# Innovating Independent Living

## Business Models for Internet of Things in Ambient Assisted Living

Rashmi Narayanan Kannankutty

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Master of Science Thesis

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Rashmi Narayanan Kannankutty

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Delft University of Technology
Department of
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The undersigned hereby certify that they have read and do recommend to the Faculty of Technology, Policy and Management for acceptance a thesis entitled

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Rashmi Narayanan Kannankutty

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Chair(s): Prof.dr. C.P. (Cees) van Beers, TU Delft

Supervisor(s): Dr. L. (Dap) Hartmann, TU Delft

Dr. Ir. Mark de Reuver, TU Delft

External Supervisor(s): Anne van Rossum, Almende.B.V.

Alexander Marchesini, Almende.B.V.

“ To my grandma, Thangam
— *who will remain the brightest presence in my memory*

“ To my grandpa, K S Narayanan
— *who introduced me to perseverance and squeals of laughter*

“ To my uncle, Manoj mama
— *who continues to be my strongest source of inspiration*“

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> "We must find time to stop and thank the people who make a difference in our lives."
>
> — *John F.Kennedy*

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# Executive Summary


Internet of Things (IoT) refers to the use of sensors, actuators and data communication technologies built into physical objects enabling them to be tracked, coordinated or controlled across the Internet. It encompasses the vision where every object can interact with every other object, system or person over the network. This interactive network of things is expected to yield market opportunities for consumers and businesses by triggering both incremental and radical business transformations in several industry verticals.

One of the most promising application verticals of IoT is that of Ambient Assisted Living (AAL). It comprises of technical systems that support the elderly in their daily activities in order to provide an independent and safe lifestyle. Such applications are needed in countries such as Netherlands that is faced with an aging population. The aging population is rising and is feared to be a burden on the working citizens and the health care system of the country.

Technological innovation in IoT is much ahead of its business potential and applications to customers' needs. The dearth of study that connects the value creating capabilities of IoT to potential economic benefits is very evident in academia. Literature also lacks an integrated approach towards designing business models for IoT. Further, IoT applications are very specific to industry verticals and empirical insight into IoT driven business models particularly in the AAL vertical is very scarce. In an attempt to address this crucial gap in literature, this master thesis project aims to investigate the design of business models that can capture the value creating capabilities of IoT in the vertical of AAL. The research was conducted in the form of a case study with the startup Distributed Organisms.B.V. (DoBots), who is currently investigating opportunities to commercialize their IoT service platform.

This thesis attempts to answer the main research question: *"How to devise a framework that captures the critical business model design issues for Internet of Things and apply it in the design of business models for an IoT service platform in the vertical of Ambient Assisted Living?"*

The study analyzes business models for IoT through the lens of the Service, Technology, Organization and Finance (STOF) model framework which presents design approaches particularly for Information and Technology (ICT) services. The IoT platform in this study adheres to the academic definition of a "service platform." The study hence draws insights from platform theory to investigate the concept of "platform openness" for the service platform. Further, it derives inspiration from related academic works in IoT to investigate the specific characteristics that should be taken into consideration while designing business models.

This research is academically relevant as it makes an empirical contribution to business model literature in IoT which is in a very nascent stage. The industry relevance lies in exposing the business potential of emerging applications from the perspective of an IoT service platform provider. Its social relevance lies in envisioning scenarios that propose technological solutions to support an aging society. The empirical inputs to the study was obtained by conducting semi-structured interviews with practitioners in the IoT domain and AAL vertical and with stakeholders in the Dutch elderly care market.

The main findings of the study are twofold. First, it specifies a framework that captures the critical design issues for IoT business models. Second, it proposes three practical scenarios where the IoT service platform studied in the case can be commercialized in view of the Dutch elderly care market.

The framework referred to as the i-STOFp framework is derived from related works in IoT literature (i), the STOF model and platform (p) theory and is consolidated further from empirical data is shown in Figure 1.

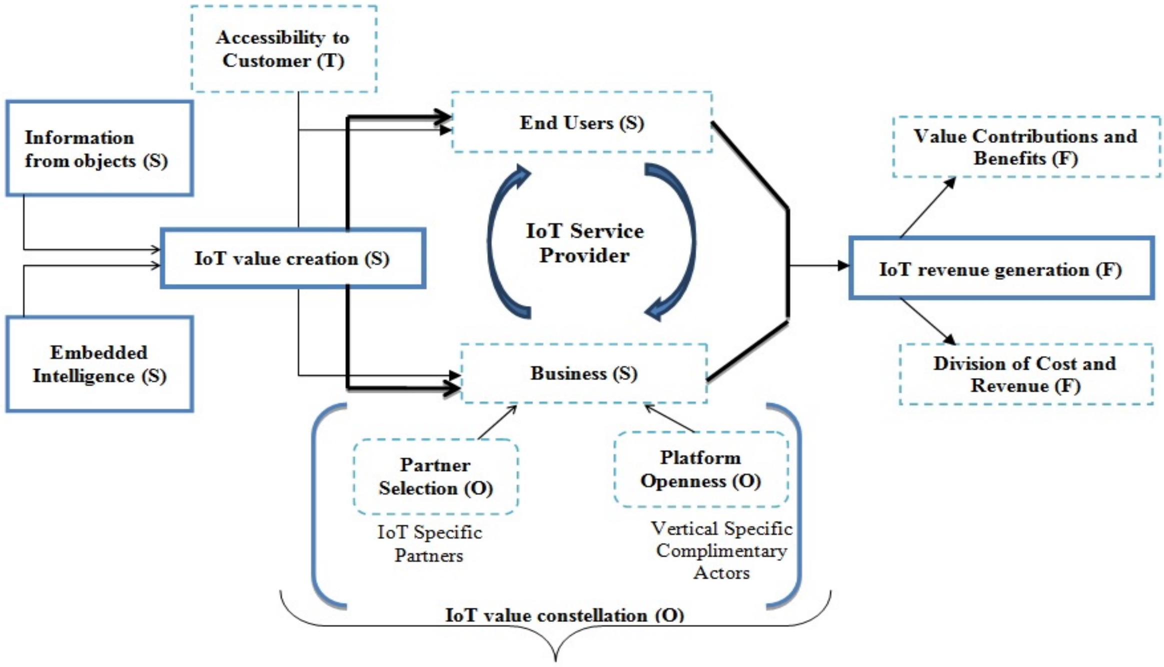


**Figure 1:** The i-STOFp framework

It captures the relations between core IoT design variables identified from available literature with those in the STOF and platform theory. According to the framework, *value creation in IoT* emerges from applications enabled by the *information* (data) from objects (sensors) and those stemming from the embedded *intelligence* of the smart objects. These give rise to two categories of services: information based services and intelligence based services. To enable provisioning of services the framework distinguishes the target market into two: *End users* who play an active role both in generation and consumption of data and *businesses* where this data can be deployed to create meaningful applications. The *IoT service provider* plays the role of a facilitator between these two actors. The vertical specificity of IoT is captured by *IoT value constellation*. It lays emphasis on *partner selection* as IoT is said to be too large for any individual service provider to manage on their own. It highlights choosing actors not merely to aid service delivery as is the case conventionally, but those with the right intent to suit the context of these services. This includes businesses within the vertical itself. *Platform openness* enables addition of services provided by complimenters thus enriching the functionalities of the IoT service platform by making it more specific to the vertical. IoT is expected to see the emergence of third party application developers (data scientists) who can make use of the big data arising from user applications. *Revenue generation in IoT* offers the potential to be more tightly coupled with its value creation than conventional ICT services. However bolder revenue models in IoT are only emerging. Finally *accessibility for customer, value contributions and benefits* and *division of cost and revenue* were also identified as critical to IoT business models. Inputs from the i-STOFp framework when applied in the AAL vertical gives rise to the following IoT enabled services:

1. Information based services: These services arise from sensor driven data analytics. Here data from sensors are interpreted to make decisions. The AAL applications lifestyle monitoring of elderly (which includes observing activities of daily living) and tracking (which includes wander detection and detecting immobility) fall under this category.

2. Intelligence based services: These services arise from occurrence of events in real time. The smart objects can detect and respond to these events. The AAL applications fall detection, intelligent alarm escalation and control application such as automatic lighting and switching fall under this category.

Inputs from the logic proposed by the framework in combination with the market research conducted give rise to three scenarios for DoBots to commercialize its IoT service platform within the AAL vertical in view of the Dutch elderly care market.

1. Scenario one suggests a mass market consumer based solution to support independent living for the elderly. Solutions conceived suggest enabling IoT services by the platform in a non intrusive way manner to ensure the well being of the elderly alongside providing an ease of mind to the family care giver.

2. Scenario two presents a care based solution enabled by IoT services to provide real time decision making to care organizations to modernize their care processes. This revolutionizes the traditional care provision of these organizations especially under the pressure of current policy changes and ensures higher quality of care for their elderly clients.

3. Scenario three presents a self-organized community based solution for the elderly stimulated by insurance companies and municipalities. This scenario becomes particularly relevant in wake of the new policy changes from 2015 which enforces decentralized provision of care and encourages promotion of innovative technologies that support elderly to become independent.

The three scenarios mentioned above envision conceptual services that are new to the market and as such offer "Innovative ways of living independently" for the elderly. The study concludes by proposing recommendations for the much needed future academic research in the field of IoT business models.

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# Chapter 1

# Introduction

Imagine a world where every object can interact with every other object, system or person over a network. This vision is referred to as the Internet of Things (IoT). It is predicted that by 2020 there will be 50 to 100 billion devices connected to the Internet thereby expanding it to IoT (Perera et al., 2013). While IoT was conceptualized as early as in 1999, the number of technological deployments relating to it has expanded only lately. This is due to rapid advances in enabling technologies such as sensor networks, cloud infrastructure, processing capacities and wireless communication technologies and decreasing hardware costs (Perera et al., 2013).

Traditional devices in networked systems have identification and memory capabilities. IoT connects objects by combining technological developments in item identification "tagging things," sensors and wireless sensor networks "feeling things" and embedded systems "thinking things" (Vermesan et al., 2010). This identification, sensing and embedded intelligence turns traditional objects in a networked system to "smart objects" in IoT as they become tools for understanding complexity and responding to it quickly (Dohr et al., 2010). IoT encapsulates three important technological layers (Sun et al., 2012):

1. Sensing/Actuation Layer: This layer consists of sensor technologies and smart objects that impact data acquisition and utilization.

2. Network Layer: This layer is supported by mobile internet and advanced wireless networks. It aims at disseminating large quantities of real time information. Here information exchange is between people and things or among things themselves.

3. Application Layer: This layer enables intelligence either by distributed data processing at the device and/or by centralized processing enabled by cloud computing and management technologies.

This resulting interactive and responsive network of things yields market opportunities for citizens, consumers and businesses alike, triggering incremental business transformations as well as radical changes (Uckelmann et al., 2011). IoT is categorized as a "disruptive technology" as it holds the potential to impact aspects of everyday life and behavior of prospective users (Atzori et al., 2010). IoT enables novel applications in several industry verticals such as smart homes/buildings, transport, health care, ambient assisted living, smart cities and environmental monitoring (Atzori et al., 2010, Miorandi et al., 2012). Some use cases are: smart homes with intelligent appliances autonomously minimizing energy usage; connected cars that react in real time to prevent accidents; body area networks that track vital signs and trigger emergency responses when life is at risk; care services that assist the elderly in their daily activities to support independent living etc. (Miorandi et al., 2012).

One of the most promising application domains of IoT is that of Ambient Assisted Living (AAL) (Atzori et al., 2010). AAL comprises of technical systems that support elderly people in their daily activities in order to provide an independent and safe lifestyle (Dohr et al., 2010). An AAL environment provides the integration of standalone assistive technologies, with elements of smart homes and tele health services (Savage et al., 2009). AAL mainly involves two elements: the provision of social support for older people at home with a range of services from traditional community alarms to the passive monitoring of individuals; the provision of medical care by monitoring health parameters to assist health care practitioners with diagnoses, treatment, teleconsultations and patient education. The need for such applications stems from the changing demographics, particularly in industrialized countries.

The Netherlands is faced with an aging population (Rolden, 2012). While improved health care increases life expectancy governments are fearing its burden on the working population and the health care system (Rolden, 2012). The aging population contributes to the rising care costs (Rolden, 2012). The elderly population are facing two main issues: First, the health care budgets are falling and elderly care organizations have to cut out on personnel and are unable to cater well to clients. Second, policy regulations are forcing elderly to live longer independently in their homes leading to the need for such services. In an IoT enabled AAL scenario, the homes of the elderly are equipped with smart objects (Dohr et al., 2010). These objects can stimulate useful applications such as: detecting the activities of elderly by using wearable and ambient sensors, monitoring social interactions, monitoring chronic diseases using wearable vital signs sensors, etc. (Atzori et al., 2010). Information and Communication Technology (ICT) services enabled by IoT can be particularly valuable in assisting elderly persons to live independently for longer (Atzori et al., 2010, Dohr et al., 2010). This study investigates the value creating capabilities and business potential of IoT in the specific vertical of AAL. Further it focuses on the provision of assistive technology for social support. The medical care provision is outside the scope of this study. The research is primarily set in the Dutch elderly care market which is the playground of the AAL vertical.

The remainder of the section is structured as follows: Section 1-1 introduces the problem under investigation, Section 1-2 describes the theoretical basis of the study, Section1-3 presents the research objective, Section 1-4 presents the research approach and design, Section 1-5 presents the contributions of the study, Section 1-6 presents the research scope and limitations and finally Section 1-7 elaborates the outline of this report.

## 1-1 Problem Statement

While the possibilities offered by IoT seem manifold, technological innovation is said to be much ahead of the business aspects, services and applications to customers' needs that IoT can cater to (Ma and Zhang, 2011). Lately, numerous IoT technologies such as smart objects, sensors and embedded smart technologies are already being used in many industries (Sun et al., 2012). However, the current applications are in their infancy and the business potential of such technologies are yet to be leveraged (Bucherer and Uckelmann, 2011). There is need to create novel IoT services and applications (Ma and Zhang, 2011). To help realize the economic benefits of IoT workable business models are required to show where opportunity lies. Despite its seemingly positive potential, scholarly attempts and empirical research to understand emerging IoT business models that companies can adapt is very scarce. The mainstream of the IoT research is focused on different technological layers (Leminen et al., 2012). A lack of study into business models that relate the technological value creating capabilities of IoT to potential economic benefits is evident (Sun et al., 2012). Thus, to provide a path towards broader development of the IoT and realize economic benefits, there is a pressing need to present workable models to identify business opportunities.

The main questions that needs to be answered are:

1. What could be the value creating capabilities of IoT?
   With IoT the predictable pathways of information is changing as the physical world itself is turning into an information system (Chui et al., 2010). But how can this provide opportunities to further investigate customer requirements, broaden application domains and provide useful services?

2. How does a company profit from the IoT technologies?
   In IoT, the costs for sensors, actuators, software and hardware can be calculated well, but how to establish an economic basis for innovative services and applications supported by IoT (Bucherer and Uckelmann, 2011, Ma and Zhang, 2011)?

Literature thus lacks an integrated approach towards designing business models for IoT. In other words there is a gap in identifying the critical business model design issues to be considered for the domain of IoT. But generic business model frameworks have challenges as IoT applications have been domain specific. Profiting from IoT depends on progress in respective industry verticals in order to create economies of scale and thus critical mass on the markets (Leminen et al., 2012). Business model literature in IoT have been found in industry verticals such as smart cities and postal logistics (Perera et al., 2013, Sun et al., 2012). However, empirical insight into IoT driven business models in the AAL vertical is very scarce. This research focuses on contributing to the critical gap by investigating into IoT driven applications in the AAL vertical. Further as mentioned earlier, the study focuses only on provision of IoT enabled AAL technologies for social care.

### 1-1-1 DoBots Case Study - The Problem Owner

Distributed Organisms.B.V. (DoBots)is a startup working on artificial intelligence and machine learning algorithms. DoBots particularly fits the case study as it offers an empirical opportunity to address the central problem posed by this research. DoBots' platform architecture can be categorized as one that favors "the definition of the Internet of Things platform." DoBots' focus is in the vertical of smart buildings with a central vision to make buildings respond to user needs. DoBots moreover focuses on elderly care and the nature of services envisioned can be classified as services in the vertical of AAL.

While the startup has limited resources and capabilities, there are several directions in which the company could roll out its services. Also the delivery of services can be quite complex as it may require network players from the industry in order to penetrate into the market. The company is thus keen on investigating into the business models that can help them commercialize their IoT service platform in the AAL vertical.

Problem owner's perspective:

1. What could be the services offered by our IoT service platform in the AAL vertical?
2. Which could be the target market segments for our services and who will be the network players that enable service delivery?
3. What could be the revenue models that enable the capture of value from our IoT platform?

Problem Statement: The applications of IoT demands new ways of value creation but the research on IoT business models is in infancy and a framework that captures the value creating capabilities of IoT is absent. There is a need for comprehensive understanding of IoT business models. AAL is one of the most promising industry verticals that stand to benefit from IoT applications, however literature focusing on business models for IoT in AAL is very scarce.

## 1-2 Theoretical Background

### 1-2-1 Business Model Theory

This study builds up theoretical concepts from the Service, Technology, Organization and Finance (STOF) business model framework (Bouwman et al., 2008). The framework is visualized in Figure 1-1. The approach consists of the Service domain in which the customer value proposition serves as the primary relevant aspect of the service. The Technology domain describes the technical functionality required to realize the service offering. Organization domain is a description of the structure of the network of actors required to create and provide the service offering. The Finance domain takes into account the aspects of investments and revenue strategies for realizing economic benefits for the provided services. According to STOF model, a viable business model is one that offers both customer and network value. STOF consists of design variables called Critical Design Issues (CDIs) and success metrics Critical Success Factors (CSFs) which are tools for balancing the requirements and strategic interests within and between the domains. The STOF method provides a step by step approach with practical guidelines to design business models.

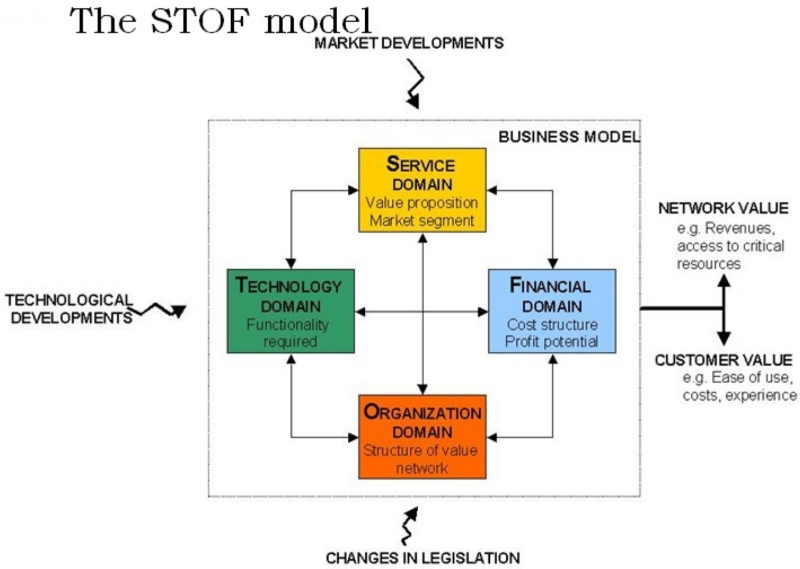


**Figure 1-1:** The STOF Model. Source (Bouwman et al., 2010)

**Motivation for using STOF:** The main question asked in IoT is "What can be done with a cluster of sensors and objects connected to each other?" In other words, technological innovation in IoT calls for services and applications that can enable traditional product innovation oriented companies to fulfill market demand (Ma and Zhang, 2011). Thus the focus is on "services." Further it is predicted that IoT environments unite participants from multiple industries in order to bring more complicated relationships to guide the service design and delivery (Ma and Zhang, 2011). These two aspects: need for services and networked or industry approach for IoT service provisioning points to the STOF model as an ideal theory to study this case. STOF encompasses the shift from product oriented innovations to service orientated innovations. Further, the underlying logic of the STOF model, its basic structure and relationships between the design issues pertaining to mobile services and its inherent components provide the necessary support for understanding, analyzing and designing IoT business models. This is elaborated in Section 3-1 on theoretical perspectives.

## 1-2-2 Platform Theory

The term platform means a physical foundation to establish activities (Sorensen, 2013). Digital platforms are either entirely software based or are mixture of physical and digital elements (Sorensen, 2013). The platform studied in this case is a "service platform." It is a combination of hardware architecture, network and an operating system or a software framework that is required to offer services to end users (Evans et al., 2006). The IoT platform in this study adheres to the definition of a software service platform because it helps connect devices over networks, provides the software framework for running applications and can delivers services to end users. The study further draws insights from the theoretical concept of "platform openness." A critical aspect of a software platform's architecture is whether it is open or closed. With an open platform, anyone with the right technical knowledge can obtain access to the services or the underlying elements provided by the platform (Gawer, 2010).

## 1-3 Research Objectives and Questions

The sections above set the context of this study and introduced the main issues in the domain. The problem statement emphasizes the lack of an approach in literature that captures the value creating characteristics of IoT. This research aims to address this gap by studying the critical business model issues required for the domain of IoT. Further it aims to design business models for the commercialization of DoBots' platform in the vertical of AAL.

Hence the following research objective is developed:

***"Identify the critical business model design issues for the domain of the Internet of Things and recommend robust business models for an IoT service platform in the vertical of Ambient Assisted Living."***

In order to guide the objective of the study as mentioned above, the main research question is formulated as follows:

***"How to devise a framework that captures the critical business model design issues for Internet of Things and apply it in the design of business models for an IoT service platform in the vertical of Ambient Assisted Living?"***

The main research question is answered by splitting it into subquestions and systematically answering each of them. Their formulation is as follows:

1. What are the design variables that can be extracted from literature to study critical business model design issues for the domain of IoT?
2. What are the current trends, customer needs and applications in the AAL vertical for the Dutch elderly care market?
3. How can the critical business model design issues of IoT be applied to the AAL vertical?
4. What could be the services and robust business models for the IoT service platform of DoBots in the AAL vertical?

Subquestion one provides the starting point for research by studying the specific business model design issues for IoT from related works in literature and combining this with STOF and platform theory. A theoretical framework will be developed for investigating business models for IoT. This will be further tested and relationships between domains will be established from field interviews.

Subquestion two intends to explore the AAL vertical and the Dutch elderly care market in order to understand the customer needs, applications and stakeholders involved.

Subquestion three intends to abstract the IoT characteristics into the AAL vertical. Here the IoT design issues derived from subquestion one will be combined with the demands in the AAL vertical in subquestion two. This points towards an IoT enabled provision of AAL services. It forms an input to the IoT service platform for design of business models in the vertical of AAL.

Subquestion four intends to design and stress test business models for the IoT service platform of DoBots in the vertical of AAL.

## 1-4 Research Approach and Design

This study chooses an exploratory, single case study based approach to investigate the research problem. This was chosen due to its compatibility with the "how" question asked (Yin, 2011). Further, qualitative case studies enable the exploration of contemporary phenomenon within its real-life context, allowing for the gathering of multiple perspectives from a range of sources thereby presenting deeper insights into the research problem under investigation (Yin, 2011). The rationale was apt in this case because support from business model literature in the IoT domain is scarce. The industry is foraying into IoT services, however applications are only emerging and there are a lot of business uncertainties in this in this area (Abodata, 2013). Thus, an exploratory research was most suited to step into this rather unchartered territory.

The research design is guided by the business model design process as suggested by Osterwalder and Pigneur (2010). It presents a practical approach towards guiding business model design and its implementation. A practical design was chosen because initial inquiry revealed that economic activities in industry regarding IoT were much ahead of the academic literature. Prospective white papers from industry provided more information on its business potential than literature did. Hence a design approach conceived in practice was expected to offer better guidance than design frameworks from literature as it acknowledges that business model design is messy and unpredictable, despite attempts to implement a process. Its "design attitude" of having to explore multiple possibilities in ambiguous and uncertain situations resonates with the exploratory nature of this research.

The phases in the design process are Mobilize, Understand, Design, Implement and Manage. This research will use the first three phases to provide structure to the research inquiry (shown in Figure 1-2). This encompasses the stages from preparing the elements for the business model design (Mobilize) to generating and testing viable concepts (Design). The last two phases Implement and Manage i.e. actual implementation and adaptation of the business model in the field as such is outside the scope of the case study.

The first phase in the research design is the **"Mobilize"** phase. This sets the stage for research. It assembles the elements for a successful business model design. In this research the elements involve literature study on business model and platform theory and related works on IoT. In addition, it involves desk research on IoT domain and understanding the capabilities of the DoBots platform. This phase provides the framework to answer subquestion one.

The second phase in the research design is the **"Understand"** phase. This investigates relevant knowledge, customers, technology and environment of study. Here information is collected, experts are reviewed, and potential customers are studied to identify needs and problems. This corresponds to the field research part of the thesis. This answers subquestions two and three.

The third phase in the research design is called the **"Design"** phase. This includes transforming the information and ideas from the previous phases into business model prototypes that can be further explored. This corresponds to the business model design and analysis process. It answers subquestion four.

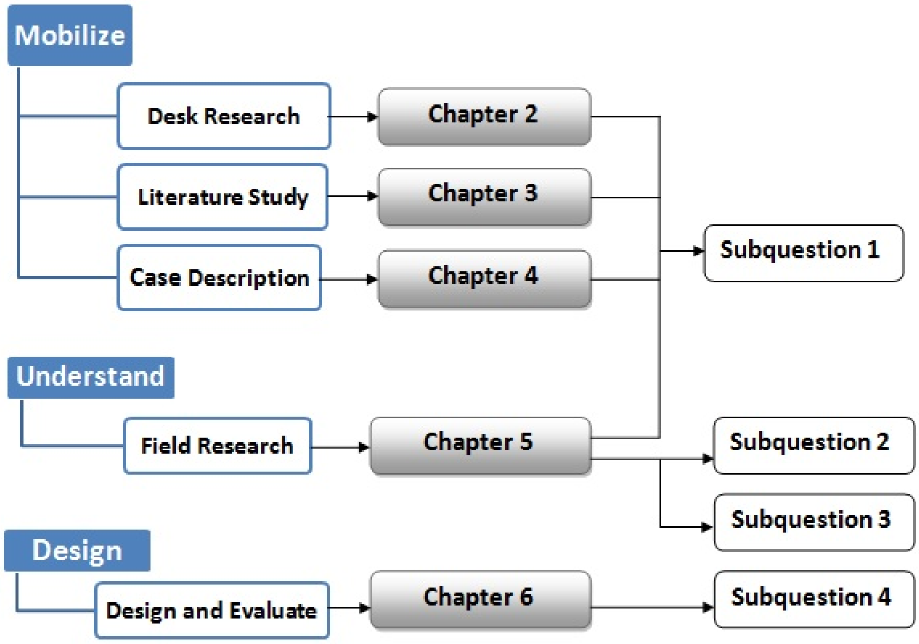


**Figure 1-2:** Research Design

# 1-5 Relevance and Contributions

## 1-5-1 Practical Relevance

This research holds practical relevance as it aims to provide a framework that captures the critical IoT business model related design issues which might be a valuable tool for IoT practitioners in their business model design. Further, it intends to recommend robust business solutions for the IoT service platform of DoBots in the vertical of AAL. The study is also socially relevant as it involves investigating technological applications to support an aging society.

## 1-5-2 Academic Relevance

The academic relevance of this research is twofold. It contributes to literature by empirical business model study in the domain of IoT. Further, it contributes to the development of the STOF model by extending it for IoT services with additions from platform theory. This extends the external validity of STOF.

# 1-6 Research Scope and Limitations

The research is qualitative, exploratory and single case study based and hence the external validity of the results could be limited. The problem is addressed and IoT business models are proposed from the perspective of a specific IoT platform provider. While the concepts from literature are generic, the conclusions drawn are based solely on the field data gathered from the interview respondents. This study does not presume to cover all relevant characteristics for designing IoT business models or cover all relevant stakeholders belonging to the domain.

The areas of IoT and AAL are very broad. The research is limited to their definitions as discussed within the study. The research is constrained to the Dutch elderly care market for two reasons. First, technology and business value related to elderly care are not merely restricted to the traditional "customer needs based" commercialization processes, but are also severely influenced by the policy regulations of organizing care in the country. Second, Netherlands is a good starting point for the purposes of technological innovations to support elderly care as the Dutch are generally familiar with dealing with technologies (Schippers and van Rijn, 2014). There are a lot of AAL based studies, research projects and pilots happening in Netherlands which makes it favorable for studying the AAL vertical.

## 1-7 Report Outline

The remained of this report is structured as follows:

**Chapter 2:** This chapter elaborates on IoT, the main domain of study IoT. It will also present insights into the AAL vertical and the Dutch elderly care market.
**Chapter 3:** This chapter elaborates on the theoretical background for developing an integrated framework for designing business models for IoT.
**Chapter 4:** This chapter introduces the case study, elaborating on the IoT platform of DoBots and its service capabilities.
**Chapter 5:** This chapter presents the results of the qualitative field research undertaken. In addition it will present insights that form inputs for business model design in the next chapter.
**Chapter 6:** This chapter will elaborate on the design of business models to demonstrate the application of the IoT business model framework in the AAL domain.
**Chapter 7:** This chapter concludes the study by presenting the main research findings, thesis reflections and future recommendations.

Chapter 2

# The Internet of Things Domain

This chapter is part of the "**Mobilize**" phase of research. It consists of desk research that elaborates on the domain of study, IoT; the application area, AAL; and the Dutch elderly care market.

## 2-1 The Internet of Things Technology

The IoT technological phenomena originates from developments in information and communication technology associated with three core areas: ubiquitous connectivity, pervasive computing and ambient intelligence. Ubiquitous connectivity is the ability of objects to connect anywhere and anytime; Pervasive computing is the enhancement of objects with processing power; Ambient Intelligence (AmI) is the capability of objects to register changes in physical environments and actively interact with processes (Dohr et al., 2010). In IoT the traditional concept of internet as an infrastructure network reaching out to endusers' terminals fades, leaving space to a notion of interconnected "smart objects" that form ubiquitous computing environments (Miorandi et al., 2012).

AmI is the technological concept driving AAL (explained in section 2-5) but also shares strong characteristics with IoT (Dohr et al., 2010). AmI environments are rich in sensing, computing and actuation capabilities and are designed to respond intelligently to the presence of users, and support them in carrying out specific tasks. AmI is mostly applied in "closed" environments such as buildings. IoT expands the AmI concepts to integrate "open" scenarios whereby new functions, capabilities and services can be accommodated at run-time without them having been necessarily considered at design time. IoT solutions can be inherently autonomous, i.e., presenting the self-configuration and self-organization capabilities needed to provide this additional degree of flexibility (Miorandi et al., 2012)(Atzori et al., 2010).

### 2-1-1 Technological Layers of Internet of Things

Figure 2-1 shows the high level abstraction of classical IoT platform architecture with its key components. IoT can be conceptualized at three levels as explained below (Miorandi et al.,

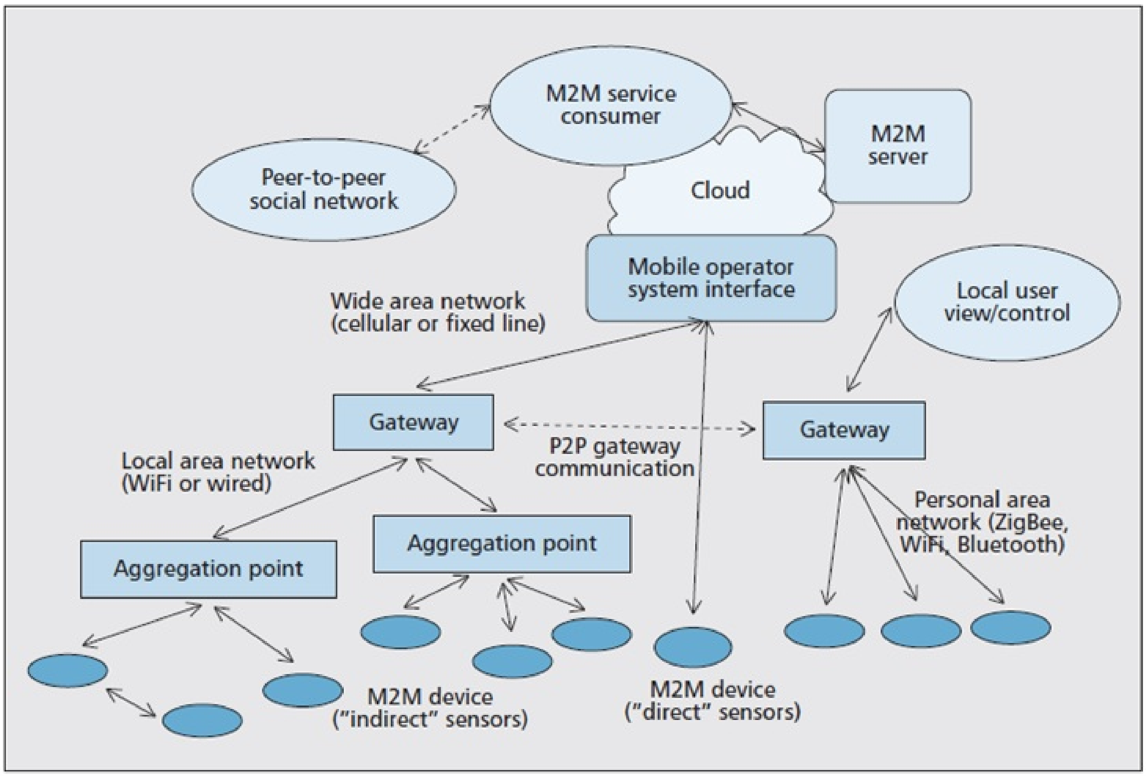


**Figure 2-1:** High Level Internet of Things Architecture. Source (Hase, 2012)

2012):

1. **Component Level (Sensing Layer)** This layer presents IoT at the component level consisting of a continuum of devices, objects or things. It can be categorized into four types:

    - Smart objects: These devices have communication capabilities, can be discovered, uniquely identified, posses basic computation and can sense some physical phenomena such as light, temperature etc. They include devices from wireless sensor networks and wireless sensor/actuation networks (Miorandi et al., 2012). The ability of detecting the physical status of things through sensors, together with collection and processing of detailed data allows these devices to immediately respond to changes in the real world (Uckelmann et al., 2011).
    - Computing devices: These include devices such as smartphones, computers and laptops. Smartphones have sensing capabilities that provide users with proximity data, route planning alongside communication capabilities such as Bluetooth and Wi-Fi technologies. This supports connections to smart objects. They also play a role in providing the user interface for personalized applications. Computers come with smaller chips, rich computation features, high performance, low costs and power consumption and carrier wifi and can interact with the smartphone and smart objects (Accenture, 2012).

- High-end devices: These include devices such as gateways that collects and process data from simpler end devices and manage their operation. Gateway aggregation points play a key role in bringing the installed short-range sensors, and other end devices online and enable interconnection between different wireless technologies (Wu et al., 2011).

2. **System Level (Network Layer)** This layer of IoT consists of a highly dynamic and radically distributed networked system, composed of smart devices that produce and consume information. The dynamism is due to the ability of smart objects to create ad hoc connections with each other, thus enabling self-management and autonomous capabilities. The connectivity provision between end devices can be categorized into three types:

    - Low energy connectivity: This consists of several lower cost radio protocols, such as Bluetooth Smart, Zigbee, Zwave, IEEE 802.11, IEEE 802.15, and power line communications through which devices at the component level can communicate with each other.
    - Mobile connectivity: The proliferation of mobile internet provides ubiquitous connectivity to the user thus disseminating real time information (Dohr et al., 2010).
    - Wireless connectivity: Advanced wireless networks provide ubiquitous coverage and delivers broadband data services at a significantly lower cost. These ubiquitous networks offers features necessary for IoT platform providers to support service delivery (Wu et al., 2011). Wireless communication protocols have developed in many directions to enable diverse scenarios from low bandwidth, low power to high bandwidth, more energy consuming technologies (Compan, 2012).

3. **Service Level (Application Layer)** In this level, the functionalities and resources provided by the smart devices (mostly in form of data streams generated) are integrated into value added services for end users. Massive increase in storage and computing power, some of it available via cloud computing, makes provision of such services available at a very large scales and at declining costs. The provision of such cloud based device management and services entails processing at one or both levels:

    - Centralized device management: In this case, the decision making, data processing and management of devices can take place by provision of centralized cloud services.
    - Distributed device management: In this case, objects are enabled in a network to create distributed platform that enable the easy implementation of services on top.

## 2-2 The Internet of Things System Level Features

IoT entails certain characteristic technological features that have to be taken into consideration while defining applications for value added services (Miorandi et al., 2012). They are presented below:

1. Heterogeneity: Devices at the component level may have varying computational and communication standpoints thus exhibiting large heterogeneity. The management of

such a high level of heterogeneity will have to be supported both at architectural and protocol levels.

2. Scalability: In larger infrastructures, scalability issues arise at device naming and addressing, data communication and networking, information, knowledge and service management levels. This should be taken into consideration while designing scalable services.

3. Ubiquitous Data Exchange: In IoT, wireless communications technologies enable smart objects to become networked thereby providing ubiquitous data coverage

4. Localization and Tracking: IoT entities can be identified and are provided with short-range wireless communications capabilities, enabling tracking of location and smart objects in the physical realm.

5. Self-organization: The complexity and dynamics that many IoT scenarios can provide calls for distributing intelligence in the system, making smart objects able to autonomously react to a wide range of different situations, thereby minimizing minimize human intervention by self organizing.

6. Embedded Security and Privacy-Preserving Mechanism: Tight interaction of IoT with physical realm, calls for secure and privacy-preserving by technology design. This is expected to represent a key requirement for ensuring acceptance by users and the wide adoption of the technology.

## 2-3 The Internet of Things Applications

There are six distinct application types in IoT (Chui et al., 2010). They are categorized broadly under **information and analysis** and **automation and control**.

1. Information and Analysis
   Networks link data from products or the operating environment, the resulting data generates better information. Analysis of this information enhances decision making. Three main application types are as follows:

   - Tracking behaviour: This involves the process of monitoring the behaviour of persons, things or data through space and time. For instance when sensors and network connections are embedded in a rental car, it can be leased for short time spans to registered members of a car service while being tracked online.
   - Enhanced situational awareness: Data from sensors when deployed in an infrastructure such as buildings can give decision makers a heightened awareness of real-time events, particularly when the sensors are used with advanced display or visualization technologies. For instance, security personnel can use sensor networks that combine video, audio, and vibration detectors to spot unauthorized entry in restricted areas.
   - Sensor-driven decision analytics: IoT can support more complex human planning and decision making by collecting and analyzing data from sensors. For instance,

in health-care sensors and data links help to monitor patient's behaviour and symptoms in real time. This allows physicians to provide better diagnosis for diseases and prescribe tailored treatment regimes.

2. Automation and Control
Making data the basis for automation and control involves converting the data and analysis collected through IoT into instructions that feed back through the network to actuators that in turn modify processes. By closing the loop from data to automated applications, systems can adjust automatically to complex situations and make many human interventions unnecessary.

    - Complex autonomous systems: The most demanding use of IoT involves the rapid sensing of unpredictable conditions and instantaneous responses guided by automated systems, thus mimicking human reactions through vastly enhanced performance levels. For instance, the automotive industry is stepping up the development of systems that can detect imminent collisions and take evasive actions.
    - Process optimization : IoT is opening new frontiers for improving processes. This improved instrumentation, multiplied hundreds of times during an entire process, allows for major reductions in waste, energy costs, and human intervention. For instance, sensors and actuators can also be used to change the position of a physical object as it moves down an assembly line, ensuring that it arrives at machine tools in an optimum position.
    - Optimized resource consumption: Networked sensors and automated feedback mechanisms can change usage patterns for scarce resources, including energy and water, often by enabling more dynamic pricing.

## 2-4 The Internet of Things Services

The web era is characterized by services that are *always on*. For instance online bank transactions, mobile applications etc. are always available when the user demands. IoT platforms on the other hand are said to enable services that are *always responsive*. These services are situation oriented, are built and automatically composed at run-time, respond to specific user needs, are tailored for the user's context and supports them in every day activities (Miorandi et al., 2012). This enhanced situational awareness augmented with the ability to perceive and respond to the surrounding environment supported by IoT adds incredibly valuable intelligence for complex decision making in a broad range of industry verticals as follows (Windriver, 2014):

**Ambient Assisted Living:** As societies' demographics change, with populations aging and life spans extending, the modern building will need to support independent living at older ages. With sensors, controllers, and intelligence, smart buildings provide technical assistance for aging people, enabling ambient assisted living (Windriver, 2014).

**Utility:** Smart metering hubs can automatically report on energy usage via networks, saving time and money of sending personnel for manual meter checking and allow companies to optimize consumption in response to supply conditions. It provides energy savings for home owners. Smart power meters and appliances will communicate with intelligent power sources to help balance supply and demand typically using Zigbee or power line (Accenture, 2012, Windriver, 2014).

**Health care:** IoT technologies can find a number of applications in the health care sector. Examples are medical sensors to monitor parameters such as body temperature, blood pressure and breathing activity. Increasingly, IoT technologies are being used in personalized health care and well being solutions. The use of wearable sensors, together with suitable applications such as running on personal computing devices enable people to track their daily activities providing suggestions for enhancing their lifestyle. They can be used to enhance current assisted living solutions (Miorandi et al., 2012).

**Smart Home/Buildings:** Equipping buildings with IoT technologies can help reduce consumption of resources associated with buildings such as energy and also improve the comfort level of its occupants by providing controlled heating, lighting, safety, and security systems (Compan, 2012). The key role is played by sensors and actuators, which are used to both monitor resource consumptions as well as to pro-actively detect and respond to users' needs (Atzori et al., 2010).

**Smart City**: Advanced IoT services make it possible to optimize the usage of physical city infrastructures and quality of life for its citizens. As an example, IoT technologies can be used to provide advanced traffic control systems in cities (Perera et al., 2013).

To sum up, it is important to highlight that while the basic features of IoT technologies such as sensing and network communication may be generic and can be deployed in several industry verticals, the applications in each vertical are very specific and are highly context dependent on the needs and the actors in that vertical.

## 2-5 Ambient Assisted Living

This section elaborates on Ambient Assisted Living, the application area of IoT chosen for study. AAL encompasses technical systems to support elderly people in their daily routine. The vision of AAL is to maintain and foster the autonomy of elderly and provide safety within their home environment. The necessity for such applications arise from the demographic changes in industrialized countries where life expectancy is on the rise and the birth rate is in decline. These circumstances require innovative and cost-effective solutions to keep the health care expenditures within the bounds of economic possibility (Dohr et al., 2010). Further, with the decentralization of health care, development of health and social care assistive technologies, governments and hospital health care are departing from hospital centric care system to support care for elderly clients closer to home with their communities.

AAL has a strong relationship to AmI, which is a technology leading to the IoT. To enable increased safety and wellbeing in one's home, the home has to become intelligent with the help of smart objects, which is the vision of AmI. IoT by definition is capable of providing all characteristics necessary for an ambient assisted environment. IoT applications and services are envisioned to have an enormous impact on independent living, as a support for an aging population (Miorandi et al., 2012). The concept involves detecting the activities of daily living and monitoring social interactions using ambient and/or wearable sensors, monitoring chronic disease using wearable vital signs sensors and in body sensors. With emergence of pattern detection and machine learning algorithms, the "smart objects" in an elderly person's living environment would be able to watch out and care for the person. Things can learn regular routines and raise alerts or send out notifications in anomaly situations. These (social) services can also be merged with the medical technology services (Vermesan et al., 2010).

## 2-6 Market Research on Organization of Dutch Elderly Care

This section presents an overview of the Dutch elderly care market. It elaborates on the organization of care in Netherlands, the key stakeholders, the current policy standing, the future changes and the role of technology in care provision from the perspective of policymakers. This elaboration is necessary in order to point out the right customers for services for assistive technology, their financial pay-ability and to learn the extent to which such technology can be funded by the government or insurance.

### 2-6-1 Organization of Elderly Care in Netherlands

In the Netherlands, care for elderly is covered under Long Term Care (LTC). LTC has a comprehensive coverage that includes predetermined criteria for client assessment and subsequent allocation of care (Colombo and Murakami, 2013, van Rooijen et al., 2013). It is organized nationally under a social insurance programme and covers the possibility to choose care services in cash, or in kind (Colombo and Murakami, 2013). The delivery of LTC services are taken care at the micro level of private care providers, either for profit or otherwise and are responsible for providing quality care for good governance of their organizations (Colombo and Murakami, 2013).

Elderly care falls under the wing of the health care system. The key stakeholders of the Dutch health care system consist of insurance companies, health care providers, consumers and the government as shown in Figure 2-2. The Dutch health care insurance system is based on a "semi-free market system" where health care insurers and providers negotiate about the prices of health care services. All Dutch citizens are obliged to take a basic health insurance package from a private health insurer and are also free to choose an additional voluntary packages whose contents can be established by the insurer (Rolden, 2012).

#### Current Policy in Elderly care

As of 2013, health care is arranged through three major laws: the Health Insurance Act, Zorgverzekeringswet (ZVW); the Exceptional Medical Expenses Act, Algemene Wet Bijzondere Ziektekosten (AWBZ) and the Social Support Act, Wet Maatschappelijke Ondersteuning (WMO) (Colombo and Murakami, 2013, Mot, 2010, Rolden, 2012) as follows.

1. The ZVW arranges for medical care including medication and health care services for general practices, hospitals, dentists, allied health professionals and mental care institutions.

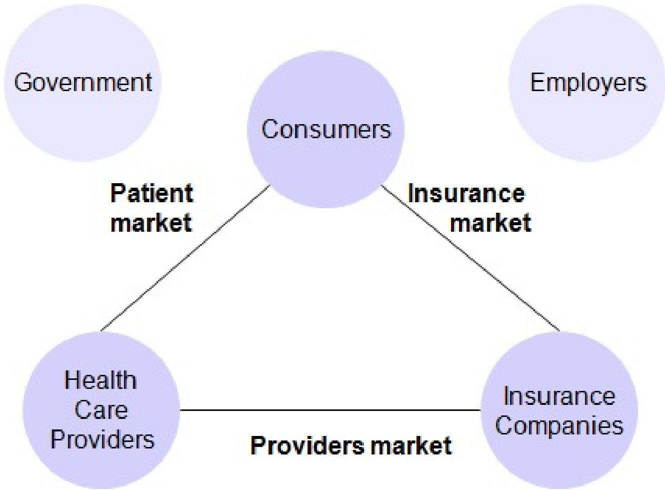


**Figure 2-2:** Main Stakeholders in the Dutch Care System. Source: (Company Records, Achmea Insurance)

2. The AWBZ is the compulsory insurance for the risk of long-term care covering care for the elderly, the disabled and chronic mental health care. It covers personal care, nursing care, counseling and treatment. In the intramural elderly care sector, it compensates the residence and care in care homes, nursing homes and long-term rehabilitation units.

3. The WMO allows every municipality to realize care in its own way. It includes giving information, advice and support to clients, informal caregivers and volunteers. In short, the WMO is mainly focused on providing extramural support, while the AWBZ is focused on intramural care.

Some important governmental organizations that play a prominent role in LTC are: Centre for Care Assessment, Centrum Indicatiestelling Zorg (CIZ) that scrutinizes applications for the elderly deciding whether the client should go in for institutional care or home based care (Colombo and Murakami, 2013, Rolden, 2012) depending on the health condition. The Dutch health care authority, Nederlandse Zorgautoriteit (NZA) monitors the quality of care in home based and institution care and supervises the contractual relationships between clients, insurers, and providers (Colombo and Murakami, 2013, van Rooijen et al., 2013). Health Insurance Board, College voor Zorgverzekeringen (CVZ) gives advice about the content of the basic insurance package to the government and administers the Health Insurance Fund (HIF) and the AWBZ fund.

The elderly LTC services consist of three sectors: informal, institutional and formal care (Colombo and Murakami, 2013).

- **Informal Care**

In informal care the assumption is that the elderly can buy care more efficiently (Colombo and Murakami, 2013). About 157,000 elderly persons received informal care in 2005, a modest share of the elderly in need of care.

- **Institutional Care**

  Institutional care is relatively heavily regulated. Institutional long-term care is available in several forms with the most intensive care given in nursing homes, and less intensive care in residential homes for the elderly. Institutional care plays a relatively heavy role in the Netherlands, at the end of 2007, 164,000 elderly clients used institutional care (6.8% of the elderly population) taking place in nursing homes and elderly institutions, for the most part (Colombo and Murakami, 2013, Mot, 2010).

- **Home Care**

  LTC policy is increasingly aiming at substitution of care towards home. The volume of care at home has been increasing considerably during the past few years. The vision is to facilitate home care thereby encouraging elderly to stay at home longer with only severe cases ending up in institutions.

#### Regulatory Dynamics in Elderly Care

The years 2013 and 2014 have seen great turbulence in the care sector in Netherlands giving rise to policy reforms that are expected to be implemented and reform care starting from 2015. The Dutch care system is currently facing a cultural shift in its organization. In the coming years, the Dutch Government is expected to focus on:

1. Ushering higher responsibility to citizen themselves and their surrounding network of friends, family and neighbors, rather than the formal system of care.
2. Drawing a sharp distinction between individual responsibility, entitlements to health care, and practical solutions.

In the future, care and support activities should only be provided through collective means if a client's financial means, health status and social network does not allow him/her to take this responsibility. In addition to this, at the LTC end, care offices will be abolished and health insurers will then become responsible for compensating medical as well as long-term care for their clients. Low level intramural care disappeared and eligible candidates will only receive indications for extramural care. From 2015, all extramural personal care and counseling will be the responsibility of the municipality (Rolden, 2012). In the social support end eligibility for domiciliary care will become entirely income dependent. Municipalities will only provide such services for those with a relatively low income, other clients will have to find their own means to acquire help with housecleaning, grocery shopping etc (Rolden, 2012).

The translations in policy reforms are as follows:

1. The current AWBZ expires in 2015. The support that was covered by AWBZ, will be added to municipalities through the WMO 2015. This includes, counseling and day care, provision of sheltered housing for people with mental disorder etc. Municipalities are

entirely responsible for support and guidance. Through the WMO a provision will be offered to people who really need it and cannot pay from their budget. Approximately 75% of the budget is transferred to municipalities, however they will receive only 60% of the current budget for customized solutions.

2. There will be a long-term care Health Insurance Act (WLZ) for frail elderly, people with disabilities requiring 24 hour care supervision and for the most vulnerable people with mental disorders. Nursing and care home comes under the Health Insurance (Movisie, 2014).

**Key Figures**

Care expenditure increases exponentially after the age of 65 (Rolden, 2012). The number of people aged over 65 will rise by around 70% between 2010 and 2040, but most analyses show that this trend will have a relatively limited impact on health care expenditure: around 20-25% of the overall increase.

1. The number of people aged 65 and older is expected to increase from 15% of the population in 2008 to 26% in 2040.
2. The Netherlands spends 3.7% of GDP on LTC. The growth in public expenditure on LTC has been above 10% in real term during 2000-10. Projections suggest that expenditure might at least double by 2050.
3. In 2010, 6.5% of the Dutch population over the age of 65 received long term care in institutions while 12.8% of the population received care at home.
4. By 2050, 26.9% of the population is projected to be over the age of 65 and 11.3% of the population to be over the age of 80. This is expected to increase the care expenditure due to elderly alone by 20% to 25%.
5. By 2041 4.7 million Dutch are 65 years or older. That is over a quarter of the working population.

### 2-6-2 Enabling Independent Living - Role of Technology and Policy

This section elaborates on the implication of current policies on technology provision in the elderly care sector. The AWBZ initially supported stimulating regulations for automation systems, but this is currently on hold due to policy changes. The ministry of health care, wellbeing and sports is said to be introducing alternative solutions (Oussoren, 2014). However starting from 2015, the municipalities and health insurers are responsible for health care (Oussoren, 2014). They are said to have the power of deciding to degree they want reimburse "home automation" products. Municipalities face budget cuts and may not offer solutions. Also, if a patient doesn't have a "care indication" he/she needs to pay for home automation costs otherwise the health care organizations may provide for products on (long/short) term. Clients of home care organizations can still depend on a discount (Oussoren, 2014).

The government is trying to promote this shift from an intramural institution based care to an extramural home based care. It is argued that the elderly also do prefer to live as independently as possible (Oussoren, 2014). This reorganization of long term care is seen as a means to sustain the soaring care expenditure (rijksoverheid, 2014a). Additionally the NZa intends to extend its policy in the form of a grant, to 2018. The aim of this new arrangement is that it corresponds to the realization of the goal of automation and monitor care to be accessible for everyone (rijksoverheid, 2014b). Currently this policy is provided to health care providers.

## 2-7 Market Dynamics

### 2-7-1 Market Dynamics in Internet of Things

As with major technological breakthroughs, the emergence of IoT is said to provoke industry disruptions and transformations (Vermesan et al., 2010). Particularly, competitive tension is seen between large market players from vertical sectors on one side and the potential for a more open environment for small and medium-sized enterprises (SMEs) and innovative entrants in IoT in an attempt to co-exist in the embryonic marketplace on the other (Schindler et al., 2012) (Vermesan et al., 2010). The incumbents focusing on competence enhancement have less difficulty in crossing the chasm created by the IoT disruption (e.g., Cisco's Intelligent Urbanization Initiative, IBM's Smart Planet) while the new entrants favour competence destroying innovations to rise rapidly to visibility and significant presence by holding market niches (e.g.,Arrayent) (Vermesan et al., 2010). While large market players can raise significant barriers to market entry for new entrants, certain characteristics of the technology is said to create incentives for vertical integration (Schindler et al., 2012). Also, because the "things" of the IoT act autonomously and as part of a densely linked ecosystem, sole control of the IoT cannot be assumed to lie with the owners of devices or with providers of essential infrastructure services alone (Schindler et al., 2012). Dynamic effects of the IoT on competition among businesses is said to depend on several factors, such as the size and nature of the other players in the market, the nature of demand and the regulatory context (Schindler et al., 2012). The burgeoning IoT industry is thus expected to emerge more from the introduction of new business models than from seniority and size features of companies (Vermesan et al., 2010).

IoT market opportunities are envisioned to include many stakeholders such as consumers, manufacturers but also standard development organizations, national research centers, service providers, network operators, and lead users (Mejtoift, 2011)(Uckelmann et al., 2011). Network operators, such as Telecom, cable and ISP providers have an increased interest in the IoT market since there is a current saturation of the human market in developed countries (Laya and Markendahl, 2013). Besides, adopters can appreciate declining costs in hardware and network connectivity while the coverage of mature communication technologies continues to expand (Laya and Markendahl, 2013). The socio economic impacts of IoT is expected to be a core element of the European digital economy in the next five to ten years (Schindler et al., 2012). The IoT industry is said to be seeing close trends from closed private ecosystems towards open networked ecosystems and business models (Leminen et al., 2012). At the same time, more and more business-to-consumer (B2C) solutions are expected to emerge besides business-to-business (B2B) solutions) that dominate the IoT solution markets today (Leminen et al., 2012). Despite its uncertainties and infancy, IoT is seen as the fastest growing IT segments. By 2020, upper estimates of its annual global economic potential across all affected sectors range from $1.4 trillion to $14.4 trillion (Schindler et al., 2012).

### 2-7-2 Platform Openness and Complimentary Markets in the Care Sector

There are several factors that point towards a push for open platforms, particularly in the care sector. As explained before, the aging population is leads to a demand for more care services for elderly people as innovative health care solutions provide services with less cost and improve quality of life for elderly people. population. This has lead to splurge in health care solutions to provide elderly care services with less cost but also improve the quality of life for the elderly people (Nikayin et al., 2013). They include assistive device providers developing products with web services such as watches, wearables for remote medical or safety monitoring as well as emergency alarming. These services are help care providers provide extra service quality while saving costs. The key issue in existing technologies and devices is that they often run of different non-inter-operable services platforms. The fragmented nature of the market increases costs to develop markets and new services. However, care service providers are finding it difficult to share data and bundle services and products from different service providers. (Nikayin et al., 2013).

The platform openness concept can be analyzed to obtain inputs into the complementary markets that can value form the DoBots platform. Examples from the Ambient Assisted Living Joint Programme (AAL-Europe, 2013) highlights the heightened activity in the area of ICT solutions for the elderly within Europe. This has helped create favorable conditions in industry, and many SMEs in particular have greatly benefited as they have acquired new knowledge of technologies, services, markets, and other actors in the field. Complementary markets represent the major market players in AAL activities as they have a direct relation and responsibility towards ensuring the safety and independent living of elderly persons (AAL-Europe, 2013). Types of complementary markets could be

1. Companies are providing technology that empowers senior living organizations with real-time data on the status condition of their residents (Oliva, 2013) (AAL-Europe, 2013).

2. There are several mobile application developers creating smartapps to be used by elderly home care takers, occupants and families. Examples of companies offering assisted living mobile apps are carevium, seniorlivingapp, gocanvas etc (Commision, 2012) (Gocanvas, 2014) (Carevium, 2014).

## 2-8 Conclusion

The section highlights the technological details of IoT and its link with the vertical of AAL. The Dutch care market and the current policy trends were presented to introduce process and key players in the organization of elderly care. A high level analysis of the care market and the IoT landscape was provide as all these aspects were to be taken into consideration for designing business models for IoT in AAL.

# Chapter 3

# Applied Theoretical Perspectives

This chapter is part of the "**Mobilize**" phase of the research. It presents the theoretical underpinning for this study. It aims at identifying and drawing relations between critical design variables that influence IoT enabled business models. The chapter begins with the business model theories, concepts and definitions in Section 3-1 where the STOF model will be described. Section 3-2 presents the platform theory and its relevance to IoT business model design and the service platform in the case. Section 3-3 presents the related works in IoT which provide insights into the variables that play a significant role in designing business models for IoT. Finally, Section 3-4 conceptualizes an hypothetical framework for designing business models in the IoT domain.

## 3-1 Business Model Theory

### 3-1-1 Business Model Definitions

Literature is fraught with various definitions for business models with the lack of a single vital theory which fully encompasses its meaning. Definitions have been varying with time, depending on changes in the landscape of the industry itself. Chesbrough and Rosenbloom (2002) defines business model as "a method of doing business by which a company can sustain itself - that is generate revenue." It is conceived as a "focusing device" that takes technological characteristics and potential as inputs and converts them through customers and markets into economic outputs by specifying where the firm is positioned in the value chain." According to the Business Model Canvas (BMC) "A business model describes the rationale of how an organization creates, delivers and captures value (Osterwalder et al., 2005)." Bouwman et al. (2008) defines business model as "a blueprint for a service to be delivered, describing the service definition and the intended value for the target group, the sources of revenue, and providing an architecture for the service delivery, including a description of the resources required, and the organizational and financial arrangements between the involved business actors, including a description of their roles and the division of costs and revenues over the business actors." Palo and Tahtinen (2011) says that "A networked business model defines the way a strategic business net creates value." The VISOR business model is defined as "how a firm responds to a customer needs, latent or established, thus creating and delivering the greatest value to the customer, in a profitable and sustainable manner and as such, optimizes costs to value creation (A.El Sawy and Pereira, 2013)."

In a nutshell, a business model is more of a tentative hypothesis, an initial foray into the market than it is a fully elaborated and defined plan of action. Technology managers must thus find the right business model or "architecture of revenue" to derive value from technologies because lack of attention to this factor might cause technologies to yield less value to the firm than they might otherwise. It matters because the same idea or technology taken to market through two different business models will yield two different economic outcomes (Chesbrough, 2010).

### 3-1-2 Relevant Business Model Theories

In order to select a suitable theory to study this case, the research objective and domain activities were revisited. The research goal as in Section 1-3 is centered around defining "critical business model issues" for IoT and recommending business models for the "services" enabled by the IoT service platform. Section 2-7 points towards the market orientation towards "open networked business models" to unite participants from multiple industries to guide service design and delivery in IoT. Further, innovation in the AAL vertical is said to require networked enterprise collaboration (Reiner et al., 2011). These views are taken into consideration while investigating relevant theories from literature. Table 3-1 shows a comparison of the theories identified that closely describe the case. They are briefly presented below.

1. According to Chesbrough and Rosenbloom (2002), choice of markets and value proposition supplies the logic required to translate between the technological and economic domains. This model was considered due to its technology - economic focus. As such it presents an enterprise perspective and lacks the design, service and network orientation sought in the study.

2. BMC by (Osterwalder et al., 2005) distinguishes the inward looking activity/role related approach of a firm to the outward looking value/customer oriented approach. BMC was considered due to its wide usage both in academic circles and by practitioners for its design, visual thinking and innovation oriented approach. However, this model does not illustrate a clear cause and effect linkage between components and provides an enterprise rather than a or networked perspective sought in this study.

3. The STOF model (Bouwman et al., 2008) was considered as it presents practical approaches on business model design for ICT, especially mobile services. IoT services by definition falls under ICT services. It is built around the interrelated perspectives of service, technology, organization and finance domains of a particular focal firm and its associated network. Thus it offers both enterprise and network perspectives. Further, it provides elaborate tooling techniques for designing critical design issues that influences business model viability thus supporting the objective of the study.

4. The networked business model for emerging technologies proposed by Palo and Tahtinen (2011) was appealing due to its focus on ubiquitous services as envisioned in IoT. But it lacks sufficient theoretical depth of study to support this research.

5. The VISOR model (A.El Sawy and Pereira, 2013) was considered due to its focus on digital business ecosystems that spawns from digital service platforms. VISOR was a strong contender as it highlighted platforms with ubiquitous access and intelligence combined with sensor data analytics which closely defines the artifact under study. However, VISOR is slightly futuristic for the still emerging IoT. It also pays attention to the user interface experience for defining the success of services which is not the objective of study here. VISOR has to its advantage that aspects derived from the platform theory are already embedded in the model. But these features of shifts focus from the objective of study which involves defining "services for the service delivery platform" to the platform itself. It also lacks design thinking.

**Comparison:** From the discussion, the STOF theory due to its emphasis on services and the networked nature for its provisioning as against a firm centric model clearly emerges as the best fit theory to study this case. Also, STOF model provides extensive inbuilt tooling options for (1) Using a structured approach to test hypothesis on business models (2) Designing business models along with practical guidelines with a systematic approach to new service development. In comparison, BMC and the framework proposed by (Chesbrough and Rosenbloom, 2002) were more focused on a single product with a single firm perspective. The VISOR model though meant for digital service platforms was not considered as the emphasis in this thesis was not merely on platforms or platform interfaces which VISOR highlights, but on the service delivery capabilities of such platforms.

Further the rationale behind the selection of STOF has a strong technological underpinning. STOF is modeled mainly for mobile innovation services. The IoT environment defined in this case study falls under ubiquitous and pervasive computing which is an extension of mobile computing. This extension is valid because while mobile computing offers low embedded device environment and high mobility, ubiquitous and pervasive computing offers higher embedded environment and higher mobility (Kalle and Youngjin, 2002). The nature of IoT services are closer to mobile and ICT service provision as explained by STOF than digital platform services offered by VISOR. Hence STOF can be described as the closest framework that can be extended to support IoT services.

### 3-1-3 STOF Model

This thesis applies STOF model for designing the business models with "service" as the central element that constitutes the model. The particular focus is on the capabilities of the "service platform" to extract most value from technology. The four elements of the model are briefly explained below.

**Service Domain:** This domain describes the service offering, its value proposition and the market segment at which the offering is targeted. In essence services are conceptualized based on the customer value it can provide. Typically ICT services are accessible anytime and anywhere and are delivered by software programs via computer hardware and communication networks.

**Table 3-1:** Categorization of Business Model Literature

| Authors | Key Components | Perspective |
|---|---|---|
| Chesbrough and Rosenbloom (2002) | Value proposition, markets, value chain, cost and profit, value network, competitive strategy | Enterprise perspective, technology-market mediation |
| Osterwalder et al. (2005) | Value proposition, target customer, distribution channel, activities, core competency, partners, costs and revenues | Enterprise perspective, technology innovation & e-business |
| Bouwman et al. (2008) | Service, Technology, Organization, Finance (STOF) | Network perspective, mobile & ICT services |
| (Palo and Tahtinen, 2011) | Actors, roles, value exchanges, modular services, dynamics | Network perspective, ubiquitous emerging technology services |
| (A.El Sawy and Pereira, 2013) | Value proposition, Interface, Service Platform, Organising Model, Revenue Model (VISOR) | Ecosystem perspective, digital enterprises |

**Technology Domain:** This domain describes the technical functionality required to realize the service offering. It is inclusive of middleware platforms, web services, networks and infrastructure as these characteristics play important roles in the service development, delivery processes, bundling and management. While the nature of service deployed forms an input requirement for the technology domain, the flexibility and design of the technology architecture in itself can also be an enabler for more services.

**Organization Domain:** This domain describes the structure of the value network required to create and provide the service offering. This is necessary because ICT services require organizations to collaborate with each other to provide necessary resources and capabilities for delivering services to the market. It also explains the firm's position within the value network. Their operation in the framework is based on exchange of information, products, services and financial assets making organizations dependent on each other functionally, strategically and financially.

**Finance Domain:** This domain describes how the value network captures monetary value and explains the financial arrangements between actors in the network. It is the bottom line of the business model, with revenues on one side and investments, costs and risks on the other.

### 3-1-4 Design Considerations in STOF Model

According to the STOF model, the viability (long term profitability) and feasibility (market adoption) of a business model is determined by balancing the requirements and interests of both customers and network players in the STOF domains (Bouwman et al., 2008). STOF provides Critical Design Issues (CDIs) which are design variables that can be tuned by practitioners or researchers in order to provide customer and network value. The CDIs in different domains are interdependent on each other and are further linked to Critical Success Factors (CSFs). The CSFs refer to "the limited number of areas in which satisfactory results will ensure that the business model creates value for the customer and the business network."

CSFs helps designers and managers focus on the CDIs that are essential for the viability of a business model. The relations of CDIs with respective CSFs are further elaborated below. The domain Service, Technology, Organization and Finance for the CDIs will be represented by capital letters (S),(T),(O) and (F) respectively.

### CSFs and CDIs of STOF Model

The CSFs that determine the customer value are: Clearly Defined Target Group, Compelling Value Proposition, Acceptable Quality of Service and Unobtrusive Customer Retention.

Compelling Value Proposition relates to the service domain and focuses on creating value for the customer. It is enabled by CDIs *creating value elements* (S) which defines creating value for target users of the service and is directly co-determined by CDIs *pricing* (F) which determines pricing the services for end users and customers and *branding* (S) which determines promoting the service.

Clearly Defined Target Group relates to the service domain and focuses on customers or market segments. It is directly influenced by CDI *targeting* (S) which determines the target group and further co-determined by *accessibility for customers* (T) which determines technical accessibility to the service for the target group.

Unobtrusive Customer Retention relates to the Service domain and focuses in *customer retention.* It is influenced by CDIs *user profile management* (T) which determines managing and maintaining user profiles with user interests and preferences and *customer retention* (S) which determines recurrent utilization of the service by customers.

Acceptable Quality of Service relates to the technology domain and focuses on functional quality of service process. It is influenced by *security* (T) determines arranging secure access and communication, *quality of service* (T) determines providing the desired levels of quality and *system integration* (T) determines integrating new services with existing services.

The CSFs that determine the network value are Acceptable Profitability, Acceptable Risks, Sustainable Network Strategy and Division of Roles.

Acceptable Profitability relates to the finance domain and focuses on providing a positive financial result to match companies' risk return profile. It is directly influenced by CDIs *pricing*, *division of costs and revenues* (F) which determines dividing cost and revenue between business partners and *acceptable customer base*(S) which is indirectly determined by network openness, customer retention and accessibility for customers.

Acceptable Risks relates to the finance domain is more inclined to mobile initiatives due to uncertainties involved with market acceptance and technology choice. It is a consequence of *division of investments* (F) which determines division of investments between partners which is further enabled by value contributions and benefits (F) which measures and quantifies partners' contributions and benefits.

Sustainable Network Strategy relates to the organization domain and concerns with securing access to resources and capabilities that are inimitable. It is influenced by CDI *network governance* (O) which determines the dominant actor to orchestrate the value network and *network complexity* (O) which determines managing increasing number if relationships in a network.

Acceptable Division of Roles focuses on the distribution of roles among firms and the integration of roles within firms that participate in the business network of a service provision. It is related to the CDI *partner selection* (O) which determines the rationale for selecting partners and *network complexity* (O) which determines managing increasing relationships with partners in a network.

### 3-1-5 The STOF Method

The STOF method defines a step by step approach to support the balanced design of business models. It consists of four steps.

In Step 1, called the quick scan, the design variables of the four domains are examined and initial design choices are formulated. It answers basic questions regarding the service concept, the technological architecture, the organizational and financial arrangements in order to yield a broad outline of the business model.

In Step 2, the quick scan is evaluated with respect to the eight CSFs, with the aim of assessing the expected viability of the model. The evaluation helps determine which parts of the business model have to be modified or refined.

In Step 3, the CDIs refine the CSFs that were evaluated negatively in Step 2.

In Step 4, an internal evaluation between the domains as well as the robustness of the design focusing on external evaluation will be done.

## 3-2 Platform Theory

The platform concept has been discussed in myriad empirical contexts within academic literature. The term platform basically means a physical foundation to establish activities (Sorensen, 2013). In the ICT domain, digital platform technologies are creating profound changes in transforming service industries (Gawer, 2010). The primary difference between the traditional discussion manufacturing oriented platforms and digital platforms is that digital platforms are either entirely software-based or they are mixtures of physical and digital elements (Sorensen, 2013). Innovation through digital platformization are features of the information economy with successful platform companies such as Apple, Google, Amazon and Facebook proving examples with potential to redesign industrial landscapes (Gawer, 2010).

The platform in this study falls under the definition of "service platforms." Technically, a service platform is a combination of hardware architecture, network, and an operating system or a software framework required to offer software services to end users (Evans et al., 2006). The main features involve facilitating the creation of software applications and increasing the value of the integrated system to consumers. Service platforms provides Application Programming Interfaces (APIs) and Software Development Kits (SDKs) for accessing services. The artifact under the case study is an integrated information system where heterogeneous resources such as devices (smart objects, sensors) and networks are organized together. These resources are aggregated with a software framework, supporting operating systems and terminals to shield heterogeneity. Hence it adheres to the definition of a software service platform that runs applications and delivers services to end users. Further, the platform also provides APIs for sharing and reusing artificial intelligence algorithms. More details on the platform studied in this case is present in Chapter 4.

Platform theory is an aggregation of many platform related concepts. The following concepts were studied in order to select those that befits the case. In principle, there are one-sided and multi-sided markets (platforms) where competition takes place (explained in detail in subsection 3-2-1). *Platform competition* focuses on how to substitute and charge parties in different sides of these platforms. In particular *multi-sided pricing strategies* enable platform providers to determine a price for each side by considering the consequences, growth and willingness to pay on the other side (Rochet and Tirole, 2005). Multi-sided platforms face challenges to achieve a critical mass of users on each side of a platform to make it valuable for the other side. This is captured by its *network effects* (Rochet and Tirole, 2005). *Platform leadership* defines strategies for platform providers to stimulate the growth of platforms and encourage involvement of complementary providers (Gawer, 2010). *Platform openness* determines how open a platform should be to influences the growth and innovation around a platform.

From an economic point of view, service platforms inherently create *multi-sided markets* (Evans et al., 2006). As the case platform is a service platform, further choices of concepts are motivated following this definition.

### 3-2-1 One-Sided and Multi-Sided Markets

One-sided markets are characterized by a traditional value chain, where value creation is sequential. Here value is added by having the output of one's activities as the input of another's (Järvi and Pellinen, 2011). Figure 3-1 presents the value and revenue flows in one-sided markets. Value flows from suppliers, through enterprises, to customers and end-users, while revenue is moves in the opposite direction.

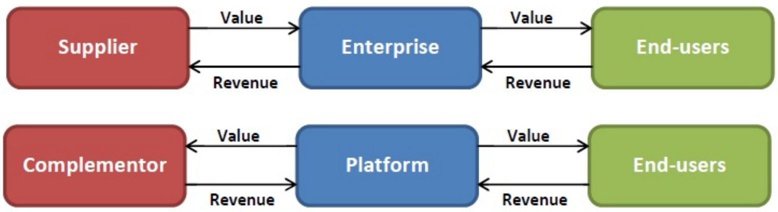


**Figure 3-1: (a)** One-Sided Market, **(b)** Two-Sided Market. Source: (Järvi and Pellinen, 2011)

In multi-sided markets, the service platform provider acts as an intermediary that must serve two or more distinct groups of consumers in order to generate demand from them (Thomas R. Eisenmann, 2008). Figure 3-1 represents the flows of value and revenue in two-sided markets. Here, the joint participation of the each group makes the platform more valuable to them (Evans et al., 2006).

Interestingly, markets that are organized around two-sided platforms could be viable as traditional one sided markets too. Apple's iPod presents such an instance of integrating vertically into the supply of a component than relying on the market (Evans et al., 2006). Thus the choice of market selection lies on the service provider. While it is acknowledged that the service platform under study has multi-sided capabilities, in order to restrict the scope, this study chooses to discuses only the single sided market catered by the service platform to its end users. Thus the concepts relating to multi-sided platforms such as *multi-sided pricing models* and *platform competition* cannot fully support the case. *Network effects* would have been relevant to explore, but it strays away from the prime objective of study. *Platform leadership* will play a stronger role for guiding platform providers once services and business models are conceived than prior to design. *Platform openness* however shows indications of being highly relevant to this case. The reasoning is explained next.

In Section 2-7 it is seen that market orientation in IoT towards "open networked business models" to unite participants from multiple industries for service design and delivery. Further Section 2-7-2 enforces that complementary markets such as assistive device providers, providers for web services such as watches, wearables for remote medical monitoring as well as emergency alarming represent the major market players in AAL activities for ensuring the safety and independent living of elderly persons (AAL-Europe, 2013). This along with the vertical specificity of IoT is taken as the motivation to study the concept of platform openness to investigate into the complimentary actors and services that can add functional value to the service platform in AAL. However, it is emphasized that the openness is studied from the perspective of providing increased functional density of applications to the end user by the service provider in the one-sided market, than discussing its possible role as a "match maker" platform for the two-sided market.

### 3-2-2 Platform Openness

A critical aspect of a software platform's architecture is whether to keep it open or closed. With an open platform, anyone with the right technical knowledge can obtain access to the services provided by the platform or its underlying elements (Gawer, 2010). Opening the platform implies determining the degree of participation of platform mediated network players (Hilkert et al., 2011). Two types of platform openness can be recognized as follows:

1. Technical Openness: From a technical perspective, the modular nature of platform architectures enables the service platform provider to open certain aspects of a platform. Technical facets such as APIs or Software Development Kits (SDKs) can be provided to complementary actors to take advantage of innovative products and services on the platform and is regarded as vertically opening a platform (Hilkert et al., 2011) . Platform providers can strategically facilitate complementary third party innovation by designing an optimal choice of openness (Cusumano, 2010).

2. Organization Openness: From an organizational perspective, platform openness involves control over the participation of complementary providers. This includes aspects such as determining whether to extend the backward compatibility for past platform generations to compliments or granting exclusive access rights to selected compliments (Thomas R. Eisenmann, 2008).

   From an organizational perspective, platform openness involves control over participation of complementary providers, the degree of interoperating with other rival platforms (Eisenmann, Parker, Van Alstyne, 2008)

This study investigates into the technical openness of the service platform to explore the external compliments needed to add increased functionality to the service platform under study. After reviewing the theory, the design variable platform openness can be identified.

**Design Variable One: Platform Openness** This variable determines what complements to develop in-house and what to be left to external firms. It also defines how open the platform should be to external complimenters.

## 3-3 Related Works on Internet of Things

While generic literature such as STOF can be used to design business models, the biggest hindrance in proceeding with the direct design in this study was the need to identify the specifics bought by the technology of IoT. So as a first step it was necessary to specify the design issues for the domain of IoT as a prerequisite to developing business models. A detailed literature review from eleven business model related papers in IoT were conducted in order to identify the characteristic design variables specific to the domain of IoT (refer Appendix -1). From the literature three prominent variables were identified as characteristic to IoT business models. This section elaborates these variables further.

### 3-3-1 Value Creation Characteristics in Internet of Things

A typical business transaction is defined by a physical product(or service) stream, information stream and money stream (Bucherer and Uckelmann, 2011). IoT enables tighter coupling of these three components and changing one component impacts the other two. We can identify two major sources of value creation in IoT. They both come from objects, but from two directions as follows:

1. Objects as a source of data (Information)

   Several past works have pointed towards data or information as one of the main value creating elements in IoT. Miorandi et al. (2012) points out that, conceptually IoT is about objects acting as providers and/or consumers of data related to the physical world. The focus is thus on data and information rather than on communication itself (Leminen et al., 2012). IoT creates value as the collected data can be used in both industry and customer driven value creation processes by the provision of information everywhere (Mejtoift, 2011). Consumers are thus not just passive actors, but play a significant role in the after market that delivers usage data and feedback to service providers for co-creation of values leading to novel business opportunities (Leminen et al., 2012) (Laya and Markendahl, 2013). However, a detailed insight into the use of information for value creation is obtained from the work of Bucherer and Uckelmann (2011) who says "information itself may become a major source for value creation and thus the value proposition." Information can be used to enable applications under the category of information and analysis: tracking behaviour, enhanced situational awareness, sensor driven data analytics (Chui et al., 2010) (Elaborated in Section2-3).

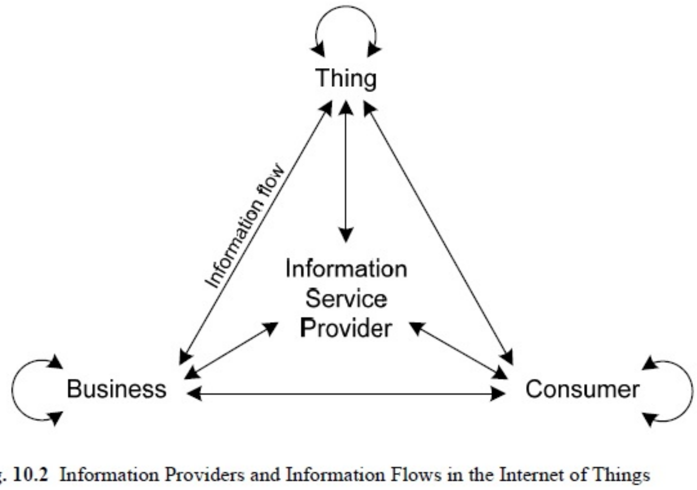


**Figure 3-2:** Information Flow in Internet of Things (Bucherer and Uckelmann, 2011)

2. Objects as things that think (Intelligence)

   The second key aspect is the usage of objects as a co-creative partner because the things within a network can think for themselves (Mejtoift, 2011). With increasing the embedded intelligence in things, they think and act more by themselves. This network of thinking things presents the fundamentals of IoT and forms the co-creative layer (Mejtoift, 2011). It obtains its basis from the first point where data collected from objects are analyzed to provide feedback through a network of actuators that can in turn modify processes.

The visualization of information flow between things, consumers and businesses facilitated by a service provider is shown in Figure 3-1. The information exchange between the nodes in IoT network and the involvement of all stakeholders in the "win-win" information exchange are pointed as key issues in designing IoT business models (Bucherer and Uckelmann, 2011). Thus the option for choosing or combining the two sources of value creation for IoT gives rise to the design variable, IoT value creation. This variable represents the related works from IoT business model literature for value creation.

**Design Variable Two: IoT value creation** This variable enables the option of designing services that utilize data and thus information from things for value creation and/or combines this with intelligent applications enabled by the network of things that think. It points to the importance of involving consumers, businesses and service providers in the value exchange.

### 3-3-2 Revenue Generation in Internet of Things

Literature offers some starting points for discussing the revenue generation characteristics in IoT. Providing paid access to information and enabling information distribution between participating stakeholders are suggested (Bucherer and Uckelmann, 2011). Prices can be increased or decreased depending on time-dependency concerning value of information (Bucherer and Uckelmann, 2011). Business opportunities exist for monetizing customized or pre-processed messages such as alert messages based on automatic sensor triggering (Fleisch, 2010). Sun et al. (2012) suggests revenue creation by optimization procedures such as enhanced management efficiency enabled by IoT. Extensive user feedback most (often via the smartphone) that links the smart object with other resources on the internet and the user in a relevant context is said to enable consumer contact and opportunities for additional revenue (Fleisch, 2010).

The revenue generation opportunities above are manifold and shows a clear link towards the value creation capabilities of IoT. Different value creation characteristics in IoT can be monetized differently, giving rise to the creation of a design variable IoT revenue model to represent the related works above on revenue generation.

**Design Variable Three: IoT revenue generation** This variable provides the flexibility to design revenue models in IoT based on the chosen value creation capabilities.

### 3-3-3 Vertical Domain Specific Characteristics of Internet of Things

Profiting from the IoT ecosystem's business potential is said to be dependent on progress in its respective vertical domains (Leminen et al., 2012). It is emphasized that solutions should have tailored approaches dedicated to particular industry segments involving a thorough understanding of the corresponding needs (Laya and Markendahl, 2013). Next, IoT envisions market opportunities that includes many actors such as chip makers, sensing device manufacturers, system integrators, service providers, network operators, customers and finally users (Mejtoift, 2011). IoT services are argued to be part of a complex value constellation (demonstrates the complexity of value creation grows way beyond today's 2- dimensional value chains and value networks to include the Internet of Things (Mejtoift, 2011).), where the end consumer is not necessarily directly involved with the service provider. Also new players such as network operators are entering the IoT market thus there is a shift from the traditional service provider - customer delivery model to the newer alternative relations between actors to successfully provide the services (Laya and Markendahl, 2013). IoT environments more participants from multiple industries would join in and bring more complicated relationship which needs to be carefully researched to guide service design (Ma and Zhang, 2011). The key actors identified may be consumers, network actors in a business, actors for service delivery and the service provider itself (Bucherer and Uckelmann, 2011). The choice for designing the inclusion of specific actors while design business models gives rise to the design variable IoT value constellation.

**Design Variable Four: IoT value constellation** This variable provides the flexibility for choosing actors for service provisioning offering both business and service delivery capabilities.

To sum up, this section assembles related works from literature on IoT business models. These works emphasize the IoT specific characteristics that should be taken into consideration while designing business models and form the basis of deriving the hypothetical framework to design business models for IoT.

## 3-4 Applying the STOF Model to Internet of Things

This section draws on the definitions of IoT design variables as explained in Section 3-3 to establish hypotheses between the IoT variables and CDIs in STOF model and platform theory in order to establish a theoretical framework to guide research. The relation between variables for IoT business models are analyzed in the Service, Technology, Organization and Finance domains. This framework is derived from the perspective of the IoT service provider who wishes to offer services via the service platform to end users.

The definitions of the "IoT design variables" from related works and the design variable "platform openness" from platform theory are similar to the definition of STOF CDIs. The STOF CDIs can be used provide the supportive elements that elaborates the design variables further. Hence it is necessary to draw parallels and relations between the additional design variables and the core STOF CDIs and related CSFs. The Table 3-1 shows the relations.

**Table 3-2:** Categorization of Design Variables in the STOF database

| Design Variable | STOF domain | STOF CDIs | STOF CSFs |
|---|---|---|---|
| IoT value creation (IoT related works) | Service | Targeting, Value Elements, Accessibility to customers | Clearly Defined Target Group; Compelling Value Proposition |
| IoT revenue generation (IoT related works) | Finance | Value Contributions and Benefits; Division of Cost and Revenue; Value Elements | Acceptable Profitability |
| IoT value constellation (IoT related works) | Organization | Partner selection | Acceptable Division of Roles |
| Platform openness (Platform theory) | Organization | Network Openness | Acceptable Division of Roles; Acceptable Profitability; Compelling Value Proposition |

**Service Domain:** The CDIs in the Service domain are *targeting, creating value elements, branding* and *customer retention*.

1. The design variable *IoT value creation* points to the value creating capabilities of IoT. This variable is important to the service provider to define the value proposition of services to be delivered by the platform. This can be directly related to the STOF CDI *value elements* and hence is classified under the Service domain.

2. *IoT value creation* further points out that information can be used by the service providers for value creation between the industry and consumers. These stakeholders form part of the market, hence the variable *IoT value creation* can also be said to influence CDIs *targeting* in the Service Domain.

The relations to the other CDIs under the Service domains *branding* and *customer retention* are not clearly visible from the related works. Further, while the importance of these CDIs are acknowledged for refining business models, their role in designing new models is marginal and hence is considered outside the scope of study of this thesis.

**Technology Domain:** The CDIs in the Technology domain are *security, quality of service, system integration, accessibility for customers* and *management of user profiles.*

1. *IoT value creation* though categorized under the Service domain can be said to influence the CDI *accessibility for customers* in the Technology domain. This is because the service provider should make the objects and the service offering via the platform available to the customers in order to get information or usage data from them. Due to its close linking with the customers, the CDI *accessibility to customers* is related to CDI *targeting* as in traditional STOF theory.

The relations to the other CDIs under the Technology domain *security, quality of service, system integration* and *user profile management* are not clearly visible from the related works. Further, while the importance of these CDIs are acknowledged for refining implemented business models, their role in designing new models is marginal and hence is considered outside the scope of study of this thesis.

**Organization Domain:** The CDIs in the Organization domain are partner selection, network openness, network governance and network complexity. *IoT value constellation* can be clearly categorized under the Organizational domain.

1. *IoT value constellation* can be closely related to the CDI "Partner Selection" as it supports the service provider in selecting the actors with the right resources and capabilities to help service provision. However, this design emphasizes the need for selecting partners, not merely for service provision but also new actors such as network operators who might play non-traditional roles in IoT and also functional actors specific to the chosen vertical.
2. The design variable from platform theory, *platform openness* is classified under the Organizational domain. Here the service provider should decide the openness of the platform for external complimentary actors. *Platform openness* is very similar to STOF CDI network openness. However, the former term is used as it makes the platform under study explicit.

*IoT value constellation* thus encapsulates both *partner selection* and *platform openness.* It is apparent that this variable can be related to the other CDIs *network governance* and *network complexity.* However, studying these relations is estimated to be too complex and is left outside the scope of this study.

**Finance Domain:** The CDIs in the Finance domain are *pricing, division of investments, division of costs and revenues* and *valuation of contribution and benefits.* The IoT design variable *IoT revenue generation* is categorized under this domain.

1. *IoT revenue generation* can be said to be closely related to the STOF CDIs *division of costs and revenue* and *valuation of contributions and benefits.* This is because the

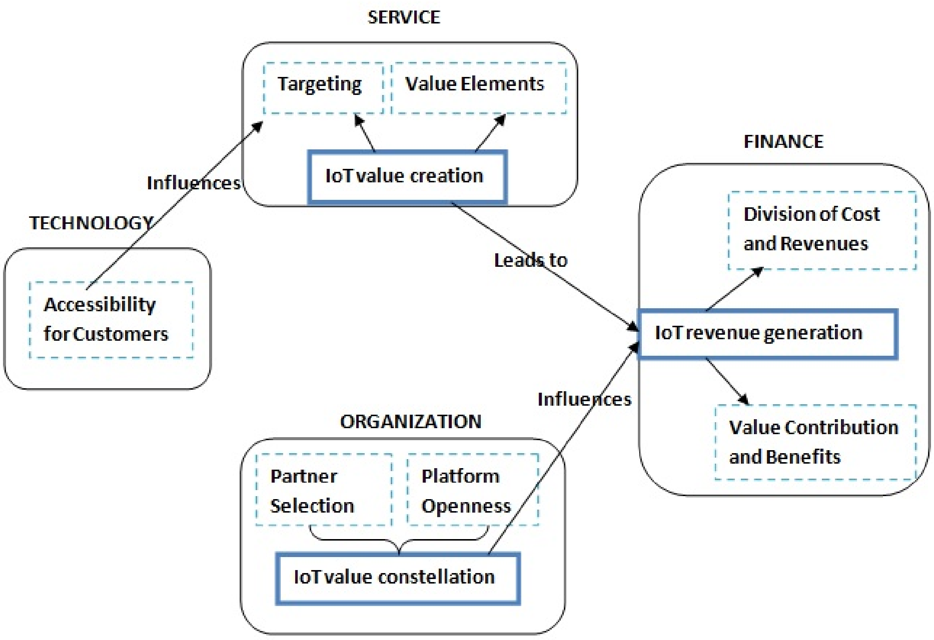


**Figure 3-3:** Applying STOF model to Internet of Things

variable *IoT value constellation* in the Organization domain points to the probable diversity in actor roles and hence the important for services to plan the revenue division between these actors.

2. From definition *IoT revenue generation* can be designed based on *IoT value creation*.

It is apparent that the remaining CDIs *pricing* and *division of investments* play an important role within this domain. However, studying these relations is estimated to be too complex and is left outside the scope of this study.

In the analysis above, the definitions of the IoT design variables that was learned from theory are used to establish hypotheses between the variables and STOF CDIs because together they provide the pieces to establish a framework for specifying IoT business models. This hypothetical framework is intended to give insights into the important aspects to be considered while designing business models for IoT. The visualization of the framework derived from the above analysis as shown in the Figure 3-3. The dark blue blocks indicate IoT design variables and dotted blue blocks indicate STOF and platform variables. It will be used as a blueprint in field research and will be further consolidated for designing IoT business models.

## 3-5 Conclusion

This chapter draws insights from related works in IoT business model literature and combines it with STOF and platform theory to arrive at a framework for designing business models for IoT. This framework will be used as a blueprint for field research. It will be further specified and clear relations will be drawn between the deign variables, CDIs and domain after analyzing empirical data.

# Chapter 4

# Case Study - DoBots

This chapter is part of the "**Mobilize**" phase of the research. Here the case platform of DoBots is investigated to study its technological and functional capabilities. The explanation follows discussing with platform capabilities with researchers from DoBots and learning company documents. An attempt has been made to support the technical details with academic literature. This section has been evaluated within the company.

## 4-1 DoBots Platform - Technology Description

In Section 2-1 of Chapter 2 the technological layers of IoT was explained. In this section these layers are related to the IoT service platform of DoBots.

### 4-1-1 Platform Architecture

The DoBots platform supports a distributed information technology architecture. Here the sensors perform local functions before communicating the partial results to the network (Miorandi et al., 2012). Figure 4-2 shows a visualization of the components of the DoBots platform. The platform consists of four layers:

1. Smart Object Layer: This layer consists of smart objects that has both sensing and control units (The prototype is shown in Figure 4-1). They can be embedded into any electrical socket in a building. These are miniaturized computing nodes and can communicate with each other using Bluetooth Low Energy (BLE). It can sense parameters such as occupancy, motion, temperature and power consumption. The objects can also control lights and appliances such a microwave ovens and refrigerators. The smart object can also act as a sensor node, making it useful for tracking and tracing people in a given environment. These objects have limited nodal processing and computing power and forms the Local Area Network (LAN).

2. Localized Gateway: It addresses the issue of interoperability in device communication by permitting communication between protocols such as Zigbee, BLE and Wifi. It provides computing support within the LAN environment and connects it to the internet for cloud computing. The wireless network provides distributed computing and control capabilities to the connected environment.
3. Cloud Computing: The platform runs data processing, pattern recognition and artificial intelligence algorithms for machine learning. When the scale of computation is large, the local infrastructure above provides limitations in processing power, battery life, computation speed and communication capabilities. Hence depending on the scalability of the building, and level of access needed these services are passed on to the cloud.
4. User Interface: The smartphone of the user contributes to the platform in two different ways. First, smartphone houses sensors such as microphone, accelerometers etc. and can provide valuable insights into user activity. Second, it serves as an interface to the platform for visual information or external actuation of devices.

## 4-2 DoBots Platform - Functional Capabilities

In Sections 2-3 and 2-4 of Chapter 2 the applications and services enabled by IoT were listed. In this section the functional capabilities of an IoT platform that enables provision of such applications and services are explained. The platform of DoBots is capable of providing the following functionalities:

1. Sensing: The smart object layer is consist of sensors that can detect physical parameters such as pressure, temperature, occupancy and light. These objects infer user activity (where the users are, characteristics of the environment etc.), monitor people presence, needs and are customizable to accommodate climate conditions, lighting and safety preferences. Several artifacts in the home environment can be enriched with sensors to gather information about the user and to act independently without human interaction.
2. Reasoning: At this level, the system reasons the activities needed to be implemented. This layer provides user modeling, activity recognition and prediction, and decision making.
   - Modeling: Here the system is responsive to user behavior, and can customize the software towards user. This provides the basis for detecting changes in resident pattern.
   - Activity Prediction and Recognition: The artificial intelligence in the system can predict and recognize activities in the environment fitted with sensors. It is designed to then improve the experience of occupants in the environment.
   - Decision Making: The system employs spatial and temporal reasoning and control techniques to make sensible decisions about and for the users. The layer focuses on processing, filtering, and interpretation of sensor data before it can be used at higher levels. Here various elements of distributed model such as sensors and devices, interconnected through wireless networks are integrated and information coming from them is understood.

3. Acting: The software acquires sensory data and uses this information to reason and act on the environment. The actuating elements may be present in the smart devices themselves. The actuations can be in the form of switching the lights, alerting users on a mobile phone, calling emergency services on fire detection etc.

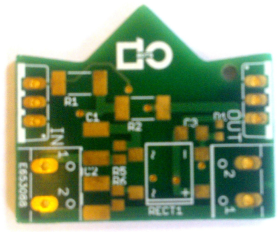

**Figure 4-1:** Smart Object Prototype (Source: Company Records, DoBots.)

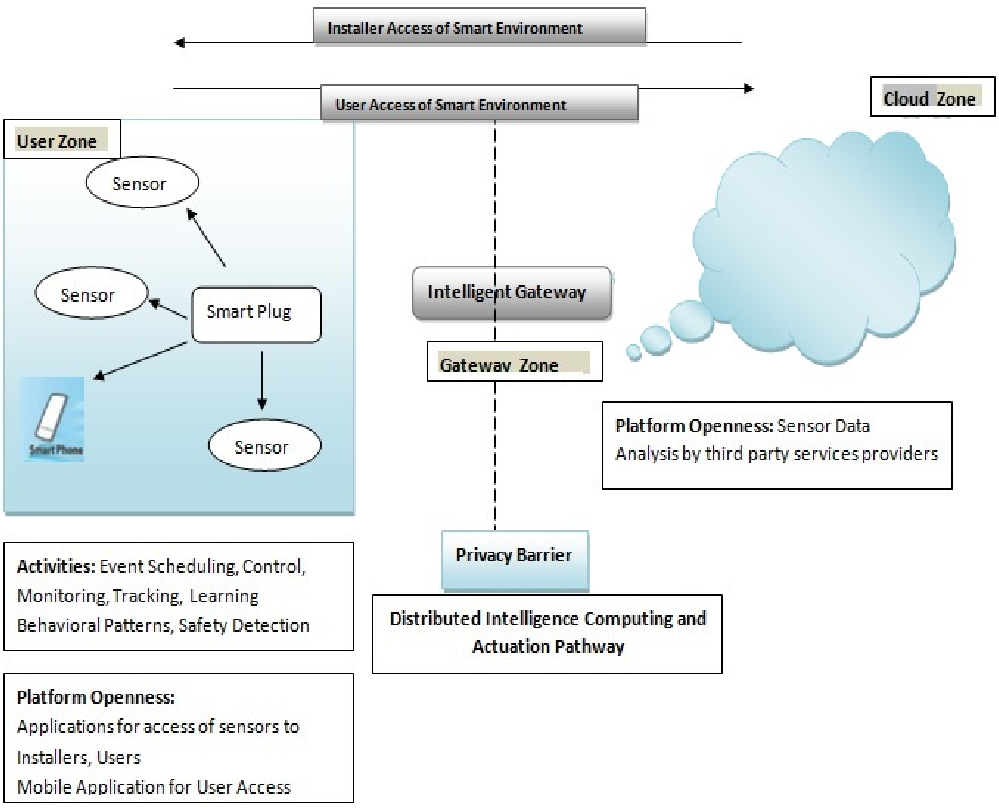


**Figure 4-2:** DoBots' Platform Components and Openness

## 4-3 DoBots Platform - Software Capabilities

In Section 3-2, the concept of a service platform was discussed. The software artifact of DoBots is an IoT service platform that provides a machine-to-machine (M2M) framework. It differs from other IoT platforms in that it connects not only low-energy, low bandwidth devices (such as Bluetooth Low Energy, Zigbee networks) but also uses high-bandwidth solutions (using the infrastructure for video and audio) for communication between devices. At the moment the platform offers the following features (DoBots, 2014):

1. It provides options for connecting devices on the fly and a tool set for module management and scheduling.
2. It provides open APIs for machine learning and artificial intelligence algorithms to third party developers. It enables specialized software for navigation and localization.
3. It offers the infrastructure for real-time data streaming between devices using the Extensible Messaging and Presence Protocol (XMPP).
4. It provides applications that run on Android operating systems, Raspberry PI or Ubuntu using the communication schemes on those platforms. It delivers cross-platform support for middle-wares such as Yet Another Robot Platform (YARP), Robotic Operating System (ROS), Android Operating System etc.

In the platform theory in Section 3-2 the openness decision for the platform was discussed. The Figure 4-2 gives a visual demonstration of the technical openness of the service platform. The DoBots platform can offer the functionality to be open in two directions. First, the platform can be opened at the user level for applications to access the sensor functionalities using smart phone or web interfaces. Next the platform can be opened to third party service providers either for complimentary service provision or sensor data analytics at the cloud level.

## 4-4 Conclusion

This section provides an overview of the technological architecture, functional and software service capabilities of the IoT platform studied in this case. Here the elements of the platform are related to the theoretical concepts of IoT described in Chapter 2 and the platform theory in Chapter 3 thereby providing practical insights into theoretical concepts for the IoT service platform.

# Chapter 5

# Qualitative Research

This chapter presents the "**Understand**" phase of the research. The field research was conducted with twin objectives. First, to learn from practitioners about capturing the value creating capabilities of IoT in order to specify the business model design issues for the domain of IoT. Second, to study the Dutch elderly care market for understanding the stakeholders involved in the care process, the user needs and applications in the AAL domain in order to design business model concepts for IoT in AAL.

## 5-1 Interview Methodology

Interviews were chosen as data collection method in order to gain a deep understanding of the problem and the reasoning behind respondent's answers. This method complements the exploratory nature of this research. This section elaborates the interview methodology which includes selecting the respondents, preparing the interview protocol and data operationalization techniques used.

### 5-1-1 Interview Respondent Selection

The selection of respondents were based on the research subquestions. The list of interviewees, their functional roles, the company and the industry sector they belong to is shown in Table 5-1. To begin with, research subquestion one consists of analyzing the generic value creation and revenue generation capabilities of IoT. Practitioners in IoT companies were consulted to help answer this question. Only IoT companies that work in sectors directly or indirectly related to AAL such as smart buildings or elderly health care were considered. A telecom player was particularly chosen as desk research had pointed towards the growing role of telecom companies in IoT. The respondents from IoT companies are labeled as IoT1, IoT2, IoT3, IoT4 and IoT5 in the table. Next in order to answer the second research subquestion, two groups of stakeholders were identified. First, the providers of elderly care which involves elderly care homes and policy actors. They were interviewed as they are the first point of contact to the elderly consumers and are labeled Care1, Care2, Care3, Care4 and Care5. Second, the technology providers in the AAL domain from whom further insight into AAL applications could be obtained. They are labeled as AAL1, AAL2, AAL3, AAL4 and AAL5. The AAL companies AAL3, AAL4 and AAL5 were particularly chosen as they had IoT technology capabilities i.e. they have smart objects (wired or wireless sensors) that run algorithms for data capture and processing and deploy cloud services. They were expected to provide significant insight into both the IoT aspects for business models as well as the care related applications in AAL. Hence, these three companies are added to the first five IoT companies for answering the first research subquestion. In total this study takes inputs from fifteen practitioners to get practical insights into IoT, the AAL domain and the elderly care process. Inputs from such a broad set of stakeholders were necessary as desk research revealed their roles as equally important. Further, this was also necessary to gain sufficient data and depth into the case for the purpose of triangulation of both sources and data during analysis.

### 5-1-2 Interview Protocol and Process

The interview protocol was designed in order to answer the subquestions one and two. In order to have scientific rigor in asking the right questions, questions from the work book (Bouwman et al., 2010) under the STOF domains were chosen. The questions were tuned towards IoT, AAL or elderly care market depending on the respondent and their knowledge on the subject. Table 5-2 presents some sample questions in the interview protocol for the three categories of respondents (detailed protocol is present in Appendix -2). The interviews were conducted from practitioners in the industry in the period between April 2014 and July 2014. They were semi-structured and deep in nature. A rough framework of the CDIs and the interview protocol were used as a blueprint in order to ask the same questions to similar categories of stakeholders. Each interview started with a brief description of functional/service capabilities of DoBots platform and further delved into questions as per the protocol or in the direction of discussion specific to each stakeholder. At the end of discussion, the protocol was examined to ensure that most questions were answered within the discussion. Audio recordings were made with the consent of the respondents. These were literally transcribed for data analysis. Detailed interview protocol is explained in the Appendix -2.

## 5-2 Data Management and Analysis Approach

The interview analysis requires particular mention as it intends to answer subquestion one, two and three and hence plays an important role in this research. The data management and analysis were experimented in multiple ways iteratively before freezing on the successive phase based analysis approach as explained in the following sections. The data management and analysis approach is visualized in Figure 5-1. To begin with a matrix array based coding (Yin, 2011) of the data under the STOF domains was conducted in Microsoft Excel with STOF preliminary variables in rows and interview respondents in columns with their relevant response filled in each cell. Next IoT and platform characteristics were extracted from the matrix data and placed into new rows in order to distinguish them further. This gave a clear picture of the nature and distribution of the data from IoT, AAL and care respondents and

**Table 5-1:** List of Interview Respondents

| SlNo | Ref. | Company | Industry | Functional Role | Date of Interview |
|---|---|---|---|---|---|
| 1 | Care1 | Care Home | Hospital & Healthcare | Managing Director | 26 $^{th}$April 2014 |
| 2 | Care2 | Care Organization | Hospital & Healthcare | Project Leader | 27 $^{th}$ June 2014 |
| 3 | Care3 | Care Home | Hospital & Healthcare | Innovation Manager | 17 $^{th}$ June 2014 |
| 4 | Care4 | Municipality | Policy and Management | Innovation Manager | 1 $^{th}$ July 2014 |
| 5 | Care5 | University | Policy and Management | Assistant Professor | 4 $^{th}$ July 2014 |
| 6 | AAL1 | Installation Company | Building Management | Operational Manager | 24 $^{th}$ June 2014 |
| 7 | AAL2 | IT and Services | Smart Homes and AAL | Project Leader | 13 $^{th}$ June 2014 |
| 8 | AAL3 | Software Services | Smart Homes and AAL | Business Development Manager | 30 $^{th}$ June 2014 |
| 9 | AAL4 | System Integrator | AAL | R&D Manager | 16 $^{th}$ June 2014 |
| 10 | AAL5 | System Integrator | Hospital & Health Care | Commercial Director | 23 $^{th}$ July 2014 |
| 11 | IoT1 | Telecom Provider | IoT - Telecom | Business Development Manager | 15 $^{th}$ July 2014 |
| 12 | IoT2 | Software Provider | IoT - Health care | Managing Director | 16 $^{th}$ July 2014 |
| 13 | IoT3 | Building Management | IoT - Smart Buildings | Hardware Innovator | 27 $^{th}$ May 2014 |
| 14 | IoT4 | Software Provider | IoT - Smart Buildings | Director Strategy & Innovation | 23 $^{th}$ April 2014 |
| 15 | IoT5 | Software Provider | IoT - Smart Buildings | Business Development Manager | 30 $^{th}$ April 2014 |

**Table 5-2:** Interview Protocol

| | Care | AAL | IoT |
|---|---|---|---|
| **Service** | What are the AAL applications deployed in elderly care? Who would like to pay for such services? | What are the services enabled by your AAL technology? What are its value creating capabilities? Which are your target markets? | What are the services enabled by your IoT technology? What are its value creating capabilities? Which are your target markets? |
| **Technology** | How do the care organizations or the elderly access such technologies? | How do you integrate to technology solutions? How do you provide access to customers | How do you integrate to technology solutions? How do you provide access to customers |
| **Organization** | Who are the stakeholders in the care process? What are the policy implications that play a role in delivery of AAL type services? | Who are your network partners for service delivery? What is the role of platform openness? Do you partner with complementary service providers? | Who are your network partners for service delivery? What is the role of platform openness? Do you partner with complementary service providers? |
| **Finance** | Do care organizations integrate AAL application with care services? How is revenue generated from using such services? | What are the revenue models for your applications? What is the basis for such models? | What are the revenue models for your services? What is the basis for such models? |

their comparative perspectives. Initially a holistic analysis of data from all stakeholders were carried out. This was not fruitful as it was impossible to extract the IoT specifics due to overlaps in IoT and AAL terminologies and related user needs. At this stage the analysis was framed in terms of categories of participants from whom from the data was collected (Namey et al., 2007). The subquestions were then revisited and subsequently an isolated phase based approach which differentiated IoT specifics from AAL needs emerged as the best alternative to answer the subquestions. This set guidelines for data reduction, where data was partitioned in a way appropriate for the hypothesis testing for phase one and market needs assessment in phase two.

At this stage the Atlas.ti. tool was bought into picture for coding to perform content analysis. Content analysis, involves the extraction of information from large quantity of texts by assessing the frequency and salience of particular words or phrases in the original text data in order to identify keywords or repeated ideas (Namey et al., 2007, Verschuren and Hartog, 2005). This research used the theory driven approach of content analysis. This approach was guided by theoretical framework defined with the hypothesis of relations drawn between design variables as derived from IoT works. The content analysis is supported by narrative analysis. "Narrative analysis presents a holistic approach to discourse that preserves context and particularity and yields information not available by other methods" (Smith, 2000). This combination of techniques was expected to offer clear interpretation and analysis of data.

As mentioned, in order to process the data systematically, the qualitative software analysis tool Atlas.ti. was used. The transcripts were coded into variables according to the analysis points. The theoretical framework proposed in Chapter 3 was used as the preliminary coding structure for the data for phase one. More codes were made during the analysis as new specific issues began to surface. The codes are visualized in the "network view" in order to see relations between variables. Each of the codes shown in the figures contains two types of numbers. The first number counts the groundedness of a code i.e. the number of associated quotations. The groundedness associates the importance of the code with respect to other codes. The second number indicates the density of a code i.e. the number of links to other codes. Further, each code is linked to its respective domain under STOF by indicating it with capital letters. For instance (S) means the code belongs to the Service domain. The codes were sometimes made for more than one quotation within an interview, when an interviewee mentioned a particular concept in different contexts within a conversation. The intention of the analysis is to learn the relations between the specified design variables for IoT business models. As such the focus is on analyzing these relationships which is supported by narrative analysis than the groundedness of the variables itself.

Phases one and two of analysis was done in isolation of each other taking inputs from a selected set of stakeholders. The results from these analyses were input into phase three where the IoT characteristics of AAL applications are abstracted. Phase three further provides the input for defining the value proposition of the service platform in Chapter 6.

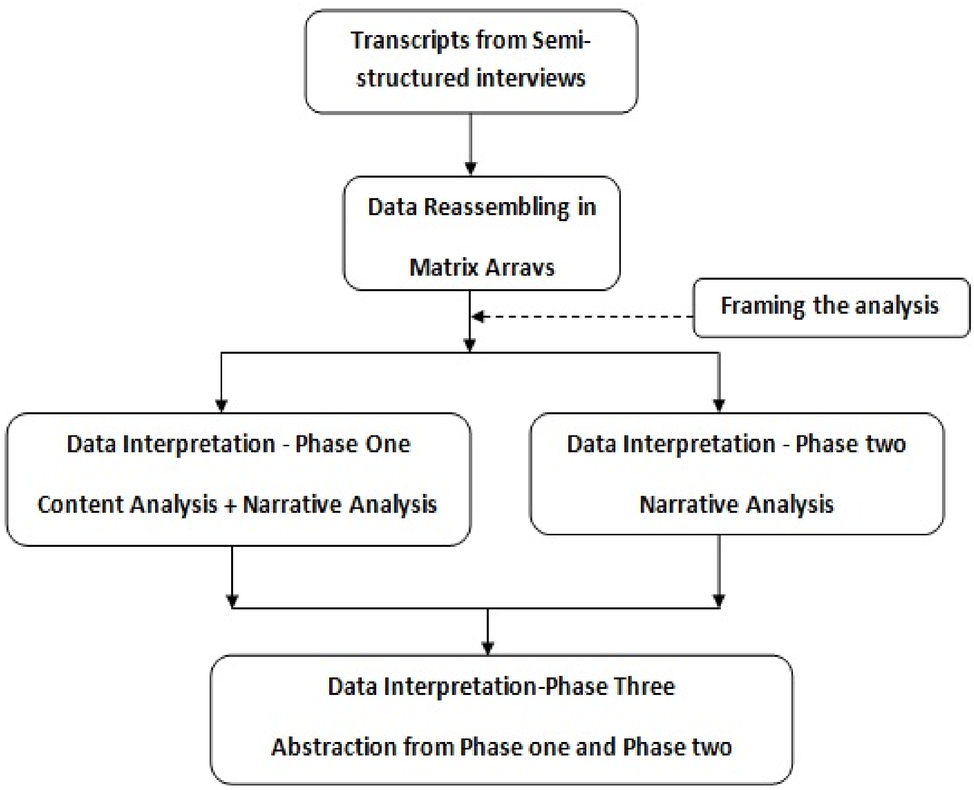


**Figure 5-1:** Steps of Data Management and Analysis

## 5-3 Interview Analysis Phase One

The main aim of phase one of interview analysis is to specify the business model framework that captures the design issues for the domain of IoT. In this phase the hypothetical framework developed in Section 3-3 is operationalized from the empirical data collected from field research. To keep up with the aim, interviews with practitioners in the IoT domain were analyzed to study how these companies monetize their IoT capabilities. To study this rationale, eight IoT related companies were analyzed in the STOF domains to establish a logic between the CDIs. The companies considered were IoT1, IoT2, IoT3, IoT4, IoT5, AAL3, AAL4 and AAL5. All the companies included here can be characterized as IoT service providers as they share certain commonalities. These companies provide either software or platform as services in their respective domain. Among the companies chosen three belonged to smart buildings sector, three belonged to the AAL sector, one is a telecom company and the last is a generic IoT platform provider with a specific focus on the health care vertical. It must be emphasized that the companies chosen have either a direct connection with AAL vertical or have been conceptualizing services in the AAL vertical or work on sectors very closely linked with AAL such as smart buildings or health care (refer definition of AAL in Section 2-5).

### 5-3-1 Service Domain

The network view generated for the service domain shows two value creating elements of IoT, information from sensors and intelligence from objects. This is facilitated by the service provider to offer services within the industry as shown in Figure 5-2. In the service domain, the CDIs investigated are *IoT value creation, creating value elements* and *targeting*. The interviews are analyzed under the CDIs.

**Value Creation**

The figure shows the elements of design variable *IoT value creation* , however it does not distinguish STOF CDI *creating value elements*. As indicated in literature, the respondents showed consensus towards using data from sensors converted to information as an important source of value creation in IoT. In the words of AAL4, "Our optical sensor collects data, the embedded software analyses this data and gives information to assess (occurences of events)." The companies also identified the need to aggregate information to provide deeper insight into a situation. According to IoT1, the telecom provider "All these things will generate enormous amount of data...turn this data into valuable insights and use it for decision making." Most respondents pointed towards sensor driven data analytics as an important application emerging from data particularly for decision making. The ownership of information was pointed as an important aspect to be considered while designing services. This ownership (not to be confused with privacy) was said to play a role in creating and limiting possibilities for business models. In relatively lesser numbers were the responses for use of intelligence of objects as a source of value creation. AAL4 says, "We are trying to make it (the system) intelligent and web based...with possibilities to bring your own device...and make intelligent routing so that the system handles the alarm on its own." When questioned about providing support services for maintenance of smart objects or sensor based devices IoT3 says, "...systems are more intelligent, so they provide more information about the maintenance...things have to be designed maintenance free." An important yet unforeseen input came from some of the respondents for the number of applications provided. AAL5 says that more applications should be provided as isolated applications become expensive. This was supported by AAL3, "we provide 20-30 different functions." Thus an optimum number of applications enabled by the information from sensors seems to be an important part of value creation in IoT.

**Target Market** Among the respondents the smart building companies have preferences for B2B markets. They have contracts with building partners for providing services in buildings by using the information from sensors. The AAL companies and IoT1 mostly had B2B2C markets, where their end users included elderly or consumers at home. None of them could be characterized as providers of direct B2C services. From interviews insights regarding the relation of variable *IoT value creation* to the CDI *targeting* was investigated. In both cases it was confirmed that *information* was used as a source of value creation by involving information exchange between end users and relevant stakeholders in businesses. IoT3 says, "the platform will have the history of that person living in a protected environment...many agencies may want access to that information...so it is also a target for new services." On the potential of IoT to connect relevant stakeholders in a given business AAL3 adds, "IoT generation allows people to organize care themselves, with neighbors and family instead of being dependent on organizations." AAL4 points out an interesting aspect of using the intelligent processing of data in order to provide different level of services to different stakeholders, "Formal caretaker has medical expertise and can understand deviations (in the system) better, but informal caretakers get more processed alarms which they can address directly."

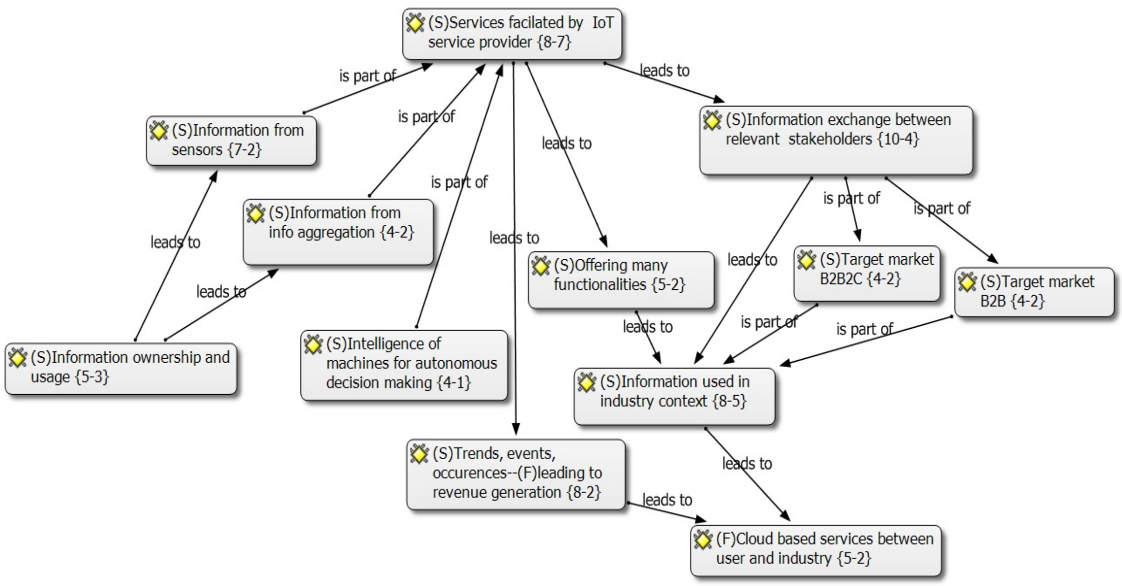


**Figure 5-2:** Network View - Service Domain

**Managerial Implications:** On investigating the variable *IoT value creation*, *information from objects* is clearly used in value creating applications, especially in sensor driven data analytics and decision making. Applications enabled by this value creating variable gives rise to **information based services** in IoT. Embedded *intelligence of objects* is yet to play a dominant role in value creation, but some companies already cite examples of its possibilities. Applications enabled by this value creating variable gives rise to **intelligence based services**. The STOF CDI *creating value elements* is integrated into *IoT value creation.* In both B2B and B2B2C markets, these two aspects of IoT value creation is used between the stakeholders for organizing services. The markets can be split into *consumers* and *businesses* (or customers) who will benefit from the information exchange while the IoT service provider facilitates value creation between the two.

### 5-3-2 Technology Domain

In the technology domain, the main CDI investigated was *accessibility for customers.* Most practitioners pointed towards the need for zero maintenance and installation requirements for smart objects. According to IoT3 "It starts with your product design...products should be made in a relatively plug and play way...anybody should be able to install them." A crucial insight derived from interviews was the importance of the smartphone for enabling accessibility to customers in IoT based applications. First was the use of smartphone as a sensor. According to IoT4 "we all come into the building and have a smart phone with us...it helps in tracking people in the building." IoT5 adds "Smartphones enable three functionalities in one: sensing, connectivity and interface...these are used in different combinations." Second was the use of smartphone for providing services to customers in form of mobile applications. IoT3 says "companies are already selling services on the mobile phone, only the phone has an impact and interaction with people to create those sort of business models. IoT5 adds to this "Our aim is to make the user happy in the building, we provide a mobile app to get insight into how people feel about the building."

**Managerial Implications:** The nature of IoT technology and services make the CDI *accessibility for customers* important for reaching the target market. Thus this CDI can remain related to the CDI *targeting* which is now split into *consumers* of data and *businesses.*

### 5-3-3 Organization Domain

The network view generated for the organization domain shows the link between the cloud services in the service domain to the *partner selection* and *platform openness* in the organization domain as shown in Figure 5-3. It captures the vertical specificity for use-cases in IoT. The interviews are analyzed under the CDIs *IoT value constellation, partner selection* and *platform openness.*

**IoT value constellation** From the figure it is observed that *IoT value constellation* is not particularly separate from but is inclusive of the CDIs *partner selection* and *platform openness.*

**Partner Selection** Generally partners are selected based on the critical resources and capabilities required to realize a service offering. Most respondents pointed to a generic value chain that involves the following actors for IoT: equipment vendors, chip makers, service/platform providers, access network operators and web infrastructure providers. But some actors prove

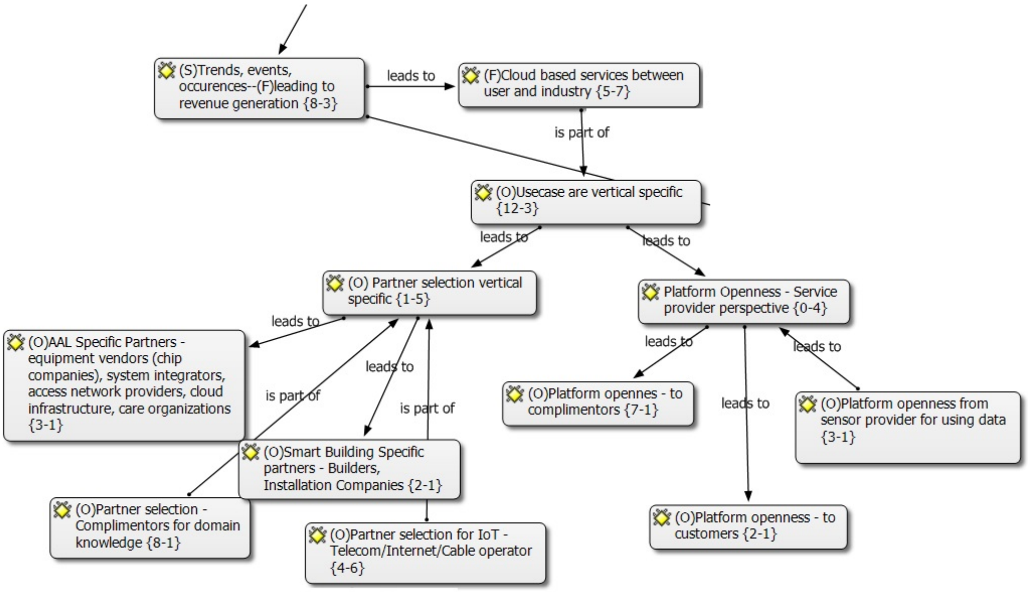


**Figure 5-3:** Network View - Organization Domain

to be more dominant than the others. Access network operators such as telecom, internet service providers and cable operators play a more prominent role in IoT. They can be attractive for service providers not merely because of their resource and capabilities, but because they have certain strategic interests for profiting from IoT technologies. As IoT4 mentions "When there are more machines on the network than people telecom providers get more data and get paid more." This is complimented by IoT3 "They have their infrastructure ready, they have stores, their mechanics, the channel and the market." According to the telecom provider IoT1, they invest in IoT to "provide value added services for customers and customer lock in." Most respondents points towards special partners who are stakeholders of their particular industry segment, for instance care organizations in case of AAL and builders in case of smart buildings as necessary partners. Even monopolies in the market are open for partnerships to gain domain knowledge from complimentary service providers.

**Platform Openness** The interview analysis proved that *platform openness* is an important design variable for IoT business models. It was supported by many practitioners. IoT3 says "nobody in the world who wants to try IoT is big enough to do their own thing." AAL4 adds "our sensor uses open standard protocols such as http, xml, sql using linux embedded platform making sure that as much software as possible is open and accessible for others." IoT4 says "We have to prepare to use almost every kind of sensor data that will be provided in the future. The sensor providers should make some openings within their software part that can put the information out." This was also supported by IoT5. These software companies are thus looking for options to have the data available to generate meaning out of it. However AAL3 highlights an important aspect of *platform openness* for IoT in the direction of protecting data, "The data we have is on how people want to live...information is so important and we won't give it out to anybody for nothing." Most respondents intend to open their platforms for added functionality to consumers. Openness is also used for giving or gaining data from sensor makers or to third party application developers for using the big data.

**Managerial Implications:** The *IoT value constellation* encapsulates CDIs *partner selection* and *platform openness* which play an important role in the design of IoT business models. *Partner selection* is important as IoT can enable actors within the specific vertical, or dominant network players such as telecom companies to play a role in service offering. These actors could be partners on one hand and customers on the other. *Platform openness* is also expected to play an important role for complimentary service providers to offer different functionalities to enrich a platform for its users. In addition, *platform openness* enabled by IoT gives rise to a new category of actors, i.e. third party developers who data specialists for providing dedicated machine learning algorithms and data analytics.

## 5-3-4 Finance Domain

The network view generated for the finance domain shows the link between the cloud services generated in the Service domain to the sources of costs and revenue in the finance domain as shown in Figure 5-4. In the finance domain, the CDIs investigated are *IoT revenue generation, division of cost and revenue* and *contribution of value and benefits*. The interviews are analyzed under these CDIs.

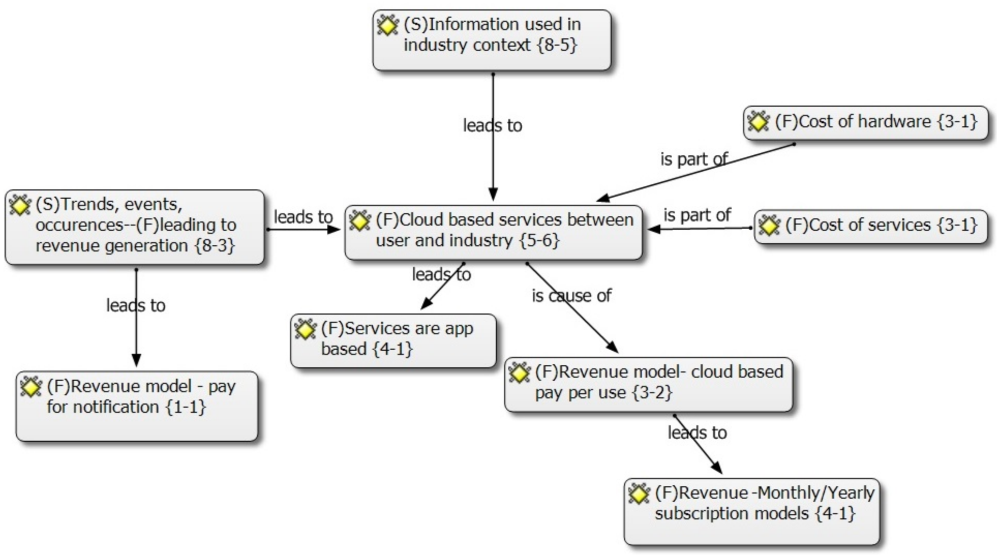


**Figure 5-4:** Network View - Finance Domain

**IoT revenue generation** On investigation, most of the IoT companies claim to be shifting from traditional contract based services to cloud based services and are clearly adopting subscription based revenue models and pay per use models. IoT4 says, "There is a huge shift into cloud development for software services (in IoT)...we will deliver more monthly or yearly subscriptions." IoT2 adds, "Basic idea is to pay for use as with regular hosting, only it is completely optimized for sensor data." Most respondents point towards the use of sensor data for monetizing IoT technology. IoT3 says "In the long term IoT is going to be service driven...with the idea of the "thing" being disposable and people paying for it as they go is following the mobile phone market. He further gives an example "All the user needs to do is buy the sensor from our web shop and turn it on...and it can be service related because if they don't pay every month or every year, they don't get to see their data through the cloud." However, the link between IoT specific value creation and revenue generation was partially highlighted by AAL4, "we try to give an ease of mind by telling the elderly that they are being monitored...they pay a few euros per-month for incidental notification." Incidental notification here refers to events or emergency situations captured by the smart objects.

**Division of Cost and Revenue and Contribution of Value and Benefits** All respondents agree that cost sources in IoT will be contributed by cost of products (smart objects) and cost of services. AAL3 and AAL5 pointed to contract based deals with customers and subscription based models with consumers in order to divide costs and revenues. These CDIs are important to be considered for IoT due to the product-service nature of the technology. Particularly in B2B2C markets, there is lack of clarity in where the value and benefit can lie. This is because while the "smart objects" are directed towards end users in order to capture data, services have to be directed towards either the end users and/or the organizations. An example for this instance was raised by AAL5 "The main question is who is the client? Is it the end customer for more quality of life or is it the organization that wants to work more efficiently?"

**Managerial Implications:** Most of the *IoT revenue generation models* are subscription based or pay per use models. Close links between revenue generation and value creation as mentioned in theory is only emerging but exists. Some practitioners suggest pay as you go models. As such direct relation with *IoT value creation* is only emerging. The product service nature of IoT technology in combination with the complex network of actors, the CDIs *division of costs and revenues* and *valuation of contributions and benefits* play an important role.

### 5-3-5 Developing the IoT Business Model Framework

In the section above, the implications were drawn by investigating *IoT design variables* on the basis of the hypothetical framework derived from theory. This section specifies the framework from the implications to capture the important CDIs for designing business models in IoT. The explanation follows below.

On investigating the variable *IoT value creation* from empirical research it becomes clear that *information from objects* and embedded *intelligence of objects* are indeed the most important value creation elements for IoT. They enable applications that provide information and intelligence based services. The STOF CDI *value creating elements* is merged to *IoT value creation*. Next IoT offers the possibility to enable value creation between all the stakeholders in the market. The markets for IoT are distinguished into *end users* and *businesses* and the *IoT service provider* facilitates services between them. The implications show the linking of the CDI *accessibility to customers* to *target markets*. This variable *IoT value constellation* can be said to encapsulate the CDIs *partner selection* and *platform openness*. *Partner selection* enables selection of specific actors within the IoT vertical. Sometimes dominant network partners such as telecom companies play a role in service offering. Businesses within a vertical can sometimes be partners when they offer services facilitated by the *IoT service provider* to their *consumers*. Hence *partner selection* can be connected to businesses in the service domain. *Platform openness* can give rise to two actors. First, complimentary service providers to improve the functional offering of the platform. Second, third party application developers are necessary to "make use of big data" generated. The *value constellation* is thus specified by *partner selection, businesses and platform openness* within an IoT vertical. It was learned that close links between *IoT revenue generation* and *value creation* capabilities as mentioned in theory are only emerging. The product-service nature of IoT technology in combination with the complex network of actors, makes the CDIs *division of costs and revenues* and *valuation of contributions and benefits* important. Further since the revenue generation from the end user and business (in the service domain) will influence how the contributions and benefits and cost and revenue between businesses, the link established between them remains as in theory. The framework generated from the links established above is called the **i-STOFp framework** as in Figure 5-5. It derives its name from IoT (i) theory, STOF model and platform (p) theory. The blocks in dark blue show the IoT design variables and those in dotted blue indicate the STOF and platform design issues.

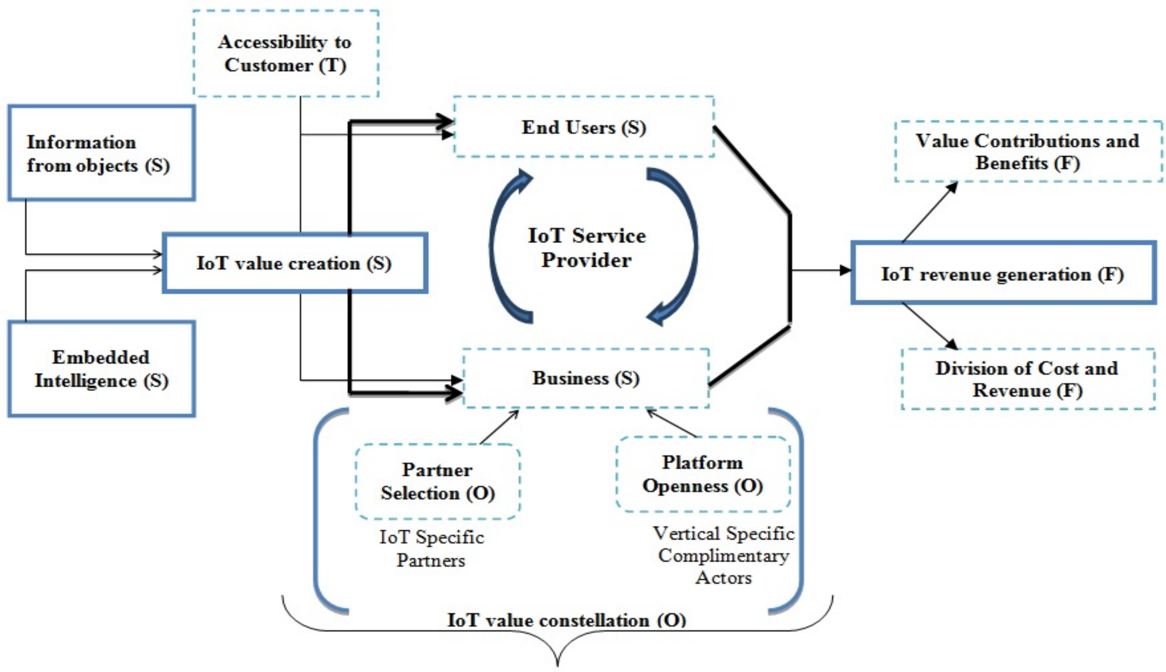


**Figure 5-5:** i-STOFp Framework

## 5-4 Interview Analysis Phase Two

Phase two of the interview analysis was conducted in order to get an insight into the Dutch elderly care market, its main stakeholders, prospective customers, current policy changes etc. The respondents whose interviews were analyzed in this phase include AAL1, AAL2, AAL3, AAL4, AAL5, Care1, Care2, Care3, Care4, Care5, IoT1, IoT2 and IoT3. A narrative analysis under the STOF domains is used in order to convey the market sentiment.

### 5-4-1 Service Domain

#### The Dutch Care Market - Policy and Trends

AAL4 sets the stage on the current market trends "... there is no money and also from the legislations in The Hague, it is not clear who is going to take care of the elderly...Is it going to be the Gemeente? Insurance companies? 2013 and 2014 are two totally difficult years...but we know that the market is going to change very drastically...People will begin staying at home as long as they can." Care4 adds "... care is shifting to the local government, but funds are still lesser." The room for technology to support care was voiced by AAL4 "we know that there are less jobs in the health care and there is a rising elderly population...the only way for care is by putting a lot of technology in between." Care2 brings out the mindset of the public towards care "many people in Netherlands are very highly treated (spoilt) with care that is a problem...they are used to it (care) and they have insurance which is centrally paid." Care4 adds "Now individuals will have to take their own responsibility, it will not come for free anymore." IoT1 points out its interest on venturing into the care sector "Care is one of the biggest sectors measured by economic activity...it has constant activity based on demand"

***Managerial Implications*** The care market is currently in a state of disorder. Policy changes have shifted roles and responsibilities of care organizations, municipalities and insurance companies. Elderly care has shifted from a traditional institutional based setup to a home based set up which has changed the market dynamics for service offering. Even AAL companies who were initially serving care institutions face challenges to investigate and create new markets. It is important to emphasize the difference between care and cure sectors. Traditionally, cure was the domain of the insurer and people expected their medically needs to be insured. Care belonged to the central government. But the current policy changes shifts care partly to insurers (cure related parts such as nursing) rest to and municipalities. These policy changes are shifting the attitude towards care and making clients more responsible.

#### AAL - Capturing User Needs and Applications

All respondents were unanimous in the applications that should be supported by AAL technologies. The context of its use was bought out best by AAL3 "if you look into care, the need of the user is "living longer at home" the single most important driver for not living longer at home is "fear of falling, fear of wandering, fear of some emergency situation at home that will make you not get out of bed or lie unattended." Care3 adds "monitoring everyday life, to see how someone is functioning, to know how things go when we are not around." Many respondents made explicit note of the importance of involving communication with the informal carer or family within the applications. AAL1 says "There must be a portal for family, informal care giver and for care homes...it should be supporting as there are less people in care, so automation will help them to watch the safety of people in rooms and also for comfort." AAL2 adds that "Some care institutions use AAL technology to their competitive advantage..to show that they are more innovative, then they get additional funding for money." The respondents point out the need to make AAL less stigmatizing and more consumer friendly. Care3 says, that AAL technology solutions should focus on "reaching people in a non-offensive way, making it easily accessible and normal." Most respondents point out that "stigmatization" is a great barrier in deploying AAL applications. AAL5 adds that the elderly say "I don't need it, I don't want it, I'm not old enough. Agitation is a factor in care." Some respondents pointed to the importance of marketing and branding care technologies. They focus on making AAL less stigmatizing and more consumer friendly and accessible. Care3 says, "but where is the Albert Heijn and Hema? They can reach the people in a non-offensive way, make it easily accessible and normal." AAL3 adds "we will also talk to local chains like media market..." AAL1 points to "Ikea as they have an elderly section, they can add these technologies ." AAL5 points to the app trends with elderly "..we have seen that they want to buy things out of a web-shop..they do it out of their own interest"

***Mangerial Implications***: The primary applications in AAL can be categorized under ***safety services***: Fall detection, wander detection, passive/active alarming, tracking activities of daily living (lifestyle monitoring for detecting abnormalities), preventing false alarms, reminders to turn off gas stoves. Another category of applications include ***comfort services***: communication with informal carer/family, automatic lighting and switching of appliances are key interests. Traditionally systems were complex with heavy wiring and also expensive. These days more concise and installation free products are expected. Further, some organizations deploy AAL for competitive advantage and efficiency. Service providers should design solutions that do not stigmatize the consumer. The branding and marketing of solutions to make it more customer friendly and accessible is required.

#### Identifying the Customer

The dilemma of pointing to a customer in the care market was evident from the interviews. The respondents and their views are represented in Figure 5-6. AAL4 says "we do not have any customer to talk to, as we don't sell it to care institutions (intramural) anymore... we have to talk to either extramural care homes or municipality." AAL1 adds "Care homes can possibly deliver care (AAL) in extramural market as a service...and let people pay for it." AAL2 stands by "contract with the municipality." Care1 points to why health care homes should be customers "we are forced to deliver work which is improved in quality and cost effective... we are quite forced to be innovative...so smart solutions are really needed in this sector". Care2 points to why healthcare institutions should not be customers "If you want to have a B2B relation with the care institutions, it means that we should make transitions from

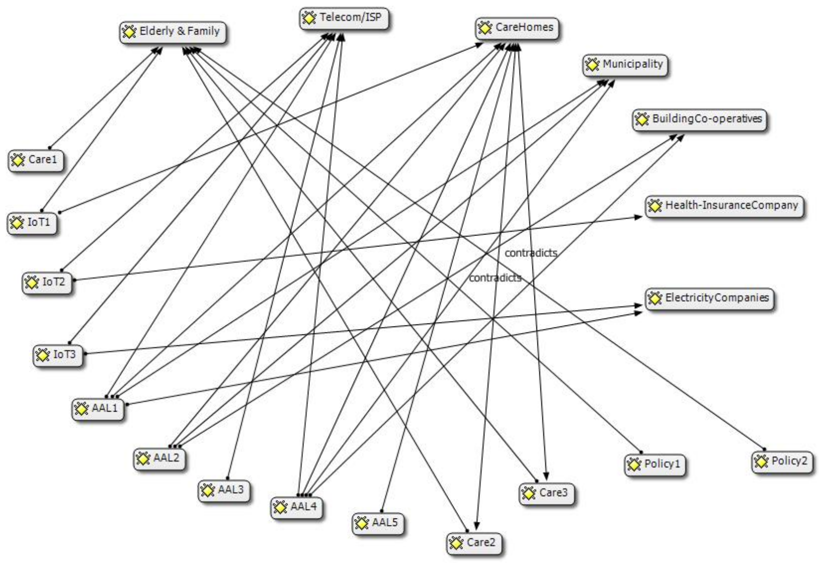


**Figure 5-6:** Perspectives of Interview Respondents on Prospective Customers

being health care providers to service providers...not sure if the market is willing for that." AAL5 points towards a gradual approach, "for the next five years, it's not B2C but B2B2C.. these are the elderly clients from care institutions. In the future, the clients will have to pay themselves for it...but at this moment, from a pure care perspective...the customer doesn't want to pay " Interestingly, although unrelated to care, the AAL and IoT companies point mostly towards the Telecom/ISP/cable companies as customers. AAL3 says "The telecom and cable companies are losing their average valued revenue per user(RPU)... consumers are also switching every year...if they offer extra services the tie they have with consumers is larger and more important, it locks them in." Energy companies were also pointed as logical providers for such services, however their role seemed less dominant than telecom players. On the current role of insurance in reimbursing care technology AAL1 says "automation is not covered by insurance yet." AAL2 adds "... insurance companies are not open or willing to pay." But the care sector says otherwise. Care3 "If they are convinced that it can make care cheaper, they tend to invest in it and provide it for the clients." Care4 explains the motivation for insurance companies to invest in care "What they are trying to accomplish now is that they look much more into infrastructure, prevention, pre-care... use more money for the preventive early diagnosis stage." Care5 supports this "there are some insurance companies that are more into new innovations than others.. they look for proof..that it works"

***Managerial Implications*:** While it is very clear that AAL technologies are targeted towards the elderly as consumers, the ambiguity of who could be probable customers becomes very evident from the field research. The ambiguity in thinking stems clearly due to (1) The complexity in the financial structure of care (2) The culture of care in the country and (3) The dilemma of whether AAL technologies are care products or a social comfort product. Traditionally in the financial structure, innovation funds were allocated for care organizations to experiment with or implement AAL technologies, this was reimbursed by insurance and the elderly consumer played only a passive role in its use. Now with the shift in laws starting from

2015, the above policy might be stopped, or may continue till 2018 (as the policy making is in progress). This implies that care homes may no longer be suitable customers, as they will not be able to reimburse from the insurance for AAL anymore. On the other hand some care institutions still seek AAL technology for competitive advantages. The elderly consumers are used to the culture of being reimbursed for care, and there is a mindset to not pay "extra" for AAL technologies. Insurance companies traditionally pay for medical cure related treatments out of health care premiums, otherwise they only play a role in stimulating innovation for preventive care but do not directly reimburse AAL technologies. Municipalities face cost cuts, so they are not favorable customers but point towards elderly to organize care on their own. Although unrelated to care sector, Telecom/ISP companies are rising as customers, giving the impression that AAL is moving out of the niche care market to consumer driven mass market.

### 5-4-2 Technology Domain

According to many respondents the technology solutions offered by AAL are traditional with heavy installation and wiring needs. According to AAL3 "traditional organizations don't have the skill to build a product that can be cost efficient...solutions are so expensive and are built on service contracts, laying wires etc" and adds "The bottom-line solution for fall detection is red alarm...and none of them are able to move to the next system as it's really hard to design something that is not annoying and reliable." AAL5 says about the kind of technology solutions customers look out for these days "Customers want plug and play, simple to use ... light and good looking devices...so they can look up online and receive online delivery of services." Care1, Care4 and AAL5 pointed towards tablets as devices increasingly used by elderly clients. Care4 says, "They use it when the see the need for it"

***Managerial Implications***: Technology design and choice of devices play an important role while designing services for elderly consumers. The devices should provide operational ease and offer minimum hassle. In addition currently applications on smartphones and tablets are already being used in care organizations to organize care processes between caregivers and home based clients. It is used for functionalities such as managing agendas, co-ordinating care, mail exchanges etc.

### 5-4-3 Organization Domain

The respondents were quite unanimous in their choice of actors for service delivery. They pointed to equipment vendors, system integrators (or software service providers), access network providers and back end infrastructure providers. A key actor in the value chain was pointed by many interviewees as Telecom/ISP and cable companies, reemphasizing the IoT thinking. IoT3 "they are big players, they already have markets ... and are waiting for service models". IoT1 supplements "It is relevant and logical that we as a telecom company are part of the solution...we connect all major hospitals on a private secure internet line...we don't want parties to misuse the info with ambiguous services." Interestingly AAL1 adds care organizations in the value chain. This is supported by Care5 "But it's also my experience that we in the Netherlands need these care organizations as intermediary.. their role is very important."

***Managerial Implications***: It can be summarized that the value chain starts from the device vendor, access network provider (Telecom/Cable/ISP), web infrastructure provider, service (platform) provider, customer and consumer. Many interviewees stressed the importance of adding care organization in the value chain. It is clear that Telecom/ISP are strong actors due to their established market, infrastructure and service provision capabilities and most importantly their need to look for companies offering value added services.

#### Platform Openness for Complimentary Services

AAL1 says "platforms should have the option of adding devices...we should be able to integrate AAL platform with additional services such as medical dispenser services.. if we have good intelligent systems which registers everything, we can provide richer solutions." AAL5 adds that isolated applications are expensive and they need to package more applications for holistic scalable solutions. AAL1 , AAL4, Care4 and Care5 highlight the need to add the functionality to communicate with the informal carer and also integrate with the work process in care organizations. AAL2 and AAL3 points towards integration with alarm central for provision of added alarm services. AAL4 highlights the use of data stemming from customer activities "the big data...its very advantageous even for the customer in the end."

***Managerial Implications***: In essence, there is a push towards the idea of platform openness to add applications to make platforms heavily care inclusive. Elderly care comes with medical care as well and solutions should involve care stakeholders such as care homes, alarm centers etc. It is observed that even market monopolies have turned to the idea of open platforms as an option for providing complimentary services. Especially, from an IoT perspective this is significant as an important driver for extending services in the care vertical. An extra service provider role for providing complementary services can be added for service offering.

### 5-4-4 Finance Domain

On inquiring into the kind of revenue models used in the AAL domain, a clear shift in models due to policy changes were observed. In the traditional B2B intramural markets, long term contract based models were used. The current shift to B2C extramural markets is seeing a cloud based subscription model emerge. Further AAL5 says "If it's about apps people don't want to buy apps...it must be for free...but if it's a product, they must have the choice..onetime or monthly...with reduced installation steps". According to Care1, "we are more positive on using such technologies as 'extra monthly services' for their elderly clients."

***Managerial Implications***: Clearly, AAL revenue models are undergoing a transition. All stakeholders identify the shift from traditional long term contract based model with care organizations to the modern cloud based subscription model with both care organizations and elderly consumers. It has to be specially noted that in healthcare there is a difference between: (1) Treatments which fall under formal medical care and are paid and organized as such and are mostly reimbursed by insurance (2) Applications outside of care and cure which care organizations adapt as part of their own business models which may or may not be reimbursed by insurance.

## 5-5 Interview Analysis Phase Three

Phase three attempts to abstract the IoT thinking into the AAL vertical. This section demonstrates the application of the i-STOFp framework derived in phase one to suit the needs of the AAL vertical derived in phase two. The i-STOFp framework specifies the critical business model design issues for the domain of IoT. These design issues mentioned in the framework are first tackled in order to provide the basis for the design of business models in Chapter 7. Phase three is abstracted under the STOF domains in this section.

### 5-5-1 Service Domain

*IoT Value Creation:* The two categories of value creating services identified for IoT were information and intelligence oriented. They are linked to AAL applications as follows:

1. Information based services: These services arise from sensor driven data analytics. Here sensors collect data and this is interpreted to make decisions. The data can further be analyzed for trends over time. The AAL applications lifestyle monitoring of elderly (which includes observing activities of daily living) and tracking (which includes wander detection and detecting immobility) fall under information based services. These services are valuable to support elderly clients to live longer in their homes. With regular monitoring elderly can organize care locally between formal and family care givers. This provides them a sense of safety and enhances their well being. These services will also be important from the perspective of an informal care giver who may not always be physically present to monitor elderly persons.

2. Intelligence based services: These services arise from occurrence of events in real time. Here the smart objects detect occurrences of events and respond to it. The AAL applications fall detection, intelligent alarm escalation and control application such as automatic lighting and switching applications (gas stove, other appliances) fall under this category. These services provide smarter ways of responding to emergencies at the location of elderly clients and ensures guaranteed safety procedures.

*Targeting:* The framework points out that information and intelligence from objects are exchanged between relevant stakeholders to organize IoT services by the platform provider. It categorizes the market into end users and businesses. In the context of AAL the end users are the elderly clients. The business includes stakeholders such as informal or family care givers, care organizations, municipality and insurance companies who stand to benefit from being part of the services. The benefits for stakeholders could be in the form of: facilitating self support or self organized care for elderly clients and care givers, responding better to emergencies for care organizations, reducing care costs by decreasing number of care visits for insurance companies or facilitating self organized care by municipalities. The main complexity pointed out by market research in phase two was in identifying customers for services in the AAL domain. By iterating between the design issues IoT value creation and target stakeholders, in combination with the inputs from market research three contexts can be identified where the information exchange between the stakeholders can be used to enable IoT for AAL. The three contexts are described as follows:

1. Information exchange between the elderly and the informal/family care giver: In the extramural context, the elderly is living independently at his/her home and the informal carer might not always be physically present. IoT can use data from elderly activities to provide information and intelligence based services to elderly and informal care givers to assure the well-being of the elderly.

2. Information exchange between elderly and formal care giver: In the extramural context, some care organizations want to replace the traditional institution based care with technology based services. IoT can enable data from elderly activities to provide information and intelligence based services to the care organization for real time decision making and improving quality of service delivery to its clients. (It must be noted here that intramural care organizations still exist and IoT services can be very valuable here. But due to the change in policies most stakeholders pointed out that the larger segment of the elderly clients are now categorized under the extramural segment. As such intramural markets were not investigated in this study.)

3. Information exchange between elderly and municipalities (insurance companies stimulate innovation): With the change in policies starting from 2015, insurance companies and municipalities play a stronger role in provision of care. Insurance companies are said to be particularly interested in stimulating technologies that support preventive care. Municipalities are focused on provision of tools for organizing self supported care for the elderly. IoT services can enable data exchange between the elderly clients and municipalities in order to manage self organized care.

The three contexts described here demonstrate scenarios where data exchange between relevant stakeholders is used for value creation. They provide the basis for designing business models and will be elaborated in detail in Chapter 6.

### 5-5-2 Technology Domain

*Accessibility to customers:* In order to reach customers, two important aspects under the technology domain were analyzed. They are the design of smart objects and the importance of smartphones for IoT based services. One of the technological barriers in AAL was that solutions were bulky with heavy installation and wiring needs. IoT can enable AAL solutions to be more compact and personalized to mobile phones.

1. Smart objects: Smart objects when designed in a compact plug and play manner can provide easier installation and maintenance of sensors. This can replace traditional AAL solutions. These objects can also be configured easily with regular software updates which is different from conventional AAL based solutions.

2. Use of computing devices: IoT enables the extended use of the functionalities of the smartphone for connectivity to internet, ease of use as an interface, ability to connect with and respond to smart objects via Bluetooth, Wi-fi or other communication protocols. Smartphones can also enable provision of personalized services to customers through mobile applications. Enabling IoT based services by providing web or mobile based applications can revolutionize conventional AAL solutions. Also tablets were pointed as devices for ease of use by elderly clients.

### 5-5-3 Organization Domain

The variable *IoT value constellation* consists of the CDIs *partner selection* and *platform openness*. These CDIs with IoT characteristics are described in detail below.

*Partner selection:* The network players for delivering IoT services are similar to the partners needed for modern cloud based AAL services. They include chipmakers, equipment vendors, access network providers and web infrastructure providers. Network providers such as telecom or internet service providers play a stronger role in IoT based services and be good structural partners. Apart from this IoT value constellation gives the flexibility to include businesses as partners. In AAL the business entities are the care organizations, insurance companies and municipalities. For instance, within AAL, an IoT service provider can partner with a care organization in order to handle alarms from the homes of the elderly. Here the care organization plays the role of a partner and not customer.

*Platform openness:* IoT applications generate a lot of data. Two categories of actors were identified for IoT. First, those that provide extra services to add functionality to the platform of the service provider in the vertical of AAL, thus making it highly care inclusive. From the interviews examples of complimentary services include opening platforms for: Health care related services, e.g. medicine reminders and health data (blood pressure) tracking; Emergency services, e.g. integrating with alarm centers; Software services for organizing care, e.g. facilitation between clients and care givers. Second, involve third party application developers (data scientists) who can use the big data generated by the platform to provide dedicated machine learning applications or data analytics.

### 5-5-4 Finance Domain

*IoT revenue generation:* In order to investigate into the relation between IoT value creation and IoT revenue generation, the IoT services defined above should be investigated. This subsection discusses how the services created above could be monetized differently based on value creation as indicated in the Table 5-3 and exlained much more by the variable IoT revenue generation in Section 3-3.

In the table an attempt has been made to relate IoT value creation to IoT revenue generation based on the definition of the variables. It is seen that both intelligence and information

**Table 5-3:** Matrix relating value creation to revenue generation

| **IoT revenue generation** | **IoT value creation** | **IoT value creation** | **IoT value creation** | **IoT value creation** |
|---|---|---|---|---|
| Services | Information Based | Information Based | Intelligence Based | Intelligence Based |
| Characteristics | Sensor driven data analytics | Sensor driven data analytics | Real time events | Real time events |
| Applications | Life-style monitoring | Tracking (Wandering/Immobility) | Fall detection, Intelligent alarm | Control & automation |
| Subscription based/-Fixed fee/Other models? | continuous access | continuous access | continuous access | continuous access |
| Time dependency | Trend analysis over time (basic services) | Non emergency (basic services) | Real time emergency events (necessary services) | comfort services |
| High quality data dependent | Trend analysis(old and new data, data aggregators) | Third party data aggregators | Third party data aggregators | Third party data aggregators |
| Pay per information access | Information access for trend analysis | Information access for tracking | - | - |
| Pay per preprocessed information | alert messages, notification on deviation | alert messages, notification on deviation | alert messages, real time intelligent alarming | automation application |

services require continuous access. As such this might favor a subscription or fixed fee based revenue model. But other options might be explored. Next on considering time dependency of value creation, information based services are no necessarily real time based. It could be decision making by data analytics gathered over periods of time. Intelligence based services are real time based and may occur from emergency situations. As such they can be classified as necessary services depending on the situation. Next, the high quality of data generated in IoT enables option of its monetization by third party data aggregators or third party developers. This provides an option of sharing information. The same information may be used by different information providers/data aggregators differently. Say in the context of the elderly client, on monitoring data from the activites of the elderly, if a health care provider is looking into this data it may be to look for detailed health deviations data for elderly. The family may just look for the basic well being elderly. The big data generated will require specialized parties, to do dedicated machine learning. Other revenue models could involve pay for information access or for receiving preprocessed information or real time intelligent handling of events.

## 5-6 Conclusion

This chapter presented the qualitative analysis of the field research conducted for this exploratory case study. The study took input from fifteen practitioners in the domains of IoT, AAL and care in order to answer the research subquestions. The analysis of the interviews

were conducted in three phases.
Phase one took insights from IoT practitioners on the value creation and revenue generation capabilities offered by their technologies. In a nutshell, the business models of these companies were inquired into by drawing parallels with the DoBots platform. These inputs were used to answer the initial design variables identified, with the blue print of the hypothetical framework, in order to specify the business model framework consolidated from empirical data. The resulting i-STOFp framework captures the important business model design issues for the domain of IoT.
Phase two involved a detailed market analysis which investigated into the needs, trends and applications in the AAL domain. It emerged that the Dutch care market is currently facing a paradigm shift in its organization making the stakeholders rather insecure and uncertain about the future.
Phase three involved no direct inputs from practitioners, instead it demonstrates the application of the i-STOFp framework (Phase one) to suit the needs and context of AAL(Phase two). It serves as a tool for practitioners to identify the IoT design issues to be considered before the design of business models. Here three contexts were obtained as a starting point to design business model. Also discussions on possible revenue models and service offerings emerged. These design inputs are further developed as full fledged business models in Chapter 6.

Chapter 6

# Business Model Design and Evaluation

This chapter presents the **"Design"** phase of the research. In this chapter the inputs from the phase three of field research as explained in Section 5-5 of Chapter 5 is used as a starting point to specify services and context for the design of business models. Chapter 4 describes the platform architecture of DoBots and its generic functional capabilities. These functional capabilities combined with field research will be used to define the specific services the platform can provide in the vertical of AAL.

## 6-1 Defining the Value Proposition of DoBots' Platform

In order to provide services in AAL, the generic service capabilities of the platform should be tuned to the specific needs in the AAL domain. By equipping buildings with smart objects designed within the company and additional sensors to collect data, the platform can be used to provide services for assisting the aging population, thus enabling independent living by providing services as explained below.

**Information Based Services**

DoBots is already working on smart objects and sensor technologies. The smart objects designed within the company in combination with current commercial sensors such as pressure sensors, geotags (Bluetooth Low Energy sensor nodes) and movement detection sensors are less intrusive tools to perform low cost human tracking (which includes wander detection and detecting immobility), indoor positioning and activity recognition. The platform can monitor lifestyle patterns of occupants and send notifications on detecting abnormalities. The wearable sensor nodes with accelerometers such as mobile phones can be combined with heterogeneous sensor nodes to obtain the non-intrusive infrastructure to detect falls. Facilities should be enabled to connect elderly people with their relatives for communication using mobile applications. These services contribute to sensor driven data analytics. Here sensors collect data and this is interpreted to make decisions. The data can further be analyzed for trends over time. Options should be made to enable web or mobile interfaces to perform trend analysis of the activity of elderly over time.

**Intelligence Based Services**

DoBots has its core software expertize in adding intelligence to machines in order to provide fully autonomously environment without human interference. This potential can be fully utilized by providing intelligence based services in the AAL domain. Here the machines detect occurrences of events in real time such as fall detection and respond by intelligent alarm escalation. Cognitive impairments may diminish the elderly person's capacity to execute daily activities (for instance in cases of mild dementia). The platform can provide applications for automatically turning off devices such as gas burners on detecting abnormal usage, detecting faulty devices that are connected to sockets, provide night route lighting and send real time alerts to care givers or the elderly on detecting these abnormalities. In addition, the platform can provide home automation features such as wireless control of lights and devices from the mobile phone to provide ease of use to the elderly.

**Smart Objects**

The smart objects along with other sensor technologies form the backbone of service provision. Field research dictates that the design of these hardware devices plays an important role in the adoption of services especially AAL is shifting towards the extramural market. Also, since the end users are elderly clients the smart objects and related sensor technology should be designed for minimal configuration, installation, maintenance and ease of use.

**Provision of Mobile Applications**

As mentioned in Chapter 4, the smartphone can be used as an active interface and the gateway to the rest of the service platform. From field research, the role of smart phone to enable provision of personalized services to customers through mobile applications was highlighted. Enabling IoT based services by providing web or mobile based applications can revolutionize conventional AAL solutions. It was also pointed out that elderly clients favor use of tablets for simple applications.

## 6-2 Business Model Design

In the Section 5-5, three contexts were arrived at for service provision between stakeholders based on information exchange. The scenarios for designing business models are developed from these contexts. In all the cases DoBots plays the role of platform and service provider. The business models are pitched from the perspective of DoBots. The scenarios presented below are the result of a second round of Quick Scan. In the first round three scenarios were sketched and brainstormed with an external expert evaluator with selected CSFs. This was necessary as the case was complex and identifying a relevant context and the right customer was extremely challenging. There was need for an external opinion before detail design of scenarios. The expert identified was an Innovation Manager at a leading insurance company. The particular expert was consulted for two reasons. First, the interviews did not have direct inputs from insurance companies. At the same time most respondents had identified insurance companies as key stakeholders as they provided the funding in care. My knowledge of the direct perspective of insurance companies on IoT services in AAL was indirect and meagre. Hence, this evaluation would provided an opportunity to get a direct insurer perspective into elderly care. Second, the expert consulted has authored books on business models in care and has deep expertize on the subject of health care particularly the Dutch market. Hence he would be able to provide sufficient inputs into all the scenarios identified. The first sketches of the scenarios, evaluation comments and summary of the expert interview are in Appendix -3 and -4. The scenarios following the brainstorm session are as follows.

### 6-2-1 Scenario 1 - Wellbeing of Elderly

**Case:** Mass market consumer based solutions to support independent living for the elderly.

**Context:** Elderly persons have to live independently longer at home but current AAL solutions are bulky, stigmatizing and not designed for extramural care. Also solutions come in isolation and are difficult for elderly to package them together. From interviews it was learned that currently family caregivers look for Do It Yourself (DIY) smart home solutions for providing safety or monitoring the elderly. It was also learned that the family of the elderly asked care organizations for solutions to monitor elderly at a distance.

**Envisioned Scenario:**

Elderly in Netherlands prefer living independently in their homes for longer. Also institutional care homes no longer support semi-dependent or independent elderly clients. However, for semi - dependent elderly persons, living alone presents risks such as falling, wandering or other emergency situations. Current solutions for this are social alarms. These are stigmatizing and not very well accepted by elderly clients. IoT based sensor solutions can be a non intrusive way of providing safety services for the elderly with options for real time notification of emergency events to informal or family care givers or a chosen formal care giver thus ensuring safety and also ease of mind by keeping the elderly monitored.

**Service Design**

*Target Market*

The solution is mass market based and targeted at the elderly population in general. However, the solution will not support elderly who are in need of complex care and is targeted at independent or semi-dependent elderly persons to provide them with safety and a sense of well being.

End users: Semi-dependent elderly clients who wish to take care of themselves and live longer independently at home by organizing care on their own.

Customers:

1. Semi-dependent elderly clients themselves with options to connect to a chosen formal/informal care giver.
2. Family caregiver who buys solutions on behalf of the elderly to monitor their activities at a distance for peace of mind.

*Value Creating Elements*

The platform provides elderly clients with information and intelligence based services for providing them a sense of security and well being. The information based services include lifestyle monitoring and tracking of elderly. With sensor driven data analysis, the informal care givers can monitor elderly even at a distance and watch out for abnormalities in behaviour.

With these services, the caregivers can receive processed messages with alerts or notifications in case of deviations. They can also be given options for trend analysis of the behaviour of the elderly over an extended period of time.

The intelligence based services help both the elderly or the family caregiver to track the behavior of elderly and be informed of deviation, unrest in bed, fall detections and reaction to emergency alarms. These services are based on real time events and occurrences. The intelligent escalation of alarms can be used to call people depending on the severity of fall. Comfort services such as applications for automatic lighting and switching appliances can be added to enhance quality of life for the elderly.

The technology and service is new to the market because the existing alternatives for safety in Netherlands involves use of the social alarms for emergency. Cloud based safety services for the mass market is only being conceived in the industry at the moment and is yet to take off. The marketing approach is also new as the service concept is branded as a non stigmatizing, non-intrusive means for the family to take care of the elderly.

*Data Ownership*

The elderly will be the data producer and owners themselves. The informal care giver can be the data consumer who can have an access to elderly client data.

*Context of use*

With these services, the daily lives of the users will change slightly. The family of the elderly who do not always stay with the them can monitor their activities online with the processed data from the information based services. The lives of the elderly clients themselves would not change too much, as the devices are used for passive monitoring in order to ensure their own safety and well-being. However, their comfort and safety can be enhanced by intelligence based services such as automating lighting and control of devices. Also the system can avoid fire accidents by detecting faulty appliances or shutting off a devices immediately.

*Effort to use*

The product infrastructure can be obtained through the online webshop, or via dedicated partners such as telecom companies who can provide support services for installation and maintenance. The services can be enabled by supporting with mobile applications and web interface with user logins and accounts.

**Technology Design**

*Applications*

The service designed by DoBots should include sending text notifications on deviations or abnormalities in the habits of the elderly. The applications mostly involves communication and interaction. The service have to be *always on* in order to track the elderly 24*7 and pass messages to the family.

The applications at the mobile or website should support functions with sensor driven data analytics for tracking of elderly and also lifestyle monitoring. In addition it should support sending in regular updates and text notification with activities of elderly with or without deviations, emergency notifications on deviations including escalation on severity levels and mobile application at the end-user for control of lights and devices.

*Devices*

Provision of services would first require the installation of smart objects designed within DoBots in combination with other sensors such as pressure sensor and movement detection sensor. These devices perform the necessary sensing function to observe the activities of the elderly in a non intrusive manner. The smart objects can further be operated from a user's smartphone or tablet for controlling lights and appliances manually or with preprogrammed settings. The intelligence of the system is distributed within the devices. A certain degree of openness will be ensured in the software to adapt to user needs. The smartphone or a computing device (computer, laptop) at the end user and customer is a prerequisite.

*Service platforms*

The system provided will be initially preprogrammed but is expected to learn from users' activities by machine learning. Further it will be adapted to user requirements and personalized to a user. The smartphone will form the interface for the user to communicate with the system. The smartphone or a web interface will form the means for a family caregiver to look into user activities. In order to enable the services the customer will have to purchase new systems (smart objects and sensors). However, the applications can be enabled on smartphones.

*Access Network*

The access network uses the fixed or wireless internet connection to connect the system to cloud services. A localized gateway enables service provision within the private home area.

**Organization Design**

Critical resources required would include provision of smart objects, access to the internet, mobile infrastructure, hosting providers, software and application platforms, customers, and customer data, billing, customer support and management.

*Partner Selection*

Structural Partners:

1. Alarm center services in case of serious emergency escalations.

2. Partnership with selected care organizations to play the role of formal care giver in case the customer does not have an option for family care giver.

3. Telecom companies are ideal partners for delivering services as they are looking forward to adding care services for elderly in their extended service portfolio. They also have the resources and capabilities that complement the capabilities of DoBots. While DoBots provide the service platform solution, telecom companies can provide support services as they have stores and are good channels to the market.

Contributing Partners:

1. Sensor suppliers, smart object vendors

2. Web infrastructure companies will be required to host data and scale cloud services

3. Channels for selling smart objects: An option is online web shop where costumers can order products and install them in a relatively easy plug and play manner. Telecom companies can make the solutions available to the masses and easy to obtain. Making the system available in general shops such as Kruidvat makes it mass available.

*Platform Openness*

Complimentary services: In Section 5-5 of Chapter 5 complimentary actors were discussed during design. In this scenario, it would be ideal to partner with ICT companies that provide software solutions for organization of care between family care givers and professional home care givers. These platforms provide care facilitation services and is complimentary in nature to that of DoBots.

Application Developers: DoBots is a start up and have limited resources and capabilities. The applications however generate enormous amount of data. DoBots will have to partner with third party application developers who can provide machine learning applications for the huge quantity of data generated.

**Finance Design**

*Cost Structure*

The sources of cost include cost of smart objects, sensors, web infrastructure, provision of services and complimentary services.

*Revenue Sources*

The sources of revenue include a one time charge for infrastructure purchase. As discussed in Section 5-5 of Chapter 5, the service provision requires continuous access. To keep the revenue model simple for mass market, a flat fee model (a fixed amount per month, independent of the actual usage) for the customer with pricing based on service offering is recommended in order to provide an integrated solution. The packages offered can be as follows:

1. Package1: Basic Services

   Basic services include lifestyle monitoring, sensor driven data analytics to see activity patterns via web-based interfaces on computer or smartphone. Deviations will be shown.

2. Package2: Basic + Necessary Services

   Necessary services include text alerts on emergencies such as fall detection, immobility, wander detection, reminders or deviations.

3. Package3: Basic + Necessary + Added Services

   Added services include complimentary ICT services for organizing home care with formal care givers. The payers of the services are the elderly clients or the families. The service packaging or bundling is recommended in order to provide the customer with choices that suit their preferences and at appropriate pricing levels for each package. Also the bundled services offer greater value than the individual services.

*Risk sources and risks*

The main financial risks threatening the viability of the business model may include: Adoption and use of the service within the target group, price the end user has to pay, satisfaction of actors concerning the financial agreements and rising competition from alternative services and new technologies.

### 6-2-2 Scenario 2 - Care as a Service

**Case:** Care based solutions to provide real time decision making to modernize care process.

**Context:** Policy changes are causing traditional intramural organizations to shift their services to suit the extramural market. Even market monopolies are extending their care portfolio by merging with extramural home care based organizations. Also increasingly they are facing competition to differentiate themselves by providing high quality care services. Some industry players are doubtful of offering solutions to care organizations due to their loss of market from intramural to extramural. However, despite the traditional mindset of caregivers and alienation towards the use of technology, there is a call for innovation from the society and government in the direction of promoting technologies for care which might present a positive opportunity for scenario two as envisioned.

**Envisioned Scenario:** The solutions are aimed at care organizations looking for non conventional means to organize care. From the interviews it was understood that many times the habits of elderly show deviations. Deviations include sleeping during the day, being active in the night (reversal of the biological clock), unrest in bed and other deviations from normal behavior have been known to be caught by sensors. Sometimes it is possible to detect diseases such as dementia at very early stages and care organizations can help clients cope with these much early on to avoid emergency situations. This presents useful information to care organization as they get more insight into the habits of their client. IoT based services can enable a new way of providing care such that all the data generated from client activities is turned into useful information to enable real time decision making at care organization in order to improve quality of care.

**Service Design**

*Target Market*

The solution is targeted at health care organizations looking for novel means of organizing care in the extramural market. Care organizations will provide these solutions as additional services to elderly clients either within their existing care homes or in extramural markets on a time frame basis. The elderly clients of the care organization are the end users of the solution. The solution will not support elderly who are in need of complex care and is targeted at independent or semi-dependent elderly persons to provide them with safety and a sense of well being.

End consumers: Semi-dependent elderly clients who wish to take care of themselves and live longer independently at home and are supported by formal care givers.

Customers:

1. Health care organizations that provide home care services in the extramural care market.

2. Insurance companies are expected to reimburse the care organizations for these solutions. (Traditionally insurance companies reimburse only cure based treatments. However from interviews it was learned that provision of budgets for ICT services largely depended on the care organization itself. Also there are some clauses in policy [as explained in the Section 2-6 of Chapter 2] that supports care infrastructure until the year 2018. However the thinking is that DoBots should have a B2B relation with care organizations, the relation with consumer is the onus of the care organization.)

*Value Creating Elements*

The platform provides care organizations with information based services. The information based services include lifestyle monitoring and tracking of elderly. With sensor driven data analysis, the formal care givers can monitor elderly even at a distance and watch out for abnormalities in behaviour. With these services, the caregivers can receive processed messages with alerts or notifications in case of deviations. They can also be given options for trend analysis of the behaviour of the elderly over an extended period of time.

The intelligence based services help formal care givers to track the behavior of elderly and get detailed information of deviation, unrest in bed, fall detections and reaction to emergency alarms. These services are based on real time events and occurrences. The intelligent escalation of alarms can be used to call people depending on the severity of fall.

The technology and service is new to the market because the existing alternatives for safety in Netherlands involves use of the social alarms for emergency. Also technological innovations in care are mostly process innovations where software tools are developed for handling care process more efficiently. There have been efforts to monitor clients remotely, but they are mostly pilot projects in the intramural set up.

*Data Ownership*

The elderly will be the data producer and/or owners themselves. The care organization will be the data consumer who can have an access to elderly client data.

*Context of use*

With these services, the daily lives of the users will change slightly. Care organizations instead of sending their employees for regular check up of clients can now reduce their frequency. On the other hand they will be complemented with more information on client activities. The lives of the elderly clients themselves would not change too much, as the devices are used for passive monitoring in order to ensure their own safety and well-being. However, their comfort and safety can be enhanced by intelligence based services, by automating lighting and control of devices. Also the system can avoid fire accidents by detecting faulty appliances or shutting off devices immediately.

**Technology Design**

*Applications*

The service should include sending text notifications on deviations or abnormalities in the habits of the elderly. The applications mostly involves communication and interaction. The service have to be *always on* in order to track the elderly 24*7 and pass messages to the care organization.

The applications at the mobile or website should support functions with sensor driven data analytics for tracking of elderly and also lifestyle monitoring. In addition it should support sending in regular updates and text notification with activities of elderly with or without deviations, emergency notifications on deviations including escalation on severity levels and mobile application at the end-user for control of lights and devices.

*Devices*

Provision of services would first require the installation of smart objects designed within the company in combination with other sensors such as pressure sensor and movement detection sensor. These devices perform the necessary sensing function to observe the activities of the elderly in a non intrusive manner. The smart objects can further be operated from a user's smartphone for controlling lights and appliances manually or with preprogrammed settings. The intelligence of the system is distributed within the devices. A certain degree of openness will be ensured in the software to adapt to user needs. The smartphone or a computing device(computer, laptop, tablet) at the end user and customer is a prerequisite.

*Service platforms*

The system provided will be initially preprogrammed but is expected to learn from users' activities by machine learning. Further it will be adapted to user requirements and personalized to a user. The smartphone will form the interface for the user to communicate with the system. The smartphone or a web interface will form the means for a family caregiver to look into user activities. In order to enable the services the customer will have to purchase new systems (smart objects and sensors).

*Access Network*

The access network uses the fixed or wireless internet connection to connect the system to cloud services. A localized gateway enables service provision within the private home area.

**Organization Design**

Critical resources would include provision of sensor technologies, smart objects, access to the internet, mobile infrastructure, hosting providers, software and application platforms, customers, and customer data, billing, customer support and management. Apart from this, care organization will form an important part of the value network for service provision.

*Partner Selection*

Structural Partners:

1. Alarm center services in case of serious emergency escalations.
2. Partnership with home care organizations for elderly as customers
3. Partnership with health care providers (hospitals) for health related services. (This will be the responsibility of complimentary service provider, as will be explained)
4. Telecom companies are ideal partners for delivering services as they are looking forward to adding care services for elderly in their extended service portfolio. They also have the resources and capabilities that complement the capabilities of DoBots. While DoBots provide the service platform solution, telecom companies can provide support services as they have stores and are good channels to the market.

5. Installation companies who help service delivery in the B2B market.

Contributing Partners:

1. Sensor suppliers, smart object vendors.
2. Web infrastructure companies will be required to host data and scale cloud services.
3. Channels for selling infrastructure: The services will be sold directly to care organizations. The infrastructure will be installed at the client either by care organization themselves or telecom partners or installation companies.

*Platform Openness*

Complimentary services: As discussed in Section 5-5 of Chapter 5, in order to make the platform heavily care inclusive, ICT companies that are e-health technology providers: with web or mobile based applications for supporting health care with quantified self characteristics will make ideal partners. This will provide extra information to care organization about their clients.

Application developers: Third party application developers who can provide machine learning applications for the big data generated. Data sharing between third party application developers is favorable in order to increase the value of aggregated data .

**Finance Design**

*Cost Structure*

The sources of cost include cost of smart objects, sensors, web infrastructure, provision of services and complimentary services.

*Revenue Sources*

The sources of revenue include a one time charge for infrastructure purchase.

The service provision requires continuous access, and hence subscription fee for basic access or minimal service plus additional charge depending on usage is suggested in order to have a usage based subscription model for care organizations. Also, revenue models based on service packages is recommended with higher fees for extended packages. The packages offered can be as follows:

1. Package1: Basic Services

   Basic services include lifestyle monitoring, sensor driven data analytics to see activity patterns via web-based interfaces on computer or smartphone. Deviations will be shown.

2. Package2: Basic + Necessary Services

   Necessary services include text alerts on emergencies such as fall detection, immobility, wander detection, reminders or deviations. As such this

3. Package 3: Basic + Necessary + Extended Services

   This includes the basic and necessary packages along with complimentary services for health data information. This provides health information alongside the information from daily activities. This also includes information assessment from third party application providers in order to increase the value of aggregated data. This solution is heavily care inclusive.

*Risk sources and risks*

The main financial risks threatening the viability of the business model may include: Adoption and use of the service within the target group, price the end user has to pay, satisfaction of actors concerning the financial agreements and rising competition from alternative services and new technologies.

### 6-2-3 Scenario 3 - Promotion of Self-Organized Care by Insurance and Municipalities

**Case:** Insurance companies and municipalities come together to provide innovative tools for community based self organized care for the elderly.

**Context:** From the year 2015, the control of elderly care process will be largely shifted to insurance companies and municipalities. Interviews reveal that though municipalities are the new guardian for social care of elderly under the WMo. Despite cost cuts, they might be looking for innovative tools to provide self organized care to citizens. Also insurance companies at the moment do not reimburse preventive care technologies, but are keen on stimulating innovation and providing discounts to such technologies for the well being of their insured customers. New business models from insurance companies include providing a personalized approaches that focuses on prevention and encouraging healthier lifestyle (voiced also in interviews Care5, Care3, expert interview -4).

**Envisioned Scenario:** Starting from 2015, social care for the elderly will be organized more by the insurers and municipality. With the push for e-Health technologies and organization of care by the elderly themselves from the government, it is possible that the insurance companies and municipalities become the flag-bearers of promoting such preventive, safety related health care technologies. The insurers and the municipality becomes the customers for such solutions. They further sell it to elderly clients or reimburse them depending on the financial or health condition so of the elderly. DoBots can have tie ups with home care providers in the region for looking into the data from all the elderly customers in the region for care provision. DoBots will pay the role of the facilitator between the municipality, insurance companies, elderly clients and care organizations.

**Service Domain**

*Target Market*

The solution is mass market based and targeted at the elderly population in general. However, the solution will not support elderly who are in need of complex care and is targeted at independent or semi-dependent elderly persons to provide them with safety and a sense of well being.

End consumers: Semi-dependent elderly clients who wish to take care of themselves and live longer independently at home by organizing care on their own.
Customers:

1. Insurance companies who wish to provide well being and preventive technologies to their clients. They can sell it to elderly clients at a discount.
2. Municipalities who wish to offer innovative technology based tools for organizing self care. They can sell it to elderly clients at a discount.

*Value Creating Elements*

The platform provides elderly clients with information and intelligence based services for providing them a sense of security and well being. The information based services include lifestyle monitoring and tracking of elderly. With sensor driven data analysis, the informal care givers can monitor elderly even at a distance and watch out for abnormalities in behaviour. With these services, the caregivers can receive processed messages with alerts or notifications in case of deviations. They can also be given options for trend analysis of the behaviour of the elderly over an extended period of time.

The intelligence based services help both the elderly or the chosen caregiver to track the behavior of elderly and be informed of deviation, unrest in bed, fall detections and reaction to emergency alarms. These services are based on real time events and occurrences. The intelligent escalation of alarms can be used to call people depending on the severity of fall. Comfort services such as applications for automatic lighting and switching appliances can be added to enhance quality of life for the elderly.

*Data Ownership*

The elderly will be the data producer and owners themselves. The informal care giver or the formal care organization representing the municipality can be the data consumer who can have an access to elderly client data.

*Context of use*

With these services, the daily lives of the users will change slightly. The care organization in the respective municipality can monitor the activities of elderly online with the processed data from the information based services. The lives of the clients themselves would not change too much, as the devices are used for passive monitoring in order to ensure their own safety and well-being. However, their comfort and safety can be enhanced by intelligence based services, by automating lighting and control of devices. Also the system can avoid fire accidents by detecting faulty appliances or shutting off a devices immediately.

*Effort to use*

The product infrastructure can be obtained through the online webshop , or via dedicated partners such as telecom companies who can provide installation support. The services can be enabled by supporting with mobile applications and web interface with user logins and accounts.

**Technology Design**

*Applications*

The service should include sending text notifications on deviations or abnormalities in the habits of the elderly. The applications mostly involves communication and interaction. The service have to be *always on* in order to track the elderly 24*7 and pass messages to the concerned municipality represented care giver.

The applications at the mobile or website should support functions with sensor driven data analytics for tracking of elderly and also lifestyle monitoring. In addition it should support sending in regular updates and text notification with activities of elderly with or without deviations, emergency notifications on deviations including escalation on severity levels and mobile application at the end-user for control of lights and devices.

*Devices*

Provision of services would first require the installation of smart objects designed within the company in combination with other sensors such as pressure sensor and movement detection sensor. These devices perform the necessary sensing function to observe the activities of the elderly in a non intrusive manner. The smart objects can further be operated from a user's smartphone (or other computing device) for controlling lights and appliances manually or with preprogrammed settings. The intelligence of the system is distributed within the devices. It is an active part of the devices. The certain degree of openness will be ensured in the software to adapt to user needs. The smartphone or a computing device (computer, laptop) at the end user and customer is a prerequisite.

*Service platforms*

The system provided will be initially preprogrammed but is expected to learn from users' activities by machine learning. Further it will be adapted to user requirements and personalized to a user. The smartphone will form the interface for the user to communicate with the system. The smartphone or a web interface will form the means for a family caregiver to look into user activities. In order to enable the services the customer will have to purchase new systems (smart objects and sensors)

*Access Network*

The access network uses the fixed or wireless internet connection to connect the system to cloud services. A localized gateway enables service provision within the private home area.

**Organization Design**

Critical resources would include provision of smart objects, access to the internet, mobile infrastructure, hosting providers, software and application platforms, customers, and customer data, customer support and management. Apart from this, care organization will form an important part of the value network for service provision.

*Partner Selection*

*Structural Partners:*

1. Alarm center services in case of serious emergency escalations.

2. Partnership with selected care organizations within a municipality to look into the well being of the elderly using sensor driven data analytics.

3. Telecom companies are ideal partners for delivering services as they are looking forward to adding care services for elderly in their extended service portfolio. They also have the resources and capabilities that complement the capabilities of DoBots. While DoBots provide the service platform solution, telecom companies can provide support services as they have stores and are good channels to the market.
4. Installation companies who help service delivery in the B2B market.

*Contributing Partners:*

1. Sensor suppliers, smart object vendors
2. Web infrastructure companies will be required to host data and scale cloud services
3. Channels for selling infrastructure: The services will be sold directly to municipalities and/or insurance companies. The infrastructure can be installed at the client either by partner care organizations or municipalities, installation companies, or telcom players.

*Platform Openness*

Application Developers: DoBots is a start up and have limited resources and capabilities. The applications however generate enormous amount of data. DoBots will have to partner with third party application developers who can provide machine learning applications for the huge quantity of data generated.

**Finance Design**

*Cost Structure*

The sources of cost include cost of smart objects, sensors, web infrastructure and provision of services.

*Revenue Sources*

The sources of revenue include a one time charge for infrastructure purchase. As the service provision involves a number of stakeholders, and is based at a community level, the number of functionalities are simplified to provide only one service package for promoting well being of elderly. This is included in a flat fee based revenue model.

1. Basic services + Necessary services

   Services are information based to include lifestyle monitoring, sensor driven data analytics to see activity patterns via web-based interfaces on computer or smartphone. Deviations will be shown. Intelligence based services include, text alerts on emergencies such as fall detection, immobility, wander detection, reminders or deviations.

*Risk sources and risks*

The main financial risks threatening the viability of the business model may include: Adoption and use of the service within the target group, price the end user has to pay, satisfaction of actors concerning the financial agreements and rising competition from alternative services and new technologies,

## 6-3 Stress Testing for Robustness

The STOF method incorporates a robustness check before the actual implementation of a new service. Robustness of business models is determined by asking "what if" questions that are related to the external conditions under which the service has to be designed and business models developed. STOF defines robustness as "Robustness (or sustainability) of a service and a business model refers to the ability to cope with changes in the business environment. A robust model maintains its value for customers as well as for business partners, even when external circumstances change."

For the current case, the "what if" questions are adapted from (Bouwman et al., 2010) and relate to competitor as well as consumer behavior in Service domain, introduction of new technology in the Technology domain, partner behaviour and regulatory changes in Organizational domain. These are tested in the three scenarios to determine the robustness of business models. The robustness check for the three scenarios are as shown in Tables 6-1, 6-2 and 6-3 respectively.

From the robustness test it can be concluded that Scenario 1 is the most robust business model concept for DoBots to adopt as it presents the opportunity to scale solutions globally and is less influenced by local changes. Scenario 3 may be considered the second best option as it is an extension of Scenario 1 and there is guarantee that the customers have the money to fund such services. Scenario 2 may be the least robust in the current situation in Netherlands as care organizations may not easily adopt new solutions at the moment.

## 6-4 Conclusion

This chapter began with specifying the service concepts for DoBots in the domain of AAL. It took inputs from Chapter 5 and continued with designing business model using the quick scan approach presented by STOF. The concepts were presented after the second round of sketching. Business models for the three scenarios are sketched in detail under the following scenarios.

1. Scenario one suggests a mass market consumer based solution to support independent living for the elderly. Solutions conceived suggest enabling IoT services by the platform in a non intrusive way manner to ensure the well being of the elderly alongside providing an ease of mind to the family care giver.

2. Scenario two presents a care based solution enabled by IoT services to provide real time decision making to care organizations to modernize their care processes. This revolutionizes the traditional care provision of these organizations especially under the pressure of current policy changes and ensures higher quality of care for their elderly clients.

3. Scenario three presents a self-organized community based solution for the elderly stimulated by insurance companies and municipalities. This scenario becomes particularly relevant in wake of the new policy changes from 2015 which enforces decentralized provision of care and encourages promotion of innovative technologies that support elderly to become independent.

**Table 6-1:** Robustness Check for Scenario 1

| | **Questions** | **Robustness Check for Scenario 1** |
|---|---|---|
| **Service** | What if alternative services are brought by competitors to the market that offer comparable or even better functionalities? | While the service concept envisioned in this scenario is rather new to market, field research does indicate that competitors are working towards similar services for the mass market. Competitors also have higher domain expertize than DoBots. However, DoBots does have an upper hand as the company is already working on smart objects and have deep software expertize. If the company can keep the cost of the infrastructure and services low while at the same time ensure scalability, it might be able to ward of competitor entry and provide first mover advantage. |
| **Service** | What if there appears to be a huge demand for the services? What if the market is expanded internationally? | DoBots may not be able to manage large scalability. However, this situation will present a great opportunity for DoBots. Either the company can let itself be bought by a big technology conglomerate who has the facilities to provide services at a larger scale or it can have extensive tie-ups with relevant partners to provide the services internationally. Monetization wise the second option will favor DoBots. |
| **Technology** | What if a new and cheaper technology becomes available? Is the technological architecture capable of absorbing a new and cheaper technology should such a technology become available on the market? | The platform works on open standards and protocols. Should a new technology whose performance supersedes that of DoBots be available, the company might be able to absorb it. However, this becomes necessary only if the technology being used by the company fails to yield results. |
| **Organization** | What if one of the partners should decide to leave the network? | Since DoBots is a startup, its capabilities are limited. If a partner leaves the network, it will hamper service delivery. To make up for this DoBots must draw strict contract with partners or keep substitute partners for delivering the same function so as to be partner independent. |
| **Organization** | What if there are changes in regulation/legislation? | The current scenario is designed with the latest policy changes in mind. It is aligned towards organizing care by the self which is the message of the latest policy changes in care. This being a mass market solution with elderly clients or family care givers as purchasers of the services, it can be this scenario can be concluded to be need dependent than legislation dependent. |

**Table 6-2:** Robustness Check for Scenario 2

| | **Questions** | **Robustness Check for Scenario 2** |
|---|---|---|
| **Service** | What if alternative services are brought by competitors to the market that offer comparable or even better functionalities? | From field research, it was learned that competitors are not very keen on care organizations as customers in the new policy era. If DoBots pursues this scenario, the company might have an upper hand as it is already working on smart objects and have deep software expertize. On the other hand certain competitors have domain expertize in care related services and might have an advantage if the offer solutions. In this case DoBots will have to differentiate its services with higher functionality or provide them at lower costs to beat competition. |
| **Service** | What if there appears to be a huge demand for the services? What if the market is expanded internationally? | DoBots being a start up has limited resources and capabilities and may not be able to manage large scalability. Also, this scenario may not be meant for large scale provision as it is dependent on the culture of care which is specific to a country. DoBots may be able to offer services to care organizations only in countries where such organizations are non-conventional and open to new solutions. |
| **Technology** | What if a new and cheaper technology becomes available? Is the technological architecture capable of absorbing a new and cheaper technology should such a technology become available on the market? | The platform works on open standards and protocols. Should a new technology whose performance supersedes that of DoBots be available, the company might be able to absorb it. However, this becomes necessary only if the technology being used by the company fails to yield results. |
| **Organization** | What if one of the partners should decide to leave the network? | Since DoBots is a startup, its capabilities are limited. If a partner leaves the network, it will hamper service delivery. To make up for this DoBots must draw strict contract with partners or keep substitute partners for delivering the same function so as to be partner independent. |
| **Organization** | What if there are changes in regulation/legislation? | The current scenario is designed with the latest policy changes in mind. However, it must be acknowledged that many care organizations are traditional and quite wary to experiment with new technology related services. In fact a positive push from legislation to adopt technology in care (as is indicated from the latest policy changes) may encourage care organize to adopt more innovative solutions in care. |

**Table 6-3:** Robustness Check for Scenario 3

| | **Questions** | **Robustness Check for Scenario 3** |
|---|---|---|
| **Service** | What if alternative services are brought by competitors to the market that offer comparable or even better functionalities? | From the interviews, not many competitors mentioned municipalities as customers and this scenario is rather new. However, if competitors bring new solutions to market, DoBots will have to differentiate its services with higher functionality or provide them at lower costs to beat competition. |
| **Service** | What if there appears to be a huge demand for the services? What if the market is expanded internationally? | Here the situation is similar to scenario 2. DoBots being a start up has limited resources and capabilities and may not be able to manage large scalability. Also, this scenario may not be meant for large scale provision as it is dependent on the culture of care which is specific to the country. New policy changes have called for distributed local government based care provision, this may not be the same globally. |
| **Technology** | What if a new and cheaper technology becomes available? Is the technological architecture capable of absorbing a new and cheaper technology should such a technology become available on the market? | The platform works on open standards and protocols. Should a new technology whose performance supersedes that of DoBots be available, the company might be able to absorb it. However, this becomes necessary only if the technology being used by the company fails to yield results. |
| **Organization** | What if one of the partners should decide to leave the network? | Since DoBots is a startup, its capabilities are limited. If a partner leaves the network, it will hamper service delivery. To make up for this DoBots must draw strict contract with partners or keep substitute partners for delivering the same function so as to be partner independent. |
| **Organization** | What if there are changes in regulation/legislation? | The current scenario is designed with the latest policy changes in mind. However it must be acknowledged that both municipalities and insurance companies are not traditional care providers. They only provide funding and support care provision. Changing laws can change this scenario drastically. For instance, if the government makes it mandatory for insurance companies to reimburse such services, there will be more adoption of services. |

The services, categorization of service offerings, partners and revenue model do share similarities across the scenarios. However, the logic of identifying the customer, nature of services, and selection of complimentary providers are scenario specific. Next the robustness check was performed on the scenarios to asses which scenario might be most suitable for DoBots to adopt. It was concluded that Scenario one presents the most robust scenario as it is less influenced by external factors.

# Chapter 7

# Conclusions and Recommendations

This research began on an exploratory pursuit aimed to design business models for the IoT service platform of DoBots in the vertical of AAL. The study has drawn insights from academic literature and empirical data in order to answer the main research question:

*How to devise a framework that captures the critical business model design issues for Internet of Things and apply it in the design of business models for an IoT service platform in the vertical of Ambient Assisted Living?*

The research investigated the IoT platform of DoBots to inquire into its service capabilities. This in combination with desk research provided the necessary technological background to study IoT. Next, inputs from the market regarding the business potential of IoT and user needs in the AAL vertical were required. This was carried out in the form of field interviews with practitioners in the domain of IoT, AAL and elderly care. Following this, a detailed qualitative analysis of the field data gathered and repeated going back and forth between field data and theory was implemented in order to answer the research questions of this study.

The main findings of the study regarding the research question is presented in Section 7-1. The reflections on theoretical contributions, implications for the IoT domain and recommendation to practitioners are presented in Section 7-2. Section 7-3 presents the challenges and limitations of the study and finally avenues for future research are suggested in Section 7-4.

## 7-1 Main Findings

This section discusses the main findings of the research by answering the initial subquestions. The first subquestion was formulated as: *What are the variables that can be extracted from literature to study critical business model design issues for the domain of IoT?* In order to answer this, main stream academic literature related to IoT business models, STOF model and platform theory were investigated to provide a theoretical framework for study as in Figure 3-3. This was used as a blue print for analyzing field interviews. Relationships between between the CDIs in the STOF domains were clear only after data analysis from field research. A modified framework that clearly specifies the important design issues for IoT was arrived at. This explains the logic for capturing the value creating capabilities for IoT business models. The framework was named the i-STOFp framework owing to its derivation from academic literature in IoT (i), the STOF model and platform(p) theory and is shown in Figure 7-1.

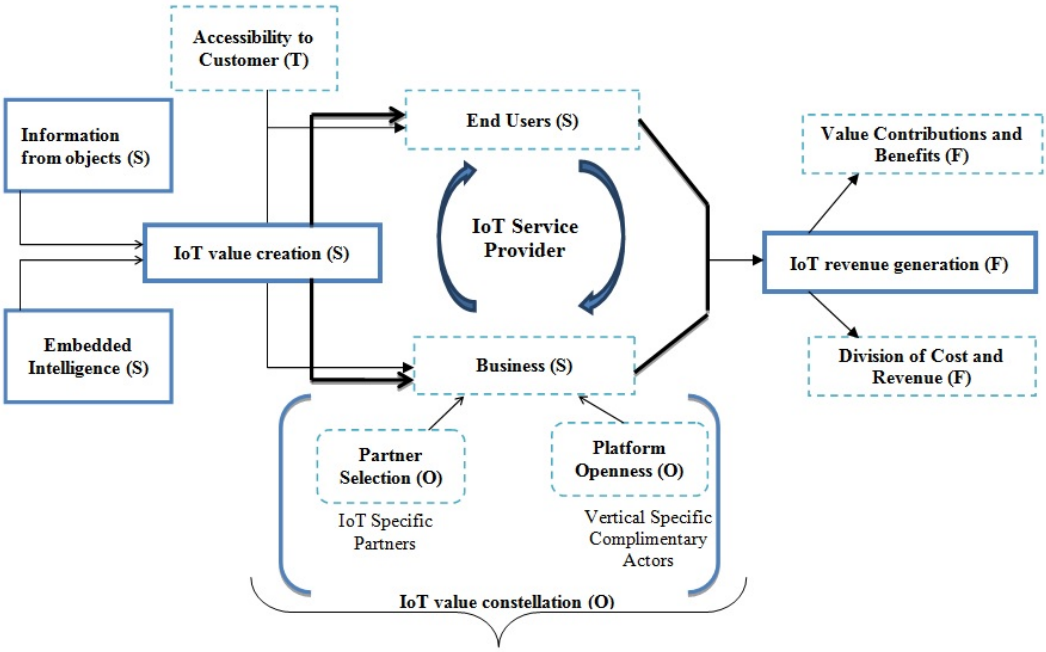


**Figure 7-1:** i-STOFp Framework

The i-STOFp framework which includes the CDIs and their underlying relations can be used as the basis for designing IoT business models. The important design issues identified from literature are answered here. In the service domain the *information from objects* and the *intelligence of objects* were derived as the two important value creating capabilities of IoT. These were related to the CDI *IoT value creation* to emphasize its distinguishing characteristic to the IoT domain. Next it was learned that the target market in IoT can be differentiated into two. First, *end users* who play an active role both in generation and consumption of data. Second, *businesses* where this data can be used to enable information and intelligence based services. The *IoT service provider* facilitates services between these two actors. In the technology domain the CDI *accessibility to customers* proved to be important to design business models for IoT especially because of its product service nature. Within this CDI the design of smart objects and the role of smartphone in order to provide services for the user was perceived as important to access the target market. Hence this CDI was linked to the CDI *targeting* considered initially, which is now distinguished into end users and businesses. In the organization domain, the CDI *IoT value constellation* was shown to encompasses *partner selection* and *platform openness*. *Partner selection* was important as IoT brings the emergence of network players such as telecom and internet service providers. These players are ideal partners not merely for their resources and capabilities for service delivery but also for their strategic interest in benefiting from emerging IoT markets. Further this CDI is closely linked to the *businesses* part of the target market in Service domain as business could play the role of both partners or customers in a specific IoT vertical. IoT was said to enable open networked business models. This was confirmed from field research with most respondents vouching for openness in their respective software offerings to provide richer solutions in the specific vertical. *Platform openness* enables two category of players. First was service providers who can provide complimentary services to enrich the functionality of a platform. Second is the expected emergence of third party application developers who can make use of the big data arising from the platform. This CDI also contributes to businesses in the Service domain. In the Finance domain, most of the *IoT revenue generation* techniques followed a cloud service based subscription or pay per use models. Close links between revenue generation and value creation capabilities as mentioned in theory are only emerging. However, the prefix IoT emphasizes the opportunities for more value creation based revenue model designs. The product-service nature of IoT technology in combination with the complex network of actors, makes the CDIs *division of costs and revenues* and *valuation of contributions and benefits* important. Further since the revenue generation from the end users and businesses (in the Service domain) will influence these CDIs the link established between them. This framework is used as a basis for designing business models for IoT in AAL.

The second research question involved *investigating the current trends in the Dutch elderly care market and applications in the AAL domain.* From field research it was learned that the elderly care market is currently facing a period of turbulence. This is due to policy changes that propose a radical shift from traditional intramural based market to extramural. Even AAL companies express difficulty in pointing to a customer in the current situation. This in addition to the rather complex financial structure (division between care and cure; notions that care technology and related services were traditionally reimbursed by insurances) makes the scene unstable for major stakeholders: elderly clients, elderly persons, family caregivers, care organizations, AAL companies, municipalities and insurance companies alike. The new laws push for decentralized care provision by directing municipalities to take control of the elderly and forcing local organization of care. The primary applications in the AAL domain can be classified under safety services and comfort services. Safety services include: fall detection, wander detection, passive/active alarming and tracking activities of daily living (lifestyle monitoring for detecting abnormalities). Comfort services include communication with informal carer/family, automatic lighting and switching applications (gas stove, other appliances). It was learned that current solutions are not suitable for the elderly and are perceived as unfriendly and stigmatizing. One of the prime requirements in the business model design was to create scenarios directed towards creating customers in the first place.

The third research question inquired *How can the critical business model design issues of IoT be applied to the AAL vertical?* This was answered by demonstrating the application of design issues of the i-STOFp framework to the AAL vertical. This step is suggested as a prerequisite to the actual design of business model as it provides a starting point to establish business model contexts, describe key partners and complimentary service providers and explore the revenue generation options in advance. The two value creating characteristics of IoT i.e. information from objects and intelligence of objects give rise to services in IoT. The information based services arise from sensor driven data analytics. The AAL applications lifestyle monitoring of elderly (includes observing activities of daily living), tracking (includes wander detection and detecting immobility) fall under this category. The intelligence based services arise from occurrence of events in real time. AAL applications fall detection, intelligent alarm escalation and control applications such as automatic lighting and switching (gas stove, other appliances) fall under this category. The difference between IoT and traditional AAL applications are the visibility and availability of data and the ability to capture, connect and communicate events in real time enabled by IoT. Information exchange for value creation between relevant stakeholders (elderly clients, family care givers, care organizations, municipality and insurance companies) facilitated by the IoT service provider are taken as inputs for designing business models. Here three contexts of information exchange for value creation were identified which was further developed into business model scenarios. The IoT value constellation demonstrated the role of special actors such as telecom players and businesses such as care organizations itself partners in service provision. IoT enables opportunities for opening the platform the provide vertical specific complimentary services in AAL. These may include medical care, emergency alarm services etc. An attempt to relate IoT value creation to revenue generation was demonstrated. This presented options of categorizing services on the basis of time criticality, information access etc.

The fourth research question asked: *What could be the services and robust business models for the IoT service platform of DoBots in the AAL vertical?* The value proposition offered by DoBots is conceptualized to consist of information and intelligent based services for AAL as explained in subquestion three. From the design considerations in the i-STOFp framework, three scenarios were identified for DoBots to commercialize its IoT service platform in the current Dutch elderly care market. First scenario suggests a mass market consumer based solution to support independent living for the elderly. Here the informal or family care giver can monitor the activities of the elderly online. The rich data set can give detailed information of the whereabouts of the elderly including tracking and lifestyle monitoring. The real time event detection can capture emergency events such as fall detection and intelligent escalation of alarms. The control action of the smart objects can further assist the elderly in automatic lighting and switching of appliances. The second scenario suggests a care based solution where DoBots can facilitate services between care organizations and elderly clients more efficiently and modernize the care process. Here the care organizations are given the software tools to remotely monitor the well being of their clients. This coupled with opening the platform for health related information provides rich datasets of clients to care organizations thereby enabling enriched care. The third scenario presents a community based solution suitable for the new policy changes starting from 2015. Here insurance companies and municipalities come together to provide innovative tools for community based self organized care for the elderly. The infrastructure and software tools can be highly subsidized by the insurance. DoBots can facilitate services between the elderly and the municipality by partnering with local care organizations and monitoring the well being of elderly clients. The stress test suggests scenario one to be the most robust as it is less influenced by policy changes and is also easier to scale internationally.

To summarize, the findings of the study arrive at the i-STOFp framework that specifies the critical business model design issues for the domain of IoT. This framework is further applied as a starting point in the design of business models for the service platform of DoBots in the vertical of AAL. Three robust business model scenarios were presented. The *STOF model* was utilized at the stages of designing CDIs, interview protocol and the design of business models itself. The *platform theory* gave the orientation for a one-sided market exploration and studying relevant vertical specific complimenters in an IoT generation pushing for open platforms. *Aggregation of existing literature in IoT* gave the necessary support for extracting IoT specific characteristics for business model design.

## 7-2 Reflections

This graduation study started with the aim of commercializing the IoT service platform of DoBots in the vertical of AAL. The first challenge arrived in the form of lack of sufficient literature on business models in IoT. Ironically, the scarcity of literature made it difficult to identify a starting point or define a boundary for scientific contribution in this study. Hence, initial research questions were quite open and mostly sought practical business model solutions from companies in their respective fields in relation to the case platform. From literature the understanding was that IoT business models are in infancy and businesses are still unsure about how to capture the value from IoT. Field research confirmed this as the IoT companies interviewed were either working on prototypes or just initiating ideas and nearly none of them had conceived complete business solutions. Most of the discussions revolved on "how it could be" rather than "what it is." However, this research turned out to be a text book example of an exploratory case study where fieldwork and data collection were undertaken prior to the most final definitions of study questions and hypothesis. The complexity of the subject paved way for itself by identifying the gaps in literature in the pursuit of defining practical business model solutions. It was nearly impossible to logically conclude on practical solutions without specifying the critical business model design issues for IoT as a starting point. It emerged that literature lacked a wholesome approach that could unite important design issues to be considered while designing IoT business models. Though IoT related works were highly fragmented, when put together they gave a fairly good picture to derive the logic for capturing value in IoT. This provided the second starting point for this research by redefining the objective. Repeated iterations between theory and field research was required to specify the CDIs that connect the dots in the IoT domain.

### 7-2-1 Theoretical Contributions

#### Contributions to Business Model Literature in IoT

The study makes some contributions to literature on IoT business models. It presents the i-STOFp framework that attempts to specify critical business model design issues for the domain of IoT. While the choice of IoT design variables were aggregated from many works in literature, this work can be considered mainly as an extension to the works of Bucherer and Uckelmann (2011) as visualized in Figure 3-2 as their work was included in all the three IoT design variables chosen. Bucherer and Uckelmann (2011) shows the importance of value creation by information provision and the splitting of markets into end users and businesses with an "information service provider" facilitating information provision between stakeholders. The current study builds on that basis (inclusive in the definition of IoT design variables) and adds intelligence from objects alongside information as value creating element. It extends on businesses in the organization domain and appends partners and complimentary service providers to specify a value constellation specific to the IoT domain. It makes connection to the finance domain and suggests possibilities of more direct links between value creation and revenue generation in IoT. It also connects the IoT revenue generation CDI to division of cost and revenue and value contributions and benefit. In essence this provides the main design issues to be considered as a starting point to business model design.

This research was also the first to study business models for IoT in the AAL vertical. Literature offers one instance in the work of Dohr et al. (2010) which succinctly describes the technological and application characteristics of traditional AAL and IoT enabled AAL. But otherwise practical business model study in this area is scarce. The study also demonstrates the application of the framework designed above in the vertical of AAL.

#### Contributions to STOF Theory

This research adds to academic literature on business models, particularly the STOF model. STOF model was developed for mobile and ICT service innovation. This study presents the first instance of the extension of STOF CDIs and application of the STOF method into the domain of IoT. It demonstrates the use of the STOF model slightly differently. Traditionally the CDIs of STOF come into play after the design of the business model in the refinement stage. This thesis demonstrated the possibility of addressing the design issues in the pre-design phase as a starting point to sketch of the business model itself. It also demonstrates the possibility of integrating concepts from platform theory into the design space of the STOF in the form of CDIs. The STOF CDIs were particularly relevant for this study as the IoT service platform can be considered as an extension of mobile internet.

### 7-2-2 Practical Contributions

#### Recommendations to DoBots

DoBots is working on the budding IoT technology in the steadily changing IoT landscape. IoT is expected to present opportunities for both industry giants and startups. With its prototype on smart objects and strong IoT service platform capabilities DoBots may be poised for a first mover advantage in the IoT domain in general. However, given its startup status, current market conditions for IoT and the Dutch elderly care, I suggest the following "next steps" for DoBots to ride on the IoT wave.

1. *Choose the right industry partners:* From the interviews it was learned that many industry giants are open to partnership as they want to benefit from IoT. This presents a perfect opportunity to DoBots to find the right partners to complement its resources and capabilities. Telecom and even energy companies are looking to do "something" in IoT. If DoBots can envision services and demonstrate use cases, these partners will be willing to join DoBots in service delivery. With respect to AAL vertical, DoBots does face competition from both traditional and modern AAL service providers. However it can take advantage of the current uncertainty in the market to define services for customers in the scenarios presented. It will be highly useful to partner with complimentary service providers to ride on the users in their platform in order to create an installed base or critical mass for DoBots' platform. DoBots could think of a consortium of relevant stakeholders interviewed in this case in order to delivery full fledged solutions.

2. *Market selection:* Currently DoBots approaches the market on a project delivery basis. DoBots also has inclinations towards B2B markets. However, the dutch care markets are inherently moving towards B2C. In order to provide scalable solutions for a long

term, DoBots will have to be more commercially driven in directions suiting the needs of the market. In the AAL vertical, DoBots might be better off by implementing Scenario one which offers solutions to the consumer in a "think global and act local" manner. It also ensures scalability unlike scenarios two and three which is more suited to the Dutch market. If preference is for a B2B solution scenario three might be favorable. But in this case, they are more dependent on the business models of the B2B customers. However, in both cases the must investigate directly the needs of the elderly clients themselves.

3. *Highlight safeguarding user data:* Data ownership and usage will crop up as an obvious element in IoT services. DoBots will have to guarantee safe provisioning of user data in order to gain the trust of consumers. It should also provide abstraction levels within home gateways and highlight the safety, security and access of data to customers/consumers.

4. *Use the benefit of smartphone/app market:* While DoBots already sees this, field research confirms and emphasizes the role of the smart phones as a means to access the customer. It provides the interface to the customer to access devices or information to the fullest

5. *Value creation:* IoT is highly vertical specific. DoBots is working on its smart object prototype. DoBots must ask themselves the question of the "use case" for the connected smart objects in a particular vertical before it looks to commercialize it. The study does highlight the steps to identify service based revenues for the platform. DoBots can try adopt similar steps in other verticals.

6. Finally, the study suggests three scenarios with different service packages in an attempt to provide integral solutions. Also the revenue model designed were more conventional keeping in mind a rather turbulent market in itself. As IoT matures, it is possible that several different revenue models emerge as more successful including web based provision of applications for devices much like the current mobile app market or pay as you go convenience models for single applications. DoBots must be willing to ride on these changes or even initiate them.

### Recommendation to IoT practitioners in general

The study concluded that though business applications in IoT are only beginning to emerge, IoT indeed has the potential to flourish. While most IoT practitioners are unsure about how to monetize their IoT technologies, platform or services, this study presents the starting point to remove the road block. The recommendations to IoT practitioners are as follows:

1. *Use of i-STOFp framework for a starting point:* Many practitioners look at IoT as a collection of hardware. However, value creation for customers is possible only by extracting use-cases relevant to a context. The i-STOFp framework derived in this study helps kick-start the translation process from IoT technology to commercialization within a specific vertical. It presents the key design issues an IoT practitioner should consider and draws direct links from value creation to revenue generation.

2. *Vertical specificity has advantages:* At the moment IoT applications are vertical specific. The technology itself can be generic. This does compel practitioners to use it in different

verticals. However, focusing on a particular vertical presents advantages for providing distinct vertical enriching services and extracting maximum value from it

3. *Data analytics is essential:* Its needless to mention that data analytics is taking over as an important element in IoT. Practitioners will have to ensure this capability in house or with third party application providers for analytics services. Especially in a B2C market, the ownership and use of customer data should be handled with care.

4. *Pay attention to smart objects:* These form the building block for IoT as it does the basic task of sensing and gathering data. Many players (big chip manufacturers/ open source hardware providers) are making offerings for smart objects. Selection and design of such objects must be robust and suit the business context. Consumers favor friendly designs.

5. *Bolder revenue models are possible:* Currently (even in the thesis), cloud based subscription models are recommended due to the nature of continuous access for IoT services. However, practitioners can engage in bolder revenue models. Some recommendations include pay as you go models for smart objects with services attached, time related, data related revenue models, application markets for smart objects with the proliferation of third party application developers just like in the mobile industry.

### Contribution to the Dutch Elderly Care

Existing Ambient Assisted Living services in Netherlands are very conventional and based on social alarms. As revealed in the interview analysis, the Dutch market is also in a phase of a paradigm shift in its organization. Though the situation is unstable at the moment, most respondents indicate that policy changes from 2015 will provide the much needed stability due to decentralization of care and the push for a sustainable elderly care system that cuts unnecessary costs. Despite initial uncertainties (as the system has to first fight resistance to an age old way of care), from analyzing the market my hunches are that the situation will soon stabilize in the new policy era. Also considering the rather complex care market, its current phase of transition and the implications on the stakeholders including the elderly persons, this study offers a much needed compilation of all the viewpoints put together. It also demonstrates solutions that can be implemented in the new era of self organized care.

The proposed Internet of Things enabled AAL service concepts that are new to the market as cloud based services for mass market are only being conceived in the industry and are yet to take off. This study proposes solutions for ***innovating ways of living independently*** for the elderly. The Dutch market is also expected to be one of the markets that can absorb such solutions sooner and many stakeholders interviewed indicated working towards the same. The marketing approach also highlights the need to brand the service as a non stigmatizing, non-intrusive and friendly and "normal" means for the elderly to live independently longer.

## 7-3 Research Limitations

This section will address the limitations of the research, that were inherently caused by design and execution of the project, or were introduced by external factors.

The first limitation of this research is that it is a single case study investigated from the perspective of a specific IoT service platform provider. While the internal validity of the results and conclusions may be high, the external validity is limited to IoT providers with similar organizational characteristics (the results are pitched from a startup perspective), technological platform and service capabilities. IoT is a very broad domain. Players here consists of both startups and industry giants. Also the variety of technological offering in IoT is myriad and depends on the players. It could be platforms, services, smart objects, sensors etc. together or isolated. Hence the generalizability of the results is very narrow and is restricted to startups that own IoT service platform similar to the nature of the artifact discussed in the study.

The research methodology considered may have had some limitations in phase one and two of data analysis. The theoretical framework was derived from only selected IoT design variables in literature. Also relations are drawn only to specific CDIs in STOF and platform theory. The i-STOFp framework derived does not presume to capture all the important and relevant CDIs for IoT business models. Also the i-STOF framework derived from empirical data took insights from IoT practitioners from both smart building and AAL verticals as by definition AAL supports elements from smart buildings (homes) as defined in Chapter 1. There were equal number of respondents from these verticals. Hence it might be safe to generalize i-STOFp framework to both AAL and smart building verticals.

In phase two inputs from some seemingly important stakeholders were left out due to time limitation posed by study. In the IoT domain it was energy companies and in the care vertical it was insurers (However inputs from insurer was taken later at the evaluation phase). However the abstraction of IoT thinking in AAL conducted at phase three in research were without these inputs. As such this might minimize the external validity of results.

The contexts for scenarios generated in phase three of field were based on the i-STOFp framework and inputs from the care market in the AAL vertical. Though they were arrived at logically, it is possible that relevant scenarios might have been overlooked due to this approach. At this stage, a scientific approach to scenario analysis taking future ambiguities and uncertainties into consideration would have increased the validity of these contexts.

Finally, the first quick scan was evaluated by the external expert who represents only a single category of stakeholder (It must be emphasized that the identified expert also has expertize in the business model design for care itself and hence has a deeper knowledge about the care market). The role of insurance companies is evident only in scenarios two and three. Scenario one presents a mass market based solutions drawn from interviews. However, the elderly clients themselves or the family care givers were not interviewed in the study. That being said, scenario one also emerged as the most robust scenario. It is acknowledged that inputs from relevant actors from the care market primarily elderly clients, family care givers, care organizations and municipalities were not taken at the evaluation stage. This limits the generalization and external validity of findings.

## 7-4 Recommendations for Future Research

The study concluded above adds only a small drop into the growing literature in IoT. As mentioned several times before, research on business models in IoT has a lot of directions to branch and gain. From the research limitations studied the following recommendations can be considered for future research.

1. First, this study identified only three IoT design variables and selected STOF CDIs from literature. An attempt can be made to extract more IoT design variables from literature and combine it with remaining STOF CDIs to arrive at a more compete framework that defines the critical design issues for IoT business models in AAL vertical. Further, this study can be pursued in the verticals of both AAL and smart buildings to evaluate if CDIs differ between IoT verticals. The i-STOFp framework derived uses only selected STOF CDIs. This was done in order to limit the scope of study and also to study the issues most relevant at the early stages of business model design. In the future this research can be extended to the other CDIS of STOF model in order to have a detailed flow of logic that capture customer and network value in IoT in other verticals.

2. Second, the VISOR model though identified as a stronger contender was not used in this case. Visor however presents strong design elements for value co-creation, sensor data analytics, platform complementarity etc. which very emerged as important aspects in the current study. This model along with concepts from platform theory can be used to further investigate business models for IoT platforms with finer focus on the service platform itself. Since IoT services are said to be slowly taking off, even the interface aspect might be more defined and can be better captured using the VISOR lends.

3. This study investigated the service platform in the single-sided market in vertical complimentary markets. However, the case platform by definition could also give rise to two-sided markets which was not investigated. Further other platform design variables such as horizontal strategy for platform openness, network effects, platform governance, platform leadership etc were not investigated. It might be interesting to define a study with these concepts to investigate different verticals in parallel.

4. In all the business models presented, the end users are elderly clients. However, I have not done any interviews as to the willingness of end users on using the platform and ideas presented. It would be important to try and find out what aspects of the service these parties are most interested in. It is particularly important to research into the habits, needs and perspectives of the elderly clients to adopt such services.

5. I have tried to address the aspect of data ownership in business transactions for IoT services. However, another area that needs detailed study is the privacy issues that such services can create. Since large amounts of information will be flowing to and from the homes of elderly consumers, security and privacy need to be closely guarded. While these information can be used for enhancing customer experiences and providing accurate services, adoption of these services may greatly be influenced by how well the information is handled. Hence, I would advise research to be done into the security aspect of the IoT services where customer information is stored and accessed in order to deliver privacy in a way the consumer is convinced and is genuinely protected.

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# Acronyms

## List of Acronyms

**IoT** Internet of Things

**BMC** Business Model Canvas

**AAL** Ambient Assisted Living

**ICT** Information and Communication Technology

**CDIs** Critical Design Issues

**CSFs** Critical Success Factors

**APIs** Application Programming Interfaces

**SDKs** Software Development Kits

**DIY** Do It Yourself

# Glossary

**disruptive technology** A disruptive innovation is an innovation that helps create a new market and value network, and eventually disrupts an existing market and value network (over a few years or decades), displacing an earlier technology (**?**). 1

# Appendix

## -1 Literature Review

While several generic business model frameworks exists in literature (E.g. STOF, VISOR, Business model Canvas, DNA model, e3 model etc.), the biggest hindrance in proceeding with the direct design of business models in this study was the need to identify the specifics bought by the technology of IoT. So as a first step it was necessary to specify the business model design issues for the domain of IoT as a prerequisite to developing business models. Literature review was used to study the existing theories on the business potential of IoT in order to investigate the core concepts to be taken into consideration while designing business models. The literature review was done to answer the question:

**What are the characteristic variables to be considered for designing business models in IoT?**

Literature on IoT can be broadly categorized into two types: Those that expand on the technological details of IoT and those that foray into the applications and the business potential offered by IoT. The second category of literature were investigated for the purpose of this research as the objective was to investigate the business potential of IoT.

**Table 1:** Abstracting characteristic design variables for IoT business models

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| 1 | **Bucherer and Uckelmann (2011)** | **Business Models for the Internet of Things** |
| | Value creation | Information as a source of value creation and value proposition. This paper draws on the seven laws of information to point out that information access, usage, time-dependency, accuracy, aggregation, pre-processing and data-mining will form important value creating elements in IoT. |

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**Table 1 – continued from previous page**

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| | Revenue generation | Information as value proposition requires rethinking of financial aspects. Revenue models (pricing models) are proposed to be based on the usage, time dependency, accuracy, aggregation and pre-processed value of information. Here the revenue generation is assumed to be directly related to the value of information. |
| | Key insights | In this paper the above mentioned views of IoT are taken as the basis for designing business model scenarios. These variables are applied to Business Model Canvas in the sectors of manufacturing, logistics, service and maintenance in order to envision future scenarios. This paper also provides a detailed outlook on the roles of things, customers, business and service providers in IoT. Importance is paid to the necessity to have a win-win situation between stakeholders involved in information exchange. |
| 2 | **Chui et al. (2010)** | **The Internet of Things** |
| | Value creation | Information and analysis. Emerging applications in IoT are said to be based on information and analysis. New networks link data from products, company assets, or the operating environment. This data will generate better information and analysis, to enhance decision making significantly. |
| | Value creation | Automation and control. Here data and analysis collected through IoT is used as instructions that feed back through the network to actuators that in turn modify processes. Closing the loop from data to automated applications can raise productivity, as systems that adjust automatically to complex situations make human interventions unnecessary. |
| | Key insights | This paper gives a good overview of emerging applications and use-cases of IoT in several industry sectors. Importance is attributed to the value creation offered by IoT which serves as a basis for applications in different sectors. |
| 3 | **Perera et al. (2013)** | **Sensing as a service model for smart cities supported by Internet of Things** |
| | Value creation | Sensor based information to understand user behaviour and user preferences |
| | Revenue generation | Sensing as a service model is proposed where revenue is generated in a typical cloud computing based XaaS pay per use manner. |
| | Value constellation | Sensors, sensor owners, sensor publishers, extended service providers, sensor data consumers (governments, business organizations, academic institutions) are part of the value chain. |

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**Table 1 – continued from previous page**

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| | Key insights | This paper draws on the views of information from sensing as the basis for designing business models for IoT. The domain of application is smart city which includes sectors such as smart home, environment monitoring and smart agriculture. The highlight is the detailed explanation of the value chain and the need for a win-win situation for all the parties involved. |
| 4 | **Sun et al. (2012)** | **A holistic approach to visualizing business models for the Internet of Things** |
| | Value creation | Value is created by real time tracking and use of location data. It specifies clearly the difference between customers who find goods at the highest quality and low cost, and businesses that acquire customer behavioral data and control inventory. |
| | Revenue generation | Pay per use, incremental management efficiency due to construction of information network platform (addresses a link to value creation). |
| | Key Insights | It uses the Design, Needs and Analysis (DNA) business model. They present a scenario in smart logistics to illustrate how the DNA Model might be applied to IoT. All the common business model design variables such as customers, partners, resources, activities, channels, customer relationships and segments, value proposition, revenue and costs are highlighted. However, the IoT specific characteristic is bought out by the above mentioned design variables. |
| 5 | **Ma and Zhang (2011)** | **On the disruptive potential of Internet of Things** |
| | Technology integration | Integration of technologies is a very important characteristic in IoT. IoT itself means the integration of the physical world and digital world, including "ubiquitous digital world" and "intelligent physical world." An IoT service should be capable of exploiting the full potential of existing information resources in IoT. Adapting from mobile Internet, a service platform to aggregate resources and the supporting operating systems and terminals to shield heterogeneity and abstract uniform resources can be built to facilitate service innovations and improve the integration level. |
| | Value constellation | It is conceptualized that in IoT environments more participants from multiple industries would join in and bring more complicated relationship which needs to be carefully researched to guide service design. Novel guide models and methodologies need to be applied to respond to complexity challenges. |

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**Table 1 – continued from previous page**

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| | Value creation | The integrated information system in IoT forms a source of value creation. The customers of IoT services can be ranged from individuals to industry giants. |
| | Key insights | This paper emphasizes the need for service and business innovation and highlights the design issues above as prominent. |
| 6 | **Fleisch (2010)** | **What is the Internet of Things? An Economic Perspective.** |
| | Value creation | IoT allows the physical world, things and places, to generate data automatically. High resolution and trusted data is said to create value with applications for both businesses and consumers. Structuring IoT applications is difficult. However two categories of value drivers are identified, the first dedicated to root causes based on machine-to-machine communication, while the other show root causes based on the integration of users. |
| | Revenue generation | High resolution data becomes economical. When things and places sport minicomputers (smart objects), the variable transaction cost converge toward zero. This produces a rebound effect because as the price of a sensing event declines, it becomes more attractive to sense more often. All the value drivers are related to reduction of real world transaction costs. |
| | Key Insights | This paper provides a starting point for an in-depth discussion on the economics of IoT. It identifies value drivers and gives pointers on how companies can utilize IoT applications. It suggests that IoT will eventually provide management systems with low-cost, high-resolution data about the real world. |
| 7 | **Mejtoift (2011)** | **Internet of Things and Co-creation of Value** |
| | Value creation | This paper suggests three layers for value creation in IoT. First, the manufacturing layer which is related to the connection between things. Second, the supporting layer which is related to adding sensors to things and the ability to collect data. Here, it is possible for IoT to provide support for both industry and customer driven value creation processes and hence, be involved in a co-creative system. Third, the co-creative layer, here the more embedded intelligence that goes into the things, the more they are able to think and act for themselves. |

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**Table 1 – continued from previous page**

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| | Value constellation | IoT envisions market opportunities including not only consumers and manufacturers but also standard development organizations, national research centers, service providers, network operators, and lead users. Consequently, the complexity of value creation grows way beyond today's 2- dimensional value chains and value networks to include other self-supporting systems, i.e. the Internet of Things. |
| 8 | **Liu and Jia (2010)** | **Business model for drug supply chain based on the internet of things** |
| | Value creation | IoT can be used to obtain production information, inspection information, storing information and consumption information in drug supply chain and make all the information available to the stakeholders. |
| | Value constellation | The industry chain of IoT consists of equipment providers, application developers, network operators, system integrators and users. Moreover, equipment providers include network equipment providers as well as terminal equipment providers which contain RFID tag manufacturers, sensor manufacturers, other hardware manufacturers and application software providers. Business model design trade offs are made in the allocation of activities to actors. |
| | Key insights | This paper uses the e3- value methodology framework as a conceptual model to describe IoT business models. They provide two approaches in which the value activities, interfaces and ports are similar. However, design trade-offs are made in the allocation of activities to actors. This paper also emphasizes the need for information provision among all stakeholders. |
| 9 | **Laya and Markendahl (2013)** | **The M2M Promise, What Could Make it Happen?** |
| | Application density | Current deployments are typically dedicated to a single applications, which leads to higher application development cost and lower average revenue per user. The M2M vendor market is extremely fragmented and solutions must be designed for each specific customer. Many small developers attempt to fill the gap with their own solution, leading to high design and deployment costs and poor economy of scale. Recently, there has been a strong focus on the benefits of shared and common infrastructure that can be used for different M2M applications so that the initial investment costs will be reduced and the range of future business opportunities will be expanded. Moreover, the M2M vendor |

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**Table 1 – continued from previous page**

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| | Value creation | When the data represents valuable information it can be a product itself, either to provide improved and customized services, reduce expenditures or optimize working times. |
| | Value constellation | IoT/M2M services are often part of a complex value chain where the traditional provider customer model does not apply. Also multiple motivations drive M2M solutions. For instance,for network operators,there is an increased interest in the M2M market since there is a current saturation of the human market in developed countries. Complexity in the service provisioning makes cumbersome the tasks of analyzing where the real value and benefits are. The real economic benefits are yet unclear in many applications. |
| | Key Insights | This paper draws examples from many IoT sectors: smart energy systems, smart homes, home care services. It provides a general insight into IoT value drivers across industry sectors. It highlights on the approach of markets as networks instead of analyzing relationships between companies in isolation. This type of analysis typically provides information about the distribution of activities among actors, activities that provides a certain type of value and the interaction patterns between different actors. The analysis of "values" is also supported by the contributions in where actors create value in networks rather that in a "value chain". |
| 10 | **Leminen et al. (2012)** | **Towards IoT Ecosystems and Business Models** |
| | Value constellation | It argues that the central element of IoT includes the concept of ecosystem as innovative businesses need partners, suppliers and customers with which they create cooperative networks. Platforms, technologies and process are said to form the core of the ecosystem while its members create the business models. |
| | Value creation | Data is defined as the hallmark of designing business models because the variety of data collected automatically from devices' information exchange helps to solve problems and enables the development of embedded services and revenue models. |
| | Key Insights | This paper gives two key insights. First, it identifies the need for an ecosystem to implement IoT business models. Next, it presents a list of past works that identifies the important design issues for IoT business models. It opines that open, scalable, secure, and standardized infrastructures are needed for IoT. The works suggest a clear trend from closed private ecosystems towards open networked ecosystems and business models. At the same time, more and more business-to-consumer (B2C) solutions are expected to emerge besides business-to-business (B2B) solutions that dominate the IoT solution markets today. |

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Table 1 – continued from previous page

| SLNo | Literature/Variables | Title/Insights |
|---|---|---|
| 11 | **CL.Ng (2013)** | **New Business and Economic Models in the Connected Digital Economy** |
| | Value creation | Digital connectivity between objects is said to give rise to consumption and experiential data. This is said to be the new economic resource for both firms and individuals. |
| | Revenue generation | The availability of consumption data as an economic resource is said to change the relationship between the customer and the firm, which could, in turn, change revenue and resource streams for firms. |
| | Key Insights | It argues that a new business model isn't just about product or service innovation (the value proposition), or the changing revenue/resource streams, such as money from ads or subscriptions (value capture), or the customer experience enabled through a digital medium (value creation), but potentially all three, due to the tighter coupling of the components. |

**Implications:** The papers mentioned above follow two patterns in the design of business models. Some papers demonstrate the use of explicit business model theory to provide a wholesome design with all the variables in the theory such as value proposition, target markets, key partners revenue models etc. fully explained (Bucherer and Uckelmann, 2011) (Sun et al., 2012). The others explain the business model implicitly using scenarios and role of customers and other actors (Perera et al., 2013). But in both cases they point the need identify IoT specific value creation characteristics and draw on these views to design business models in a specific sector.

The main design variables identified from the papers above are as follows:

1. Value creation: Value creation in IoT is said to be generated by information, data, identification capability, tracking behaviour, embedded intelligence of objects, sensing, automation and control.

2. Revenue generation: In many cases it is pointed that revenue generation can be closely linked to value creation where revenue models for companies can depend of variations in data accuracy, information aggregation, time dependency of data and data as an economic resource.

3. Value constellation: The choice of the word value constellation as against value chain or value network is inspired from the work of Mejtoift (2011). In IoT concept around value extends the traditional value chain into a complex value constellation that represents the complexity and variation in modern offerings. Many actors can form part of the value constellation: sensor owners, service providers, sensor data consumers (Governments, business, other organizations), network operators, lead users, application developers,

system integrators, hardware manufacturers and many papers point to the "things" itself as part of network.

The less prominent design variables identified are:

1. Technology integration: Integration of technologies is a very important characteristic in IoT. IoT itself means the integration of the physical world and digital world, including "ubiquitous digital world" and "intelligent physical world." An IoT service should be capable of exploiting the full potential of existing information resources in IoT.

2. Application density: Current deployments are typically dedicated to a single applications, which leads to higher application development cost and lower average revenue per user. There is need to design variety of application so as to use the common infrastructure for different applications.

## -2 Interview Protocol

The interview opens with a brief overview of the context of research, service offering, the technology infrastructure and then moves into the respective questions. Each interviewee is asked to describe his/her job position, details of the organization, experience and background in the industry before the beginning of the interview. Many times the services were termed "smart building, smart living, domotica, assisted living, ambient assisted living" etc depending on the context of the respondent. This concept was connected to provision of "AAL" type services to the elderly.

### -2-1 Interview Introduction

Dear Respondent,

My Master Thesis research objective is to "Design business models for an Internet of Things platform for services in Ambient Assisted Living (for elderly care)."

"Internet of Things" is the technology concept in which intelligent devices such as sensors, actuators, smart plugs, home appliances etc, are connected to each other and can constantly communicate with each other to anticipate and supply for user needs creating an ambient intelligent environment. The research will be applied to the case study of DoBots's IoT platform.

Brief on DoBots' IoT service platform capabilities:

- Connected intelligent device platform forming the Internet of Things.
- Platform that runs artificial intelligent and machine learning algorithms for providing services for smart living.
- People tracking and tracing with intelligent wireless sensor network, using Bluetooth.
- Control of home environment from smartphone or web, even via external networks.
- Runs pattern recognition and predictive algorithms for learning from the user of their needs and also responding to user needs for monitoring, safety, security.

## -2-2 Interview Protocol for IoT Practitioners

**Services**
Can you please brief your IoT software service/platform/product offering?
What is the current smart building/living focus: comfort, energy management, productivity?
Has the company considered smart building for elderly care?
What can sensor technologies do in IoT? Who are keen on such technologies?
*Understanding customers*
What are your target markets? Why did you go for the current target segment?
Who are keen on IoT technologies?
Within the IoT infrastructure that DoBots has, what services will be most fruitful?
What is the interest level and response to the use of Smartphone in such environment?
What are you technological/market barriers?
What can you recall as your key challenges so far?
How do you install/maintain your wireless communication infrastructure?
*Understanding End User needs*
What is the attitude of consumers towards smart solutions?
How do they react to installation , configuration etc?
Who helps them with installation?
**Technology**
Have you thought of the smart phone as a sensor in a building ?
What are users/clients asking you in your projects?
What is the newness they seek?
Do they come looking for even smarter solutions? Do they voice specific needs?
**Organization**
Who are your partners for service delivery?
What do you offer(make)? What do you outsource(buy)?
Who are your technology partners? What are the enabling technologies needed?
Which players come across to you as elements to reach your product from source to market?
Who are the major players in IoT?
Does Telecom, energy companies have a role to play?
Do service installation companies have a role to play?
Do you allow platform openness? If yes, to whom?
What are your value proposition in IoT?
What is the interest level and response to the use of Internet browser /Smartphone in such environment?
Who are your partners in service delivery?
Role of platform openness-What is the importance?
Who are the complementary service providers who might want to partner with say DoBots' platform?
What might be the dependencies on the case platform?
What is the depth of service level agreements that has to go into this?
**Finance**
What are the revenue models for your software service/platform?
Revenue From Direct Markets? From Complementary Markets?

## -2-3 Interview Protocol for AAL Practitioners

**Policy Trends**
What is the organization of LTC in Netherland, especially elderly care? Current policy changes, regulations?
Can you highlight the role of insurance companies, for domotics/AAL systems in care. What is the focus? What are the interesting drivers for these companies?
How does one access the intra/extramural market?
Do care institutions themselves provide personal home care services?
**Services - who benefits?**
Who will benefit from smart services in elderly care? Targeting the right target occupants, elderly or care organizations?
What are the pains of customers here? fewer personnel? More elderly? Expenses?
Who in care organizations can decide implementations of ICT? Do the occupants have a say in it?
What services do you offer?How are the current alternative services?
What can sensor technologies do in AAL?
Within the IoT infrastructure that DoBots has, what services will be most fruitful?
Compared to smart living services at homes, why is care so traditional?
Who are the B2B contacts(apart from municipality)
Are there any regulation or legislation domotics should follow in care? Should it go through any curve?
Who is the decision making unit in care?
**Technology:** Have you thought of the smart phone as a sensor in a building ?
What are users/clients asking you in your projects?
What are the types of sensors used? How do you handle installation and maintenance?
**Organization**
How do we deliver such services? Integrate with care? or address them separate?
How do we really implement such services? Market barriers? Legal barriers (Certification)? Regulation barriers?
Who will form a good sales channel to reach care on B2B level?
Role of platform openness-What is the importance?
Who are the complementary service providers who might want to partner with say DoBots' platform?
What might be the dependencies on the case platform?
What is the depth of service level agreements that has to go into this?
Which part of platform will they want access to?
Who are the private companies looking for added services?
**Finance**
How are revenue models designed?
Are your revenues from direct markets or complementary markets?
How so you handle revenues from opening the platform? License based?

## -2-4 Interview Protocol for Care Practitioners

What is the Organization of LTC in Netherland, especially elderly care? Regulations, divisions? Transition from institutional to home care?
What is role of insurance companies, for domotics in care? What is the focus? What are the interesting drivers for these companies?
How does one access the extramural market?
Do care institutions themselves provide personal home care services?
**Services - who benefits?**
What are the domotics (sensor) services that will create most value for elderly care organization?
Given the IoT functions of DoBots, what services will be most fruitful?
Compared to smart living services at homes, why is care so traditional?
Who are the B2B stakeholders(apart from municipality)?
What are the AAL services in care?What are alternative products or services that help carry out approximately the same tasks?
What are your experiences with similar services?
What is the state of "smartness" of your care home?
What aspects of these services do people like and dislike?
What do people expect from these services in general?
Who will benefit from smart services in elderly care? Targeting the right target occupants, care orgs?
What are the pains of customers here? fewer personnel? More elderly? Expenses?
Who in care organizations can decide implementations of ICT? Do the occupants have a say in it?
Are there any regulation or legislation domotics should follow in care? Should it go through any curve?
Who is the decision making unit in care?What is the willingness to pay for smart living services?
ICT in care-what is the current role/state of ICT (domotics related) in elderly care?
If deployed, who will pay for Assisted Living Services?
Compare the services offered by DoBots to existing services of customer?
**Technology**
How will you integrate IoT/AAL service in your care process?
What are the devices used within care and with consumers?
**Organization**
How do we delivery such services? Integrate with care? Separate?
What is the value chain for service delivery?
How do we really implement such services? Market barriers? Legal barriers (Certification)? Regulation barriers?
Who will form a good sales channel to reach care on B2B level?
Who are the complementary service providers who might want to partner with say DoBots' platform?
**Finance**
How do you get revenue from such services?
Do you integrating it with services offered to the customers or other service providers?Or do customers pay separately?

# -3 Quick Scan One

## -3-1 Scenario 1 - Theme: Well being of Elderly

**Case :** Mass market consumer based solutions to help improve quality of life for the elderly.

**Context:** Elderly have to live longer at home, while current solutions are bulky, stigmatizing and not designed for extramural care. Also solutions come in isolation and difficult for elderly to package them together.

**IoT as enabler:** Provision of intelligent services (by the service delivery platform) with the use of sleek sensors and actuators that can be retrofitted into their dwellings. The infrastructure and associated services will be cost effective. The elderly will be the data producer and owners themselves. The informal care giver can be the data consumer who can have an access to the elderly client data.

**Envisioned Scenario:** Up to now elderly were in care homes, or in their own homes. The only alarm service available for emergency was social alarms. There was minimal technological support for fall detection, or for lifestyle pattern monitoring. Such assistive technologies can be beneficial to the elderly for a sense of safety and also peace of mind for the informal care giver who is not in a position to monitor the elderly 24*7. With IoT, the elderly client will be able to receive:

1. The autonomous system characteristic can be used for, facilitating automatic decision making, with feedback by turning data into knowledge and further information. It allows actuation of events such as emergency alarming, automatic lighting, and turning off appliances.
2. A provision of personal data analysis by sensor driven data analytics with which the client can track his own activity, with options of sharing information with informal carers, thus organizing care by the self.
3. Enhanced situational awareness can help both the elderly or the mantel to track the behavior of elderly and be informed of deviation, unrest in bed, fall detections and reaction to emergency alarms.
4. Tracking of elderly for wander or immobility detection.
5. Provision of extended complimentary services on the platform such as health care related, connection to the pharmacy, pill reminders etc, to provide a wholesome care at home package as a substitute for replacing social care.

Elderly and family will purchase infrastructure and have access to services. Services can be provided in bundles where the elderly gets to choose pre-set services or make his own bundle. The service can be divided into packages depending on intensity of data provided. Basic services may include for actuation, fall and wander detection. Added services may include advanced sensor driven analytics, patterns of behavior and, lifestyle monitoring data. The revenue model may be subscription based, with different pricing for packages for service. Other complimentary services may be offered as extra options. The interface for the elderly will be the cell phone or tablet with option for downloading more functionality into the system from an online user account. The design of infrastructure will be easy plug and play with zero configuration installation and predictive maintenance. The smart phone will again play a role at the side of informal or a formal caregiver, with an app installed on their phone such that when one of her clients/patients presses the button or shouts for help, the system detects that he falls out of bed and the notification is sent. Options are to be enabled for intelligent routing system that handles alarm on its own with preferences to makes BYOD possible for large scale permeation.

Another revenue model is a flat fee for infrastructure with basic services for a fixed period and pay as you go options for add ons. IoT generation can allow people to organize care themselves, with neighbors and family instead of being dependent on organizations

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| Target Market | 1) Elderly client to take care of themselves, 2) Informal care giver who buys solutions on behalf of elderly client for extended monitoring |
| Value Creating Elements | Creating experiential data for closed loop services, providing elderly applications related with IoT characteristics by providing automation and control of devices on one side and sensor driven data analytics on the other side |
| Accessibility for Customers | IoT infrastructure with sensors and actuators with easy plug and play options. In addition the smart phone will be needed as an interface between the elderly/informal care giver and the technology. |
| Partner Selection | 1) Telecom companies would be important partners as they are looking forward to adding care services for elderly in their extended service portfolio. They also have the resources and capabilities to offer complete end to end solutions and services including marketing and hence are favorable partners. 2) Web data and cloud infrastructure hosting partners are necessary partners but play only a supporting role |
| Platform Openness | Provision of complimentary services that can support independent living by the elderly |
| Cost Structure | Cost for IoT infrastructure, BYOD for smartphones at consumer end |
| Revenue Structure | 1) Flat fee for infrastructure with basic services for a fixed period and pay as you go options for add ons, 2) Bundling of services, subscription based model |
| Channels | Mass market channels, webshops, telecom companies, MediaMarkt, Kruidvat, Hema |
| Value contributions | Mass market channels, webshops, telecom companies, MediaMarkt, Kruidvat, Hema |

## -3-2 Scenario 2 - Theme: Optimizing Care Process

**Case :** Care-based organizations want to work more efficiently and modernize their care process.

**Context:** Care organizations are facing cost cuts and reduction in personnel. Also increasingly they are facing competition to differentiate themselves, in order to retain elderly clients within the extramural transition. Despite the traditional mindset of caregivers and alienation towards the use of technology, there is a call for innovation from the society and government in the direction of promoting technologies for care.

**IoT as enabler:** Provision of intelligent services for tracking elderly clients for emergency alarms and behavioral deviation will help care organizations with real time decision making on complex events. They can document the condition of the elderly without being on site by sensor driven data analytics, thus replacing the traditional care structure. Process optimizations can be made possible by escalating alarms intelligently, routing to the alarm central, reducing false alarms, recording images of events thus effectively contributing to optimizing the care process.

**Envisioned Scenario :** From the interviews it was understood that many times the habits of elderly show deviations. Sleeping during the day, being active in the night, (reversal of the biological clock), unrest in bed and other deviations from normal behavior have been known to be caught by sensors. Sometimes it is possible to detect very early stages of diseases such as dementia, and care organizations can help clients cope with it much early on to avoid emergency situations. This presents useful information for the health care organization, as they get more insight into the habits of their client, sometimes more than what they would have known even if they were on site. All these things will generate an enormous amount of data, but data is not valuable in itself. Data should be turned into insights to be used for decision making. Such systemic decisions can be made with this information to increase quality of health care.

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| Target Market | Customer - Health care organizations will provide as additional services to elderly clients either within their existing care homes or extramurally on a time frame basis |
| Value Creating Elements | Creating experiential data for closed loop care services, providing elderly applications related with IoT characteristics by providing automation and control of devices on one side and sensor driven data analytics on the other side |
| Customer Relationships | Direct B2B with care, indirect B2B2C with elderly client |
| Accessibility for Customers | The IoT infrastructure will be purchased by the care organizations, who further have the responsibility to connect in elderly clients' homes and enable provision of services |
| Partner Selection | 1) Municipality as they are the new caregivers and can promote technology innovation, 2) Telecom companies are already having health care organizations as customers. Since they also have secure lines and a market reach, they form ideal partners |
| Network Openness | Provide necessary openness to allow inclusion of relevant services, particularly related to care provision and efficiency enhancement |
| Cost Structure | Infrastructure purchase to be made by care organization to be installed in client's home. It would be for a fixed period to begin with. |
| Revenue Structure | Subscription model for basic service provision, with add-ons for extra services |
| Channels | Direct: health care organizations, indirect: municipality |

## -3-3 Scenario 3 - Theme: Provision for Preventive Care by Insurance Company

**Case :** Insurance companies provide care, futuristic scenario

**Context:** Insurance companies will have more responsibilities in the new care provision. They tend to invest in technologies that reduce care costs and improve quality of life. Insurance companies would like to support preventive care, but they need quantified information on client behavior in exchange. They are also looking for competitive advantage in the newly organized care regulations.

**IoT as enabler:** Provision of intelligent services with the use of sensors and actuators for elderly. Enabling exchange of health-related data to the insurer for risk assessment. Monitoring of lifestyle patterns of elderly by an insurance company. Elderly on the other hand benefit by costs being reimbursed by insurance companies and at the same time experiencing the usage of the services and having access to their own data.

**Envisioned Scenario:** Starting from 2015, social care for the elderly will be organized more by the insurers and municipality. The municipality faces cost cuts, the insurers however are said have money and also play a powerful role. With the push for e-Health technologies and organization of care by the elderly themselves, it is possible that the insurance companies become the flag-bearer of promoting such preventive technologies.

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| Target Market | Mass market solution. Customer - Insurance Companies, Consumers - Elderly Clients, Elderly associations |
| Value Creating Elements | A provision of personal data analysis by sensor driven data analytics with which the client can track his own activity |
| Customer Relationships | Direct B2B for recovering payments |
| Accessibility for Customers | The IoT infrastructure will be purchased by the elderly clients themselves or the family but will be reimbursed by insurance |
| Partner Selection | 1) Telecom companies would be important partners as they are looking forward to adding care services for elderly in their extended service portfolio. They also have the resources and capabilities to offer complete end to end solutions and services including marketing and hence are favorable partners. 2) Web data and cloud infrastructure hosting partners are necessary partners but play only a supporting role |
| Network Openness | Provide necessary openness to allow inclusion of relevant services, particularly related to care provision and efficiency enhancement |
| Cost Structure | Cost for IoT infrastructure, BYOD for smartphones at consumer end |
| Revenue Structure | 1)Flat fee for infrastructure with basic services for a fixed period and pay as you go options for add ons 2)Bundling of services, subscription based model |
| Channels | Mass market channels, webshops, telecom companies, MediaMarkt, Kruidvat, Hema |

## -4 Evaluation with CSFs from External Expert

The evaluation with expert was conducted on 7th August 2014. The comments and advice were received from the external expert on the first sketch of business models. They are indicated in Table 2. The expert identified is an innovation manager in a leading insurance company with deep expertize in study of business models in care.

### -4-1 Summary of Expert Interview

*Business models of insurance companies:*

The goal of the insurance company is to share risks to reduce the risks in costs. They also want to have prevention so that people don't get sick. In health care, insurance companies would like people to take more responsibility and give them the tools to take handle their own health and cure. Increasingly hospitals may be one of the places to just touch in treatment process; otherwise they can do it themselves. IoT can help people to take care of themselves in leading a healthy life etc.

Insurance can pay and that's logical if it is part of a medical treatment. Otherwise insurers can still stimulate and help to find other ways to get these technologies used but then it is not

**Table 2:** Evaluation with CSFs

| CSF | Scenario1 | Scenario2 | Scenario3 |
|---|---|---|---|
| Compelling Value Proposition | Satisfactory (this can be a logical add on to other overall service package around a house/apartment) | Satisfactory (this is not so much a choice of consumers but part of care process) | Unsatisfactory (this is not perceived a logical extension of an insurance product or welfare services) and has the risk of being perceived not objective |
| Clearly Defined Target Group | Satisfactory (if it is aimed at relatively healthy target group and their environment) | Satisfactory (this involves medical care and thereby at doctors prescription) | Satisfactory |
| Acceptable Profitability | Satisfactory (under the condition that it involves mass consumer technology and accessible prices) | Unsatisfactory (should be integrated part of care process which is reimbursed via insurance premium, then it is satisfactory, this also means it stays rather expensive compared to mass-market applications) | Satisfactory (as integrated part of care process which is reimbursed via insurance premium, this also means it stays rather expensive compared to mass-market applications) |
| Acceptable Division of Roles | Un)satisfactory (the actual provision of the care and alarm services behind the technology needs further work and more clear links, I do not know if Telecom suppliers will get such a dominant role and would also look at technology suppliers Apple, Google, Samsung, etcetera) | Unsatisfactory (in this model you need the insurance companies to pay the bills as integrated part of health care. I do not know if Telecom suppliers will get such a dominant role). | Unsatisfactory (Insurance companies are able to be an important player to organize and finance the system and if needed provide services at a distance and invest in new companies but eventually insurance companies need other partners to overcome the last mile to actual care at home. I do not know if Telecom suppliers will get such a dominant role). |

payment out of health care premiums. It differs between medical treatments/care and the additional services. It is not only about costs. Insurance would still so something as long as it has sharing of risks. Basic insurance covers only medical. Lifestyle related goes into extras. When it's just consumption then it's not insurance. That can be included in the additional insurance. Falling of elderly can be an aspect that is insurance related as there are lot of costs related with fall and its pretty much applicable. From a payee point of view, it can be two. Either its a medical indication and then the insurance company can pay. When there is no medical indication people have to pay for it themselves. Insurance is not paying a role in providing assistive technologies yet as these technologies are still exploratory and not proven. They also prefer to have new technology in general - e/m health and integrate them in the total treatment and care process. Additional insurance can be more lifestyle related. They want the role of paying health care providers than doing it ourselves. Because otherwise it becomes a double system.

*Medical V/s Social Care*

Its complicated to distinguish between the two. Insurance can reimburse everything we let people pay for to share. That's the basic principle. Basic insurance that's purely medical.

*Current Policy Trends:*

With change in policies, the social care is getting into regular care in Netherlands. That's more complex care, nursing, at home etc. Part of the care is cut of the care and put into the municipality and the social environment. Part of care that is in cure is now us as part of insurance company. Thiuszorg home care, going to people and nursing.. not surgery based, but this is more giving people a shower, helping them with beds, giving some medicines stuff like that. That goes to care side. The care part which is more related to cure is going to insurance. For cure which is ZvW related, insurance pays. In the WmO related care side we should stimulate but don't necessarily pay. For social care, Thuiszorg who are now in the AWBZ are the most logical direct partners. Even in the thuiszorg related care if its nursing then its via the insurance company. For non - nursing care its going to be the Municipality.

*Stimulating Innovation:*

Stimulating AAL services for the elderly for social are currently on the edges of their business models. The business models of an insurance company are that they get premium paid for care and cure. When solutions are to take care, it goes under insurance. But if it's just about quality of life, insurance cannot pay for it. They can however stimulate it and support innovation and adoption by funding research projects, or offer collective contracts or as an additional service. When there is medical indication then they pay. Else, they offer a different product than an insurance and can make it a service. E.g. call center for emergency cases. They also offer collective contracts. For instance, to union of elderly people. There are a few hundred thousand people in the Netherlands who are member of collective group and the can purchase different things. This does not necessarily fall from health care premiums but with an intention to support innovation and preventive care. In the future if insurance companies get into the role of promoting such technologies themselves.

After this evaluation the scenarios were refined as present in Chapter 6.

## -5 Notes on Quick Scan Two from External Expert

This was received on 31st August 2014.

Scenario 1: Good scenario for the non-medical services which help people to live more comfortable and be able to manage daily life on a better way.

Scenario 2: I believe this scenario as being the medical treatments I described and then the way this is organized currently in delivery. Organizations and financing is your starting point and core to extend upon with new technologies and partners.

Scenario 3: I specifically believe in the first and second scenario. Challenge is to find the way in which they can interact to support each other. I believe that there is a large market for non-medical prevention based activities (scenario 1) and medical (scenario 2). Insurance companies and municipalities have an interest in both and can take a passive or more active role in that. Scenario 3 means that insurance companies and/or municipalities take an leading role (and in 1 and 2 they do not) I believe this is a relevant scenario. Specifically in the provision of medical care this will be in close cooperation with the health care providers. In scenario 1 it will be with different and partly new partners.