to navigate him to the location of the book shelf. On arriving the location of the book shelf, Matthew sees the book sitting on the shelf, so he places his phone near the book to obtain a seamless preview of the book on his Smart phone using the facility available in the SnEB app. Matthew leaves the library after borrowing the book and drives back home.

After two days, Matthew's research group colleague (David) visits him at his flat. While Matthew was making dinner for both of them, David looked around Matthew's living room and spots the literature review book on Matthews reading table, David picks the book and tugs it in his bag without informing Matthew. The following day Matthew could not find the book, so Matthew opens the Locate Lost/Stolen Book facility available on the SnEB app on his mobile device, which shows him the current location of his borrowed literature review book (enabled by a miniature GPS chip embedded in the bind of the book); this idea is explained in section 3.4.1. Matthew selects the location icon of the pin pointed location on the map and discovers it is David's house address. He calls David to ask him if he is home to the affirmative, so he drives on his car to David's house to ask for his borrowed book to be returned. David smiles with a grin and hands the book over to Matthew. On the SnEB app Matthew confirms that he has retrieved the lost book and 99p charge is debited to his bank account for the location service. David ask Matthew how he knew the book was with him, so Matthew encourages him to download the SnEB app to enjoy the same service.

5.3.3 Home Environment IoT Scenario

Pamela Sturgeon is an accountant with a foremost accounting firm in New York. He observed that 50% of electricity and water consumed at home is actually wasted every month due to lack of information on consumption. Consequently, he develops an interest in efficient management of available resources, by installing smart appliances at home. The smart meter optimize energy generation and consumption using a series of smart meters that choose the best time slots from amongst different power utilities and discriminate between consumption times. The result is more sensible and economic power consumption. The installed smart meters analyze consumption, and seamlessly send the results to a user’s mobile device every fifteen minutes.

In order to cut cost and attain efficiency in energy consumption, a user can adapt his consumption to times with lower rates especially at night. Also, he can save energy costs by 10% by monitoring his domestic appliances over the Internet and switching them on and off remotely. Sturgeon has the smart meter installed for her on a Saturday, which could be read remotely, doing away with the estimated meter readings and bills. The next day being Sunday, there was a power cut because of high voltage in the neighbourhood, but remote reconnection was initiated automatically and Sturgeon's home voltage was also stabilized.

However, when Sturgeon received his first bill, the cost had doubled. This is because Sturgeon had made no effort to adapt her consumption to times with lower rates because of his busy schedule at work. This incident nearly dampened Sturgeon's excitement of signing up to an IoT enabled smart grid. Sturgeon decides to put a call to her energy service providers, and she was reminded that her opting for a smart meter also require an effort on her part. Sturgeon did not take advantage of the energy consumption data facility, which is part of her smart meter package, and it is available on the Home and Environment IoT app that was installed on his mobile device. This app provides real time information on consumption and cost. Figure 5-3 shows the illustration of this scenario.

FIGURE 5-3: HOME ENVIRONMENT IOT SCENARIO

Sturgeon decides to make use of the energy consumption data facility. The application changes color to red during high consumption times with higher rates and to green during low consumption times with lower rates. Sturgeon observed that the high consumption times were also during the day time while the low consumption times were at night, so she adapted her home smart meter to times with low consumption rates. She adapted her smart meter such that if she forgot to turn off any appliance after usage in the morning at 8am, the appliances will be turned off automatically. Over a two-week period, Sturgeon observed that her bill has drastically reduced as he now pays 60% of what he used to pay when he had the traditional metering devices.

As part of her Smart home drive, Sturgeon acquires an iDrink Station (iDS), which is part of the Home and Environment IoT app. She wakes up to her iDS brewing her predetermined morning drink based on wake up modes set on the iDS facility on the Home and Environment IoT app. Sturgeon was out for office work and at close of work she hops on a bus to head back home. She drops off the bus and walks a short distance to her flat. As soon as she walks within 250 metres radius of her house address, the iDS starts brewing her favourite evening drink. Three days later, the iDS reports a brand of coffee that is one of Sturgeon's favourite is not available, so a change of status query is sent to the supplier system and notifies the supplier to make a delivery for the next day.

Sturgeon’s account is on the red as she was expecting a loan payment in two weeks’ time. She browses the net to see how much it will take to purchase a lawn mower, as the weed at her garden are attracting insects and rodents to her environment. Google takes her to a website that shows that a new lawnmower will cost her £300. The company however has exciting news for her. They have for rental; IoT enabled lawnmowers that instantly report how much of them you use. Sturgeon drives to the store supplies her credit card details and borrows the lawnmower. She makes use of the lawnmower the following day being Saturday and had her credit card charged £5 for every hour she spent mowing. The three scenarios described and illustrated above were applied towards the design of prototypes using JustInMind online software. See appendix B for the screenshots of prototypes and correspending task description.

5.4 Sampling strategy

The experimental survey carried out as part of this thesis underwent a thorough ethical review process and approval granted. A certificate was subsequently issued by the Science and Technology C-REC of the University of Sussex (see Appendix 9.6 for the certificate of approval). The methodology for determining participants sample size for the within-subjects design was based on an online sample size calculator (Survey System, 2012) and focuses on users of digital technology products in the United Kingdom, which has an estimated population size of 67,000,000 in 2018. However, the research was carried out in the suburban city of Brighton and Hove with an estimated population size of 280,000 in 2018, and participants were selected from the estimated University of Sussex student and staff population size of about 17,000. This is because the university's staff and students population may all use the library to read and borrow books, they may all need to monitor their health, and they all leave in homes.

Hence, using the online sample size calculator for the population size of 17,000, with a confidence level of 95% and confidence interval of 12, a sample size of 66 was derived.

- The **confidence interval** (also called margin of error) is the plus-or-minus figure usually reported in opinion polls (Survey System, 2012). For example, if 50% of the subjects in this experiment pick a particular option, it could be inferred that if that question was asked of the entire relevant population (Sussex University staff and students), between 38% (50-12) and 62% (50+12) would have picked that answer.
- The **confidence level** has to do with how sure the researcher can be that the true percentage of the population who would pick an answer lies within the confidence interval. The 95% confidence level means 95% certainty about this relevant population lying within the confidence interval (Survey System, 2012).

A study by Bellemare et al. (2014) using experimental method in economics found that a sample size range of between 66 to 738 is ideal for a within-subjects experiment in a high variation scenario, while a sample size range of 20 to 218 subjects is ideal in a low variation scenario. Although the use of experimental methods in economics was considered an anomaly in the past (Friedman, 1953; Robinson; 1977; Starmer, 1999), several researchers have justified its usage as part of interdisciplinary research and research on **human behavior (**Moscati, 2007; Guala, 2009; Serra 2012).

The sample size data range for within-subjects design by Bellemare et al. (2014) guided the choice of the sample size of the within-subjects design in this thesis. This is because the main data captured in this research also have to do with **human behaviour** (**user inclinations** towards the five generic components of DTBMs). Therefore, the study findings by Bellemare et al. (2014) justify the within-subjects sample size of 66 for the experimental survey in this thesis, which falls within the range of number of subjects required in both high variation and low variation scenarios.

The power advantage of within-subjects design also makes it suitable to use this sample size. For instance, "the between-subjects version of a standard t-test requires a sample size of 128 to achieve a power of .80, whereas the within-subjects version only requires a sample size of 34 to achieve the same power (Statistics Solutions, 2019)."

5.5 Recruitment of participants

Two approaches were adopted to recruit participants; purposive and opportunistic methods. The purposive approach was adopted to pick respondents with the aim of targeting Smart phone users. In essence, all participants should have some level of experience with the use of Smart phones and their corresponding apps. The selection of the purposive method also implied that students/staff with some experience in the use of Smart phones who are known to the researcher were approached and recruited. The advantage of the purposive approach is that it ensures that the right respondents are identified and researched.

The opportunistic approach entailed recruiting participants within the University of Sussex campus that the researcher meets in the public space and through posters and leaflets on notice boards around the campus. However, the purposive method established above was useful in ascertaining the suitability of these categories of individuals who indicated their interest to take part in the experiment. A total of 66 people took part in the experiment in University of Sussex.

5.6 Experimental tasks

An experiment was conducted from June 2018 to September 2018 as part of the research. After giving the participants a comprehensive description of what the research is about and having them sign the relevant forms, a single channel (Survey Monkey email invite) was used to send the questionnaires to the participants. This was to ensure that responses to the questionnaire are available in a single format.

The first tasks of the experiment involved participants responding to two sets of questionnaires. The first set of questionnaire was a 14-item questionnaire highlighting participants demographic factors relevant to this research, while the second was a questionnaire containing 16 items investigating user habits/behaviour towards an existing digital technology product (Smartphone). These group of questionnaires made up independent variables for demograhic factors and dependent variables for the Smartphone questions. These tasks took about 20 minutes. And five (5) minutes was allowed for rest before the next task.

The second tasks introduced the participants to IoT educational tools that were designed as part of this research giving them an opportunity to acquaint themselves with IoT. The educational tools were three IoT scenario diagrams (health monitoring, use of library and borrowing books, and a home environment IoT scenarios) and three Just-In-Mind clickable IoT prototypes (Android phone app) for these three IoT scenarios. As part of this second task, participants were first given the opportunity to view the three IoT scenario diagrams. This activity lasted for about 15 minutes and was followed by a hands-on exercise with the three Just-In-Mind clickable IoT app prototypes as was described in sub-section 5.4 above. Participants were required to navigate each of the clickable prototypes activating events without the researcher telling them what to do. This task took not more than 30 minutes. A 5 minutes break was allowed for participants to prepare for the next tasks.

The third tasks involved participants completing a two-part questionnaire. The first part was an 11-item questionnaire on user experience with the hands-on educational tool (the three IoT application prototypes - health monitoring, use the of library and borrowing books, and a home environment IoT scenarios). The second part questionnaire was a 20-item questionnaire of psychometric questions on user disposition to acquire the three IoT products based on the scenarios context**.** This particular questionnaire also made up the dependent variables and these third tasks took about 20 minutes. The data that were gathered were used in testing the hypotheses deduced in sections 2 and 5.1 This was aimed at determining the likelihood of IoT adoption of existing DTBM and also help to answer the research questions.

5.6.1 Procedure to anonymise participants data

All participants signed a consent form and they were adequately briefed about every aspect of the study before their participation. All collected data were anonymised using the anonymisation facility of survey monkey instead of personally-identifying information to ensure privacy, because survey monkey prompted email invitations were used to collect data and custom data was added in contacts before participants respond to the questionnaire. Email invitations are particularly useful in tracking respondents such that survey results will include the email address and IP address of each respondent by default, implying that, the first name, last name, phone number and custom data about participants can be tracked since this information are included in the collector.

Given the foregoing, the anonymous response facility in the survey monkey email collector was turned on so that data that makes experiment participants personally identifiable would not be included in the results of questionnaire survey. The UK Data Protection Law was summarily explained to participants and a copy of the Act principles and the information website was handed out to them upon request (a copy of the Act principles is attached with the application).

5.6.2 Procedure for participants to withdraw from the experiment

Participants were informed of the procedure to withdraw their data in the future if they so wished after they must have completed the experiment. The procedure to withdraw from the experiment either midway into the experiment or after completing the experiment involves participants sending an email request to the researcher to indicate that they no longer want their data to be used as part of the results of the study. The reason for this method was because a single channel of data collection was used to collect the data (survey monkey email invitation) which creates a unique identifier for each participant.

The researcher is therefore bound to delete any trace of such a participant from the survey monkey repository. If a participant wished to confirm that his/her data is deleted, they would be advised to make an appointment with the researcher to view the questionnaire response repository to confirm that their data is completely deleted. The deadline for such withdrawal was set at 2 weeks after the data collection date. However, no participant made this request, so this procedure was not triggered.

5.6.3 Location

The study was carried out at the VLSI and Graphics laboratory at Chichester I building of the University of Sussex.

5.7 Design of Questionnaire

Questionnaires design entailed constructing question-items that relate to user inclinanations towards each of the five generic components of existing DTBM based on Smartphone and IoT products context, and question items for a novel future implementation and atomic BM idea for one of the three IoT scenarios (use of the library and borrowing of books IoT scenario).

The advantages of using a questionnaire survey over other methods of collecting primary data is the high level of reliability and the flexibility they provided for the researcher to collect a wide range of primary data. This helps to lower costs and save on both time and labour. Since the questionnaire was distributed to participants through an online mechanism (Survey Monkey), it proved easy to use for the participants and cheap and labour-saving for the researcher.

The questions were mostly closed-ended questions in which participants chose an answer or several answers from the options provided, while few open-ended questions allowed participants to add information beyond what is contained in options provided. The ability to use closed-ended questions allowed the researcher to collect data that was both in-depth and specific. The advantages of close-ended questions are as follows:

- it is easier and quicker for respondents to answer
- the answers of different respondents are easier to compare
- answers are easier to code and statistically analyze
- the response choices can clarify question meaning for respondents
- respondents are more likely to answer about sensitive topics

However, closed-ended questions also have demerits[24] such as:

- Ideas that the respondent would not otherwise have known could be suggested.
- Answers could be obtained from respondents who have no opinion or no knowledge of the subject-matter.
- Respondents' desired answer may not be among the response choices, presented leading to frustration.
- Respondents may be confused if many response choices are offered.

Despite these demerits, the validation objective in this thesis makes closed-ended questions more suitable. Nonetheless, attempts have been made in the questionnaire design to reduce the influence of some of these demerits through a purposive participants recruitment approach, and ensuring choices provided in the relevant question items are not ambiguous and not many. As outlined earlier in sections 2 and 5, five (5) 'user-centric' generic components of the business model of two existing digital technology firms were identified: three (3) main components (price,

[24] https://help.surveyanyplace.com/en/support/solutions/articles/35000042308-closed-ended-question

product training, product subscription) associated with the product value offering and two components (satisfaction and trust) associated with user perception of product value offering. In this report, these five components were phrased as follows by the researcher: 1) customer price perception , 2) acceptability of training, 3) inclination towards product/service subscription or full purchase, 4) customer satisfaction indicators, and 5) potential for customer trust; with some of the components broken down into sub-question items.

Objective measures such as the time taken to complete a scenario, the completion rate, and error recovery duration (Whiteside, Bennett, & Holzblatt, 1988), where not considered in this research, although the research partly followed a scenario-based methodology. Instead, subjective measures in the form of Likert-type questionnaire were used for this study, as participants were expected to indicate their **inclinations** towards the five generic components of the DTBM based on Smartphone and IoT products contexrt. Demographic factors (also as independent variables) and usability questions (for descriptive analysis) were also constructed for one of the educational tools (Just-in-mind prototypes).

In general, questionnaires were designed in the form of Likert-type or multi-item position scales as well as a range of single choice and multi-choice questions with the aim of measuring the variables/components of the business model outlined above. It should be noted that in this type of study, researchers are inclined to adopt Likert scale questions in a between-subject design to allow a range of indepth statistical tests, but the within-subject design adopted in this research, although has its advantages, imposed limits on the statistical tests that could be performed on data obtained from measurement items.

Consequently, the uniqueness of this research approach implied that each of the five generic components of the DTBM had single questions/measurement items constructed as pre-experiment independent variables (for Smartphone) and post-experiment dependent variables (for the three IoT scenarios), which contrast with the convention of constructing several questions for one component as part of a Likert scale in this type of study. This resulted in categorical data for each of the generic components of the DTBM and thus initially hamstringing direct parametric analysis in this study. But, the data were transformed to numeric interval scale using MSI as described in section 5.8.

Originally, the questions were designed as Likert-type ordinal scale with different number-point scales (four, five, six), but during data processing, it was decided that the Likert-type data should be merged to obtain a consistent four-point scale. The choice of a four-point scale was because the original questions consisted of either four options or more but not less than four options, so transforming all the questions to four options was tenable. A total of 61-item questionnaire were generated for the independent and dependent variables. The items were pilot tested with 3 subjects, and were then tested with 66 subjects from the same population, students and staff of University of Sussex. Two pre-experiment questionnaires were administered before the users started the experiment and two post-experiment questionnaires were administered after the users completed the experiment.

The first part of the pre-experiment questionnaire was used to gather information about the general demographics and characteristics of the participants (age range, gender, technology usage expertise, level of education attained, profession, monthly income, number of years using digital technology products). The second part of the pre-experiment questionnaire was used to gather user inclinations towards purchase and ownership of their previous or current Smartphone, thereby investigating how the participants perceived the generic components of the DTBM identified in section 2. This second part of the pre-experiment questionnaire also included question items to guage participants' aquaintance with locating books in the library and the data gathered here was used as part of a problem-solution validation approach for the *'use of the library and borrowing of books IoT scenario'*.

Conversely, the first part of the post-experiment questionnaire was used for the participants to report on their experience using the educational tools - the three IoT scenarios and three JustInMind prototypes, constructed as usability-type questions. While, the second part of the post-experiment questionnaire was constructed to mirror the second part of the pre-experiment questionnaire, in that, it was used to gather potential user inclinations towards purchase and ownership of the IoT products and services in the context of the three IoT scenarios.

This was aimed mainly at investigating user inclinations towards each of the five generic components of the DTBM identified in section 2. Also, the second part of the post-experiment questionnaire included question items to guage participants' perception of the library book location solutions available in the "use of the library and borrowing of books IoT scenario" wireframe.

5.7.1 Measurement instruments for five generic business model components

Recall that in section 5.1, we discussed about a confounding problem associated with within-subject design known as learner effect and stated that the questionnaire design was used as a tool to mitigate against it. This was done by:

(a) constructing for the three IoT scenarios (post-experiment question items), general and subjective questions, targeting IoT as a whole, instead of questions design for each of the three IoT scenarios. This first questions design approach was also useful in ensuring that results and findings are used to make recommendation about IoT as a whole; and

(b) the questions and the options for the pre-experiment product context (Smartphone) and the post-experiment product context (IoT) were phrased in such a way that they are not so similar, yet conveying the same meaning in measuring participants' inclinations towards the five generic components of existing DTBM applicable to Smartphone and IoT products. Thus, in a narrow sense, mitigating against participants answering duplicitous/repeated questions in succession.

The question-items that were used to measure user inclinations towards each of the five generic components of existing DTBM based on Smartphones and IoT products context were composed by the researcher for the purpose of originality. This was because the research design informed the use of single-item questions for each of the generic components of the existing DTBM, although there are a number of question-item constructs for these components in the literature.

Also, as highlighted earlier in sub-section 5.7, during data preparation, the options of these questions, where necessary, were transformed using SPSS Transformation tool to form a four-point Likert-type ordinal scale. This was done by way of merging the options that were not selected by the participants to the options that were closely similar in meaning to the merged option. These are comprehensively illustrated below in this sub-section.

The order of the options, where necessary, were re-ordered to start in descending order of rank instead of how they were ordered in the questionnaire, which was in ascending order of rank. For instance, questions with the following order of options: (a) Very important (b) Important (c) Not important (d) Not very important, were reordered to (a) Not very important (b) Not important (c) Important (d) Very important.

Furthermore, each of the items of the five generic components of DTBM renamed and abbreviated during data preparation to safe space and enable readability of processed results. The question-items applied to Smart phones were abbreviated with the suffix **'Sp'**, while those applied to the three IoT scenarios context were abbreviated as **'IoT'**.

For ethe data for user inclinations towards each of the five generic components of existing DTBM based on Smartphone and IoT products context, the description of these transformations presents the original questions for each of the pre-experiment questions (that is for Smartphone) with the prefix 'Smartphone **[During the experiment…]'**, while the transformation of the original questions for each of the pre-experiment questions are represented with the prefix 'Smartphone **[During data preparation…]'**.

Similarly, the description of the transformation of the original questions in the context of the five identified business model components present each of the post-experiment questions (that is for the three IoT scenarios context) with the prefix 'IoT scenarios **[During the experiment…]'**, while the transformation of the original questions for each of the post-experiment questions are represented with the prefix 'IoT scenarios **[During data preparation…]'**.

(a) Customer price perception: For this component, three question items were constructed; two questions to measure price range a user may be willing to pay and one question for inclination to consider price before purchase the product context (that is Smartphone/app on one hand and IoT scenarios on the other hand).

i) Price consideration question

- Smartphone **[During the experiment…]:** *How important was it for you to consider the price of your previous/current Smart phone in the light of the accessories and apps that were available in it before purchasing the Smart phone? (a) Very important (b) Important (c) Fairly important (d) Not important (e) Not very important.*

Note: During data preparation, option (c) was recoded and merged to (b) to conform to the data processing objective of a uniform four-point scale. The question was also transformed and abbreviated and the options' order was reversed in line with data processing and result presentation objectives as shown below.

- Smartphone **[During data preparation…]:** *Inclination to consider product price -* ***IncCPP (Sp)****? (a) Not very important (b) Not important (c) Important (d) Very important.*
- IoT scenarios **[During the experiment…]:** *In the context of the 3 IoT scenarios that you just completed, would you consider it important to assess the price of your preferred IoT products/services before purchasing it? (a) Very important (b) Important (c) Fairly important (d) Not important (e) Not very important.*

Note: During data preparation, option (c) was merged to (b) for uniformity. The question was also transformed and abbreviated and the options order was reversed in line with data processing and result presentation objectives as shown below.

- IoT scenarios **[During data preparation…]:** *Inclination to consider product price -* ***IncCPP (IoT)****? (a) Not very important (b) Not important (c) Important (d) Very important.*

ii) Price range question: The question-items contructed for the price range were not used for primary validation, but were applied for descriptive purposes.

- Smartphone **[During the experiment…]:** *If you are satisfied with your previous/current Smart phone, and a new version is released; how much extra would you be inclined to pay in addition to the purchase price of your previous/current Smart phone to obtain the new version of your Smart phone? (a) Less than £100 (b) From £100 to £150 (c) From £150 to £200 (d) From £250 to £300 (e) More than £300.*

Note: During data preparation, option *(e) above* was merged to option *(d)* to represent the uppermost range of price and also to conform to the data processing objective of four-point scale. Also, the order of the options were not reversed as they were in line with the rank order objective.

- Smartphone **[During data preparation…]:** *Price range willing to pay -* ***PRWTPx (IoT)****? (a) Less than £100 (b) From £100 to £150 (c) From £150 to £200 (d) From £250 to £300 or more*
- IoT scenarios **[During the experiment…]:** *In the context of the 3 IoT scenarios that you just completed, how much will you be inclined to pay to*

obtain any one of the 3 IoT products/services including the connected devices (sensors, RFID tags, NFC tags) and mobile applications? (a) Less than £100 (b) From £100 to £200 (c) From £200 to £300 (d) From £300 to £400 (e) From £400 to £500 (f) More than £500.

Note: IoT products and services (and accessories) could be viewed as an addition to a the nest of digital technology gadgets owned by a user, so the decision was to pair/compare the range of price for this with how much extra (adding to the price of the old version of that particular Smartphone) a user may be willing to pay for a new version of a Smartphone. During data preparation, options *(e)* and *(f) above* were merged to option *(d)* to represent the uppermost range of price and also to conform to the data processing objective of a four-point scale. Also, the order of the options were not reversed as they were in line with the rank order objective.

- IoT scenarios **[During data preparation…]:** *Price range willing to pay for IoT with accessories - **PRWTPx (IoT)**? (a) Less than £100 (b) From £100 to £200 (c) From £200 to £300 (d) From £300 to £400 or more.*

iii) Price range question (mobile apps)

- Smartphone **[During the experiment…]:** *How likely are you to pay £5.99 or more for an app? (a) Not Likely (b) Likely (c) Very Likely (d) I will only pay a lesser amount (e) I only use free apps.*

Note: The questions and the options for the Smartphone and IoT were phrased in such a way that they are not so similar, yet conveying the same meaning. During data preparation, option *(c)* above was recoded and merged to option *(a)* to also ensure the data processing and presentation objective of a four-point scale. Also, the order of the options were reversed in line with the low to high order objective.

- Smartphone **[During data preparation…]:** *Price range willing to pay - **PRWTPapp (Sp)**? (a) I only use free apps (b) Pay a lesser amount (c) Not likely (d) Likely.*
- IoT scenarios **[During the experiment…]:** *Given that the IoT services illustrated in the scenarios might form part of a mobile application excluding any other connected device, how much would you be ready to pay for the mobile application? (a) I only use free apps (b) Less than £1 (c) From £1 to £2 (d) From £2 to £5 (e) From £5 to £10 (f) More than £10.*

Note: During data preparation, options *(e)* and *(f) above* were merged to option *(d)* to represent the uppermost range of price and also to conform to the data processing objective of a four-point scale. Also, the order of the options were reversed in line with the low to high order objective.

- IoT scenarios **[During data preparation…]:** *Price range willing to pay for IoT apps - **PRWTPapp (IoT)**? (a) I only use free apps (b) Less than £1 (c) From £1 to £2 (d) From £2 to £5 or more.*

(b) Acceptability of training: For this component also, only a single question was constructed for each of the product context (that is Smartphone on one hand and IoT scenarios on the other hand) as outlined below:

- Smartphone **[During the experiment…]:** *How helpful was the user manual to you when you purchased your Smart phone? (a) Very helpful (b) Helpful (c) Fairly helpful (d) Not helpful (e) Not very helpful.*

Note: During data preparation, option *(c)* above was recoded and merged to option *(b)* in order to have a uniform four-point scale with the other datasets. The question was transformed and abbreviated and the order of the options were reversed as shown below.

- Smartphone **[During data preparation…]:** *Inclination to value training - **IncVT (Sp)**? (a) Not very helpful (b)Not helpful (c) Helpful (d) Very helpful.*
- IoT scenarios **[During the experiment…]:** *How valuable will it be to you if you are offered to be specially trained to use your preferred IoT products/services before or after purchase? (a) Very valuable (b) Valuable (c) Fairly valuable (d) Not valuable (e) Not very valuable.*

Note: During data preparation, option *(c) above* was recoded and merged to option *(b)* for uniformity of scales to four-point limit and the order of the options were reversed as shown below.

- IoT scenarios **[During data preparation…]:** *Inclination to value training - **IncVT (IoT)**? (a) Not very valuable (b)Not valuable (c) Valuable (d) Very valuable.*

(c) Product/service subscription plan: For this component, only a single question was constructed for each of the product context (that is Smartphone on one hand and IoT scenarios on the other hand) as outlined below:

- Smartphone **[During the experiment…]:** *When you are subscribing for an app, which subscription plan would you likely prefer? (a)Weekly (b)Monthly (c)Quarterly (d)Annually*

Note: During data preparation, the question was transformed and abbreviated, but the options order was not changed as shown below.

- Smartphone **[During data preparation…]:** *Inclination to set-up subscription plan -* ***IncSSP (Sp)****? (a)Weekly (b)Monthly (c)Quarterly (d)Annually*
- IoT scenarios **[During the experiment…]:** *If you are to subscribe for products and services on one of your preferred IoT platform, which subscription plan will best suit your net income? (a)Weekly (b)Monthly (c)Quarterly (d)Annually (e) Not applicable as I will opt for full payment at point of purchase*

Note: During data preparation, option *(e)* above was recoded and merged to option *(d)*, also to conform to the data processing objective of a four-point scale.. The question was transformed and abbreviated and the order of the options were reversed as shown below:

- IoT scenarios **[During data preparation…]:** *Inclination to set-up subscription plan -* ***IncSSP (IoT)****? (a)Weekly (b)Monthly (c)Quarterly (d)Annually.*

(d) Customer satisfaction indicators: For this component, two questions were constructed to measure satisfaction and likelihood of recommending product to family and friends as a result of satisfaction derived from the experience with the product context (that is Smartphone on one hand and IoT scenarios on the other hand).

i) Satisfaction question

- Smartphone **[During the experiment…]:** *How would you rate your experience using a Smart phone (a) Very dissatisfied (b) Dissatisfied (c) Satisfied (d) Very satisfied (e) Not sure.*

Note: During data preparation, option *(e) above* was merged to option *(a)*, also to conform to the data processing objective of a four-point scale. Also, the order of the options were not reversed as they were in line with the data preparation and presentation objective as shown below:

- Smartphone **[During data preparation…]:** *Inclination to be satisfied with product value offering -* ***IncSPVO (Sp)****? (a) Very dissatisfied (b) Dissatisfied (c) Satisfied (d) Very satisfied.*
- IoT scenarios **[During the experiment…]:** *Rate the level of satisfaction that you likely have for the IoT scenarios that you just completed? (a) Very satisfied (b) Satisfied (c) Fairly satisfied (d) Dissatisfied (e) Very dissatisfied.*

Note: During data preparation, option *(c) above* was merged to option *(b)*, as both could be viewed as having the same weighting. The question was transformed and abbreviated and the order of the options were reversed as shown below.

- IoT scenarios **[During data preparation…]:** *Inclination to be satisfied with product value offering -* ***IncSPVO (IoT)****? (a) Very dissatisfied (b) Dissatisfied (c) Satisfied (d) Very satisfied.*

ii) Recommendation question: This question-item was not used for primary validation, but was applied for descriptive purposes.

- Smartphone **[During the experiment…]:** *Have you recommended your current or previous Smart phone and corresponding apps to friends and family members? (a) Yes (b)No (c) Not sure.*

Note: During data preparation, it was observed that the question was a Yes/No question, which will not enable a four-point scale. However, option (c) was merged to (b).The question was also transformed and abbreviated and the options order was reversed in line with data processing and result presentation objectives as shown below.

- Smartphone **[During data preparation…]:** *Likelihood to recommend to family and friends -* ***LRFF (Sp)****? (a) No (b)Yes.*
- IoT scenarios **[During the experiment…]:** *Will you likely recommend at least one of this IoT applications to friends and family members? (a) Very likely (b) Likely (c) Fairly likely (d) Unlikely (e) Very unlikely.*

Note: During data preparation, option *(c) above* was merged to option *(b)* in order to conform to the four-point scale data processing objective. This question-item was not used for the primary validation, but was applied for descriptive purposes. The question was transformed and abbreviated and the order of the options were reversed as shown below.

- IoT scenarios **[During data preparation…]:** *Likelihood to recommend to family and friends - **LRFF (IoT)**? (a) Very unlikely (b)Unlikely (c) Likely (d)Very likely.*

(e) Potential for customer trust: Two questions were constructed for this component to measure trust and likelihood of socio-religious influence on purchase, which may partly stem from user trust (Beyari and Abareshi, 2019) of the product (in this case Smartphone on one hand and IoT scenarios on the other hand).

i) Trust question

- Smartphone **[During the experiment…]:** *How hesitant were you before you purchased your previous or most recent Smart phone? (a) Very hesitant (b) Hesitant (c) Not hesitant (d) Not very hesitant (e) Not sure.*

Note: The reason for using hesitance to measure trust here was because according to several studies on product purchase activities (Cho et al., 2006; Han and Kim, 2017), hesitation arises from trust issues that may be identified by the customer at the point of purchase while assessing or getting to know the product he/she intends to buy. During data preparation, option *(e) above* was merged to option *(a)*, as *(e)* in order to ensure the four-point scale uniformity objective. Also, the order of the options were reversed to ensure they were in line with the data processing and presentation objective as shown below.

- Smartphone **[During data preparation…]:** *Inclination to trust product value offering - **IncTPVO (Sp)**? (a) Not very hesitant (b) Not hesitant (c) Hesitant (d) Very hesitant.*
- IoT scenarios **[During the experiment…]:** *Given your view of the IoT scenarios, how would you likely categorize your trust for using this products/services? (a) Very trustworthy (b) Trustworthy (c) Fairly trustworthy (d) Not trustworthy (e) Not very trustworthy.*

Note: During data preparation, option *(c)* above was merged to option *(b)* in order to ensure the four-point scale uniformity objective. The question was transformed and abbreviated and the order of the options were reversed as shown below.

- IoT scenarios **[During data preparation…]:** *Inclination to trust product value offering - **IncTPVO (Sp)** (b)Not trustworthy (c) Trustworthy (d)Very trustworthy.*

ii) Socio-religious influence question: This question-item was also not used for primary validation, but was applied for descriptive purposes.

- Smartphone **[During the experiment…]:** *Have you recommended your current or previous Smart phone and corresponding apps to friends and family members? (a) Yes (b)No (c) Not sure.*

Note: During data preparation, it was observed that the question was a Yes/No question, which will not enable a four-point scale. However, option (c) was merged to (b) as participants did not pick this option when they completed the questionnaire. The question was also transformed and abbreviated and the options order was reversed in line with data processing and result presentation objectives as shown below.

- Smartphone **[During data preparation…]:** *Likelihood of socio-religious influence on purchase -* ***LOSIOP (Sp)****? (a) No (b)Yes.*
- IoT scenarios **[During the experiment…]:** *Will you likely recommend at least one of this IoT applications to friends and family members? (a) Very likely (b) Likely (c) Fairly likely (d) Unlikely (e) Very unlikely (f) I don't know.*

Note: During data preparation, option *(c) above* was merged to option *(b) and (f)* was merged with option *(e)* for the uniformity objective. The question was transformed and abbreviated and the order of the options were reversed as shown below.

- IoT scenarios **[During data preparation…]:** *Likelihood of socio-religious influence on purchase -* ***LOSIOP (IoT)****? (a) Very unlikely (b)Unlikely (c) Likely (d)Very likely.*

5.7.2 Questions on user experience with the educational tool (three Just-In-Mind IoT scenario prototypes)

The questions were constructed to reflect on the fact that the embedding components (such as sensors) that would have been seamlessly receiving and sending data to the things (such as 'books' in the use of the library IoT scenario) were not prototyped because of time and cost constraints, so they were only part of the IoT scenarios diagrams and descriptions that were shown and described to the experiment participants by the researcher.

The choice of a suitable measurement mechanism for the prototypes was also reflective on whether the objective of the experiment is to increase productivity or to improve appeal for the user. The former implies objective measures should be used, which is in tandem with the research objective, while the latter implies subjective measures should be used, although in certain cases (not in this research) both measures can be applied (Lewis, 1995).

Hence, the prototypes were mobile application prototypes developed using JustInMind, and the questions that were constructed to measure user experience with the IoT scenario prototypes were modifications of the usability.gov usability-type questions that followed the outline set by Alty (1992) for a five-point Likert-scale subjective measures to be used by experiment participants to give feedback on the prototypes' ease of use, interface appeal, etc. A single open-ended question was constructed for a general commentary on suggestion of improvements by participants. The questions are outlined in table 5-1.

TABLE 5-1: IOT PROTOTYPE USABILITY QUESTION-ITEMS

Construct	**Questions**	
usability.gov	During experiment	During preparation
	Overall in general, the application is easy to use	UXWET1
	In general, the functions are placed in the right places	UXWET2
	Controls like buttons and text fields are appropriately sized	UXWET3
	It was easy to use the app at first attempt, I did not struggle to reach any buttons	UXWET4
	It is easy to understand what the different icons mean	UXWET5
	The app behave as explained by the researcher and the scenario sketch	UXWET6
	Moving to and from the different areas of the application is clear and not disorienting	UXWET7
	I always knew what to do next to perform a specific task	UXWET8
	I quickly learned how to use the application	UXWET9
	The interface is aesthetically pleasing	UXWET10
	What can be improved in the application? How would you change the function/structure/appearance. You can bring up any new issue this questionnaire did not address.	

The questions were constructed generally for the three IoT prototypes instead of each prototype based on the subjective nature of the questions and the reduced role this factor contributed to the general objective of the research as a whole. The questionnaire construct for this aspect of the study was applied for descriptive analysis purposes alone, as the research design was not focused on using this factor for cause and effect, although inferences were still drawn from the result of this factor in chapter 6.

5.7.3 Questions for novel future implementation idea for IoT (the use of the library and borrowing of books IoT scenario context)

Question-items were also constructed to investigate within-subjects participants' acceptance of the novel implementation and atomic business model idea for the use of the library and borrowing of books IoT. The questions for this IoT implementation idea focused on a library book location solution grouped into pre-experiment and post experiment questions, based on a problem-solution approach as follows:

(a) Pre-experiment questions

1. How often do you use the library? (a) Very often (b) Often (c) Fairly often (d) Not often (e) Not very often (f) Never.

Note: During data preparation, the question was rephrased and abbreviated, and option (f) was merged to (e), while option (c) was merged to (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Frequency of library use (FLU): (a) Not very often (b) Not often (c) Often (d) Very often.

2. How would you rate your ease of locating a bookshelf to pick a book of your choice in the library? (a) Easy (b) Fairly easy (c) Not easy (d) Not very easy (e) I have never used the library.

Note: During data preparation, the question was rephrased and abbreviated, and option (e) was merged to option (d) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Ease of locating library books on shelves (ELLBS): (a) Not very easy (b) Not easy (c) Fairly easy (d) Easy.

3. How often do you borrow books from the library? (a) Very often (b) Often (c) Fairly often (d) Not often (e) Not very often (f) Never.

Note: During data preparation, the question was rephrased and abbreviated, and option (f) was merged to (e), while option (c) was merged to (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Frequency of borrowing library book (FBLB): (a) Not very often (b) Not often (c) Often (d) Very often.

4. In the course of borrowing library books, have you ever lost any before? (a) Yes (b) No (c) Not applicable as I have never borrowed a library book before (d) Not applicable, but I have lost some personal books in the past.

Note: During data preparation, the question was rephrased and abbreviated. Also, we could not attain a four-point ordinal scale for this question item, because options (c) and (d) are similar in meaning to option (b), so they were merged to (b) in order to form 2-point nominal scale. The rank order of the options were reversed to ascending order as follows:

During data preparation: Loss of borrowed library book previously (LBBP): (a) No (b) Yes.

5. Have you ever paid the Library admin for a lost borrowed library book and/or for delay in returning a borrowed library book? (a) Yes (b) No (c) Not applicable as I have never borrowed a library book/never lost a borrowed library book/never delayed to return same.

Note: During data preparation, the question was rephrased and abbreviated. Also, we could not attain a four-point ordinal scale for this question item, because options (c) and is similar in meaning to option (b), so it was merged to (b) in order to form 2-point nominal scale. The rank order of the options were reversed to ascending order as follows::

During data preparation: Paid to replace lost library book previously (PRLLBP): (a) No (b) Yes

(b) Post-experiment questions

1. In the context of the use of the library and borrowing books IoT scenario that you just completed, how important do you view the indoor location/positioning application services for library books? (a) Very important (b) Important (c) Fairly important (d) Not important (e) Not very important.

Note: During data preparation, the question was rephrased and abbreviated, and option (c) was merged with (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Perception of book location service (PBLS): (a) Not very important (b) Not important (c) Important (d) Very important

2. How do you consider the seamless book preview application services for library books as highlighted in the use of the library and borrowing books IoT scenario that you just completed? (a) Very important (b) Important (c) Fairly important (d) Not important (e) Not very important.

Note: During data preparation, the question was rephrased and abbreviated, and option (c) was merged with (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Perception of seamless book preview (PSBP): (a) Not very important (b) Not important (c) Important (d) Very important

3. Will you be inclined to have the lost book recovery application services for your personal books that you value? (a)Very likely (b) Likely (c)Fairly likely (d) Unlikely (e) Very unlikely.

Note: During data preparation, the question was rephrased and abbreviated, and option (c) was merged with (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Likelihood of downloading book location app (LDBLA) (a)Very unlikely (b) Unlikely (c) Likely (d) Very unlikely

4. Will you be inclined to pay for recovery of a lost borrowed book using the tracking application service highlighted in the use of the library and borrowing books IoT scenario? (a)Very likely (b) Likely (c)Fairly likely (d) Unlikely (e) Very unlikely (f) Never

Note: During data preparation, the question was rephrased and abbreviated, and option (f) was merged with (e), while option (c) was merged with (b) in order to form a four-point scale for uniformity with the other question items and the rank order of the options were reversed to ascending order as follows:

During data preparation: Likelihood of paying for lost book location service

(LPLBLS): (a)Very unlikely (b) Unlikely (c) Likely (d) Very unlikely.

5.7.4 Pilot test

The experiment was pilot tested on a total of three people who performed the experimental tasks resulting in a minimal improvement of the experimental tasks.

5.8 Method of Successive Interval (MSI)

Any study design in which data is collected in Likert-type (note: not Likert scale) ordinal scale that may solely or partly involve parametric statistical analysis imposes a constraint on the researcher(s) to convert the ordinal measurement scale into interval or ratio scale. The method of successive interval (Asdar and Badrullah, 2016; Waryanto and Milafati, 2006) is one of such means of carrying out this transformation. It does this transformation taking into account the normal distribution of the data for the items being measured (Asdar and Badrullah, 2016).

MSI involves the calculation of the proportion of each option on the ordinal scale that is used, then finding the suitable value proportional to the normal dispersion (Waryanto and Milafati, 2006). That is, apart from converting the original data from ordinal scale to interval scale, it ensures the transformed data conforms to the normal distribution of the original data (Waryanto and Milafati, 2006). This implies that the MSI cannot solve the problem of outliers and it also transforms the errors associated to each point and weight in the ordinal scale.

Usually in ordinal scale measurements, assuming survey options for each question item are as follows: very likely, likely, unlikely, and very unlikely; in order to carry out non-parametric statistical analysis, each option is assigned an *attribute value*, that is; Very likely = 4, likely = 3, unlikely = 2, and very unlikely = 1. These *attribute values* are what MSI transforms to interval scale for parametric statistical analysis. There are seven steps involved in transforming ordinal scale to interval scale (Waryanto and Milafati, 2006), which are outlined as follows:

1. Calculation of the frequency of the response data for each option of a question item;
2. Divide the frequency of the response data by the number of samples in order to determine the proportion (P) for each option;
3. Sequentially sum up the proportion for each option to determine the cumulative proportion (PK);

4. Use the standard normal distribution to determine the value of Z for each cumulative proportion;
5. For each value of Z, find the density value (DK);
6. Calculate the Counting Scale Value (SV) for each option
7. Determine the Transformed Scale Value (TSV)

As stated in subsection 5.7.1 above, because the question items constructed to measure user inclinations towards each of the the five generic components of the existing DTBM based on Smartphone and IoT products context were single Likert-type (not Likert scale) ordinal scale data. There was an earlier need to transform the data to numeric interval scale to enable a statistical test associated with within-subjects design to be conducted. Also, each of the options for the matched pairs of user inclinations, which were in four-point, five-point, and six-point Likert-type ordinal scale during the experiment were transformed to four-point Likert-type ordinal scale during data processing for uniformity of scales for each generic component.

The illustration of the MSI transformations of these four-point ordinal scale data to interval scale data for each of the user inclinations towards the five generic components (price, product training, product subscription, satisfaction and trust) of the DTBM adoption framework for IoT applied to the pre-experiment product context(Smartphone) and the post-experiment product context (three IoT scenarios) can be seen in **appendix B.**

The results of each transformation is reported in **section 6.3**. It is also important to re-emphasize that the user inclinations towards each of the five generic components of the existing DTBM as applied to Smart phones were abbreviated with a suffix **'Sp'**, while their application to the three IoT scenarios context were abbreviated with a suffix **'IoT'** in the transformation operation**.**

5.9 Analysis Method

The use of within-subjects design in this research is unique in its application for a business model research, as business model research designs are mainly approached qualitatively and between-subjects in its quantitative research approach. The analysis of data gathered from the research was carried out in SPSS 22 Software which allows one to run both parametric and non-parametric tests.

Parametric data analysis assumes that the data is gotten from a type of probability distribution (normal, poisson, etc), therefore, inferences are made about the parameters of the distribution (Geisser & Johnson, 2006). Most well-known elementary statistical methods are parametric. Correct assumptions made through parametric methods are capable of producing more accurate and precise estimates. However, parametric analysis, though intended, was not possible as explained below.

Certain developments in the cause of data processing guided the decision on the types of statistical tests to perform that will still conform to the within- subjects related sample design. The inital intention was to use correlations analysis and simple cross tabulation descriptives (frequency and percentages). But, in order to obtain in-depth statistical validation for the within-subjects research design for DTBM adoption framework for IoT, it was decided that a nonparametric statistical test that uses numerical data - **sign test** (see section 5.9.1 and 6.6 for description and results of the sign test respectively) should also be used.

The Sign test was even more ideal for this research design, because of the non-normality of the distribution and presence of outliers (in an irredeemable way) for matched pairs of user inclinations. This deviates from parametric statistical tests, which are sensitive to violations of assumptions of normality. See section 2 of appendix B for results of normalty test and box plots for detection of outliers for matched pairs of these related group. The sign test is described in the next subsection, followed by description of correlation analysis as used in this research.

5.9.1 Sign test for user inclination towards each of the five generic components of the DTBM based on Smartphone and IoT

Sign test is the non-parametric equivalent of the Friedman test[25] (Laerd, 2015B), which is used to determine whether there are any statistically significant differences between the distributions of two related groups (Laerd, 2015A). Particularly, it determines whether median differences exist between the two related group. The groups are related as they contain the same cases in each group and each group represents a repeated measurement on the same dependent variable (Laerd, 2015A). As it is the case with Friedman test for three or more related groups, the sign test is mostly useful in analysing data in a within-subjects design for a situation in which the differences between the two related groups are not normally distributed.

[25] Friedman test is the non-parametric alternative of the one-way repeated measures ANOVA for three or more related groups.

Usually, participants in a within-subjects design are tested at two time points (independent variable) or under two different conditions (independent variable) on the same continuous dependent variable (Laerd, 2015A). The application of the sign test in this research is structured around the *'objects'* independent variable as *'matched pairs'*, not the *'condition'* or *'time points'* independent variable as reported in section 5.1.

The aspect of this research that the **sign test** is ultimately applied for validation is to ascertain the likelihood of IoT **adoption** of existing DTBM, by *determining if there is a significant difference between matched pairs of user inclinations towards each of the five generic components of existing DTBM based on two DT products (Smartphone and IoT).* This **adoption** concept is possible because the *"Sign test tests the null hypothesis that the median of the differences between two related groups is 0 (zero) in the population"* (Laerd 2015A).

The null hypothesis of the sign test are stated as follows:

> $\mathbf{H_0}$: median difference, θ = 0. (where θ is the Greek lowercase letter 'theta')

The alternative (non-directional) hypothesis is stated as follows:

> $\mathbf{H_A}$: median difference, θ ≠ 0.

If the sign test was **not** statistically significant ($p > .05$), it implies that that there is no sufficient evidence that the median of the differences between the two related groups (**matched pairs**) is not equal in the population. Therefore, the null hypothesis cannot be rejected and the alternative hypothesis cannot be accepted. Conversely, if the test **is** statistically significant ($p < .05$), the alternative hypothesis can be accepted, while the null hypothesis is rejected (Laerd 2015A). The results of the Sign test for the **matched pairs** of user inclinations towards each of the five generic components of the DTBM are reported in section 6.5.2.

5.9.2 Protocol for drawing conclusions for likelihood of IoT adoption of DTBM using the Sign test results

This research is not focused on proving the null hypotheses of the sign test, rather it uses a combination of the alternate hypothesis and the mdeian difference to logically design a protocol for summerizing the findings from the sign tests. The results of the Sign test are used in drawing conclusions to meet the research objectives. Hence, in this research, the **primary protocol** for the likelihood of IoT **adoption** of existing DTBM are as follows:

(a) If H_A is statistically significant for any of the **matched pairs of user inclinations** towards each of the **five generic components** of existing DTBM based on Smartphone and IoT products, then the alternative hypothesis is accepted and the null hypothesis is rejected. Therefore, it may be concluded that the likelihood of that **generic component of DTBM** contributing towards IoT adoption of DTBM is limited.

(b) If H_A is not statistically significant for any of the **matched pairs of user inclinations** towards each of the **five generic components** of existing DTBM based on Smartphone and IoT products, then the null hypothesis cannot be rejected and the alternative hypothesis cannot be accepted. Therefore, it may be concluded that the likelihood of that **generic component of DTBM** contributing towards IoT adoption of existing DTBM is more likely.

Also, since we are calculating median differences between Inc_Sp and Inc_IoT, (that is: Inc_IoT - Inc_Sp) as part of the sign test, so:

(a) If Inc_IoT - Inc_Sp returns positive differences for Inc_IoT, it means users are more positively inclined towards any of the five generic components of existing DTBM with respect to IoT products context than Smartphone products context. In this case, the tendency for conclusions to be made that there is more likelihood for IoT adoption of DTBM is high.

(b) If Inc_IoT - Inc_Sp returns negative differences for Inc_IoT, it means users are more positively inclined towards any of the five generic components of existing DTBM with respect to Smartphone than IoT products context. In this case a tendency for conclusions to be made that the likelihood of IoT adoption of DTBM is low.

Now, a combination of the alternate hypothesis results on one hand, and the median differences on the otherhand is used in defining a protocol for conclusions to be drawn for each matched pair of user inclinations as follows:

- If H_A is not significant and the median diference is positive for Inc_IoT compared to Inc_Sp, we may conclude a **high** likelihood of IoT adoption of existing DTBM.

- If H_A is not significant and the median difference is negative for Inc_IoT compared to Inc_Sp, we may conclude a **medium** likelihood of IoT adoption of existing DTBM.
- If H_A is significant and the median difference is positive for Inc_IoT compared to Inc_Sp, we conclude a **medium** likelihood of IoT adoption of existing DTBM.
- If H_A is significant and the median difference is negative for Inc_IoT compared to Inc_Sp, we conclude a **low** likelihood of IoT adoption of existing DTBM

5.9.3 Correlation analysis

Correlation analysis was used to test for linear relationships between two variables of the non-parametric primary data. Correlation analysis for bivariates of the user inclinations towards the generic components DTBM applicable to Smartphone and IoT products context were carried out using Spearman rho, thus testing hypotheses H_{A1}, H_{A2}, H_{A3}, H_{A4}, and H_{A5}. Spearman rho was also applied to test the relationship between one demographic data (product usage experience) and *"user inclinations towards some of the generic components of the DTBM applicable to Smartphone and IoT products,"* and subsequent comparisons made on the results summaries for these two digital technology products context (smartphone and IoT). Thus, hypotheses $H_{A1.1}$, $H_{A2.1}$, $H_{A3.1}$, $H_{A4.1}$, and $H_{A5.1}$ were tested.

The reason for using non-parametric Spearman correlations is because as a non-parametric measure, it does not rely upon fulfilling the assumption of normality as compared to Pearson correlations, which are bounded by assumptions of data being fulfilled for its results to be reliable (Kowalski, 1972). "The correlation coefficient can take values from +1 to -1, which indicates a perfect positive (+1) or negative (-1) association of ranks. A correlation coefficient of zero (0) indicates no association between the ranks. Whilst there are no guidelines for determining how strong the association is for different values (unlike with a Pearson's correlation), the closer the correlation coefficient is to zero, the weaker the association between the ranks, and the closer the correlation coefficient is to +1 or -1, the stronger the association between the ranks (Laerd, 2015C)."

5.9.4 Descriptive frequencies and percentages

Frequencies and percentages were reported for selected multichoice questions for conclusions to be drawn comparative in a descriptive analysis context. This was applied to the data of the library IoT and for certain groups of datasets that was gathered. Although these datasets did not have any direct bearing on the main contribution of this thesis, the role of these data was to show the percentage of participants that selected the options that supported the library IoT scenario and the general notion of IoT in terms of the multi-choice datasets. This is discussed further in chapter 6.

5.10 Chapter summary

This chapter described the methodology adopted for this research. It explains that within-subjects participants were recruited on an opportunistic and purposive approach. A linear approach (Laerd, 2015A) to the experimental tasks was adopted and participants carried out experimental tasks on two levels of the within-subjects factor in consecutive succession. The within-subjects factor was representative of an "object" instead of the conventional abstract "time points" and "condition." In particular, Smartphone and IoT products context were the two levels of the within-subjects factor (digital technology product).

Three IoT scenarios (health monitoring, home environment, use of the library and borrowing of books) were described and wireframed using Just-in-mind. They were applied as educational tools for participants to get acquainted with IoT, as part of experimental tasks towards responding to a post-experiment questionnaire. The researcher relied on participants' previous experience in acquiring a Smartphone in order for them to respond to a pre-experiment questionnaire. No observation was carried out during the experiments, as participant relied on a mostly closed-ended questionnaire to gather primary data. The questionnaire was single-item question construct for each of the five generic components and also consisted questions on the use of the library IoT scenario, both constructed by the researcher, Also usability-type questions and multi-choice questions were part of the questionnaire.

In particular, the experimental tasks and questionnaires were used in obtaining participants' inclinations towards each of the five generic components of existing DTBM that were identified in chapter 2, based on Smartphone and IoT products context. Relevant data obtained for the matched pairs of user inclinations towards each of the five generic components of existing DTBM based on Smartphone and IoT products context were subjective measures in categorical ordinal scale. However, in order to fulfill the aims and objectives of this research, an indepth statistical analysis was necessary.

Hence, the options for some of the question-items, were firstly merged to form a uniform four-point scale. This uniform four-point ordinal scale data were then transformed to interval scale using the method of successive interval (Asdar and Badrullah, 2016; Waryanto and Milafati, 2006). Finally, a description of three analysis methods (sign test, Spearman rho, and cross tabulation descriptives) and how they were applied in the research were reported.

In the next chapter, results and analysis are reported beginning with the results of the MSI transformation. The results of the sign test are reported next, followed by the Spearman correlation results for the matched pairs of user inclinations towards the five generic components of DTBM applied to Smartphone and IoT products context. Finally results of descriptives are reported followed by the chapter summary.

CHAPTER SIX

6 Results and analysis

This chapter presents findings and discusses the result of data analysis. It begins with reports on participants' demography and data preparation in sections 6.1 and 6.2. Recall that as noted in section 5.9.1, Laerd (2015A) emphasized that numeric data are desirable in order to carry out Sign test. Hence, the Method of Successive Interval (Asdar and Badrullah, 2016; Waryanto and Milafati, 2006) was applied to transform matched pairs of user inclinations from their original categorical ordinal scale to interval scale. See sections 5.8, 6.3, and section 1 of appendix B for reports and results for the MSI transformations. Thus, the results for the MSI transformations are reported in section 6.3. This is followed by reports on the normality test and outlier detection in section 6.4.

The transformed values were then used in **sign test** to validate the DTBM adoption framework for IoT based on user inclinations towards the five generic components of DTBM applied to Smartphone and IoT products context. In particular, the **sign test** was used in determining whether there was a significant difference (or equal means) between matched pairs of user inclinations towards the five generic components of the DTBM applied to Smartphone and IoT product contexts. Correlations analysis were also carried out on these dataset.

Consequently, the quantitative validation approach for the existing DTBM adoption framework for IoT based on user inclinations towards the five generic components of DTBM applied to Smartphone and IoT products context are described in section 6.5. This is followed by the protocol for reporting results of the sign test and correlations analysis in section 6.5.1. The results of the sign test are reported next in section 6.5.2, followed by the Spearman correlation results for the matched pairs of user inclinations towards the five generic components of DTBM applied to Smartphone and IoT products context in sections 6.5.3.

Also, results of the Spearman correlations for two demographic data versus some of the generic components are reported in section 6.5.4. Subsequently reported in section 6.6, are results of cross tabulation descriptives (frequencies and percentages) for the datasets of the matched pairs of user inclinations. This is followed by results of descriptives (frequencies and percentages) representing multi-choice question-items in section 6.6.1 to be discussed comparatively as part of findings in section 7.

Furthermore, the results of the cross tabulation descriptives and reliability test using Cronbach Alpha for the usability constructs for the hands-on educational tool (Just-in-mind prototypes for the three IoT scenarios) are reported in section 6.7. Also, the results of cross tabulation descriptives (frequencies and percentages) and Spearman correlations for the novel future implementation and atomic business model idea for IoT application in the library is reported in section 6.8. Finally, the summary of the chapter is outlined in section 6.9.

6.1 Demography of participants

A total of 66 participants were drawn from the Sussex university community, out of which 32 were female (48.5%) and 34 were male (51.5%). 9.1% of participants were in the age range of 18-20, 33.3% in the age range of 21-30 and 47.0% were in the age range of 31-40, while those over 40 years old was 10.6%. Nineteen participants (28.8%) had monthly income below £500 and only 3 (4.5%) had income over £2,000. Digital technology product usage expertise had the fewest number participants - 2 (3%) who categorized themselves as expert users, while participants - 24 (36.4%) who categorized themselves as experienced users were more than other categories (see Table 6-1).

TABLE 6-1: DEMOGRAPHIC DETAILS OF PARTICIPANTS

Factors	Frequency	Percentage
Gender		
Male	34	51.5%
Female	32	48.5%
Age		
18-20	6	9.1%
21-30	22	33.3%
31-40	31	47.0%
41-50+	7	10.6%
Monthly income (£)		
100 and below	6	9.1%
101 to 300	7	10.6%
301 to 500	6	9.1%
501 to 1000	20	30.3%
1001 to 1500	17	25.8%
1501 to 2000	7	10.6%
2001 and above	3	4.5%
DT Product usage expertise		
Novice	5	7.6%
Fairly experienced	23	34.8%
Experienced	24	36.4%
Very experienced	12	18.2%
Expert	2	3%
Educational level attained		
High school	7	10.6%

Undergraduate	27	40.9%
Postgraduate research	23	34.8%
Postgraduate research	9	13.6%

6.2 Data preparation

The collected primary data was scrutinized and prepared for statistical analysis. Since data was collected through Survey Monkey, it was then transferred to an MS Excel and checked for its quality and to determine if there was any missing data. A total of 66 responses were obtained with no missing data . Some of the data were recoded and transformed for data organisation as highlighted in sub-sections 5.7.1 and 5.7.2. In the next section, the results of the MSI transformations of the ordinal data of the five generic components of the DTBM adoption framework data are reported. See appendix B for the transformation operations.

6.3 Results of MSI transformation of five generic components of digital technology BM adoption framework for IoT

As discussed in section 5.8 and mentioned in the previous section, the method of successive interval (MSI) was used in transforming data obtained from the within-subjects participants for the five generic components of the DTBM adoption framework for IoT, as applied to a Smartphone context and the three IoT scenarios context, from ordinal scale to interval scale. This transformed data was used to carry out sign test as reported in section 6.4. The seven step process for carrying out the method of successive interval transformation that was outlined in section 5.8 was implemented on each matched pair of user inclination as can be seen in section 11.1 of appendix C. The results of this transformation are reported below in tabular format.

1(i) Transformation results for Inclination to consider product price - IncCPP (Sp)
Table 6-2 is the summary of the MSI transformation of the ordinal data of IncCPP (Sp).

TABLE 6-2: MSI RESULTS FOR QUESTION-ITEM IncCPP (Sp)

Options	**Before transformation (ordinal scale)**	**After transformation (interval scale)**
Not very important	1	1.0000
Not important	2	1.6138
Important	3	2.7160
Very important	4	4.1242

(ii) Transformation results for Inclination to consider product price - IncCPP (IoT).

Table 6-3 is the summary of the MSI transformation of the ordinal data of IncCPP (IoT).

TABLE 6-3: MSI RESULTS FOR QUESTION-ITEM IncCPP (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Not very important	1	1.0000
Not important	2	0
Important	3	2.7222
Very important	4	4.2476

2(i) Transformation results for Inclination to value training - IncVT (Sp)

Table 6-4 is the summary of the MSI transformation of the ordinal data of IncVT (Sp).

TABLE 6-4: MSI RESULTS FOR QUESTION-ITEM IncVT (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Not very helpful	1	1.0000
Not helpful	2	1.5833
Helpful	3	2.6994
Very helpful	4	4.1504

(ii) Inclination to value training - **IncVT (IoT)**: (a) Not very valuable (b)Not valuable (c) Valuable (d) Very valuable.

Table 6-5 is the summary of the MSI transformation of the ordinal data of IncVT (IoT).

TABLE 6-5: MSI RESULTS FOR QUESTION-ITEM IncVT (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Not very valuable	1	0
Not valuable	2	1.0000
Valuable	3	3.5191
Very valuable	4	4.5974

3(i) Inclination to set-up subscription plan - **IncSSP (Sp):** (a)Weekly (b)Monthly (c)Quarterly (d)Annually.

Table 6-6 is the summary of the MSI transformation of the ordinal data of IncSSP (Sp).

TABLE 6-6: MSI RESULTS FOR QUESTION-ITEM IncSSP (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Weekly	1	1.0000
Monthly	2	2.8258
Quarterly	3	3.9541
Annually	4	4.6806

(ii) Inclination to set-up subscription plan - **IncSSP (IoT):** (a)Weekly (b)Monthly (c)Quarterly (d)Annually.

Table 6-7 is the summary of the MSI transformation of the ordinal data of IncSSP (IoT).

TABLE 6-7: MSI RESULTS FOR QUESTION-ITEM IncSSP (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Weekly	1	1.0000
Monthly	2	2.5245
Quarterly	3	3.4820
Annually	4	4.2476

4(i) Inclination to be satisfied with product value offering - **IncSPVO (Sp)**: (a) Very dissatisfied (b) Dissatisfied (c) Satisfied (d) Very satisfied.

Table 6-8 is the summary of the MSI transformation of the ordinal data of IncSPVO (Sp).

TABLE 6-8: MSI RESULTS FOR QUESTION-ITEM IncSPVO (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very dissatisfied	1	1.0000
Dissatisfied	2	0
Satisfied	3	2.4461
Very satisfied	4	3.8984

(ii) Inclination to be satisfied with product value offering - **IncSPVO (IoT)**: (a) Very dissatisfied (b) Dissatisfied (c) Satisfied (d) Very satisfied.

Table 6-9 is the summary of the MSI transformation of the ordinal data of IncSPVO (IoT).

TABLE 6-9: MSI RESULTS FOR QUESTION-ITEM IncSPVO (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very dissatisfied	1	0
Dissatisfied	2	0
Satisfied	3	1.0000
Very satisfied	4	1.8047

5(i) Inclination to trust product value offering - **IncTPVO (Sp)**: (a) Not very hesitant (b) Not hesitant (c) Hesitant (d) Very hesitant.

Table 6-10 is the summary of the MSI transformation of the ordinal data of IncTPVO (Sp).

TABLE 6-10: MSI RESULTS FOR QUESTION-ITEM IncTPVO (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very hesitant	1	1.0000
Hesitant	2	1.9567
Not hesitant	3	2.9803
Not very hesitant	4	4.2139

(ii) Inclination to trust product value offering - **IncTPVO (IoT):** (a) Not very trustworthy (b)Not trustworthy (c) Trustworthy (d)Very trustworthy.

Table 6-11 is the summary of the MSI transformation of the ordinal data of IncTPVO (IoT).

TABLE 6-11: MSI RESULTS FOR QUESTION-ITEM IncTPVO (IoT)

Options	**Before transformation (ordinal scale)**	**After transformation (interval scale)**
Not very trustworthy	1	0
Not trustworthy	2	1.0000
Trustworthy	3	3.1465
Very trustworthy	4	4.7782

It is pertinent to point out that tables 6-3, 6-8, and 6-9 are not consistent with the other tables because none of the 66 participants chose the corresponding response choices. So, in the MSI transformation process results in the assignment of 0 to the affected response choices.

6.4 Test of distributed normality and detection of outliers

The test of normal distribution of data of each generic components of the DTBM adoption framework for IoT (applied to both Smartphone and the three IoT scenarios context) was examined by the Shapiro Wilk test and Kormolgorov. The result indicates the non-normal distribution of datasets for the five generic components and every other variables tested in this study. Several outliers were also detected, thus rendering any attempt to normalize the data impossible without introducing bias into the results. Thus the statistical analytical test (Sign test and Spearman rho) used in this study were such that were not sensitive to the effect of non-normality of the dispersion and presence of outliers.

6.5 Quantitative validation of the DTBM adoption framework for IoT

A researcher's interpretation about a test result is referred to as an *inference* (Mahoney, 2008; Gregory, 2000; Messick, 1989) and this is what is subject to validation in a research. Messick (1989) suggest that validity can only be used as a tool to evaluate inferences about a test result, but the test itself cannot be said to be valid, which is aimed at ensuring that correct interpretations are made based on the inferences. For instance, a doctor checking the heart rate of patients over time measures the heart rate of these persons of interest (existing attribute), and not all persons of interest will have the same heart rate (variations in the attribute). The implication is that an investigation into specific attribute will require valid interpretations or inferences to be made from the test.

It is suggested that the scientific acceptance of a construct depends on whether the same topics/constructs are grouped together by tying observable properties of the topics/construct to one another (Garrison, 1994; Moss, 1992; Messick, 1989; Cronbach & Meehl, 1955). Construct validity can be empirically explored by means of Rasch analysis and is opined to be central to any quality assessment (Boone & Rogan, 2005), while internal consistency reliability associated with scores derived from items of a construct or scale can be empirically evaluated using Cronbach's alpha (Cronbach & Meehl, 1955).

However, in terms of published work (literature) related to business model research, there are limited facets or too few relevant items that could be grouped to make up a construct representing each of the five generic components of the business model framework identified in section 2. Hence, the research designed constructs for each of the five generic components of existing DTBMs were each represented as single-item ordinal-type question format in the questionnaire design as could be seen in sub-section 5.7.1; which made it impossible to carry out a construct validity test using Rasch or reliability test using Cronbach alpha.

Nonetheless, Gregory, (2000) posit that validity is a unitary concept, which implies that there are various types of validity. This points us to how validity may be conducted in a BM research. Particularly, in a related study, Paltalidis (2014) applied expert intuition in a between-subject context to validate a B2B e-commerce BM framework. The validation exercise had sought to determine whether experts from the academic community and practitioners from the business community agree with the main aspects of the designed framework. This "agreement" was measured by Levene's test for homogeneity of variance between matched pairs of opinion data from "experts" and "practitioners".

Conversely, in this research, users (participants in the experiment) were recruited as "experts" in a within-subject context, to ascertain their inclinations towards the generic components of the DTBM applicable to Smartphone and IoT products. Hence, a primary quantitatitve validation exercise was carried out, which sought to determine the **equality of means**[26] of matched pairs[27] of inclinations of the within-

[26] Or if differences between the matched pairs are significant.

[27] Matched pairs as used here refers to the **user inclinations** towards the **five generic components** of the DTBM applied to **Smartphone** and **IoT products**. Example, for the *"training"* component, the matched pair will be: **IncVT (Sp)** and **IncVT (IoT).**

subject participants towards the five generic components of the DTBM based on to *Smartphone* and *IoT product context* using the **sign test,** as earlier discussed in section 5.9.1.

Also, a secondary validation exercise was carried out to determine the relationship strenght (rs) between the matched pairs of user inclinations using Spearman rho. In the next section, the results of the sign test are reported, followed by results of the Spearman rho for the matched pairs.

6.5.1 Procedure for reporting results of the sign test and correlation analysis

Recall that the primary data for the matched pairs of user inclinations was originally obtained as categorical ordinal data. So, in order to carry out sign test for the within-subjects design, the options of the original categorical ordinal data for matched pairs of user inclinations towards five generic components of DTBM applied to Smartphone and IoT were transformed by:

(a) recoding (merged) the options to form a uniform four-point scale. See section 5.7.1 for the merging transformation; and

(b) transforming the recoded four-point ordinal data to numerical variables using MSI. See sections 5.8 and 6.3, and section 1 of appendix B for the MSI transformations.

Also, recall that in section 5.9.1, it was stated that the Sign test is not sensitive to normal dispersion of data being fulfilled. Hence, since the normality test failed for the matched pairs of user inclinations in their: **(i)** original categorical ordinal data form, **(ii)** recoded categorical ordinal data form, and **(iii)** MSI transformed data form (that is numeric interval scale), the results of sign test using (iii) for the primary validation exercise was justified and is reported in section 6.5.2. If there was normality of distribution for the matched pairs of user inclinations in any of (i), (ii) or (iii), then the use of sign test may be called to question. See section 2, appendix B for results of normality test.

Correlations analysis was not carried out on the numerical data that was obtained through MSI transformation. This is because, as stated in section 5.9.2., Kowalski (1972) highlighted that Pearson correlations should only be tested on numerical data, and they also do not produce reliable results when the distribution of data are not normally dispersed. So, the results of Spearman correlation analysis for the matched pairs of user inclinations using (ii) is reported in section 6.5.3. Although Spearman rho was carried out using data formats of (i)[28] and (iii)[29] also, it was not reported mainly because of no major differences between data formats of (i), (ii) and (iii) in terms of significant correlations. Also, the use of (ii) as the data format for drawing conclusions from the correlation analysis is in sync with its use for carrying out MSI transformation in order to perform the Sign test. (Refer to section 12.2 to 12.4 of appendix D for these results).

Results of Spearman rho of one demographic factor (product usage experience) and the user inclination to be satisfied with product value offering for smartphone context compared to IoT products context are reported in 6.5.4. The result reporting decision also follows the same procedure stated above. Results of Spearman rho using (ii) was reported because there was no major differences in terms of significant correlations for the Spearman rho performed using data format of (i) and (ii). (Refer to sections 12.5 and 12.6 of appendix D for these results).

Finally, the results of descriptives (frequencies and percentages) for the matched pairs of user inclinations using (i) and (ii) can be seen in section 12.8 of appendix D for comparative purpose. Results obtained using (ii)[30] are reported and discussed in this section. These reporting protocols are in line with best practices in relation to using recoded data to validate research conclusions (Lavrakas, 2008).

6.5.2 Results of the sign test

The results of the sign test was carried out using the MSI transformed ordinal to interval data of the matched pairs of user inclinations[31]. Recall that each of the matched pairs of user inclinations were abbreviated with parentheses enclosing the product context; for instance IncVT (Sp) represented user inclination towards the 'training' component for the smartphone context in parentheses. However, in SPSS, in order to carry out the sign test, parentheses was not allowed for the mathematical operation. So, the label was changed to Inc_VT. This was done for each of the matched pairs as could seen in the results of the sign test in appendix C, sections 1 to 5. The five hypotheses associated with determining the equality of means of the matched pairs of user inclinations towards each of the five components of the DTBM

[28] See serial number 1 in section 12.2. of appendix D.
[29] See serial number 3 in section 12.2 of appendix D.
[30] the recoded categorical ordinal data.
[31] Recall as stated in section 5, the phrase 'matched pairs of user inclinations' refers to the 'user inclinations towards the five generic components of DTBM based on Smartphone and IoT products context'

applied to Smartphone and IoT products context and corresponding summaries of the sign test are as follows:

(1) Inclination to consider product price - IncCPP (Sp) and IncCPP (IoT)

It was hypothesized that,

- *H_{A1}: There is a significant difference in user inclination to consider the price of IoT products as compared to existing digital technology products.'*

The results of the sign test for IncCPP_Sp and IncCPP_IoT are summarized as follows:

> A sign test with continuity correction was conducted to determine the likelihood of IoT adoption of existing DTBM, based on user inclinations to concider product price of the IoT as compared to their inclinations to consider product price of Smartphones. Sixty six participants were recruited to the study who each took part in pre-experiment and post-experiment exercises. The pre-experiment task relied on their previous experience during aquisition of their Smartphone, while the post-experiment exercise involved participants getting acquainted with three IoT scenarios and wireframe. They reported their pre-experiment inclinations to consider Smartphone price and post experiment inclinations to consider IoT products price using pre and post experiment question-items.
>
> Data are medians unless otherwise stated. Of the 66 participants recruited to the study, 55 participants were more inclined to consider the price of IoT products compared to 11 participants who were more inclined to consider the price of Smartphone. There was a statistically significant median increase in users' inclination to consider product price (0.006200) applicable to IoT products context (2.722200) as compared to the Smartphone (2.716000), $z = 5.29$, $p < .0005$.

See serial number 1 of section 12.1, appendix D for results of the Sign test for IncCPP_Sp and IncCPP_IoT. Recall that in section 5.9.2, a logical and reasonable procedure was designed by this researcher, for drawing conclusions for the likelihood of IoT **adoption** of existing DTBM using the positivity of the median mean and the p value of the results of the Sign test. Thus using that protocol, since the differences between user inclinations to consider product price of Smartphone compared to IoT is siginificant, and postive differences found for IoT context compared to the Smartphone context, the above Sign test result summary indicate a **medium** likelihood of IoT adoption of existing DTBM based on the '**Price' component**.

(2) Inclination to value training - IncVT (Sp) and IncVT (IoT)

It was hypothesized that:

- H_{A2}: *There is a significant difference in user inclination to value training to use IoT products as compared to existing digital technology products.*

The results of the Sign test for IncVT_Sp and IncVT_IoT are summarized as follows:

> A sign test with continuity correction was conducted to determine the likelihood of IoT adoption of existing DTBM, based on user inclinations to value training for use of the IoT products as compared to their inclinations to value training for use of Smartphone. Sixty six participants were recruited to the study who each took part in pre-experiment and post-experiment exercises. The pre-experiment task relied on their previous experience during aquisition of their Smartphone, while the post-experiment exercise involved participants getting acquainted with three IoT scenarios and wireframes. They reported their pre-experiment inclinations to value training for use of Smartphone and post experiment inclinations to value training for use of IoT products using pre and post experiment question-items.
>
> Data are medians unless otherwise stated. Of the 66 participants recruited to the study, 56 participants were more inclined to value training for use of IoT products compared to 10 participants who were more inclined to value training for use of Smartphone. There was a statistically significant median increase in users' inclination to value training (0.819700) applicable to IoT products context (3.519100) as compared to the Smartphone (2.699400), $z = 5.53$, $p < .0005$.

See serial number 2 of section 12.1, appendix D for results of the Sign test for IncVT_Sp and IncVT_IoT. Also, using the protocol of 5.9.2, since the differences between user inclinations to value training for use of Smartphone compared to IoT is siginificant; and postive differences found for the IoT context compared to the Smartphone context, the above Sign test result summary indicate a **medium** likelihood for IoT adoption of existing DTBM base on the **'Training' component**.

(3) Inclination to set-up subscription plan - IncSSP (Sp) and IncSSP (IoT)

It was hypothesized that:

- H_{A3}: *There is a significant difference in user inclination to set-up subscription plan for IoT products value offering as compared to existing digital technology products value offering.*

The results of the Sign test for IncSSP_Sp and IncSSP_IoT are summarized as follows:

> A sign test with continuity correction was conducted to determine the likelihood of IoT adoption of existing DTBM, based on user inclinations to set-up subscription plan to acquire IoT products as compared to their inclinations to set-up subscription

plan to acquire Smartphones. Sixty six participants were recruited to the study who each took part in pre-experiment and post-experiment exercises. The pre-experiment task relied on their previous experience during aquisition of their Smartphone, while the post-experiment exercise involved participants getting acquainted with three IoT scenarios wireframe. They reported their pre-experiment inclinations to set-up subscription plan to acquire Smartphone price and post experiment inclinations to et up subscription plan to acquire IoT products using pre and post experiment question-items.

Data are medians unless otherwise stated. Of the 66 participants recruited to the study, the tasks elicited a decrease in 8 participants inclination to set-up subscription plan to acquire IoT products compared to 56 participants who were more inclined to set-up subscription plan to acquire Smartphone. There was a statistically significant median decrease in users' inclination to set-up subscription plan (-.301300) applicable to IoT products context (2.524500) as compared to the Smartphone (2.825800), $z = 5.53$, $p < .0005$.

See serial number 3 of section 12.1, appendix D for results of the Sign test for IncSSP_Sp and IncSSP_IoT. Also, using the procedure of 5.9.2, since the differences between user inclinations to set-up subscription plan to acquire Smartphone compared to IoT was siginificant; and postive differences were not found for the IoT context compared to the Smartphone context, the above Sign test result summary indicate a **low** likelihood for IoT adoption of existing DTBM base on the '**Subscription plan' component**.

(4) Inclination to be satisfied with product value offering - IncSPVO (Sp) and IncSPVO (IoT)

It was hypothesized that:

- *H_{A4}: There is a significant difference in user inclination to be satisfied with IoT products value offering as compared to existing digital technology products value offering.*

The results of the Sign test for IncSPVO_Sp and IncSPVO_IoT are summarized as follows:

A sign test with continuity correction was conducted to determine the likelihood of IoT adoption of existing DTBM, based on participants' inclination to be satisfied with IoT product value offering as compared to their inclinations to be satisfied with Smartphones value offering. Sixty six participants were recruited to the study who each took part in pre-experiment and post-experiment exercises. The pre-experiment task relied on their previous experience during aquisition of their Smartphone, while the post-experiment exercise involved participants getting acquainted with three IoT scenarios and wireframes. They reported their pre-experiment inclinations to be satisfied with Smartphone value offering and post experiment inclinations to be satisfied with IoT products value offeringe using pre and post experiment question-items.

Data are medians unless otherwise stated. Of the 66 participants recruited to the study, 0 participants were more inclined to be satisfied with IoT products value offering compared to 62 participants who were more inclined to be satisfied with Smartphone value offering. There was a statistically significant median decrease in users' inclination to be satisfied with the value offering (-1.446100) applicable to IoT products context (1.000000) as compared to the Smartphone (-1.446100), $z = -7.75$, $p < .0005$.

See serial number 4 of section 12.1, appendix D for results of the Sign test for IncSPVO_Sp and IncSPVO_IoT. Using the protocol of 5.9.2, since the differences between user inclinations to be satisfied with the product value offering of IoT compared to Smartphone were siginificant; and postive differences were not found for the IoT context compared to the Smartphone context, the above Sign test result summary indicate a **low** likelihood of IoT adoption of existing DTBM base on the **'Satisfaction' component**.

(5) Inclination to trust product value offering - IncTPVO (Sp) and IncTPVO (IoT)

It was hypothesized that:

- H_{A5}: *There is a significant difference in user inclination to trust IoT products value offering as compared to existing digital technology products value offering.*

The results of the Sign test for IncTPVO_Sp and IncTPVO_IoT are summarized as follows:

A sign test with continuity correction was conducted to determine the likelihood of IoT adoption of existing DTBM, based on user inclinations to trust IoT products value offering as compared to their inclinations to trust Smartphones value offering. Sixty six participants were recruited to the study who each took part in pre-experiment and post-experiment exercises. The pre-experiment task relied on their previous experience during aquisition of their Smartphone, while the post-experiment exercise involved participants getting acquainted with three IoT scenarios wireframe. They reported their pre-experiment inclinations to trust Smartphone value offering and post-experiment inclinations to trust IoT products value offering using pre and post experiment question-items.

Data are medians unless otherwise stated. Of the 66 participants recruited to the study, 52 participants were more inclined to trust IoT product value offering

> compared to 13 participants who were more inclined to trust Smartphone value offering. There was a statistically significant median increase in partcipants' inclination to trust the value offering (0.166200) applicable to IoT products context (3.146500) as compared to the Smartphone (2.980300), $z = 4.71$, $p < .0005$.

See serial number 5 of section 12.1, appendix D for results of the Sign test for IncTPVO_Sp and IncTPVO_IoT. Also, using the protocol of 5.9.2, since the differences between user inclinations to trust the product value offering of IoT compared to smartphone is siginificant; and postive differences found for the IoT context compared to the Smartphone context, the above Sign test result summary indicate a **medium** likelihood of IoT adoption of existing DTBM base on the '**Trust' component**.

6.5.3 Results of correlation analysis for matched pairs of user inclinations

Recall that in the section 6.5.1, it was outlined that since there were no marked differences in terms of significant correlations for the Spearman rho of results for the matched pairs of user inclinations using the original ordinal data, recoded ordinal data (to four-point scale), and MSI transformed data; then, the results of the recoded (four-point scale) ordinal data would be reported.

Hence, since there were no marked differences in terms of significant correlations for these three data forms, the results of the recoded ordinal four-point scale is herein reported.[32] The five hypotheses associated with determining the relationship strenght of the matched pairs of user inclinations towards each of the five components of the DTBM applied to Smartphone and IoT products context and corresponding summaries of the Spearman rho are as follows:

(1) Inclination to consider product price - IncCPP (Sp) and IncCPP (IoT)

It was hypothesized that '***$H_{A1.1}$*: *There is a positive relationship between user inclinations to consider the price of existing digital technology products and user inclination to consider price of IoT products.'*** The summary of the results for the Spearman correlations analysis to test this hypothesis is detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between user inclinations to consider the price of existing digital technology products and user inclination to consider price of IoT products. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant,

[32] See sections 2, 3, 4 of appendix D for results of the Spearman rho original ordinal data, the merged ordinal four-point scale data, and the MSI transformed data forms respectively.

> strong positive correlation between user inclinations to consider the price of existing digital technology products and user inclinations to consider price of IoT products, $r_s(64) = .377, p < .0005$

The above reporting format was outlined by Laerd (2015C). The result of the Spearman rho shows a relationship strenght (r_s) of .377, while 64 in the parentheses was gotten from sample size - 2 (that is, 66-2 = 64), and the *p* represents the significance level (*p*-value). See serial number 1 in section 12.3 of appendix D for results of the Spearman correlationsof IncCPP (Sp) and IncCPP (IoT). The conclusions drawn from the Spearman correlation results summary in comparison to/combination with that of the Sign to will be outlined in section 7.

(2) Inclination to value training - IncVT (Sp) and IncVT (IoT)

It was hypothesized that '***$H_{A2.1}$*:** *There is a positive relationship between user inclinations to value training to use existing digital technology products and user inclination to value training to use IoT products.* ' The summary of the results for the Spearman correlations analysis to test this hypothesis is detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between user inclination to value training to use existing digital technology products and user inclination to value training to use IoT products. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was no statistically significant, correlation between user inclination to value training to use existing digital technology products and user inclination to value training to use IoT products, $r_s(64) = .166, p = .355$.

See serial number 2 in section 12.3 of appendix D for results of the Spearman correlationsof IncVT (Sp) and IncVT (IoT).

(3) Inclination to set-up subscription plan - IncSSP (Sp) and IncSSP (IoT)

It was hypothesized that '***$H_{A3.1}$*:** *There is a positive relationship between user inclinations to set-up subscription plan to acquire existing digital technology products and user inclinations to set-up subscription plan to acquire existing digital technology products IoT products.* ' The summary of the results for the Spearman correlations analysis to test this hypothesis is detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between user inclinations to set-up subscription plan to acquire existing digital technology products and user inclinations to set-up subscription plan to acquire IoT products. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant, strong positive correlation between user inclinations to set-up subscription plan to acquire existing digital technology products and user inclinations to set-up subscription plan to acquire IoT products, $r_s(64) = .744, p < .0005$.

See serial number 3 in section 12.3 of appendix D for results of the Spearman correlationsof IncSSP (Sp) and IncSSP (IoT).

(4) Inclination to be satisfied with product value offering - IncSPVO (Sp) and IncSPVO (IoT)

It was hypothesized that '$\boldsymbol{H_{A4.1}}$: *There is a positive relationship between user inclinations to be satisfied with existing digital technology products value offering and user inclinations to be satisfied with IoT products value offering.'* The summary of the results for the Spearman correlations analysis to test this hypothesis is detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between user inclinations to be satisfied with existing digital technology products value offering and user inclinations to be satisfied with IoT products value offering. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was no statistically significant correlation between user inclinations to be satisfied with existing digital technology products value offering and user inclinations to be satisfied with IoT products value offering, $r_s(64) = .117$, $p = .349$.

See serial number 4 in section 12.3 of appendix D for results of the Spearman correlationsof IncSPVO (Sp) and IncSPVO (IoT).

(5) Inclination to trust product value offering - IncTPVO (Sp) and IncTPVO (IoT)

It was hypothesized that '$\boldsymbol{H_{A5.1}}$: *There is a positive relationship between user inclinations to trust existing digital technology products value offering and IoT products value offering.'* The summary of the results for the Spearman correlations analysis to test this hypothesis is detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between user inclination to trust existing digital technology products value offering and user inclination to trust IoT products value offering. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was no statistically significant correlation between user inclinations to trust existing digital technology products value offering and user inclinations to trust IoT products value offering, $r_s(64) = .481$, $p = -.088$.

See serial number 5 in section 12.3 of appendix D for results of the Spearman correlationsof IncTPVO (Sp) and IncTPVO (IoT).

6.5.4 Results of correlation analysis between product usage experience and the matched pairs of user inclinations

The Spearman correlations result using the recoded ordinal data format (to four-point scale) of the matched pairs of user inclinations is reported here. The two hypotheses to determine the association between product usage experience and user inclinations to be satisfied with product value offering for smartphone context compared to IoT products context and corresponding summaries of the Spearman rho are as follows:

(1) Inclination to be satisfied with product value offering - IncSPVO (Sp)

It was hypothesized that '$H_{A6.1}$: *There is a positive relationship between product usage experience and user inclination to be satisfied with smartphone value offering.'* The summaries of the results to test this hypothesis are detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between product usage experience and user inclinations to be satisfied with the value offering of existing digital technology products. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was statistically significant, strong positive correlation between product usage experience and user inclinations to be satisfied with the value offering of existing digital technology products, $r_s(64) = .350$, $p < .004$.

See serial number 1 in section 12.5 of appendix D for results of the Spearman correlations of product usage experience and IncSPVO (Sp). The next summary is for IncSPVO (IoT) as follows:

(2) Inclination to be satisfied with product value offering - IncSPVO (IoT)

It was hypothesized that '$H_{A6.2}$: *There is a positive relationship between product usage experience and user inclination to be satisfied with IoT products value offering.'* The summaries of the results to test this hypothesis are detailed below:

> A Spearman's rank-order correlation was run to assess the relationship between product usage experience and user inclination to be satisfied with the value offering of of IoT products. Sixty six participants were recruited. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was no statistically significant correlation between product usage experience and user inclinations to be satisfied with the value offering of IoT products, $r_s(64) = -.035$, $p = .779$.

See serial number 2 in section 12.6 of appendix D for results of the Spearman correlations of product usage experience and IncSPVO (IoT). From the results summary of correlations between product usage experience and satisfaction with product value offering, it could be established that there was a significant positive relationship between product usage experience and satisfaction with the value offered for the smartphone context but the IoT product context returned not negative insignificant correlations.

6.6 Results of frequencies and percentages for the matched pair of user inclinations

Summaries of results of descriptives (frequencies and percentages) for the datasets of the matched pairs of user inclinations towards the five generic DTBM applied to Smartphone and IoT products are as follows:

6.6.1. Results of descriptives (frequencies and percentages) for multi-choice question-items

Three multichoice question items were selected for reporting in this sub-section, as they were useful for the comparative analysis and discussion of findings in chapter 7. Of note, are the response sets for loyalty reward. Because of how the question items were constructed for loyalty rewards for smartphone on one hand, and likely user expectation for loyalty reward to acquire IoT products on the otherhand, this component could not be used as part of the value offering for both products context in terms of generic components identified in chapter 2. Hence they are used for descriptive analysis purposes. Summaries for frequencies and percentages for relevant multi-choice questions summarized in tables 6-12 to 6-14 below.

TABLE 6-12: RESPONSE ON PAST RECEIPT OF LOYALTY REWARD (SMARTPHONE)

Loyalty reward (Sp)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	18.2	18.2	18.2
	No	49	74.2	74.2	92.4
	Not sure	5	7.6	7.6	100.0
	Total	66	100.0	100.0	

TABLE 6-13: RESPONSE ON IMPORTANCE OF RECEIPT OF LOYALTY REWARD (IOT)

Loyalty rewards (IoT)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	49	74.2	74.2	74.2
	Selected	17	25.8	25.8	100.0
	Total	66	100.0	100.0	

A look at tables 6-12 and 6-13 shows that 12 participants (18.2%) indicated they have previously received loyalty rewards from their smartphone vendors, while 49 (74.2%) indicated they have never received a loyalty reward from their smartphone vendor and 5 (7.6%) were not sure. On whether loyalty reward was important to them with respect to the IoT scenarios they completed, 49 of the participants (74.2%) indicated it was important to them, while 17 (26.8%) indicated it was not important to them.

Although privacy and security are also integral parts of the value offering for smartphone and IoT products, the main study was not focusing on both. However, participants were ask to indicate for the IoT context, if privacy and security was important to them with respect to IoT products. This question was not developed for the smartphone product, because as mentioned earlier, the researcher was only focusing on the five generic components that was identified and selected for the main investigation.

TABLE 6-14: RESPONSE ON IMPORTANCE OF PRIVACY AND SECURITY (SMARTPHONE)

		Privacy and Security (IoT)			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	24	36.4	36.4	36.4
	Selected	42	63.6	63.6	100.0
	Total	66	100.0	100.0	

Also, it was necessary to obtain responses from the particpants on whether they have used a type of IoT enabled gadgets before. So, the following frequency tables (6-15 to 6-18) are results of the their responses:

TABLE 6-15: RESPONSE ON IMPORTANCE OF PRIVACY AND SECURITY (IOT)

		Apple watch			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	59	89.4	89.4	89.4
	Selected	7	10.6	10.6	100.0
	Total	66	100.0	100.0	

TABLE 6-16: RESPONSE ON PREVIOUS/CURRENT OWNERSHIP OF GOOGLE GLASS

		Google glass			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	62	93.9	93.9	93.9
	Selected	4	6.1	6.1	100.0
	Total	66	100.0	100.0	

TABLE 6-17: RESPONSE ON PREVIOUS/CURRENT OWNERSHIP OF FITBIT

		Fitbit			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	57	86.4	86.4	86.4
	Selected	9	13.6	13.6	100.0
	Total	66	100.0	100.0	

TABLE 6-18: RESPONSE ON PREVIOUS/CURRENT OWNERSHIP OF NIKE FUELBAND

		Nike Fuelband			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not selected	64	97.0	97.0	97.0
	Selected	2	3.0	3.0	100.0
	Total	66	100.0	100.0	

6.6.2 Results of reliabilty test for usability construct for the hands-on educational tool (three Just-in-mind IoT prototypes)

The results of the reliability test using Cronbach Alpha for the data obtained for usability question-items (construct) for the hands-on educational tool (Just-in-mind prototypes for the three IoT scenarios) are reported below:

A questionnaire was employed to measure usability constructs for the hands-on educational tool - three Just-in-mind IoT prototypes. The construct consisted of ten questions. The scale had a high level of internal consistency, as determined by a Cronbach's alpha of 0.833.

6.7 Results of frequencies and percentages for variables of the library usage IoT scenario

Summaries of the descriptives (frequencies and percentages) for the novel future implementation and atomic business model idea for IoT application in the library are summarized in tables 6-19 to 6-26 as follows:

6.7.1 Difficulty or ease measures in the location of books in the library

This question items were aimed at assessing the ease or difficulty participants may exeprience in locating books in the library ; and also to investigate if they have ever lost and paid for replacement of a library book that they borrowed.

(1) Frequency of library usage

TABLE 6-19: FREQUENCY OF LIBRARY USAGE

FLU		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very often	9	13.6	13.6	13.6
	Not often	15	22.7	22.7	36.4
	Often	28	42.4	42.4	78.8
	Very often	14	21.2	21.2	100.0
	Total	66	100.0	100.0	

(2) Ease in locating library book on bookselves

TABLE 6-20: EASE IN LOCATING LIBRARY BOOK ON SHELVES

ELLBS		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very easy	5	7.6	7.6	7.6
	Not easy	24	36.4	36.4	43.9
	Fairly easy	26	39.4	39.4	83.3
	Easy	11	16.7	16.7	100.0
	Total	66	100.0	100.0	

(3) Frequency of borrowing library books

TABLE 6-21: FREQUENCY OF BORROWING LIBRARY BOOKS

FBLB		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very often	13	19.7	19.7	19.7
	Not often	17	25.8	25.8	45.5
	Often	30	45.5	45.5	90.9
	Very often	6	9.1	9.1	100.0
	Total	66	100.0	100.0	

(4) Lost of borrowed book previously

TABLE 6-22: LOST OF BORROWED BOOK PREVIUOSLY

LBBP					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	50	75.8	75.8	75.8
	Yes	16	24.2	24.2	100.0
	Total	66	100.0	100.0	

(5) Paid to replace lost book previously

TABLE 6-23: PAID TO REPLACE A LOST LIBRARY BOOK PREVIOUSLY

PRLLBP					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	43	65.2	65.2	65.2
	Yes	23	34.8	34.8	100.0
	Total	66	100.0	100.0	

6.7.2 Question-items for perception of the library IoT application prototype

The data shown in the tables below were in response to question items investigating participants opinion of the novel implementation idea in the library for location of books within and outside the library, and assess the likelihood of users paying for a lost borrowed book to be tracked and recovered using the facility[33] suggested in the IoT scenario (section 5.2.2) and the IoT prototype (section 2 of appendix B).

(6) Perception of book location system

TABLE 6-24: PERCEPTION OF BOOK LOCATION SYSTEM

PBLS					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important	1	1.5	1.5	1.5
	Important	45	68.2	68.2	69.7
	Very important	20	30.3	30.3	100.0
	Total	66	100.0	100.0	

(7) Perception of seamless book preview

TABLE 6-25: PERCEPTION OF SEAMLESS BOOK PREVIEW

PSBP					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unlikely	2	3.0	3.0	3.0
	Likely	52	78.8	78.8	81.8
	Very likely	12	18.2	18.2	100.0
	Total	66	100.0	100.0	

(8) Likelihood of downloading book location application

TABLE 6-26: LIKELIHOOD OF DOWNLOADING BOOK LOCATION APP

LDBLA					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very unlikely	1	1.5	1.5	1.5
	Unlikely	5	7.6	7.6	9.1
	Likely	59	89.4	89.4	98.5

33 This is the proposed atomic business model for the novel future implentation idea for IoT in the library.

	Very likely	1	1.5	1.5	100.0
	Total	66	100.0	100.0	

(9) Likelihood of paying for lost book location service

TABLE 6-27: LIKELIHOOD OF PAYING FOR LOST BOOK RECOVERY SERVICE

LPLBLS					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very unlikely	1	1.5	1.5	1.5
	Unlikely	6	9.1	9.1	10.6
	Likely	58	87.9	87.9	98.5
	Very likely	1	1.5	1.5	100.0
	Total	66	100.0	100.0	

Although this idea requires further indepth investigation, a discussion of a comparison of the frequencies of positive responses to the solution part versus the ease or difficulty frequency response set is given in section seven.

6.8 Chapter summary

This chapter presented the results of data analysis. Data analysis, which was carried out using the Sign test, Spearman correlations, and descriptive frequencies and percentages, enabled the hypotheses developed in this thesis to be tested, thus validating the within-subject design approach. Also, results of a major transformation on the primary data necessary for the conduction of the primary validation exercise were reported. The transformation of ordinal data to interval data using the method of successive interval proved useful in a unique way to broaden the reach of analytical method used in testing the hypotheses.

This was contingent upon the need to use continuous data for the within-subjects design. In summary, the Sign test was a useful tool for the design of the main objective of the research using a within-subjects design approach, particularly in the aspect of not ignoring normal dispersion of data gathered. This is not a celeberatory note, because, although normality of data was desired, as it should be in every experimental research intent on advance statistical analysis, a researcher may not have control over data obtained from experimental participants.

Also, if the research data is such that cannot be remedied or transformed to be more normal without introducing bias in the results, alternative statistical tests have to be sought. Hence, the use Sign test mitigated against this issue, returning results that were very useful in fulfilling the objectives of this research. The summary of findings and discussions are presented in the next chapter.

CHAPTER SEVEN

7 Conclusions

In today's global and fiercely competitive digital technology market, the emergence of a new technology eclicitates anxiety among practitioners as to the potential disruptive nature of such technology. The Internet of Things proves to be such a technology, with its potential to automate employee roles leading to redundancies on one hand; and send firms that are unwilling to adapt out of business. In manufacturing, agriculture, etc, IoT is emerging as a major player in their ecosystem. However, at the lower end of consumers, IoT may prove beneficial in the ever changing world of consumer expectation. Tech savvy consumers are always looking out for the next release of a technological stunner that can help them in their daily activities, which IoT may provide.

But, the full potential of IoT may not be realised, especially in a B2C setting, if technology firms and their vendors do not tailor appropropriate BMs to their IoT products. There seems to be an advancement in IoT in B2B (manufacturing and agriculture, etc) more than there is in B2C. User expectations for DT products have increased over the last two decades. Fuelled by new technologies and the growing availability of advanced product features and services, user expectations evolve rapidly. Consumers are not willing to compromise on product and service quality (Shah and Murtaza, 2015), especially when it has to do with DT products. IoT products to the end user must have to meet quality standards and reliabilty, such that could secure the trust and satisfaction of the user for the IoT product.

Nonetheless, IoT is still at its infancy of end-user acceptance and/or knowledge of its existence. A tool for making end-users aware of IoT and also accept its prevalence by acquiring its products, this researcher suggest, in consonance with the findings of Bankinter (2011), is a buiness model. A business model that offers user satisfaction and trust as a service, is essential to the advancement of IoT. This is even more important as Iot is an intrusive technology with capibilities that makes this researcher to refer to IoT as being among 'the technology of the gods'.

As mentioned in sections 2 and 5 of this research, the convention or conservative approach to BM research is usually to gather opinions from experts and business owners in order to obtain primary data about definitions, consructs, components, and nodes that may make up a new BM proposal or an existing one, which an outside researcher may be working on. However, the approach in this research, brought to bear by cost constraints and access to managers of IoT-inclined business firms and experts, led to the design of this study in a way that could be acceptable and reused by other researchers and business firms.

Also, although the BM adoption model was not applied to real world DT business case studies, the involvement of end-users served a two-pronged alternative to the foregoing. This researcher refers to this as a 'reverse logic' 'buttom-up' approach to BM research. Particularly, as it was a user-led approach to BM research, in which primary data on identified generic components of the BM of two DT giants are investigated for the likelihood of their adoption for use in IoT.

Application interfaces of three IoT scenarios were wireframed using Just-in-mind prototyping software in this study. Users were able to click through different menus of the designed prototype as part of educating themselves about the various possible scenarios of IoT. Their perception of this three IoT scenarios, which they became acquainted with through the 'educational process', was used in testing their pre-purchase decisions with respect to their current/previous smartphone versus their pre-purchase decsion with respect to the IoT scenarios[34], using each of the five identified generic components of existing DTBM measurement intruments. In the primary validation approach, price, training, and trust were found to have a medium likelihood of being adopted by IoT, while subscription and satisfaction were found to have a low likelihood of being adopted for use in IoT.

Thus, this research answered the questions of: RQ1) What are the major components of an IoT space?; RQ2) Is there a significant difference in the inclinations of users towards components of existing digital technology business model as compared to IoT? Are there any positive relationships between these user inclinations towards components of existing digital technology business models and IoT?; RQ3) What type of relationship exist between product usage experience and user inclinations towards existing digital technology business models on hand, and IoT on the other hand?; RQ3) What is the likelihood of IoT adopting existing digital technology business models?

[34] Not for products for each of the three IoT scenarios, but for IoT products context as a whole.

7.1 Summary of findings and discussions

1. Summary of hypothesis test based on the sign test results

The sign test, which was the main hypothesis testing mechanism in this thesis, was useful in determining if significant differences existed between the the matched pairs of user inclinations towards each of the five generic DTBM based on smartphone and IoT products context. Although the differences between the matched pairs of user inclinations towards each of the five generic components of DTBM were found to be significant, the number of **positive differences** found for the IoT context in comparison to the smartphone context in terms of participants' inclinations were in relation to **three** components (price, training, and trust), which may suggests a **medium likelihood** for IoT adoption of smartphone BM strategies relating to these components. The summary of the hypothesis and results for the sign test can be seen in table 7-1.

TABLE 7-1: SUMMARY OF SIGN TEST RESULTS BASED ON UNIQUE PROCEDURE

Matched pairs	Significance (p-value)	Median increase	Likelihood of IoT adoption of existing DTBM based on procedure
H_{A1}. IncCPP_Sp and IncCPP_IoT	$p < .0005$	Positive	Medium likelihood
H_{A2}. IncVT_Sp and IncVT_IoT	$p < .0005$	Positive	Medium likelihood
H_{A3}. IncSSP_Sp and IncSSP_IoT	$p < .0005$	Negative	Low likelihood
H_{A4}. IncSPVO_Sp and IncSPVO_IoT	$p < .0005$	Negative	Low likelihood
H_{A5}. IncTPVO_Sp and IncTPVO_IoT	$p < .0005$	Positive	Medium likelihood

In contrast, as could be seen in table 7-1, **two** of the matched pairs (satisfaction and subscription) were found not to have positive differences. which may suggests a **low likelihood** for IoT adoption of smartphone BM strategies relating to these components. This was were the sign test proved most usefulful; as its result interpretation procedure was used by this researcher to develop a protocol (see section 5.9.2) to make conclusions from the sign test results. Particularly, in relation to suggesting the likelihood of IoT adoption of existing DTBM, such that, the significance of the differences were not used as the main and only reason to invalidate the hypotheses. The insentitivity of the sign test to normal dispersion was benefitial to the research as original, recoded, and transformed data for the matched pairs of user inclinations failed the normality test.

2. Summary of hypothesis test based on Spearman correlations

The Spearman rho for the matched pairs of user inclinations returned positive significant correlations for two of the matched pairs of user inclinations, while two of the other matched pairs, although positive, did not return significant correlations.

One of the matched pair returned negative insignificant correlations. The summary of the hypothesis and results for the Spearman rho can be seen in table 7-2.

TABLE 7-2: SPEARMAN RHO FOR THE MATCHED PAIRS OF USER INCLINATIONS

Matched pairs	Significance (p-value)	Correlation coefficient	Relationship strenght
$H_{A1.1}$. IncCPP_Sp and IncCPP_IoT	$p < .0005$	.377**	Moderate
$H_{A2.1}$. IncVT_Sp and IncVT_IoT	$p = .355$	.166	Weak
$H_{A3.1}$. IncSSP_Sp and IncSSP_IoT	$p < .0005$	.744**	Moderate
$H_{A4.1}$. IncSPVO_Sp and IncSPVO_IoT	$p = .117$	.349	Moderate
$H_{A5.1}$. IncTPVO_Sp and IncTPVO_IoT	$p = -.088$	.481	Weak

3. From the results summary of correlations between product usage experience and satisfaction with product value offering, it could be established that there was a significant positive relationship between product usage experience and satisfaction with the value offered for the smartphone context but the IoT product context returned negative insignificant correlations. This may suggest that because users were more experienced in the used of smartphones there was a tendency to be satisfied with the its value offering. While for the IoT satisfaction context, their usage experience was not really brought to bear in terms of them not really having tangible experience with IoT products in real life. This may suggest usage experience of old DT product may not have an influence on user satisfaction with a new DT product.

4. Results as seen from the frequency and percentages tables of the multi-choice response data for the loyalty reward component of a product value offering showed that; few users indicated they have received loyalty rewards from their smartphone vendors in the past. This contrast with more users indicating that loyalty reward was an important factor to them with respect to IoT products. Also few users indicated they have ever aquired IoT type products such as fitbit, etc; thus justifying the need for this research.

Finally, the frequencies and percentages response set for the novel future implementation and atomic BM idea for the use of the library and borrowing of books IoT suggests participants were inclined to accepting the novel idea especially, as participants indicated as frequent library users, were also more receptive of the location solutions proposed. They also indicated in terms of the percentages to be receptive of the idea of paying for lost book recovery using the app.

7.2 DTBM adoption representation map for IoT (CBMF4IoT)

Based on the general SCP BM framework representation map modified and described in chapter 4, the IoT adoption of smartphone BM focused on nodes that were relevant to the generic components of DTBM for IoT proposed in this research. Figure 7-1 shows the CBMF4IoT representation map based on the general SCP framework for business models.

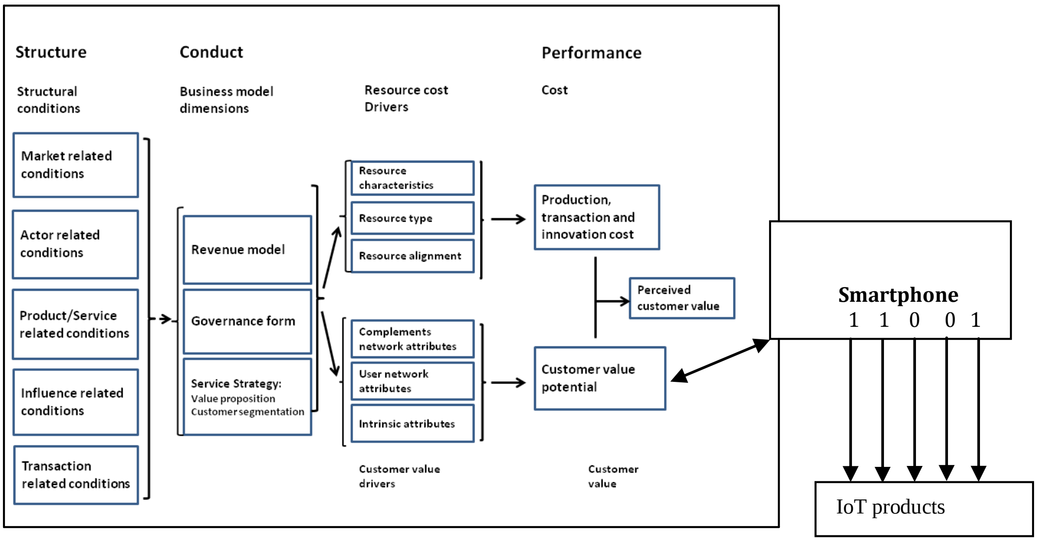

FIGURE 7-1: CBMF4IOT BASED ON GSCP FRAMEWORK FOR BM

In the above business model framework representation map, it could be seen that there is a value activity between IoT and smartphone. The five arrows represent the five generic components of the DTBM. The numbers 1 and 0 representative of how many of the components that were statistically tested had a medium likelihood for IoT adoption of smartphone BM. While two components had low likelihood. so the map illustrates the results of the Sign test of the matched pairs of user inclinations. So this modified framework representation map partly depends on validated data from the end-user.

This modifications to the general SCP representation map may be re-usable for other nodes within the general SCP BM representation map and this will be explained in section 7. For instance, in a situation where a business technology firm (firm B) produces a new third party IoT app and seeks to adopt the 'revenue model' of established firms that are already in the business of producing apps. Then, firm B commisions a research company to conduct a study of ninety (90) similar technology firms to determine the likelihood of adopting one or two or all of the five generic components the revenue model[35] (rentals, usage fees, subscription, licensing for usage, certificates) that may be used by these ninety (90) established firms. This hypothetical situation is as shown in figure 7-2.

[35] http://www.bmnow.com/revenue-models-quick-guide/

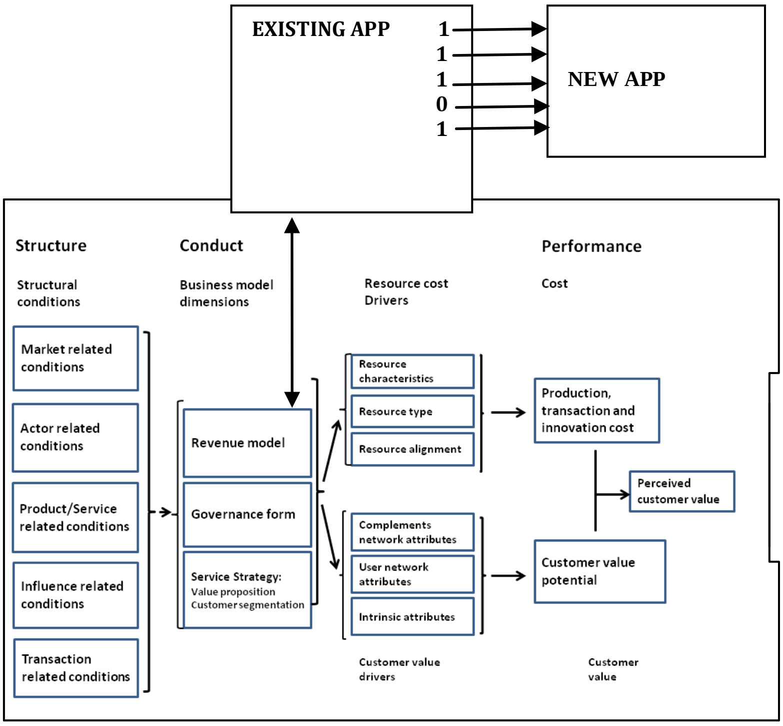

FIGURE 7-2: MODIFIED GSCP FRAMEWORK SHOWING ADOPTION LIKELIHOOD OF A PRODUCT REVENUE MODEL

In such a situation, the design may investigate which of the aforementioned five revenue model components they currently use (or would have prefered to use) for their current app versus which revenue model component they would prefer for this new app. Then, the research company may adopt the same within subjects-design of this research with the same modification and logic applied to modify the general SCP BM framework representation map used for IoT adoption of the smartphone BM.

For instance if the result of such a study using the Sign test and procedure proposed in this research returns high or medium likelihood of adoption for the rentals, subscription, and licensing for usage, and certificates components of the revenue model, while the result returns a low likelihood of adoption for the usage fees component of the revenue model, then as could be seen in the modified general SCP framework of figure 7-2, four of the arrows from the existing app to the new app are denoted with '1' for adoption while one of the arrow is denoted with '0' indicating no adoption. This hyspothetical situation demonstrates the resusability of the unique procedure proposed in this research.

7.3 Contribution to knowledge

The contribution of this research work is discussed with respect to the state-of-the-art in the area of IoT implementations for the end-user. A Business Model is meant to add value to the user and generate revenue for the business firm. The unique research approach involved identifying components of the BMs of established DT firms in order to support a user-led investigation into the likelihood of IoT adoption of existing DTBM. the five components identified in chapter two were subscription, training, price, satisfaction, and trust.

Although several DTBMs were highlighted in chapter 2.2, these five generic components of DTBM were relevant to this research, as they were subjective instruments that could be measured with data obtained from end-users, rather than business owners, experts, or practisioners. The approach to the literature review was a type of business-technology co-design, whereby the business model related literature enabled subjective measures to be identified, while the DT literature enabled the selection of three IoT use case scenarios for illustration description and developement of Just-in-mind wireframes. In particular, the three IoT scenarios and prototypes that were developed were in the area of health monitoring, home environment, and a novel future IoT implementation and atomic BM idea proposed by this researcher for the use of the library and borrowing of books.

7.3.1Unique protocol for business model adoption

The within-subjects design for the experiment provided an opportunity for a challenging but innovative approach to analysing data in a BM research context. In particular, the question items for the matched pairs of user inclinations towards the five generic components of existing DTBM were single-item question constructs with primary data obtained in categorical ordinal scale for the matched pairs of user inclinations. This resulted in discovery in the literature a statistically validated method for transforming ordinal data to interval data.[36] This was then used for indepth statiscal analysis using the **Sign test** as the primary validation method. The Sign test procedure enabled enabled the design of a uniques procedure for IoT adoption of DTBM by this researcher. The results of the test obtained from the

[36] The method of successive interval.

procedure were fed into the modified general SCP framework for BM representation map logically.This procedures could be re-usable in any BM research context especially in were new products are released by firms or invented.

7.4 Limitations and future research

The limitation of this study is that business model research for IoT, is in the early stages, thus theories are being proposed for IoT BM, but few are accompanied with real world implementation. Although materials gotten from the literature on the BM of two DT firms were few, they were useful for the identification of the BM components investigated in this research. Also, the within-subjects design for a BM research was a limitation in terms of the sample population which made data gathered to be susceptible to failures in normality tests, and failure in significant values.

BM researches are mostly qualitative in the literature, which resulted in a linear approach to executing the experimental tasks, in contrast to the random approach and number of experimental runs. Although there was an attempt by the researcher to mitigate against this using the question-items in the questionnaire as a tool. Also, the state-of-the-art of IoT also meant that the novel iot implementation ideas proposed in this research are indeed meant for the future.

7.5 Recommendations for future research

The study will benefit from further validation of the BM adoption framework in the context of between-subjects design using the Wilcoxson Signed ranked test. Also, the action research on the modified general SCP framework for BM for other segments of the framework to test the reusability of the representation map and it will be useful to also obtain the opinions of practioners (IoT DT firms). In terms of the novel IoT implementation idea for the library, resource availablity could ensure first step advancement for the idea in terms of the business case, for the library organization.

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9. Appendix A

9.1 Participant invitation sheet

Participants needed for an Internet of Things (IoT) business model experiment

Dear Colleagues,

As part of my PhD research at the University of Sussex, I am conducting a study on a customer-focused business model framework for the Internet of Things (CBMF4IoT).

I will be appreciative of your participation in my study, but you are expected to have some previous experience with the use of digital technology products.

The tasks will take 90 minutes or less, which involves educating yourself about the Internet of Things (IoT) by observing/going through three IoT scenario diagrams, making use of clickable prototypes designed for each scenarios, and completing a 61-item questionnaire. Each participant will receive a ticket for a raffle draw to win an Amazon Fire tablet worth £30. The winner will be contacted after all the experiment process is completed.

In developing the experiment and questionnaire, we found that many participants were interested in the study as they considered the subject matter to be relevant to their activities and they also found the tools employed in the experiment to be engaging. We encourage you to forward this request to other people you think might be interested.

The Sciences & Technology Cross-Schools Research Ethics Committee has approved the study; and all data collected will be anonymised and kept strictly confidential. All experiments will take place in the Computer Graphics Centre in the Informatics Department, which is located in Chichester 1, Room 128, University of Sussex.

If you are interested in taking part, please contact me via be41@sussex.ac.uk

Thanks for your support.

9.2 Participant information sheet

A CUSTOMER-FOCUSED BUSINESS MODEL FRAMEWORK FOR THE INTERNET OF THINGS

Thank you for participating in this survey about a customer-focused business model framework for the Internet of Things (CBMF4IoT). The information you provide will be treated as strictly confidential and for academic research purpose only and please endeavour to fill out the questionnaire. Kindly provide as many real information as possible and to the best of your knowledge, and please tick in the option box as appropriate. Thanks for your cooperation.

Before filling out the questionnaire please read the participant information below.

This sheet seeks to provide information, and advice, with respect to an individual's participation in support of the specified research project:

1. The project is entitled '*A Business Model Framework for the Internet of things"*, and will consider existing digital technology business models and how these models could be adopted/enhanced for IoT;

2. This research is being conducted by *Bassey itam Eyo* in support of his studies for a PhD in Informatics at the University of Sussex;

3. The research is being supervised by *Dr. Natalia Beloff and Dr. Martin White*, who are first and second supervisors respectively appointed by the University;

4. Participation in this research is totally voluntary, and assurances are given to the effect that no negative consequences will arise from refusal to participate, from limiting participation, or from withdrawing (prior to theses submission) input that arose from any earlier participation in the research project;

5. The tasks will take 90 minutes or less, which involves educating yourself about IoT by observing/going through 3 IoT scenario diagrams, making use of clickable prototypes design for each scenarios, and completing an 61-item questionnaire. Each participant will receive a ticket for a raffle draw to win an Amazon Fire tablet worth £30. The winner will be contacted after all the experiment process is completed;

6. Each individual is advised to fully consider if necessary prior to participation, any disadvantages, side effects, risks and/or discomforts that may arise from participation in this research;

7. All data collected in this experiment will be held as confidential as all information obtain will be anonymised and will be used only in a summarised form. Therefore no individual or private information will be presented or shared with a third party. The results of the research will be analysed and used as part of my thesis.

8. This study has been approved by the Sciences & Technology Cross-Schools Research Ethics Committee (crecscitec@sussex.ac.uk). The project reference number is ER/BE41/1. The University of Sussex has insurance in place to cover its legal liabilities in respect of this study.

Contact point for further information:

Researcher: be41@sussex.ac.uk

If you have any concerns regarding the way the research has been conducted, you can contact my supervisor and the ethics committee who reviewed the project:

Dr. Natalia Beloff, N.Beloff@sussex.ac.uk

Sciences & Technology Cross-Schools Research Ethics Committee (C-REC), crecscitec@sussex.ac.uk

Thanks for taking time to read the information sheet

Date:

9.3 Consent form for experiment participants

PROJECT TITLE: A business model framework for the Internet of things

Project Approval Reference: ER/BE41/1

I agree to take part in the above University of Sussex research project. The project has been explained to me and I have read and understood the Information sheet, which I may keep for records. I understand that agreeing to take part means that I am will to:

Have an educated experience about Internet of Things (IoT) using 3 scenario diagrams and 3 clickable prototypes;
Respond to an 61-item questionnaire.

I understand that any information I provide is confidential, and no information that I disclose will lead to the identification of any individual in the reports on the project, either by the researcher or any other party.

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.
I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act of 1998.

Name: ____________________
Signature ____________________
Date ____________________

This section is for the researcher:

I believe that ____________________ understands the above project and gives his/her consent voluntarily

Name: ____________________
Signature ____________________
Address ____________________
Date ____________________

9.4 Pre-experiment questionnaire

PART I: DEMOGRAPHIC QUESTIONS

* 1. What is your age range?

- 18 to 20
- 21 to 30
- 31 to 40
- 41 to 50
- 51 to 60
- 61 to 70
- 71 or older

* 2. How would you categorize yourself as a user of digital technology products and services?

- Novice
- Fairly experienced
- Experienced
- Very experienced
- Expert

* 3. What is your gender?

- Male
- Female
- Prefer not to say

4. What is the highest level of education you have completed?

- Did not attend school
- High school
- Undergraduate
- Postgraduate taught
- Postgraduate research

* 5. Which of the following is your discipline/profession?

- Healthcare
- Architect
- Engineer
- Education
- IT/ICT
- Social work
- Management/Finance
- Music/Theatre arts

Other (please specify)

* 6. How much is your monthly income?

- £100 and below
- £101 to £300
- £301 to £500
- £501 to £1000
- £1001 to £1500
- £1501 to £2000
- 2001 and above

* 7. Which of the following digital technology products have you used? (You can select as many as you have used)

- Mobile devices
- PC
- Mobile applications
- E-Commerce applications
- Cloud applications
- Desktop applications
- Mobile games
- Online games
- I have not used a digital technology product before

* 8. How long have you probably used the aforementioned products?

- Less than 1 year
- 1-5 years
- 5-10 years
- 10 to 15 years
- 15 years and above

* 9. How would you categorize yourself as a user of digital technology products and services?

- Novic
- Fairly experienced
- Experienced
- Very experienced
- Expert

* 10. How often do you use the library?

- Very often
- Often
- Fairly often
- Not often
- Not very often
- Never

* 11. How would you rate your ease of locating a bookshelf to pick a book of your choice in the library?

- Easy
- Fairly easy
- Not easy
- Not very easy
- I have never used the library

* 12. How often do you borrow books from the library?

- Very often
- Often
- Fairly often
- Not often
- Not very often
- Never

* 13. In the course of borrowing library books, have you ever lost any before?

- Yes
- No
- Not applicable as I have never borrowed a library book before
- Not applicable, but I have lost some personal books in the past

* 14. Have you ever paid the Library admin for a lost borrowed library book and/or for delay in returning a borrowed library book?

- Yes
- No
- Not applicable as I have never borrowed a library book/never lost a borrowed library book/never delayed to return same

QUESTIONNAIRE ON A CUSTOMER-BASED BUSINESS MODEL FRAMEWORK FOR THE INTERNET OF THINGS

USER HABITS WITH ALREADY EXISTING DIGITAL TECHNOLOGY PRODUCTS/SERVICES - SMART PHONES/APPS

This part deals with user previous experience from the point of purchase to the actual usage of a Smart phone and corresponding apps.

* 15. Do you currently have a Smart phone?

- Yes
- No

* 16. Which of the following brands of Smart phone have you used?

- Samsung
- Apple
- HTC
- Nokia
- Blackberry
- Mention any other brand of Mobile device you have used here

* 17. How would you rate your experience using a Smart phone?

- Very dissatisfied
- Dissatisfied
- Satisfied
- Very satisfied
- Not sure

* 18. How hesitant were you before you purchased your previous or most recent Smart phone?

- Very hesitant
- Hesitant
- Not hesitant
- Not very hesitant
- Not sure

* 19. Did you set up a subscription plan to pay for your Smart phone?

- No (I paid in full)
- Yes

* 20. How often do you use apps on you Smart phone?

- Very often
- Often
- Fairly often
- Not often
- Not very often

21. Which of the following app stores have you used to purchase and download your most recent digital technology technology device/service/application? (You can pick as many as you have used)

- Apple app store
- Google Play store
- Nokia app store

Mention any app store you have used not listed here

* 22. How likely are you to pay £5.99 or more for an app?

- Not Likely
- Likely
- Very Likely
- I will only pay a lesser amount
- I only use free apps

* 23. When you are subscribing for an app, which subscription plan would you likely prefer?

- Weekly
- Monthly
- Quarterly
- Annually

* 24. If you are satisfied with your previous/current Smart phone, and a new version is released; how much extra would you be inclined to pay in addition to the purchase price of your previous/current Smart phone to obtain the new version of your Smart phone?

- Less than £100
- From £100 to £150
- From £150 to £200
- From £250 to £300
- More than £300

* 25. How important was it for you to consider the price of your previous/current Smart phone in the light of the accessories and apps that were available in it before purchasing the Smart phone?

- Very Important
- Important
- Fairly important
- Not important
- Not very important

* 26. How helpful was the user manual to you when you purchased your Smart phone?

- Very helpful
- Helpful
- Fairly helpful
- Not helpful
- Not very helpful

* 27. Have you benefited from loyalty rewards/discounts in buying/using your Smart Phone and corresponding apps?

- Yes
- No
- Not sure

* 28. Which of this products have you used before? (Select as many as possible)

- Apple watch
- Google glass
- Fitbit
- Nike Fuelband
- None of the above

Mention any other similar product you have used.

* 29. How likely did your social or cultural or religious values influence your adoption or rejection of a previous or most recent mobile product/service?

- Very likely
- Likely
- Fairly likely
- Unlikely
- Very unlikely
- I do not know

* 30. Have you recommended your current or previous Smart phone and corresponding apps to friends and family members?

- Yes
- No
- Not sure

9.5 Post experiment questionnaire

QUESTIONS ON OVERALL USER EXPERIENCE WITH THE EDUCATIONAL TOOL (THE THREE IOT PROTOTYPES)

This part deals with overall user perception after the hands-on exercise with the Just-In-Mind clickable prototypes of the three IoT scenarios (health monitoring, home environment, use of the library and borrowing books).

* 31. Overall in general, the application is easy to use

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 32. In general, the functions are placed in the right places

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 33. Controls like buttons and text fields are appropriately sized

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 34. It was easy to use the app at first attempt, I did not struggle to reach any buttons

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 35. It is easy to understand what the different icons mean

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 36. The app behave as explained by the researcher and the scenario sketch

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 37. Moving to and from the different areas of the application is clear and not disorienting

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 38. I always knew what to do next to perform a specific task

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 39. I quickly learned how to use the application

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 40. The interface is aesthetically pleasing

- Strongly Disagree
- Disagree
- Not sure
- Agree
- Strongly agree

* 41. What can be improved in the application? How would you change the function/structure/appearance. You can bring up any new issue this questionnaire did not address.

PSYCHOMETRIC QUESTIONS ON USER DISPOSITION TOWARDS THE THREE IoT USE CASE SCENARIOS.

This part deals with the potential for users to adopt IoT.

* 42. In terms of satisfaction, how likely does your experience with the three IoT scenarios that you just completed align with your experience using already existing digital technology products/services (e.g. Smart phones, mobile apps)?

- ○ Very likely
- ○ Likely
- ○ Fairly likely
- ○ Unlikely
- ○ Very unlikely

* 43. In the context of the given IoT scenarios that you just completed, how likely would you be inclined to purchase such IoT products and services?

- ○ Very likely
- ○ Likely
- ○ Fairly likely
- ○ Unlikely
- ○ Very unlikely

* 44. In the context of the 3 IoT scenarios that you just completed, how much will you be inclined to pay to obtain any one of the 3 IoT products/services including the connected devices (sensors, RFID tags, NFC tags) and mobile applications?

- ○ Less than £100
- ○ From £100 to £200
- ○ From £200 to £300
- ○ From £300 to £400
- ○ From £400 to £500
- ○ More than £500

* 45. Given that the IoT services illustrated in the scenarios might form part of a mobile application excluding any other connected device, how much would you be ready to pay for the mobile application?

- ○ I only use free apps
- ○ Less than £1
- ○ From £1 to £2
- ○ From £2 to £5
- ○ From £5 to £10
- ○ More than £10

* 46. Which of the following app stores would you readily use to purchase and download your IoT application? (You can pick as many as you have used)

- [ ] Google Play store
- [ ] Apple app store
- [ ] Nokia app store

Mention any app store you would use that is not listed here

* 47. How would you like to purchase of your preferred IoT products/services?

- ○ Subscription
- ○ Full payment at point of purchase
- ○ Not sure

* 48. If you are to subscribe for products and services on one of your preferred IoT platform, which subscription plan will best suit your net income?

- ○ Weekly
- ○ Monthly
- ○ Quarterly
- ○ Annually
- ○ Not applicable as I will opt for full payment at point of purchase

* 49. In the context of the completed scenarios, what mode of payment would you likely use to purchase your preferred IoT products/services?

- ○ Credit card
- ○ Debit card
- ○ Direct debit
- ○ Mobile payment
- ○ PayPal
- ○ Cash

* 50. How valuable will it be to you if you are offered to be specially trained to use your preferred IoT products/services before or after purchase?

- ○ Very valuable
- ○ Valuable
- ○ Fairly valuable
- ○ Not valuable
- ○ Not very valuable

* 51. What medium of training would you likely prefer for this special training?

- Onsite at Company solution centre
- Virtual training by and e-assistant
- Soft copy user manual
- Not sure
- Hardcopy user manual

* 52. In the context of the IoT scenarios that you just completed, which of the following will determine your satisfaction with an IoT product/service? (You can pick as many as possible)

- Aesthetics
- Ease of use
- Price
- Brand name
- Customer Service offering
- Privacy and Security
- Loyalty rewards

* 53. Rate the level of satisfaction that you likely have for the IoT scenarios that you just completed

- Very satisfied
- Dissatisfied
- Satisfied
- Very dissatisfied
- Fairly satisfied

* 54. Will you likely recommend at least one of this IoT applications to friends and family members?

- Very likely
- Unlikely
- Likely
- Very unlikely
- Fairly likely

* 55. Given your view of the IoT scenarios, how would you likely categorize your trust for using this products/services?

- Very trustworthy
- Not trustworthy
- Trustworthy
- Not very trustworthy
- Fairly trustworthy

* 56. How likely will your social or cultural or religious values determine your adoption of any of the completed IoT use cases?

- Very likely
- likely
- Fairly likely
- Unlikely
- Very unlikely
- I don't know

* 57. In the context of the 3 IoT scenarios that you just completed, would you consider it important to assess the price of your preferred IoT products/services before purchasing it?

- Very important
- Important
- Fairly important
- Not important
- Not very important

* 58. In the context of the use of the library and borrowing books IoT scenario that you just completed, how important do you view the indoor location/positioning application services for library books?

- Very important
- Important
- Fairly important
- Not important
- Not very important

* 59. How do you consider the seamless book preview application services for library books as highlighted in the use of the library and borrowing books IoT scenario that you just completed?

- Very important
- Important
- Fairly important
- Not important
- Not very important

* 60. Will you be inclined to have the lost book recovery application services for your personal books that you value?

- Very likely
- Likely
- Fairly likely
- Unlikely
- Very unlikely

* 61. Will you be inclined to pay for recovery of a lost borrowed book using the tracking application service highlighted in the use of the library and borrowing books IoT scenario?

- Very likely
- Likely
- Fairly likely
- Unlikely
- Very unlikely
- Never

9.6 The ethic committee approval certificate

UNIVERSITY OF SUSSEX

Sciences & Technology C-REC
crecscitec@admin.susx.ac.uk

Certificate of Approval	
Reference Number	ER/BE41/1
Title Of Project	A Business Model Framework for the Internet of Things (IoT)
Principal Investigator (PI):	Natalia Beloff
Student	Bassey Itam Eyo
Collaborators	
Duration Of Approval	6 months
Expected Start Date	17-Sep-2013
Date Of Approval	23-May-2018
Approval Expiry Date	31-Oct-2018
Approved By	Karen Long
Name of Authorised Signatory	Anna Hobbs
Date	24-May-2018

*NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:

Amendments to protocol

* Any changes or amendments to approved protocols must be submitted to the C-REC for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects

* Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the C-REC.

Feedback regarding any adverse(1) and unexpected events(2)

* Any adverse (undesirable and unintended) and unexpected events that occur during the implementation of the project must be reported to the Chair of the Science and Technology C-REC. In the event of a serious adverse event, research must be stopped immediately and the Chair alerted within 24 hours of the occurrence.

Monitoring of Approved studies

The University may undertake periodic monitoring of approved studies. Researchers will be requested to report on the outcomes of research activity in relation to approvals that were granted (full applications and amendments).

Research Standards

Failure to conduct University research in alignment with the Code of Practice for Research may be investigated under the Procedure for the Investigation of Allegations of Misconduct in Research or other appropriate internal mechanisms (3). Any queries can be addressed to the Research Governance Office: rgoffice@sussex.ac.uk

(1) An "adverse event" is one that occurs during the course of a research protocol that either causes physical or psychological harm, or increases the risk of physical or psychological harm, or results in a loss of privacy and/or confidentiality to research participant or others.

(2) An "unexpected event" is an occurrence or situation during the course of a research project that was a) harmful to a participant taking part in the research, or b) increased the probability of harm to participants taking part in the research.

(3) http://www.sussex.ac.uk/staff/research/rqi/policy/research-policy

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10 Appendix B

10.1 Just-in-Mind prototypes of the three IoT use-case scenarios (home screen) and description of experimental task for the prototypes.

The JustInMind prototyping tool is used to design prototypes for the three IoT use-case scenarios. The Wireframe is developed using Android Phone interface. On the home screen, the three IoT apps icon are identified as 'LibIoT' for the use of the library and borrowing books IoT scenario, 'HomeEnvIoT' for home environment IoT scenario, and 'HealthMonIoT' for health monitoring IoT scenario. This is shown in figure 1 below.

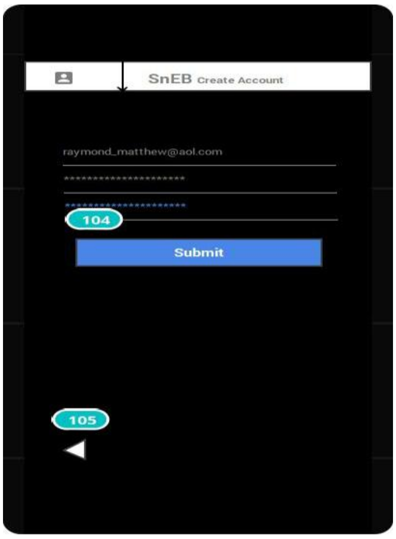


Figure 1: Home Screen

Figure 2: Smart and Embedded Books Welcome

Figure 3: SnEB Create Account

The numbers with white font and light blue above the icons/apps/menus indicate that the icons are wireframes and thus clickable. To-do outlines for all the pages of each of the three prototypes are described below itemized from a) to c).

10.2 Use of the library and borrowing of books IoT wireframe

1. On the home screen, tap on LibIoT icon, this takes the experiment participant (referred to as the user in subsequent tasks outlined below) to the Smart and Embedded Books (SnEB) Welcome page.

2. On the Smart and Embedded Books (SnEB) Welcome page, tap on the 'Create Account' button. This opens the SnEB Create Account page.

3. On the SnEB Create Account page, tap on the 'Submit' button, which takes the user to the Account Subscription page. (Note: the username, password and confirm password text fields already have data entries, such that the user does not need to type in any text. This is aimed at working within the experimental tasks time constraints).

4. On the Account Subscription page, tap on the 'Subscribe' button (Note: the user bank

account details are already entered in the relevant text fields). This takes the user to the SnEB Start page.

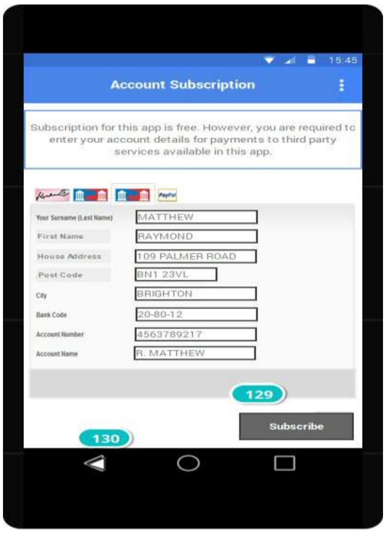


Figure 4: Account Subscription

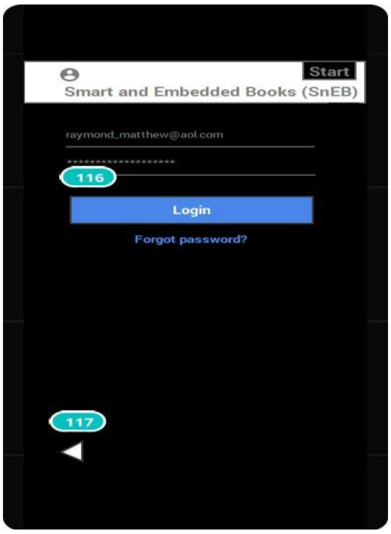


Figure 5: Smart and Embedded Books Start

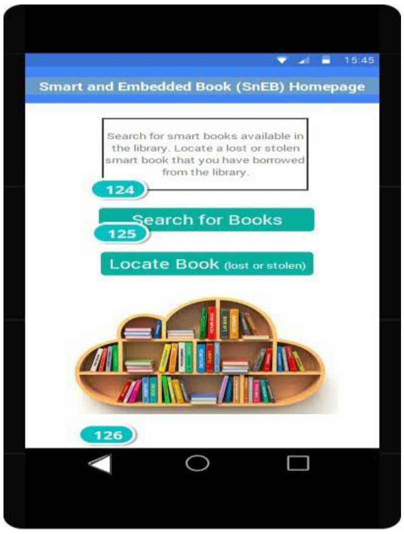


Figure 6: Smart and Embedded Books Homepage

5. On the Smart and Embedded Books (SnEB) Start page, tap on 'Login' button (Note: username and password field entries are already entered), which takes the user to the homepage.

6. On the Smart and Embedded Books (SnEB) Homepage, tap on 'Search for Books' button to search for available smart books on your chosen subject.

7. On SnEB Search for Books page, tap the search text field (Note: the search title of the book - Literature review books - is keyed in already). A list of three smart books on the title of the book searched pops up on the List of smart book resource searched page. Tap on 'The Balfour Declaration Literature' item. This takes the user to the Locate Smart Book Shelf page.

Figure 7: Search for Smart book

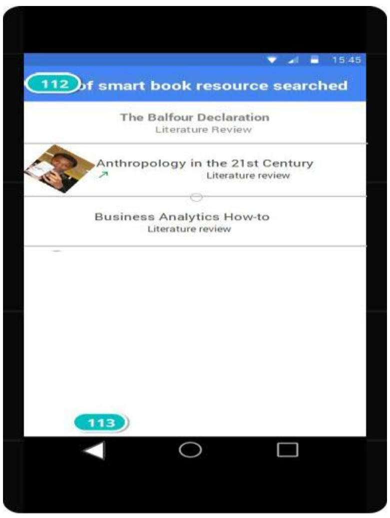


Figure 8: List of smart book resource searched

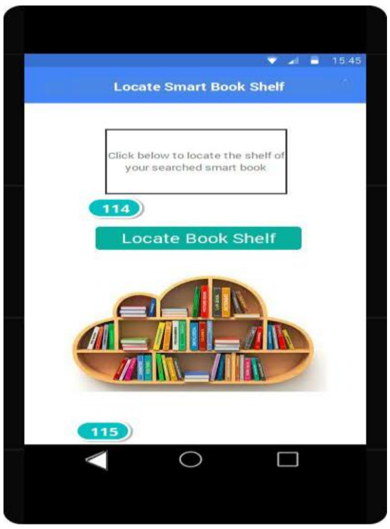
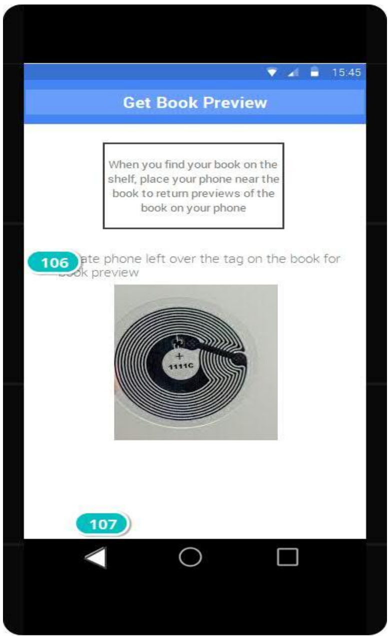


Figure 9: Locate Smart Book Shelf

8. On the Locate Smart Book Shelf page, tap on 'Locate Book Shelf' button to guide the user to the location of the book shelf, which opens the Library Indoor Book Shelf Positioning page.

9. On the Library Indoor Book Shelf Positioning page, the user should tap on black location icon when she locates the smart book shelf, which opens the Get Book Preview page.

10. On the Get Book Preview page, rotate the phone left near the Smart book on the shelf to see the book preview on your Smart phone.



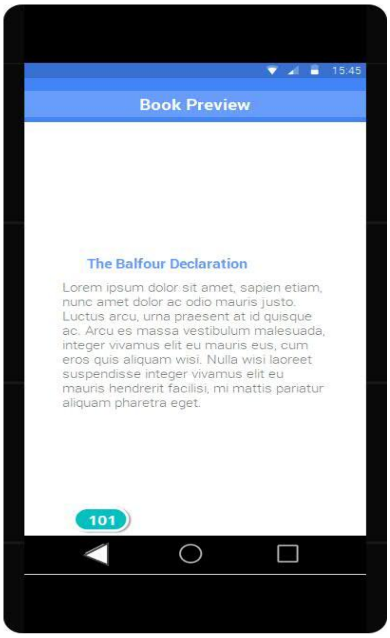


Figure 10: Library Indoor Book Shelf Positioning

Figure 11: Get Book Preview

Figure 12: Book Preview

11. On the Book Preview page, tap on the 'backwards arrow' button on the bottom left of the screen to go back to SnEB homepage, then tap on 'Locate Book (lost or stolen)' button, which takes the user to the Smart Book Tracker page.

12. On Smart Book Tracker page, the user is required to key in the title of the Smart book that is lost or stolen and press the enter key, which for the purpose of this experimental task is 'The Balfour Declaration - Literature Review and has already been keyed into the text field to save time, so the user is expected to tap on the text field, which takes the user to the Lost or Stolen Book Location Map page.

13. On the Lost or Stolen Book Location Map page, tap on the 'blue location' icon to reveal the address where the lost book can currently be found.

14. On Location Address of Lost Book page, tap on 'Book Retrieval Complete? Click Here' button after the user has visited the address to recover the lost Smart Book. The user bank account is debited to the tune of £0.99 for the Smart book location and recovery service.

Figure 13: Smart Book Tracker

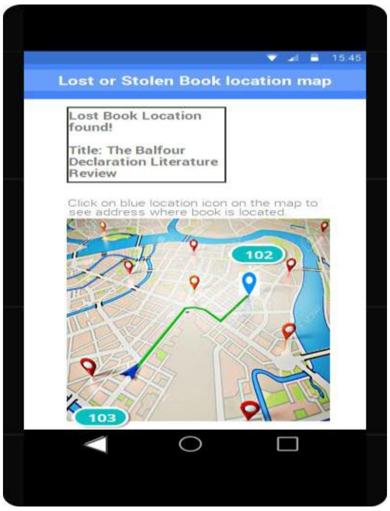


Figure 14: Lost Book or Stolen Location map

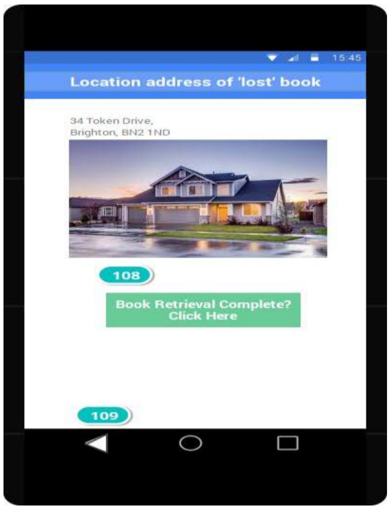


Figure 15: Location Address of Lost Book

15. On the Payment for Lost Book Recovery page, tap on the 'backward arrow' button at the bottom left of the screen to take the user back to the SnEB homepage. On the SnEB homepage, tap on the 'backward arrow' button at bottom left of the screen to take user back to the home screen.

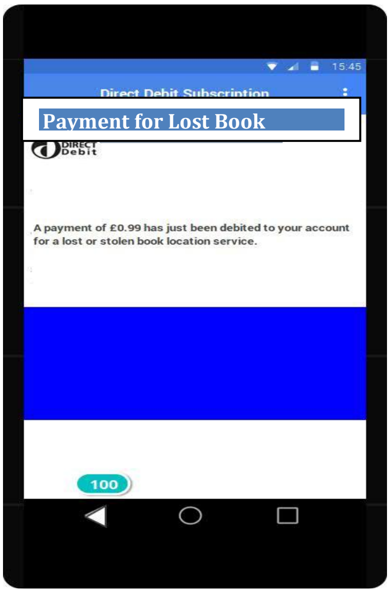


Figure 16: Smart Payment for Lost Book Recovery.

10.3 Home environment IoT wireframe

1. On the home screen, tap on HomeEnvIoT icon, this takes the user to the Home and Environment IoT Create Account page.

2. On the Home and Environment IoT Create Account page, tap on the 'Create Account' button, which takes the user to the Account Subscription page. (Note: the username, password and confirm password text fields already have data entries, such that the user does

not need to type in any text. This is aimed at working within the experimental tasks time constraints).

Figure 17: Home and Environment IoT Create Account

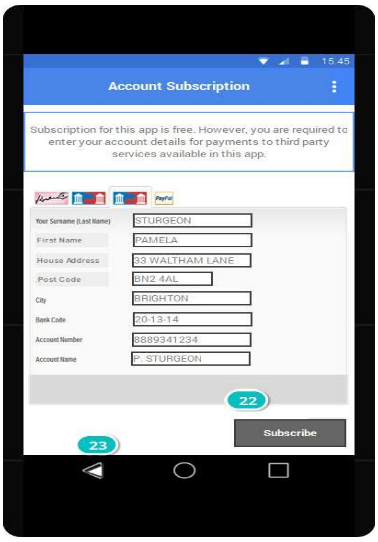


Figure 18: Account Subscription

Figure 19: Home and Environment IoT Login

3. On the Account Subscription page, tap on the 'Subscribe' button (Note: the user bank account details are already entered in the relevant text fields). This takes the user to the SnEB Start page.

4. On the Home and Environment IoT Login page, tap on 'Login' button (Note: username and password field entries are already keyed in), which takes the user to the Home and Environment IoT homepage.

4. On the Home and Environment IoT page, tap on the 'Lists of Things' button, which takes the user to the Home and Environment Smart Kits page.

5. On the Home and Environment Smart Kits page, there are three icons indicating appliances that IoT enabled appliances that have been added to the Home and Environment

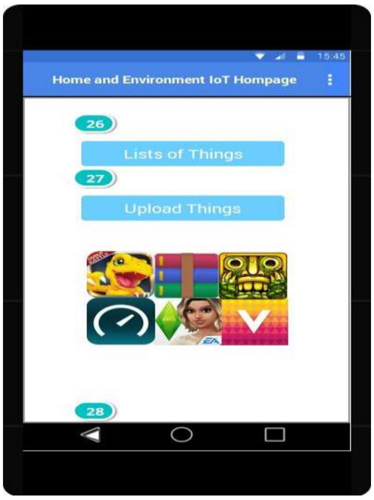


Figure 20: Home and Environment IoT Homepage

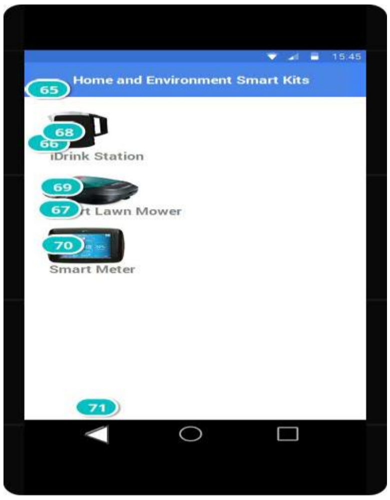


Figure 21: Home and Environment Smart Kits

Figure 22: iDrink Station Home Mode Dashboard

app. Tap on the 'iDrink Station' icon, which opens the iDrink Station Home Mode Dashboard.

6. On the iDrink Station Home Mode Dashboard, tap on 'Click here to start your brew' button, which takes the user to the iDrink Station Dashboard Start Brew Timer page.

7. On iDrink Station Dashboard Start Brew Timer page, in order to save time for participants, the type of drink, its quantity, and temperature are already preset on the screen. Tap on 'Start Brewing' button. Note

8. On iDrink Station Dashboard Brewing page, the drink timer starts reading, and when it has finished reading and preparing the drink, tap on 'Click here to pour over when complete' button. This takes the user back to the On iDrink Station Home Mode Dashboard.

Figure 26: iDrink Station Dashboard Start Brew Timer

Figure 27: iDrink Station Brew Reading

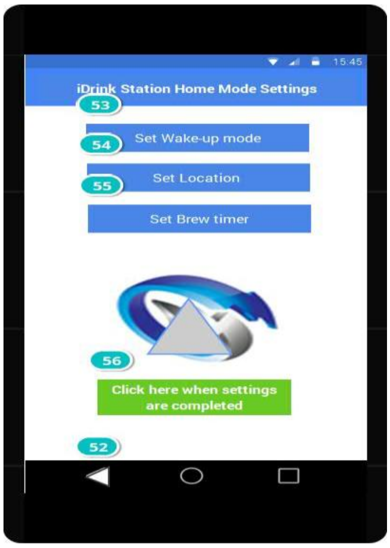


Figure 28: iDrink Station Home Mode Settings

9. On the iDrink Station Home Mode Dashboard, assuming the user wants to change the settings for the home mode, tap on 'Click here to change your settings' button, which opens the iDrink Station Home Mode Settings.

10. On iDrink Station Dashboard Home Settings, tap on 'Set wake-Up Mode' button, which opens the iDrink Station Set Wake Up Mode page.

11. On the iDrink Station Set Wake Up Mode page, tap on 'Set Wake Up Mode' button, it takes the user to iDrink Station Wake Up Mode and when this mode is triggered, it, through linked sensors in the bedroom, gets the iDrink Station to prepare user's morning drink in the kitchen. Tap on 'Continue to Home Mode Settings' button, this takes the user back to Home Mode page. (Note: the four wake up mode times displayed on the screen are already preset on the wireframe screen to safe experiment participants' time).

12. There is an option of setting your wake up mode to the preset alarm of your Smart

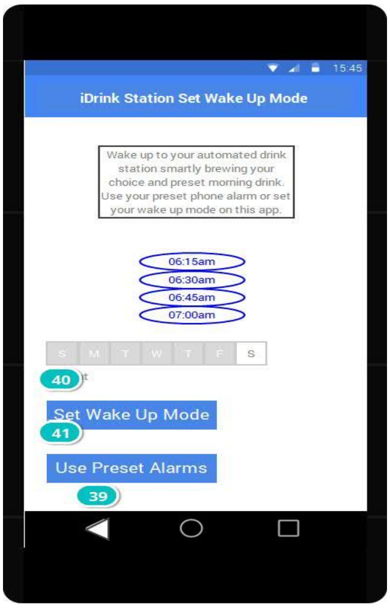


Figure 30: iDrink Station Set Wake Up Mode

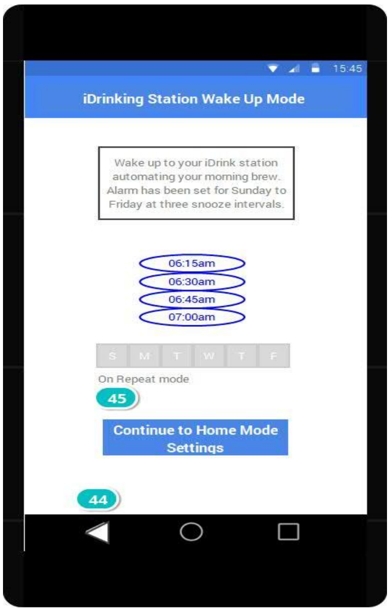


Figure 31: iDrink Station Wake Up Mode

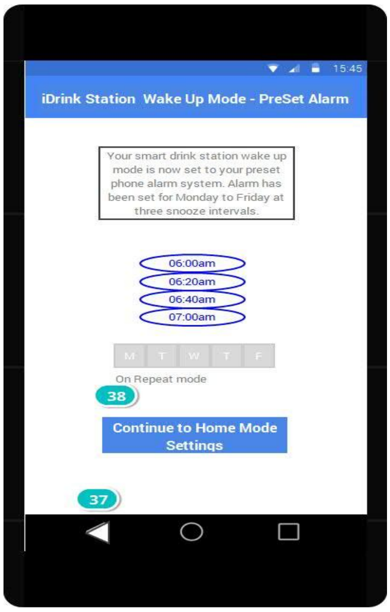


Figure 32: iDrink Station Wake Up Mode - Preset Alarm

phone. On Wake Up Mode Settings page, tap 'Use Preset Alarms' button, which takes the user to the iDrink Station Preset Alarm page and the wake up mode is thus set to the phone's alarm settings. Tap on 'Continue to Home Mode Settings' button to go back to Home Mode Settings page.

13. On iDrink Station Home Mode Settings page, tap on 'Set Location' button, which opens the Home Mode - See Location Map page. Tap on 'See Location Map' button.

14. On iDrink Station Home Mode - Location Map page, tap on the blue location icon to see a landscape view of your street and confirm your house address.

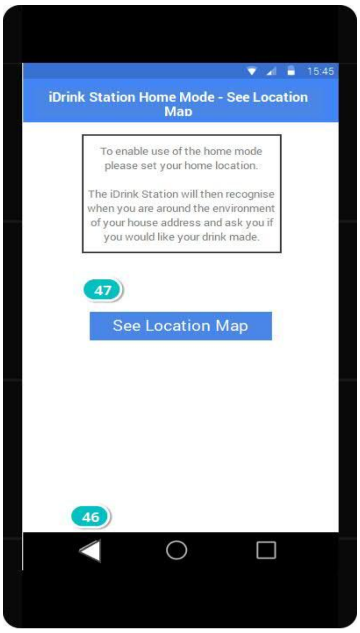


Figure 33: iDrink Station Home Map - Location Map

Figure 34: iDrink Station Home Station Home

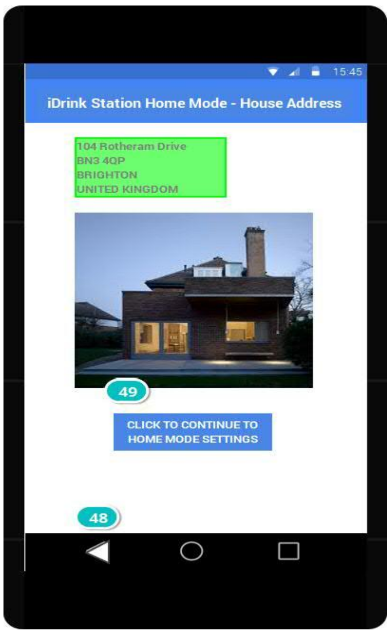


Figure 35: iDrink Mode - See Location Mode - House Address

15. On iDrink Station Home Mode - House Address page, tap on 'Click to Continue To Home Mode Settings' button to go back to iDrink Station Home Mode Settings page.
16. On iDrink Station Home Mode Settings page, tap on 'Set Brew Timer' button, which opens the On iDrink Station Set Brew Timer page.
17. On iDrink Station Set Brew Timer page, tap on 'SAVE' button to set the selected brew duration, which in this case is 2 minutes 30 seconds. For the purpose of saving time during this experimental task, the set time on the screen is fixed.

Figure 36: iDrink Station Set Brew Timer

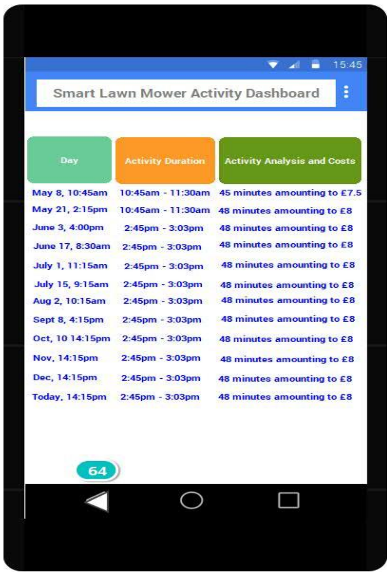


Figure 37: Smart Lawn Mower Activity Dashboard

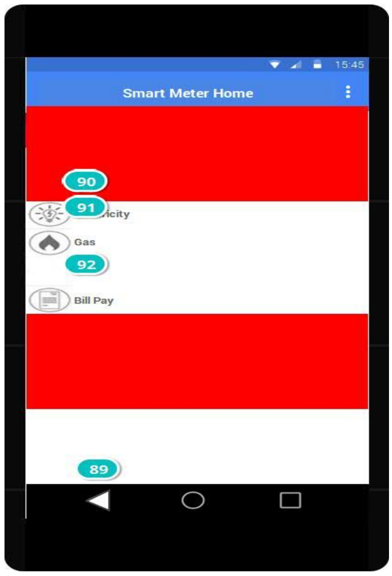


Figure 38: Smart Meter Home

18. iDrink Station Home Mode Settings page, tap on 'Click here when settings are completed' to take the user back to the iDrink Station Home Mode Dashboard page.
19. On iDrink Station Home Mode Dashboard page, the user can tap on any of the 'Disable Wake Up Mode', 'Disable Brew Timer', 'Disable Location' buttons, which will take the user back to the iDrink Station Home Mode Settings page to set and enable this functions. Tap on the back arrow button at the bottom left of the screen to go back to iDrink Station Home Mode Dashboard page, and on this current page also tap on the back arrow button at the bottom left of the screen. This will take the user to the Home and Environment Smart Kits page.
20. On the Home and Environment Smart Kits page, tap on 'Smart Lawn Mower' icon. This opens the Smart Lawn Mower Activity Dashboard page. The page shows the usage history of a rented Smart lawn mower indicating the 'Day', 'Activity Duration', 'Activity Analysis and Cost'. The benefit of renting instead of buying the lawn mower is that a lot of money is saved by the user and the lawn mower is automated to debit the user's account after every usage .

21. Tap on the 'back arrow' button on the bottom left of the screen to go back to the Home and Environment Smart Kits page.

22. On the Home and Environment Smart Kits page, tap on the 'Smart Meter' icon, which opens the Smart Meter Homepage.

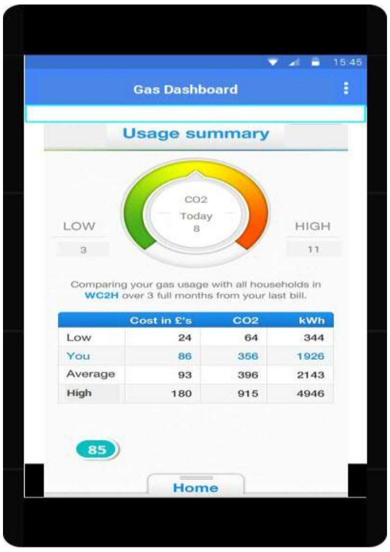


Figure 39: Gas Dash Board

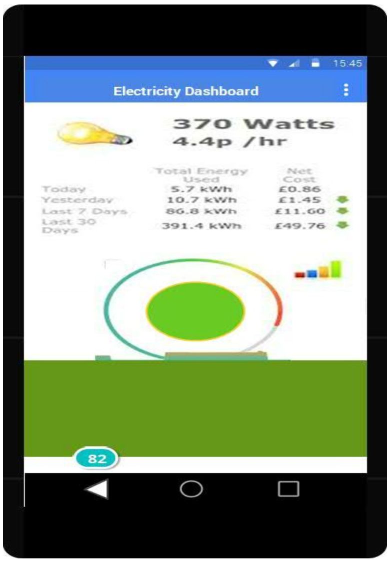


Figure 40: Electricity Dashboard

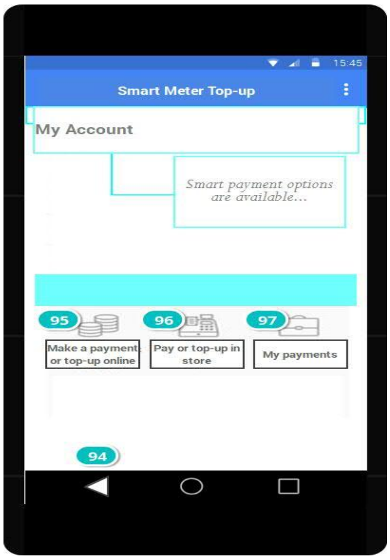


Figure 41: Smart Meter Top-up

23. On the Smart Meter Home page, tap on 'Electricity' icon, which takes the user to the Electricity Dashboard. Tap the 'backward arrow' button to go back to the Smart Meter Homepage. Repeat the same step for the 'Gas' icon.

24. On the Smart Meter Home page, tap on the 'Bill Pay' icon. This opens the Smart Meter Top-Up page.

25. On the Smart Meter Top-Up page, tap on 'Make a payment or Top-up Online' button, which opens the Smart Meter Top-up Online page.

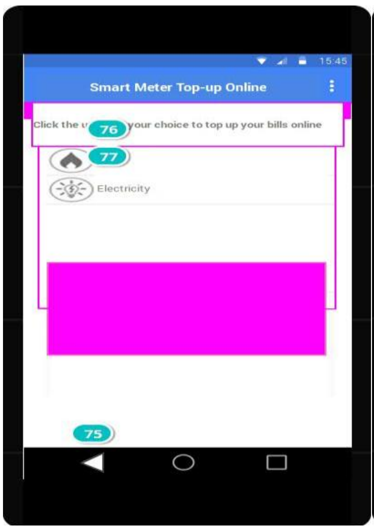


Figure 42: Smart Meter Top-up Online

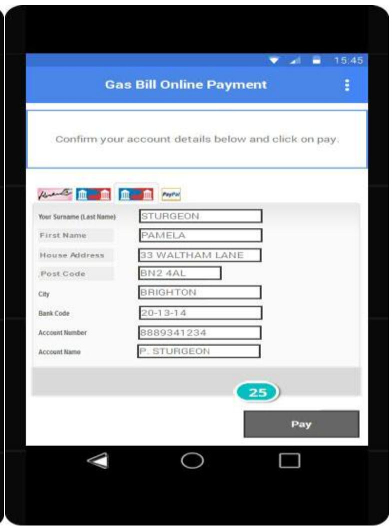


Figure 43: Gas Bill Online Payment Gateway

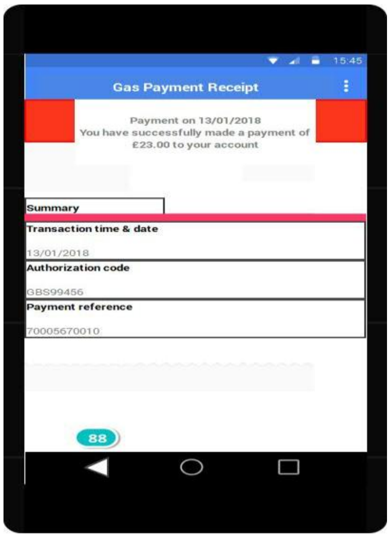


Figure 44: Gas Payment Receipt

26. On the Smart Meter Top-up Online page, tap on 'Gas' icon. This takes the user to the Gas Bill Online Payment Gateway page. Tap on 'Pay' after you have confirmed your preloaded bank account details, which takes the user to the Gas Payment Receipt page. Tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up Online page.

27. On the Smart Meter Top-up Online page, tap on 'Electricity' icon. This takes the user to the Electricity Bill Online Payment Gateway page. Tap on 'Pay' after you have confirmed your preloaded bank account details, which takes the user to the Electricity Payment Receipt page. Tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up Online page. Tap again on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up page.

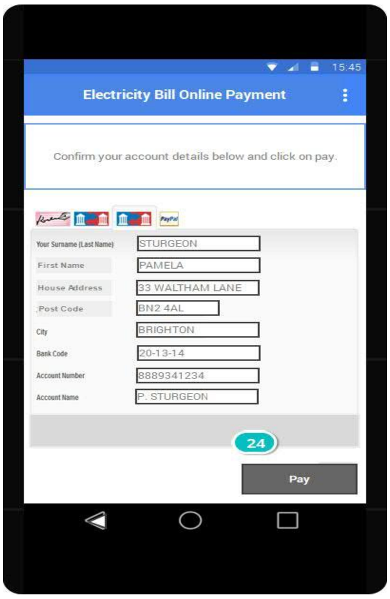


Figure 45: Electricity Bill Online Payment Gateway

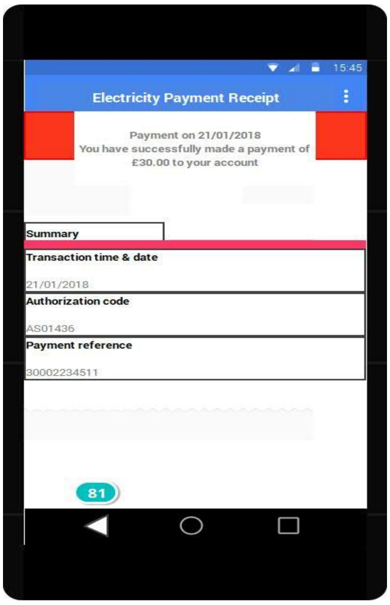


Figure 46: Electricity Payment Receipt

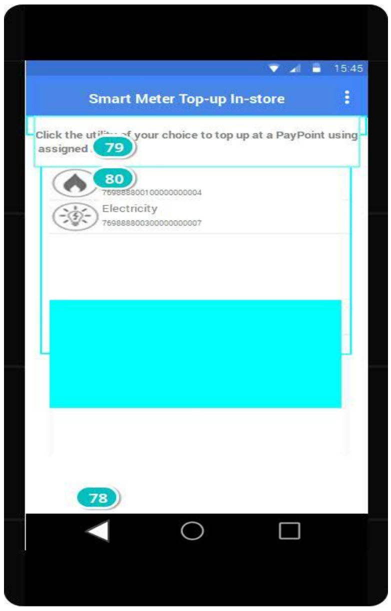
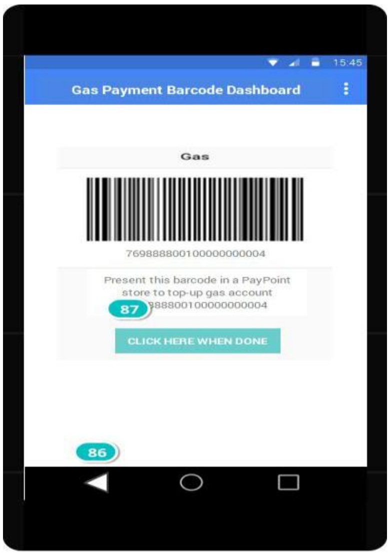
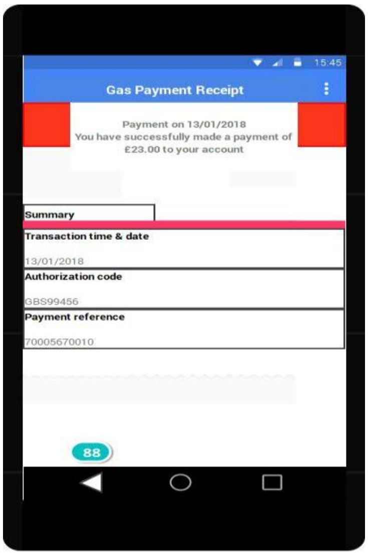


Figure 47: Smart Meter Top-up In-store

28. On the Smart Meter Top-up page, tap on 'Pay or top-up in-store' button. This takes the user to the Smart Meter Top-up In-store page. This top-up procedure automatically generates barcodes for each of the utilities (Gas and Electricity).

29. Tap on the 'Gas' icon on the Smart Meter Top-up In-store page, which opens the Gas Payment Barcode page. The barcode is shown to a PayPoint assistant in-store for scanning and payment for the gas bill. Tap on 'Click here when done' button, and an e-receipt is generated on the user's smart phone. Tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up In-store page. Repeat this same step for the Electricity utility payment in-store, then again tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up page.





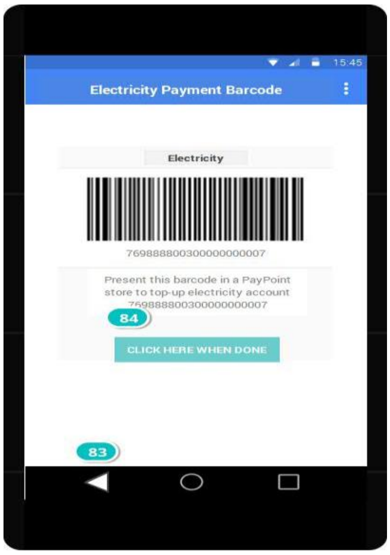
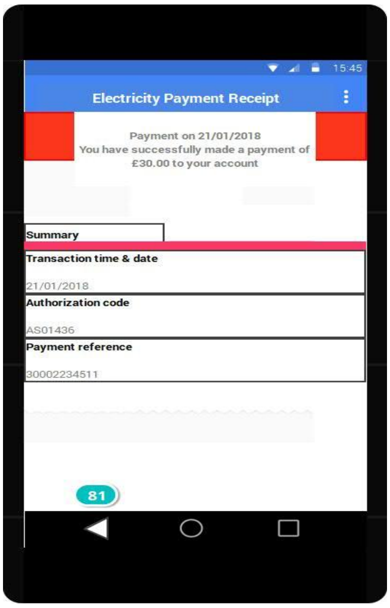


Figure 48: Gas Payment Barcode **Figure 49:** Gas Payment Receipt **Figure 50:** Electricity Payment Barcode

30. On the Smart Meter Top-up page, tap on 'MyPayments' button to view your payment history. Tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Top-up page. Then again tap on the 'backward arrow' button on the bottom left of the screen to go back to the Smart Meter Home page. Tap on the 'backward arrow' button again on the bottom left of the screen to go back to the Home and Environment Smart Kits page. Finally tap on the 'backward arrow' button on the bottom left of the screen to go back to the Home and Environment IoT homepage.



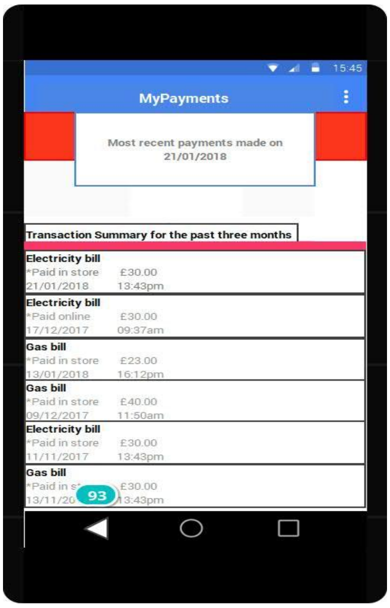


Figure 51: Electricity Payment Receipt **Figure 52:** MyPayments

31. Assuming the user acquires new ioT enabled appliances and wants to add them to the Home and Environment IoT app, on the Home and Environment IoT homepage, tap on 'Add Things', which opens the Home and Environment Add New Smart Kits page. Tap on the

'Browse' search text field, which pops up a list of two new IoT enabled devices (on the wireframe, the two new detected smart appliances - smart cooker and CCTV are selected already). Tap on 'CLICK HERE TO ADD SELECTED SMART THING' button. This takes the user to a Home and Environment Smart Kits page showing the five smart appliances that are now available on the Home and Environment IoT app. However for the purpose of this experimental task, this page has no active links and events, as three of this appliances have already been linked with events in the JustInMind wireframe as earlier illustrated.

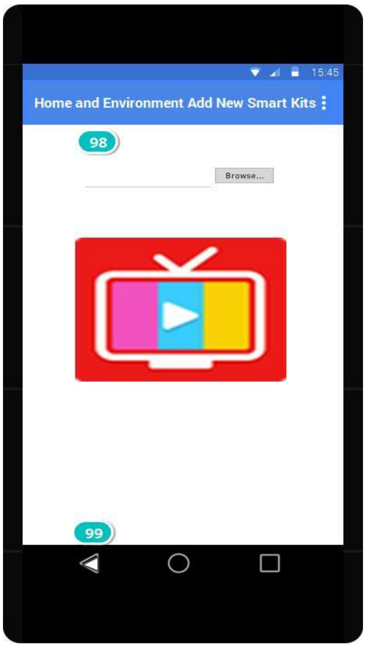


Figure 53: Home and Environment Add New Smart Kits

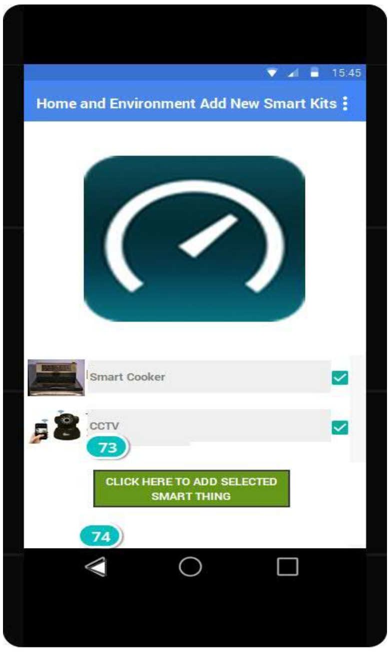


Figure 54: Home and Environment Add New kits

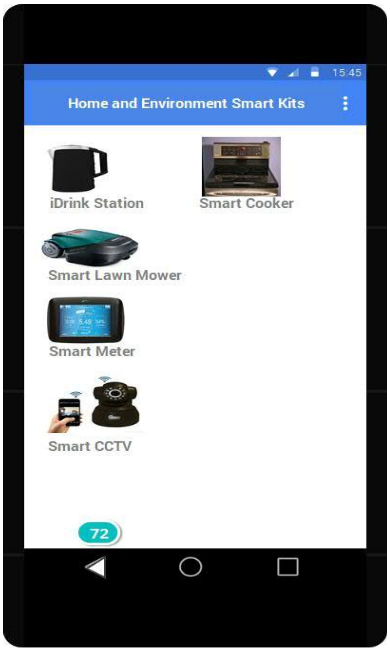


Figure 55: Home and Environment Smart Kits

32. On the Home and Environment Smart Kits page, tap on the 'back arrow' button on the bottom left of the screen to go back to the Home and Environment IoT homepage. On the homepage, also tap on the 'back arrow' button on the bottom left of the screen to go back to the home screen.

10.4 Health monitoring IoT wireframe

1. On the home screen, tap on 'HealthMonIoT' icon, this takes the user (experiment participant) to the Health Monitoring IoT Sign Up page.

2. On the Health Monitoring IoT Sign Up page, tap on the 'Sign up' button, which takes the user to the Account Subscription page. (Note also that the username, password and confirm password text fields already have data entries, such that the user does not need to type in any text. This is aimed at working within the experimental tasks time constraints).

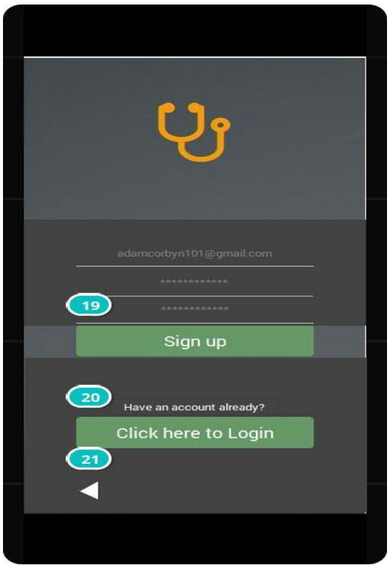


Figure 56: Health Monitoring Sign Up

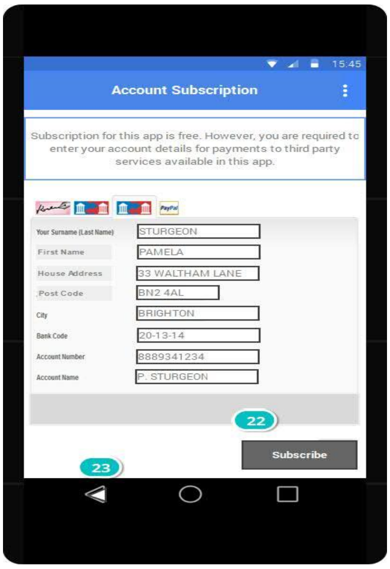


Figure 57: Account Subscription

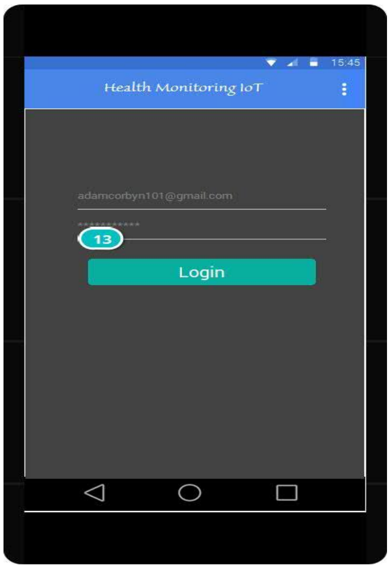


Figure 58: Health Monitoring Login

3. On the Account Subscription page, tap on the 'Subscribe' button (Note: the user bank account details are already entered in the relevant text fields). This takes the user to the Health Monitoring IoT Login page.

4. On the Health Monitoring IoT Login page, tap on 'Login' button (Note: username and password field entries are already entered), which takes the user to the homepage.

5. On the Health Monitoring IoT Homepage, tap on 'Outdoor Air Quality' button to open the Outdoor Air Quality Dashboard. The dashboard is seamlessly updated as the air quality sensors installed receive and transmit atmospheric data. Note that PM10 refers to an ambient healthy air quality with heavy particulate matter (PM) indicating less particle pollution in the atmosphere; while PM2.5 refers to an unhealthy air quality with tiny particulate matter indicating severe particle pollution in the atmosphere that should warrant precautionary measures to protect user health. Tap on the 'backward arrow' button at the bottom left of the screen to go back to the Health Monitoring IoT Homepage.

6. Repeat the above routine for the Indoor Air Quality.

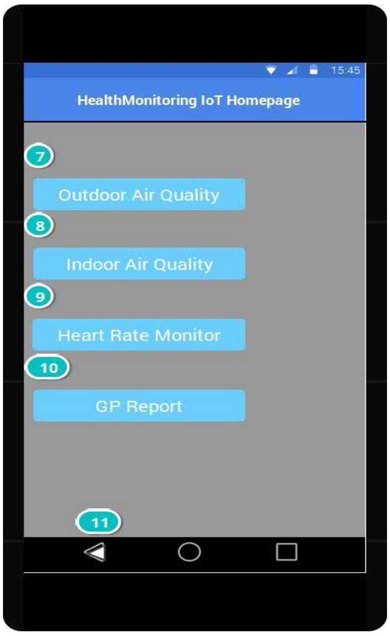


Figure 59: Health Monitoring IoT Homepage

Figure 60: Outdoor Air Quality Dashboard

Figure 61: Indoor Air Quality Dashboard

7. On the Health Monitoring IoT Homepage, tap on Heart Rate Monitor to open the Heart Rate Monitor Dashboard.

8. On Heart rate Monitor Dashboard page, the data highlights a "Today's" beat per minute (bpm) reading of 115, which is not good for the user, as a result of which an alert is triggered suggesting that the user has fluid in the chest. Tap on the 'Click Here for Medication' button, which takes user to the Prescription Cloud.

9. The Prescription Cloud page outlines user prescription history. Tap on 'Click Here to Buy' button to pay for "Today's" prescribed drug, which opens the Medication Payment Gateway page. This page also outlines user prescription history.

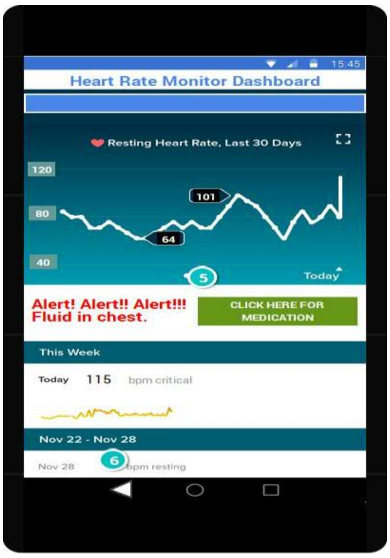


Figure 62: Heart Rate Monitor Dashboard

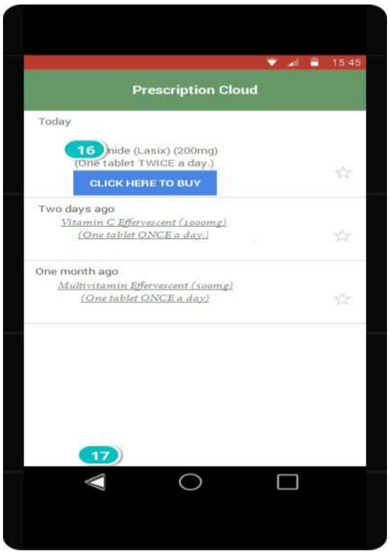


Figure 63: Prescription Cloud

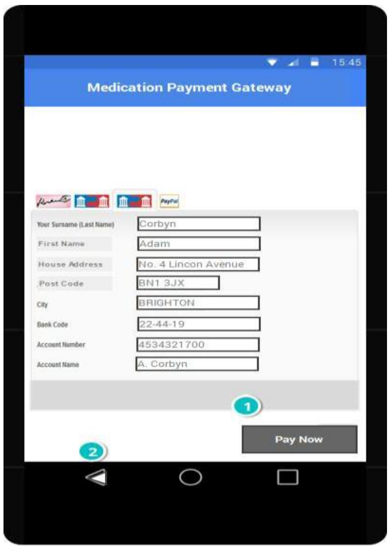
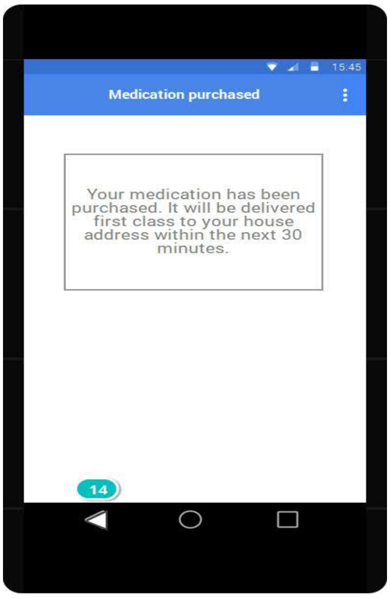


Figure 64: Medication Payment Gateway

10. On the Medication Payment Gateway page, tap on 'Pay Now' button, which takes user to the Medication Purchased page.

11. On the Medication Purchased page, tap on the 'backward arrow' button at the bottom left of the screen to go back to the Health Monitoring IoT Homepage.

12. On the Health Monitoring IoT Homepage, tap on 'GP Report' button to open the GP Report Cloud, where GP messages on detected conditions and possible appointments are received by the user. The user can also send messages and enquiries to the GP on issues relating to his/her health.



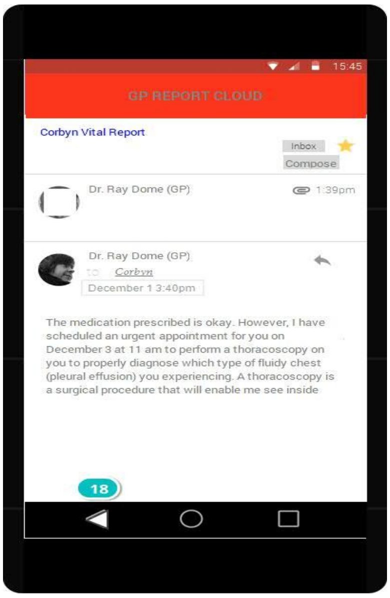


Figure 65: Medication Purchased **Figure 66:** GP Report Cloud

11. Appendix C

11.1 MSI transformation of the five generic components of the DTBM adoption framework for IoT

As reported in section 5.7.1, three question items were constructed for this component. Two questions to measure price range a user may be willing to pay and one question for inclination to consider price before purchase the product context for the Smartphone/app on one hand and IoT scenarios on the other hand. However, the transformation from ordinal to interval scale was only carried out on **inclination to consider price** question item. However, the price range question items will be used in the cross tabulation descriptive analysis and correlation analysis.

1. The MSI transformation for to IncCPP (Sp)

Each option of IncCPP (Sp) is assigned an *attribute value* that could be used for non-parametric analysis as follows:

(a) Not very important = 1;

(b) Not important = 2;

(c) Important = 3;

(d) Very important = 4.

Step 1: Determine the frequency of the response data for each option

- Not very important = 2;
- Not important = 3;
- Important = 32;
- Very important = 29.

Step 2: Determine the proportion (P_n) of response data for each option by dividing the frequency of choice with number of samples

- Proportion for not very important option (P1) = 2/66 = 0.03
- Proportion for not important option (P2) = 3/66 = 0.05
- Proportion for important option (P3) = 32/66 = 0.48
- Proportion for very important option (P4) = 29/66 = 0.44

Step 3: Calculate the cumulative proportion (PK_n) of P_n by summing the proportion sequentially for each option

- PK1 = 0.03

- PK2 = 0.03 + 0.05 = 0.08

- PK3 = 0.08 + 0.48 = 0.56

- PK4 = 0.56 + 0.44 = 1.00

Step 4: Use the standard normal distribution to determine the value of Z for each cumulative proportion

A normal Z distribution table is used in finding the Z values. If the desired value of Z is not found in the Table, then the closest value is used by linear interpolation. Z value for each cumulative proportion is the distance from the midpoint of the normal curve Z to respective cumulative proportions, as shown in figure 11-1.

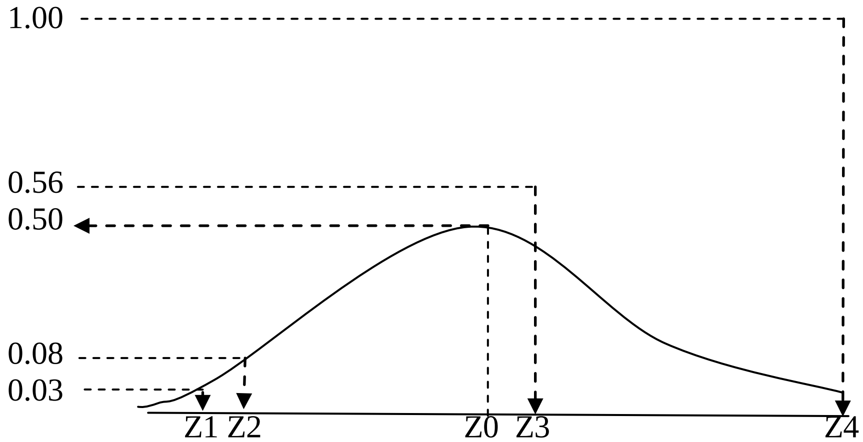


Figure 11-1: Z values in normal curve for response data for ITCPP (Sp)

∴ for PK1 = 0.03,

*The area of the Z0 to Z1 = PK1 – 0.5 = –0.47

On the Z table there is no negative integers so, the next step is to locate the size area 0.47 in the Z distribution table. The size area 0.47 is not in the Table, therefore the closest size area is 0.47062. Z value that corresponds to the size area 0.47062 is 1.89.

*Finally, the value Z1 = –1.89.

Using the same method above we obtain Z2, Z3, and Z4 for each PK2, PK3, and PK4 as follows:

For PK2 = 0.08; Z0 to Z2 = PK2 – 0.5 = –0.42 → Z2 = –1.41

For PK3 = 0.56; Z0 to Z3 = PK3 – 0.5 = 0.06 → Z3 = 0.16

For PK4 = 1.00; Z0 to Z4 = PK4 – 0.5 = 0.5 ≅ Unlimited ≅ 0 → Z4 = ~

Step 5: For each value of Z, find the density value (DZ)

Density values are in the ordinate (y) column in the normal curve size Table. Now, using the probability density function formula:

$$f(x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-x^2}{2}}$$

For Z1 = –1.89, DZ1 =

$$f(Z1) = \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}}$$

f(Z1) = 1/2.50662 * 5.96584 = 1/14.95410

∴ DZ1 = f(Z1) = 0.06687

The same operation carried out for DZ2, DZ3, DZ4 results as follows:.

For Z2 = –1.41 , DZ2 = f(Z2) = 0.14763

For Z3 = 0.16, DZ3 = f(Z3) = 0.39387

For Z4 = ~ , DZ4 = 0

<u>Step 6</u>: Calculate the Counting Scale Value (SV) for each option

$$SV = \frac{\textit{density lower limit – density upper limit value}}{\textit{suitable cumulative proportion – underneath cumulative proportion}}$$

That is, $SV = \frac{DZ_{n-1} - DZ_n}{PK_n - PK_{n-1}}$

∴ SV1 = (0 – 0.06687) ÷ (0.03 – 0) = – 2.2290

SV2 = (0.06687 – 0.14763) ÷ (0.08 – 0.03) = – 1.6152

SV3 = (0.14763 – 0.39387) ÷ (0.56 – 0.08) = –0.5130

SV4 = (0.39387 – 0) ÷ (1 – 0.56) = 0.8952

<u>Step 7</u>: Determine the Transformed Scale Value (TSV)

Increase the smallest Scale Value (SV) by one (1) to obtain a *new smallest SV* and add this *new smallest SV* to each of SVs to obtain the Transformed Scale Value (TSV). The aim of this procedure is to ensure that the smallest SV, when transformed, will be equal to one (1). Now, the smallest SV is SV1 = -2.2290;

∴ To transform each SVs, 3.2290 need to be added to each SV;

∴ TSV1 = –2.2290+ 3.2290 = 1.0000

TSV2 = –0.6152 + 3.2290 = 1.6138

TSV3 = 0.5130 + 3.2290 = 2.7160

TSV4 = 0.8952 + 3.2290 = 4.1242

The TSVs are the result of the sequential transformation from the ordinal scale to the distance (interval) scale. The results are shown in table 11-1.

Table 11-1: Transformation Results from the ordinal to interval Scale for question item IncCPP (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Not very important	1	1.0000
Not important	2	1.6138
Important	3	2.7160
Very important	4	4.1242

This transformation process carried out on question item IncCPP (Sp) above, is also performed on other question items associated with the generic components of the BM framework. The next transformation is performed for the post-experiment question item IncCPP (IoT).

2. Inclination to consider product price - IncCPP (IoT)

Step 1

- Not very important = 1;
- Not important = 0;
- Important = 38;
- Very important = 27.

Step 2

- Proportion for not very important option (P1) = 1/66 = 0.02
- Proportion for not important option (P2) = 0/66 = 0
- Proportion for important option (P3) = 38/66 = 0.57
- Proportion for very important option (P4) = 27/66 = 0.41

Step 3

- PK1 = 0.02
- PK2 = 0.02 + 0 = 0.02
- PK3 = 0.02 + 0.57 = 0.59
- PK4 = 0.59 + 0.41 = 1.00

Step 4

Z1 = -2.06.
Z2 = -2.06.
Z3 = 0.23
Z4 = ~

Step 5

DZ1 = 0.04780

DZ2 = 0.04780

DZ3 = 0.38853

DZ4 = 0

Step 6

SV1 = (0 – 0.04780) ÷ (0.02 – 0) = –2.3000

SV2 = (0 – 0.06687) ÷ (0.02 – 0.02) = 0

SV3 = (0.04780 – 0.36653) ÷ (0.59 – 0.02) = –0.5778

SV4 = (0.38853 – 0) ÷ (1 – 0.59) = 0.9476

Step 7

TSV1 = –2.3000 + 3.3000= 1.000

TSV3 = 0.5778 + 3.3000= 2.7222

TSV4 = 0.9476 + 3.3000= 4.2476

The results are shown in table 11-2.

Table 11-2: Transformation Results from the ordinal to interval Scale for question item IncCPP (IoT)

Options	**Before transformation (ordinal scale)**	**After transformation (interval scale)**
Not very important	1	1.0000
Not important	2	0
Important	3	2.7222
Very important	4	4.2476

3. Inclination to value training - IncVT (Sp)

Step 1

- Not very helpful = 6;
- Not helpful = 4;
- Helpful = 42;
- Very helpful = 14.

Step 2

- Proportion for not very helpful option (P1) = 6/66 = 0.09
- Proportion for not helpful option (P2) = 4/66 = 0.06
- Proportion for helpful option (P3) = 42/66 = 0.64
- Proportion for very helpful option (P4) = 14/66 = 0.21

Step 3

- PK1 = 0.09
- PK2 = 0.09 + 0.06 = 0.15
- PK3 = 0.15 + 0.64 = 0.79

- PK4 = 0.79 + 0.21 = 1.00

Step 4

Z1 = –1.35

Z2 = –1.04

Z3 = 0.81

Z4 = ~

Step 5

DZ1 = 0.16038

DZ2 = 0.23230

DZ3 = 0.28737

DZ4 = 0

Step 6

SV1 = (0 – 0.16038) ÷ (0.09 – 0) = – 1.7820

SV2 = (0.16038 – 0.23230) ÷ (0.15 – 0.09) = – 1.1987

SV3 = (0.23230 – 0.28737) ÷ (0.79 – 0.15) = 0.0826

SV4 = (0.28737 – 0) ÷ (1 – 0.79) = 1.3684

Step 7

TSV1 = –1.7820+ 2.7820= 1.0000

TSV2 = –0.1987 + 2.7820 = 1.5833

TSV3 = 0.0826 + 2.7820 = 2.6994

TSV4 = 1.3684 + 2.7820 = 4.1504

The results are shown in table 11-3.

Table 11-3: Transformation Results from the ordinal to interval Scale for question item IncVT (Sp)

Options	**Before transformation (ordinal scale)**	**After transformation (interval scale)**
Not very helpful	1	1.0000
Not helpful	2	1.5833
Helpful	3	2.6994
Very helpful	4	4.1504

Now, using the steps laid out in the foregoing, the results of the remaining transformations are shown in tables 11-4 to 11-10.

Table 11-4: Transformation Results from the ordinal to interval Scale for question item IncVT (IoT)

Options	**Before transformation (ordinal scale)**	**After transformation (interval scale)**
Not very valuable	1	0
Not valuable	2	1.0000
Valuable	3	3.5191
Very valuable	4	4.5974

Table 11-5: Transformation results from the ordinal to interval Scale for question item IncSSP (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Weekly	1	1.0000
Monthly	2	2.8258
Quarterly	3	3.9541
Annually	4	4.6806

Table 11-6: Transformation Results from the ordinal to interval Scale for question item IncSSP (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Weekly	1	1.0000
Monthly	2	2.5245
Quarterly	3	3.4820
Annually	4	4.2476

Table 11-7: Transformation Results from the ordinal to interval Scale for question item IncSPVO (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very dissatisfied	1	1.0000
Dissatisfied	2	0
Satisfied	3	2.4461
Very satisfied	4	3.8984

Table 11-8: Transformation Results from the ordinal to interval Scale for question item IncSPVO (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very dissatisfied	1	0
Dissatisfied	2	0
Satisfied	3	1.0000
Very satisfied	4	1.8047

Table 11-9: Transformation Results from the ordinal to interval Scale for question item IncTPVO (Sp)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Very hesitant	1	1.0000
Hesitant	2	1.9567
Not hesitant	3	2.9803
Not very hesitant	4	4.2139

Table 11-10: Transformation Results from the ordinal to interval Scale for question item IncTPVO (IoT)

Options	Before transformation (ordinal scale)	After transformation (interval scale)
Not very trustworthy	1	0
Not trustworthy	2	1.0000
Trustworthy	3	3.1465
Very trustworthy	4	4.7782

11.2 Results of normality test for the recoded ordinal data (to four-point scale) of the matched pairs of user inclinations

Warnings

IncCPP (Sp) is constant when IncCPP (IoT) = Not very important. It will be included in any boxplots produced but other output will be omitted.

1. IncCPP (IoT)

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	IncCPP (IoT)	N	Percent	N	Percent	N	Percent
IncCPP (Sp)	Not very important	1	100.0%	0	0.0%	1	100.0%
	Important	38	100.0%	0	0.0%	38	100.0%
	Very important	27	100.0%	0	0.0%	27	100.0%

Descriptives[a]

	IncCPP (IoT)			Statistic	Std. Error
IncCPP (Sp)	Important	Mean		3.08	.122
		95% Confidence Interval for Mean	Lower Bound	2.83	
			Upper Bound	3.33	
		5% Trimmed Mean		3.14	
		Median		3.00	
		Variance		.561	
		Std. Deviation		.749	
		Minimum		1	
		Maximum		4	
		Range		3	
		Interquartile Range		1	
		Skewness		-.946	.383
		Kurtosis		1.649	.750
	Very important	Mean		3.67	.092
		95% Confidence Interval for Mean	Lower Bound	3.48	
			Upper Bound	3.86	
		5% Trimmed Mean		3.69	
		Median		4.00	
		Variance		.231	
		Std. Deviation		.480	
		Minimum		3	
		Maximum		4	
		Range		1	

	Interquartile Range	1	
	Skewness	-.749	.448
	Kurtosis	-1.560	.872

a. IncCPP (Sp) is constant when IncCPP (IoT) = Not very important. It has been omitted.

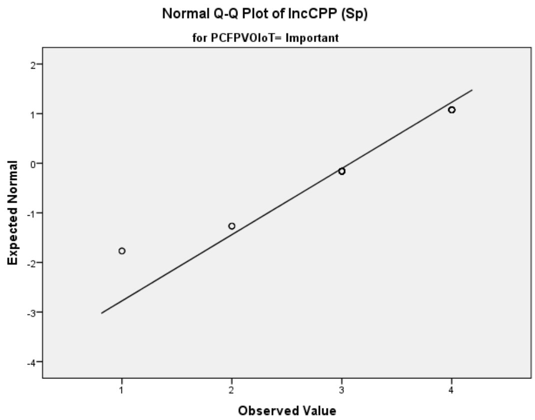
Tests of Normality[a]

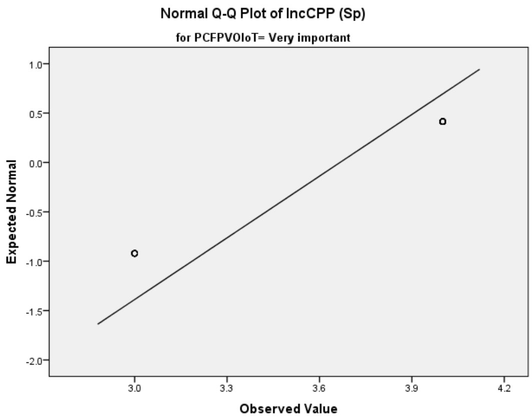
		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	IncCPP (IoT)	Statistic	df	Sig.	Statistic	df	Sig.
IncCPP (Sp)	Important	.326	38	.000	.772	38	.000
	Very important	.423	27	.000	.597	27	.000

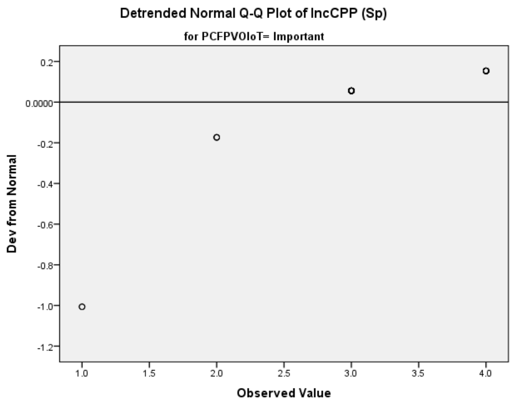
a. IncCPP (Sp) is constant when IncCPP (IoT) = Not very important. It has been omitted.

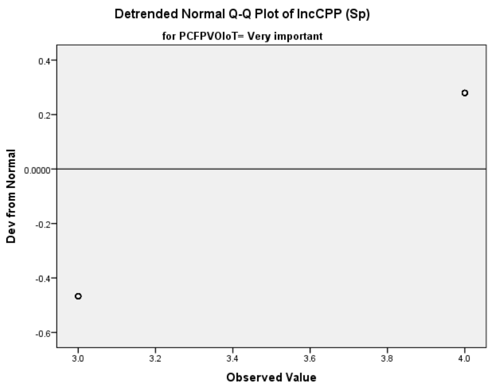
b. Lilliefors Significance Correction

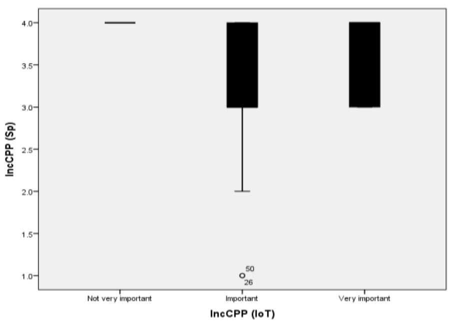
IncCPP (Sp)











Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
IncVT (Sp)	66	100.0%	0	0.0%	66	100.0%
IncVT (IoT)	66	100.0%	0	0.0%	66	100.0%

Descriptives

			Statistic	Std. Error
IncVT (Sp)	Mean		2.97	.099
	95% Confidence Interval for Mean	Lower Bound	2.77	
		Upper Bound	3.17	
	5% Trimmed Mean		3.02	
	Median		3.00	
	Variance		.645	
	Std. Deviation		.803	
	Minimum		1	
	Maximum		4	
	Range		3	
	Interquartile Range		0	
	Skewness		-1.046	.295
	Kurtosis		1.299	.582
IncVT (IoT)	Mean		3.18	.057
	95% Confidence Interval for Mean	Lower Bound	3.07	
		Upper Bound	3.30	
	5% Trimmed Mean		3.18	
	Median		3.00	
	Variance		.213	
	Std. Deviation		.461	
	Minimum		2	
	Maximum		4	
	Range		2	
	Interquartile Range		0	
	Skewness		.658	.295
	Kurtosis		.676	.582

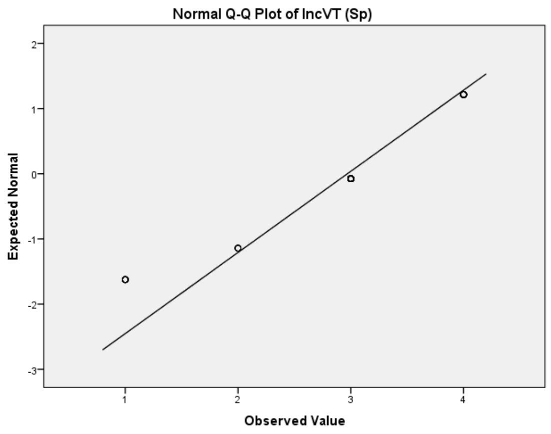
Tests of Normality

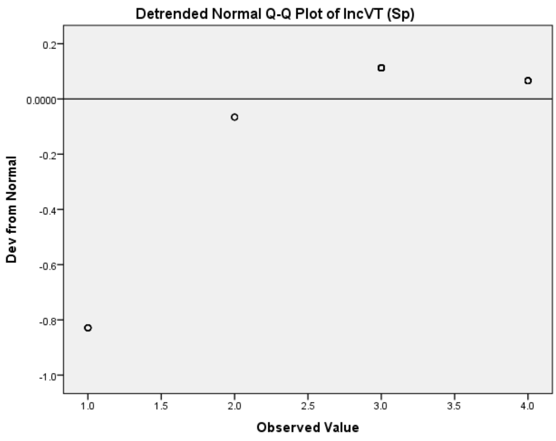
	Kolmogorov-Smirnov[a]	Shapiro-Wilk

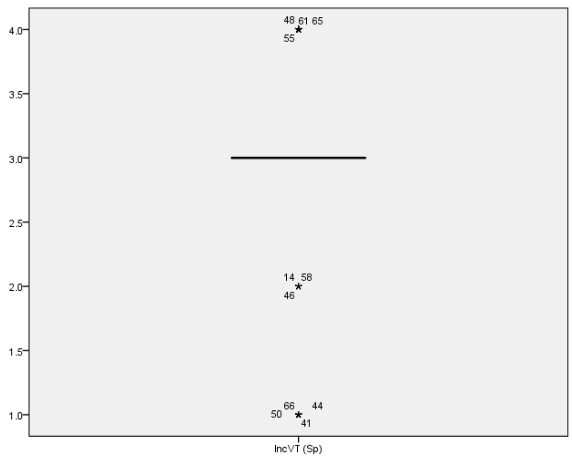
	Statistic	df	Sig.	Statistic	df	Sig.
IncVT (Sp)	.364	66	.000	.746	66	.000
IncVT (IoT)	.441	66	.000	.617	66	.000

a. Lilliefors Significance Correction

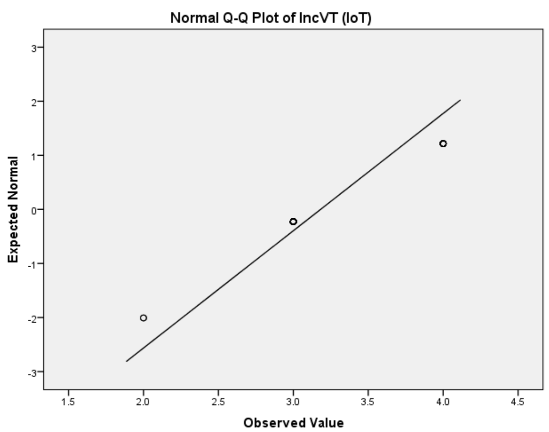
IncVT (Sp)

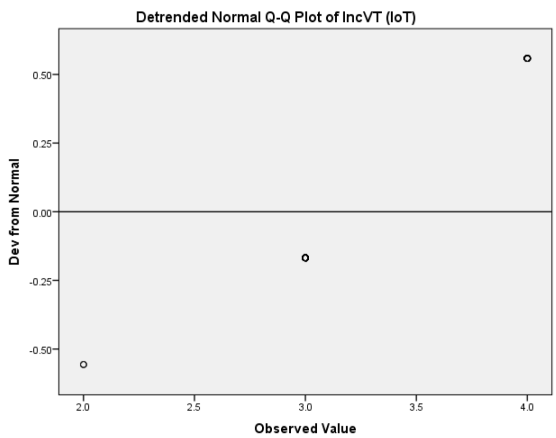


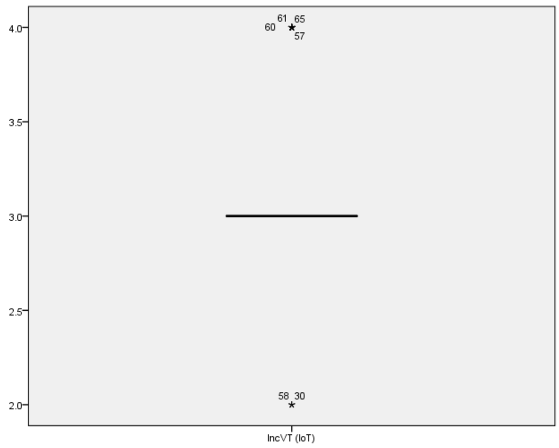




IncVT (IoT)







Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
IncSPVO (Sp)	66	100.0%	0	0.0%	66	100.0%
IncSPVO (IoT)	66	100.0%	0	0.0%	66	100.0%

Descriptives

			Statistic	Std. Error
IncSPVO (Sp)	Mean		3.30	.094
	95% Confidence Interval for Mean	Lower Bound	3.12	
		Upper Bound	3.49	
	5% Trimmed Mean		3.39	
	Median		3.00	
	Variance		.584	
	Std. Deviation		.764	
	Minimum		1	
	Maximum		4	
	Range		3	
	Interquartile Range		1	
	Skewness		-1.435	.295
	Kurtosis		2.771	.582
IncSPVO (IoT)	Mean		3.24	.053
	95% Confidence Interval for Mean	Lower Bound	3.14	
		Upper Bound	3.35	
	5% Trimmed Mean		3.21	
	Median		3.00	
	Variance		.186	
	Std. Deviation		.432	

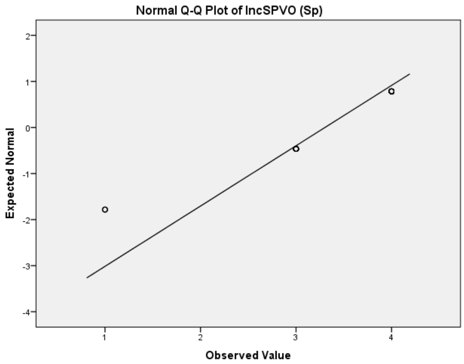
	Minimum	3	
	Maximum	4	
	Range	1	
	Interquartile Range	0	
	Skewness	1.230	.295
	Kurtosis	-.503	.582

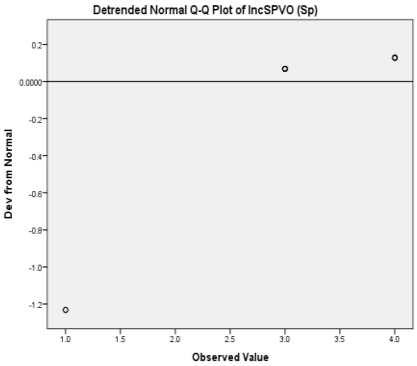
Tests of Normality

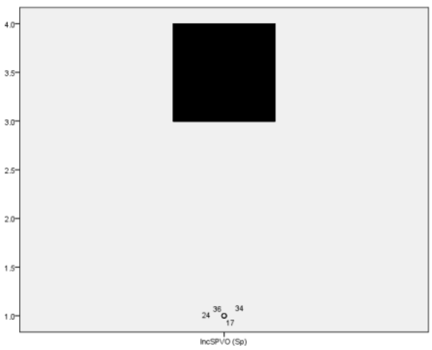
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IncSPVO (Sp)	.285	66	.000	.696	66	.000
IncSPVO (IoT)	.470	66	.000	.532	66	.000

a. Lilliefors Significance Correction

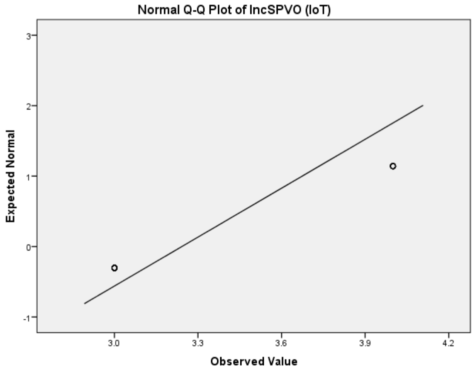
IncSPVO (Sp)

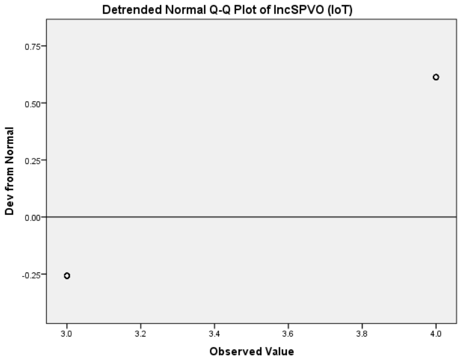


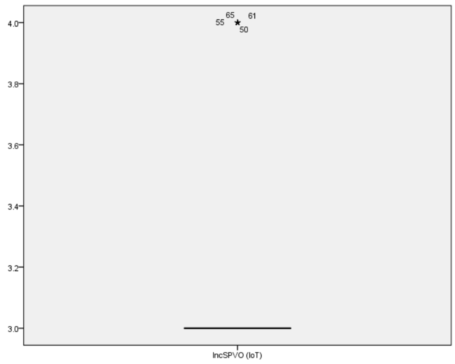




IncSPVO (IoT)







Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
IncSSP (Sp)	66	100.0%	0	0.0%	66	100.0%
IncSSP (IoT)	66	100.0%	0	0.0%	66	100.0%

Descriptives

			Statistic	Std. Error
IncSSP (Sp)	Mean		2.44	.102
	95% Confidence Interval for Mean	Lower Bound	2.24	
		Upper Bound	2.64	
	5% Trimmed Mean		2.41	
	Median		2.00	
	Variance		.681	
	Std. Deviation		.825	
	Minimum		1	
	Maximum		4	
	Range		3	
	Interquartile Range		1	
	Skewness		1.047	.295
	Kurtosis		-.154	.582
IncSSP (IoT)	Mean		2.62	.116
	95% Confidence Interval for Mean	Lower Bound	2.39	
		Upper Bound	2.85	
	5% Trimmed Mean		2.63	
	Median		2.00	
	Variance		.885	
	Std. Deviation		.941	
	Minimum		1	

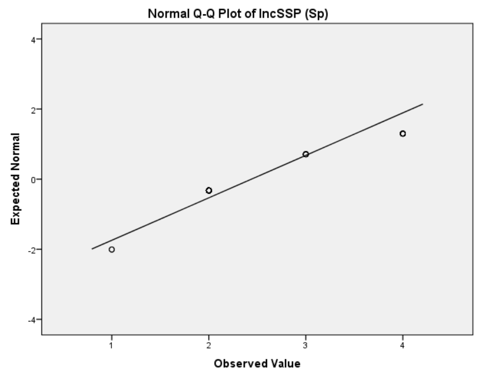
	Maximum	4	
	Range	3	
	Interquartile Range	2	
	Skewness	.495	.295
	Kurtosis	-1.174	.582

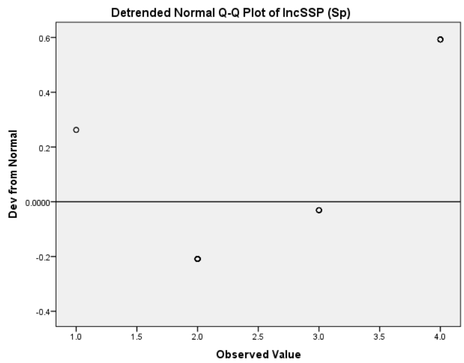
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IncSSP (Sp)	.415	66	.000	.679	66	.000
IncSSP (IoT)	.352	66	.000	.759	66	.000

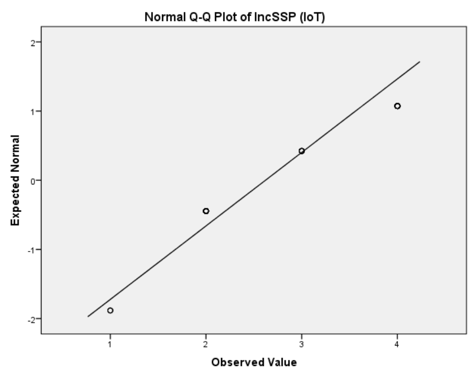
a. Lilliefors Significance Correction

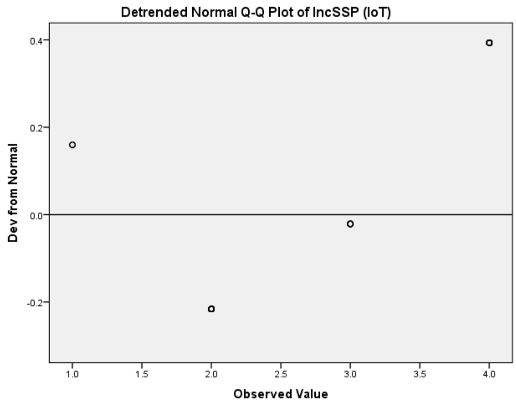
IncSSP (Sp)

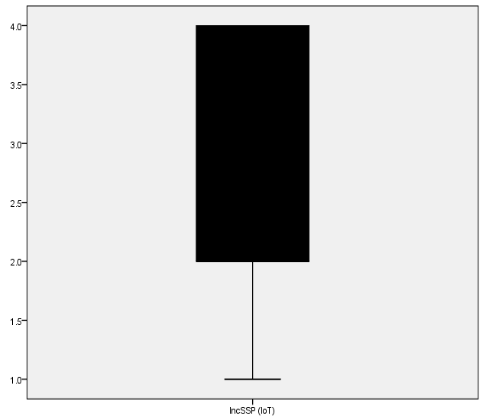




IncSSP (IoT)







Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
IncTPVO (Sp)	66	100.0%	0	0.0%	66	100.0%
IncTPVO (IoT)	66	100.0%	0	0.0%	66	100.0%

Descriptives

			Statistic	Std. Error
IncTPVO (Sp)	Mean		2.83	.105
	95% Confidence Interval for Mean	Lower Bound	2.62	
		Upper Bound	3.04	
	5% Trimmed Mean		2.87	
	Median		3.00	
	Variance		.726	
	Std. Deviation		.852	
	Minimum		1	
	Maximum		4	
	Range		3	
	Interquartile Range		1	
	Skewness		-.439	.295
	Kurtosis		-.270	.582
IncTPVO (IoT)	Mean		3.06	.043
	95% Confidence Interval for Mean	Lower Bound	2.98	
		Upper Bound	3.15	
	5% Trimmed Mean		3.05	
	Median		3.00	
	Variance		.119	
	Std. Deviation		.345	

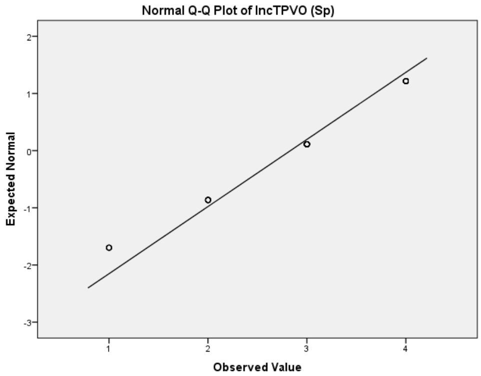
	Minimum	2	
	Maximum	4	
	Range	2	
	Interquartile Range	0	
	Skewness	.991	.295
	Kurtosis	5.390	.582

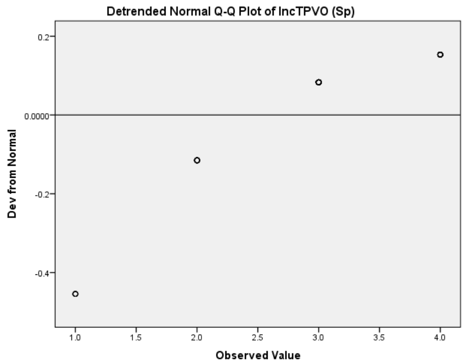
Tests of Normality

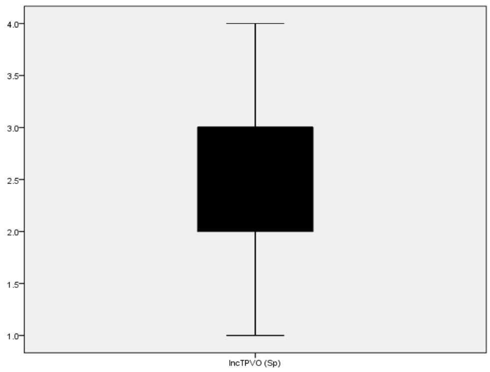
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
IncTPVO (Sp)	.275	66	.000	.856	66	.000
IncTPVO (IoT)	.479	66	.000	.463	66	.000

a. Lilliefors Significance Correction

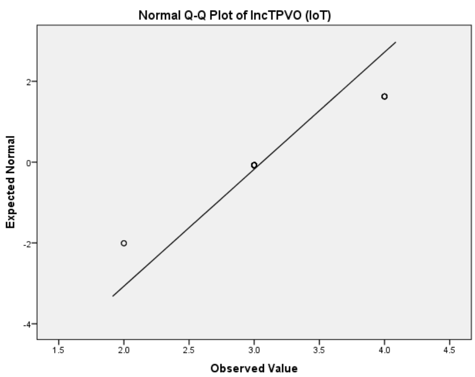
IncTPVO (Sp)

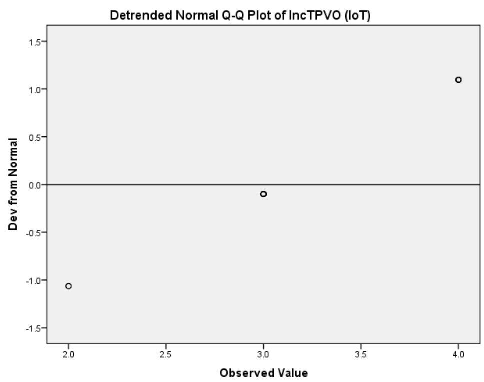


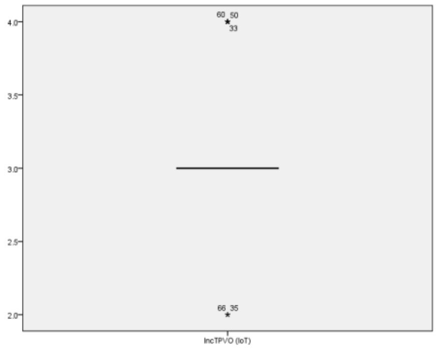




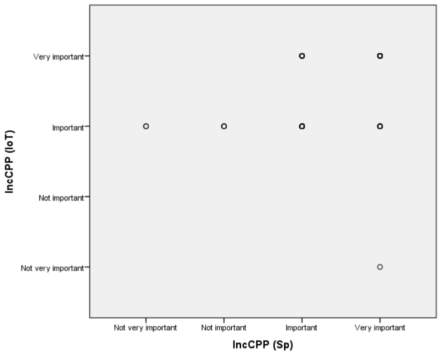
IncTPVO (IoT)

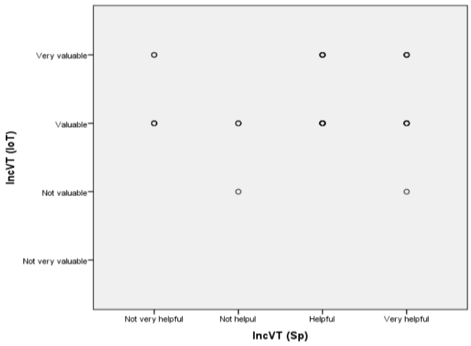


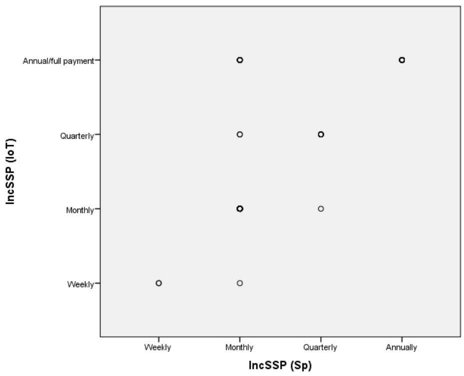


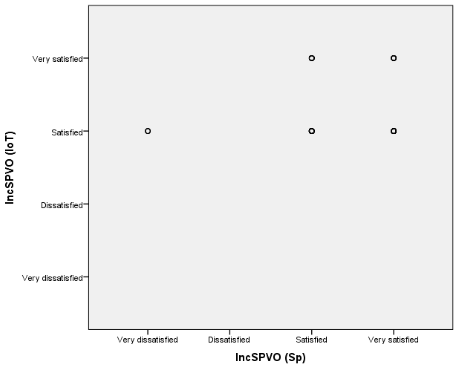


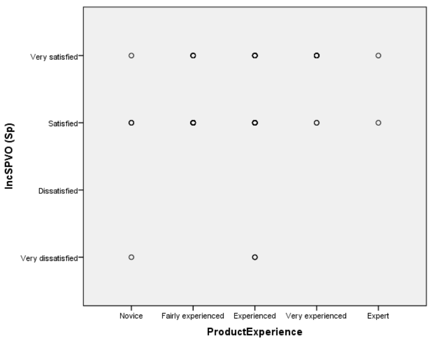
11.3 Scatterplots for the Spearman correlations

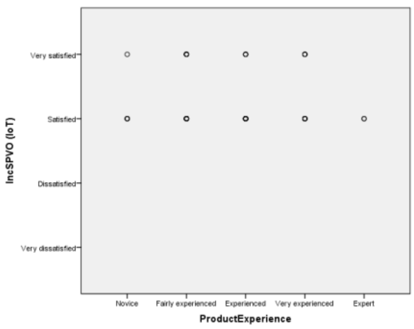


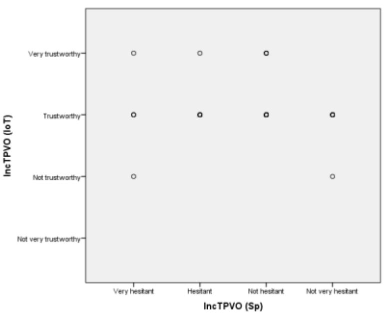












12 Appendix D

12.1 Results of the Sign test for the matched pairs of user inclinations

1. Sign Test Result for IncCPP_SP and IncCPP_IoT

Report

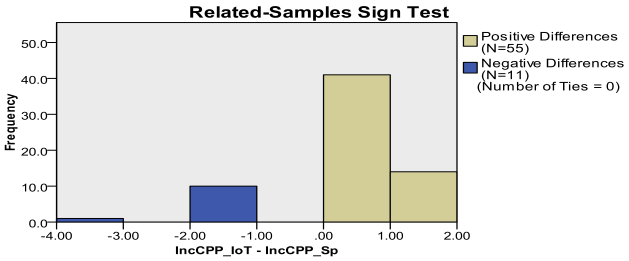
Median

IncCPP_Sp	IncCPP_IoT	differenceCpp
2.716000	2.722200	.006200

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between IncCPP_Sp and IncCPP_IoT equals 0.	Related-Samples Sign Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.



Total N	66
Test Statistic	55.000
Standard Error	4.062
Standardized Test Statistic	5.293
Asymptotic Sig. (2-sided test)	.000

2. Sign Test Result for IncVT_SP and IncVT_IoT

Report

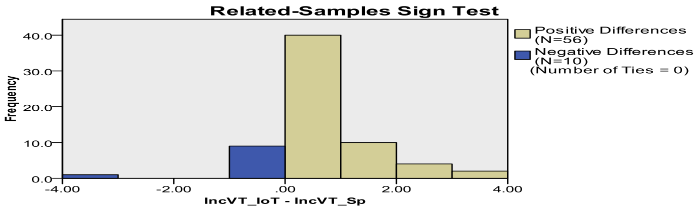
Median

IncVT_Sp	IncVT_IoT	differenceVT
2.699400	3.519100	.819700

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between IncVT_Sp and IncVT_IoT equals 0.	Related-Samples Sign Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.



Total N	66
Test Statistic	56.000
Standard Error	4.062
Standardized Test Statistic	5.539
Asymptotic Sig. (2-sided test)	.000

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
IncVT_Sp	66	100.0%	0	0.0%	66	100.0%
IncVT_IoT	66	100.0%	0	0.0%	66	100.0%
differenceVT	66	100.0%	0	0.0%	66	100.0%

3. Sign Test Result for IncSSP_SP and IncSSP_IoT

Report

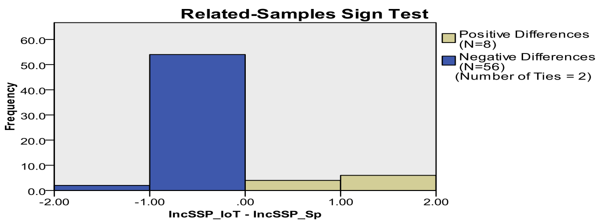
Median

IncSSP_Sp	IncSSP_IoT	differenceSSP
2.825800	2.524500	-.301300

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between IncSSP_Sp and IncSSP_IoT equals 0.	Related-Samples Sign Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.



Total N	66
Test Statistic	8.000
Standard Error	4.000
Standardized Test Statistic	-5.875
Asymptotic Sig. (2-sided test)	.000

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
IncSSP_Sp	66	100.0%	0	0.0%	66	100.0%
IncSSP_IoT	66	100.0%	0	0.0%	66	100.0%
differenceSSP	66	100.0%	0	0.0%	66	100.0%

4. Sign Test Result for IncSPVO_SP and IncSPVO_IoT

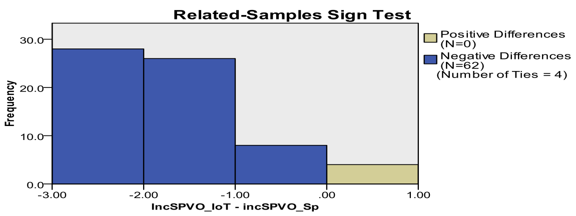
Report

Median		
incSPVO_Sp	IncSPVO_IoT	differenceSPVO
2.446100	1.000000	-1.446100

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between incSPVO_Sp and IncSPVO_IoT equals 0.	Related-Samples Sign Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.



Total N	66
Test Statistic	.000
Standard Error	3.937
Standardized Test Statistic	-7.747
Asymptotic Sig. (2-sided test)	.000

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
incSPVO_Sp	66	100.0%	0	0.0%	66	100.0%
IncSPVO_IoT	66	100.0%	0	0.0%	66	100.0%
differenceSPVO	66	100.0%	0	0.0%	66	100.0%

5. Sign Test Result for IncTPVO_SP and IncTPVO_IoT

Report

Median

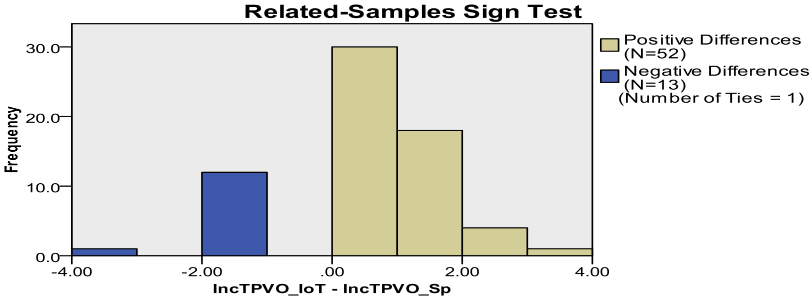
IncTPVO_Sp	IncTPVO_IoT	differenceTPVO
2.980300	3.146500	.166200

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between IncTPVO_Sp and IncTPVO_IoT equals 0.	Related-Samples Sign Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Related-Samples Sign Test



Total N	66
Test Statistic	52.000
Standard Error	4.031
Standardized Test Statistic	4.713
Asymptotic Sig. (2-sided test)	.000

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
IncTPVO_Sp	66	100.0%	0	0.0%	66	100.0%
IncTPVO_IoT	66	100.0%	0	0.0%	66	100.0%
differenceTPVO	66	100.0%	0	0.0%	66	100.0%

12.2 Results of the Spearman correlation analysis for original ordinal data for the matched pairs of user inclinations

1) Inclination to consider product price - IncCPP (Sp) and IncCPP (IoT)

Correlations

			IncCPP (Sp)	IncCPP (IoT)
Spearman's rho	IncCPP (Sp)	Correlation Coefficient	1.000	.330**
		Sig. (2-tailed)	.	.007
		N	66	66
	IncCPP (IoT)	Correlation Coefficient	.330**	1.000
		Sig. (2-tailed)	.007	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

2) Inclination to value training - IncVT (Sp) and IncVT (IoT)

Correlations

			IncVT (Sp)	IncVT (IoT)
Spearman's rho	IncVT (Sp)	Correlation Coefficient	1.000	.209
		Sig. (2-tailed)	.	.092
		N	66	66
	IncVT (IoT)	Correlation Coefficient	.209	1.000
		Sig. (2-tailed)	.092	.
		N	66	66

3) Inclination to set-up subscription plan - IncSSP (Sp) and IncSSP (IoT)

Correlations

			IncSSP (Sp)	IncSSP (IoT)
Spearman's rho	IncSSP (Sp)	Correlation Coefficient	1.000	.695**
		Sig. (2-tailed)	.	.000
		N	66	66
	IncSSP (IoT)	Correlation Coefficient	.695**	1.000
		Sig. (2-tailed)	.000	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

4) Inclination to be satisfied with product value offering - IncSPVO (Sp) and IncSPVO (IoT)

Correlations

			IncSPVO (Sp)	IncSPVO (IoT)
Spearman's rho	IncSPVO (Sp)	Correlation Coefficient	1.000	-.063
		Sig. (2-tailed)	.	.614

		N	66	66
	IncSPVO (IoT)	Correlation Coefficient	-.063	1.000
		Sig. (2-tailed)	.614	.
		N	66	66

5) Inclination to trust product value offering - IncTPVO (Sp) and IncTPVO (IoT)

Correlations

			IncTPVO (Sp)	IncTPVO (IoT)
Spearman's rho	IncTPVO (Sp)	Correlation Coefficient	1.000	.039
		Sig. (2-tailed)	.	.756
		N	66	66
	IncTPVO (IoT)	Correlation Coefficient	.039	1.000
		Sig. (2-tailed)	.756	.
		N	66	66

12.3 Results of the Spearman correlation analysis for recoded ordinal data (to four-point scale) for the matched pairs of user inclinations

1) Inclination to consider product price - IncCPP (Sp) and IncCPP (IoT)

Correlations

			IncCPP (Sp)	IncCPP (IoT)
Spearman's rho	IncCPP (Sp)	Correlation Coefficient	1.000	.377**
		Sig. (2-tailed)	.	.002
		N	66	66
	IncCPP (IoT)	Correlation Coefficient	.377**	1.000
		Sig. (2-tailed)	.002	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

2) Inclination to value training - IncVT (Sp) and IncVT (IoT)

Correlations

			IncVT (Sp)	IncVT (IoT)
Spearman's rho	IncVT (Sp)	Correlation Coefficient	1.000	.116
		Sig. (2-tailed)	.	.355
		N	66	66
	IncVT (IoT)	Correlation Coefficient	.116	1.000
		Sig. (2-tailed)	.355	.
		N	66	66

3) Inclination to set-up subscription plan - IncSSP (Sp) and IncSSP (IoT)

Correlations

			IncSSP (Sp)	IncSSP (IoT)
Spearman's rho	IncSSP (Sp)	Correlation Coefficient	1.000	.744**
		Sig. (2-tailed)	.	.000
		N	66	66
	IncSSP (IoT)	Correlation Coefficient	.744**	1.000
		Sig. (2-tailed)	.000	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

4) Inclination to be satisfied with product value offering - IncSPVO (Sp) and IncSPVO (IoT)

Correlations

			IncSPVO (Sp)	IncSPVO (IoT)
Spearman's rho	IncSPVO (Sp)	Correlation Coefficient	1.000	.117
		Sig. (2-tailed)	.	.349
		N	66	66
	IncSPVO (IoT)	Correlation Coefficient	.117	1.000
		Sig. (2-tailed)	.349	.
		N	66	66

5) Inclination to trust product value offering - IncTPVO (Sp) and IncTPVO (IoT)

Correlations

			IncTPVO (Sp)	IncTPVO (IoT)
Spearman's rho	IncTPVO (Sp)	Correlation Coefficient	1.000	-.088
		Sig. (2-tailed)	.	.481
		N	66	66
	IncTPVO (IoT)	Correlation Coefficient	-.088	1.000
		Sig. (2-tailed)	.481	.
		N	66	66

12.4 Results of the Spearman correlation for MSI transformed data (interval scale) for the matched pairs of user inclinations

1) Inclination to consider product price - IncCPP (Sp) and IncCPP (IoT)

Correlations

			IncCPP_Sp	IncCPP_IoT
Spearman's rho	IncCPP_Sp	Correlation Coefficient	1.000	.394**
		Sig. (2-tailed)	.	.001
		N	66	66
	IncCPP_IoT	Correlation Coefficient	.394**	1.000

		Sig. (2-tailed)	.001	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

2) Inclination to value training - IncVT (Sp) and IncVT (IoT)

Correlations

			IncVT_Sp	IncVT_IoT
Spearman's rho	IncVT_Sp	Correlation Coefficient	1.000	.131
		Sig. (2-tailed)	.	.295
		N	66	66
	IncVT_IoT	Correlation Coefficient	.131	1.000
		Sig. (2-tailed)	.295	.
		N	66	66

3) Inclination to set-up subscription plan - IncSSP (Sp) and IncSSP (IoT)

Correlations

			IncSSP_Sp	IncSSP_IoT
Spearman's rho	IncSSP_Sp	Correlation Coefficient	1.000	.744**
		Sig. (2-tailed)	.	.000
		N	66	66
	IncSSP_IoT	Correlation Coefficient	.744**	1.000
		Sig. (2-tailed)	.000	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

4) Inclination to be satisfied with product value offering - IncSPVO (Sp) and IncSPVO (IoT)

Correlations

			incSPVO_Sp	IncSPVO_IoT
Spearman's rho	incSPVO_Sp	Correlation Coefficient	1.000	.117
		Sig. (2-tailed)	.	.349
		N	66	66
	IncSPVO_IoT	Correlation Coefficient	.117	1.000
		Sig. (2-tailed)	.349	.
		N	66	66

5) Inclination to trust product value offering - IncTPVO (Sp) and IncTPVO (IoT)

Correlations

			IncTPVO_Sp	IncTPVO_IoT
Spearman's rho	IncTPVO_Sp	Correlation Coefficient	1.000	-.085
		Sig. (2-tailed)	.	.498
		N	66	66

	IncTPVO_IoT	Correlation Coefficient	-.085	1.000
		Sig. (2-tailed)	.498	.
		N	66	66

12.5 Results of the Spearman rho between product usage experience and IncSPVO using original data

1) Inclination to be satisfied with product value offering and IncSPVO (Sp)

Correlations

			ProductExperience	IncSPVO (Sp)
Spearman's rho	ProductExperience	Correlation Coefficient	1.000	.372**
		Sig. (2-tailed)	.	.002
		N	66	66
	IncSPVO (Sp)	Correlation Coefficient	.372**	1.000
		Sig. (2-tailed)	.002	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

2) Inclination to be satisfied with product value offering and IncSPVO (IoT)

Correlations

			ProductExperience	IncSPVO (IoT)
Spearman's rho	ProductExperience	Correlation Coefficient	1.000	.023
		Sig. (2-tailed)	.	.854
		N	66	66
	IncSPVO (IoT)	Correlation Coefficient	.023	1.000
		Sig. (2-tailed)	.854	.
		N	66	66

12.6 Results of the Spearman rho between product usage experience and IncSPVO using recoded data (to four-point scale)

1) Inclination to be satisfied with product value offering and IncSPVO (Sp)

Correlations

			ProductExperience	IncSPVO (Sp)
Spearman's rho	ProductExperience	Correlation Coefficient	1.000	.350**
		Sig. (2-tailed)	.	.004
		N	66	66
	IncSPVO (Sp)	Correlation Coefficient	.350**	1.000
		Sig. (2-tailed)	.004	.
		N	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

2) Inclination to be satisfied with product value offering and IncSPVO (IoT)

Correlations

			ProductExperience	IncSPVO (IoT)
Spearman's rho	ProductExperience	Correlation Coefficient	1.000	-.035
		Sig. (2-tailed)	.	.779
		N	66	66
	IncSPVO (IoT)	Correlation Coefficient	-.035	1.000
		Sig. (2-tailed)	.779	.
		N	66	66

12.6 Results of reliability test on educational tool (Just-in-mind IoT prototypes)

Case Processing Summary

		N	%
Cases	Valid	66	100.0
	Excluded[a]	0	.0
	Total	66	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.833	.835	10

Item Statistics

	Mean	Std. Deviation	N
UXWET1	3.08	.474	66
UXWET2	3.02	.447	66
UXWET3	2.82	.700	66
UXWET4	2.88	.775	66
UXWET5	2.94	.630	66
UXWET6	2.88	.713	66
UXWET7	2.94	.721	66
UXWET8	2.82	.677	66
UXWET9	3.03	.554	66
UXWET10	2.85	.638	66

Inter-Item Correlation Matrix

	UXWET1	UXWET2	UXWET3	UXWET4	UXWET5	UXWET6	UXWET7	UXWET8	UXWET9	UXWET10
UXWET1	1.000	.575	.181	.193	.479	.392	.194	.139	.284	.140
UXWET2	.575	1.000	.157	.227	.441	.537	.242	.314	.247	.062
UXWET3	.181	.157	1.000	.555	.149	.202	.405	.254	.570	.213
UXWET4	.193	.227	.555	1.000	.363	.446	.455	.309	.582	.242
UXWET5	.479	.441	.149	.363	1.000	.429	.229	.335	.270	.245
UXWET6	.392	.537	.202	.446	.429	1.000	.495	.559	.360	.196
UXWET7	.194	.242	.405	.455	.229	.495	1.000	.450	.583	.314
UXWET8	.139	.314	.254	.309	.335	.559	.450	1.000	.384	.327
UXWET9	.284	.247	.570	.582	.270	.360	.583	.384	1.000	.405
UXWET10	.140	.062	.213	.242	.245	.196	.314	.327	.405	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
UXWET1	26.17	14.695	.416	.446	.827
UXWET2	26.23	14.640	.466	.469	.824
UXWET3	26.42	13.510	.473	.429	.823
UXWET4	26.36	12.512	.606	.519	.809
UXWET5	26.30	13.753	.489	.387	.821
UXWET6	26.36	12.727	.629	.571	.806
UXWET7	26.30	12.799	.604	.461	.809
UXWET8	26.42	13.294	.543	.428	.816
UXWET9	26.21	13.400	.672	.569	.806
UXWET10	26.39	14.242	.370	.232	.832

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
29.24	16.433	4.054	10

12.7 Results of frequencies and percentages for library IoT scenario

Statistics

		FLU	ELLBS	FBLB	LBBP	PRLLBP	PBLS	PSBP	LDBLA	LPLBLS
N	Valid	66	66	66	66	66	66	66	66	66
	Missing	0	0	0	0	0	0	0	0	0
Mean		2.71	2.65	2.44	1.24	1.35	3.29	3.15	2.91	2.89
Mode		3	3	3	1	1	3	3	3	3
Sum		179	175	161	82	89	217	208	192	191
Percentiles	25	2.00	2.00	2.00	1.00	1.00	3.00	3.00	3.00	3.00
	50	3.00	3.00	3.00	1.00	1.00	3.00	3.00	3.00	3.00
	75	3.00	3.00	3.00	1.25	2.00	4.00	3.00	3.00	3.00

Frequency Table

FLU

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very often	9	13.6	13.6	13.6
	Not often	15	22.7	22.7	36.4
	Often	28	42.4	42.4	78.8
	Very often	14	21.2	21.2	100.0
	Total	66	100.0	100.0	

ELLBS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very easy	5	7.6	7.6	7.6
	Not easy	24	36.4	36.4	43.9
	Fairly easy	26	39.4	39.4	83.3
	Easy	11	16.7	16.7	100.0
	Total	66	100.0	100.0	

FBLB

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not very often	13	19.7	19.7	19.7
	Not often	17	25.8	25.8	45.5
	Often	30	45.5	45.5	90.9
	Very often	6	9.1	9.1	100.0
	Total	66	100.0	100.0	

LBBP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	50	75.8	75.8	75.8
	Yes	16	24.2	24.2	100.0
	Total	66	100.0	100.0	

PRLLBP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	43	65.2	65.2	65.2
	Yes	23	34.8	34.8	100.0
	Total	66	100.0	100.0	

PBLS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not important	1	1.5	1.5	1.5
	Important	45	68.2	68.2	69.7
	Very important	20	30.3	30.3	100.0
	Total	66	100.0	100.0	

PSBP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Unlikely	2	3.0	3.0	3.0
	Likely	52	78.8	78.8	81.8
	Very likely	12	18.2	18.2	100.0
	Total	66	100.0	100.0	

LDBLA

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very unlikely	1	1.5	1.5	1.5
	Unlikely	5	7.6	7.6	9.1
	Likely	59	89.4	89.4	98.5
	Very likely	1	1.5	1.5	100.0
	Total	66	100.0	100.0	

LPLBLS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very unlikely	1	1.5	1.5	1.5
	Unlikely	6	9.1	9.1	10.6
	Likely	58	87.9	87.9	98.5
	Very likely	1	1.5	1.5	100.0
	Total	66	100.0	100.0	

12. 8 Smart Living Room prototype development requirements

A Smart Living Room IoT Box prototype and application is propose, which will automate mobile chargers, desk/night lamps, temperature and humidity control, and control how you stay in the living room. The box will integrate several sensors that could be combined to control various appliances in the living room. Temperature sensors will be used to control fans and coolers, while the light sensor will be used to control desktop lamps and ceiling lights, presence sensors will be used to control how long you stay in the living room and motion sensors can also be programmed to alert one on intrusion into the living room. A timer is included so that one can know for how much time their appliance was switched on. This would help a lot for knowing how much electricity is consumed by the appliance. A WiFi module is added so that one can control appliances from outside. Appliances can be connected to the power socket present on the box with a plug that will make connecting anything easily.

The Box will be programmed to request a mode for any of the sensors that one intends to use for controlling the. The box will work by requesting threshold for a given sensor (for instance threshold temperature for temperature sensor), whereby, if the threshold is exceeded, the appliance connected either turns on or off. It also has a timer mode in which you can just set the time in hours and minutes you want your device to be switched on.

Sensors:

As already told, the project uses six sensors in total. Below is a description on how they work.

1. Temperature sensor (LM35): Gives a voltage on one of its pins which becomes high or low depending on the temperature of the sensor. The arduino reads the voltage and converts it to readable temperature.
2. Humidity sensor (DHT11): Gives a certain clock signal of both temperature and humidity. The arduino converts those signals to readable temperature and humidity. (Used here only for humidity).
3. Light sensor (LDR): Gives a high resistance when placed in dark and low resistance when placed on a place full of light. The resistance changes with change in intensity of light. The arduino reads the resistance.

4. Clap sensor (Electret Microphone): Gives a low power signal when a loud sound is detected. The arduino detects the low signal and sets the outlet high.
5. Motion Sensor (PIR Sensor): Detects the motion of a human and gives a high output when detected. Actually detects that radiation given out by a human.
6. Presence Sensor (Ultrasonic Distance Sensor- HC-SR04): Transmits an ultrasound that goes, reflects and comes back. Arduino measures the time taken by it and gives the distance. When the distance becomes low, that means that you are present in front of it so it detects your presence.
7. Arduino Wifi Shield: A wifi module that ensures that someone sitting anywhere else can switch on their appliance.

This proposed prototype modifies on an home automation box built by Saiyam (http://www.instructables.com/id/The-Bedroom-Automation-Box/) by adding a WiFi module. After putting together the device, the next step will be to leverage on one of the IoT software development kit: ThingSpeak, which has an API that enables data from the box to be posted and reviewed.