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"SMART HOME" - FROM A CONCEPT TO A LIVING PRODUCT

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Abstract

We live in a rapidly changing world where the most visible worldwide trends are, for example, the abundance of information, technological advancement and the growing average life expectancy of the population. This has revolutionized the development of new conceptualized products that are becoming more common and important to business life. In this study, smart home as an example of those new products was chosen to be the object with the aim of examining how to properly productize a smart home.

Although used for home automation and assistive technology mostly, the smart home concept could be applied to all situations where its key features exist. When developing smart homes for different needs, new product development processes combined with product portfolio management was the essential. Therefore, the Development Funnel (Von Stamm 2008) was used as the theoretical framework for finding the main challenges and solutions of smart home productization.

The qualitative research approach was applied for the empirical part of the study. In-depth interviews with semi-structured questions were conducted with two interviewees: a smart home entrepreneur and a designer. Product positioning, customer definition, cost-speed balancing in R&D were found as the most challenging aspects, whilst focusing on customer segmentation, holistic user experience with integrated system schemes and setting the ultimate goal as "being smarter" were seen as the main solutions.

The findings implicated a requirement for adopting the "products guiding market needs" approach and introducing industrial standards for smart homes and their development. However, because of the wide-ranging research scope and only a few primary data sources, the study had its limitations. Further research could use more interviews or study the efficiency of new product development from the "market-driven" vs "technology-pull" perspectives.

Keywords/tags (subjects)
Smart home, technology, productization, new product development, product portfolio management

Miscellaneous

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1 Introduction

This study discusses the concept of Smart Home and how smart home can be applied broadly and deeply to different fields. Smart home is often referred to home automation facilitated residences or housing, but if dissecting it from the definition and composition, it might be fair to ask for what more and where else the smart home might be used. The study analyzes the attributes of a smart home, studies the process to develop the smart home as a new product and explores the possibilities of using smart home as one fundamental cell to construct various product portfolios.

1.1 Background

The world is changing rapidly with a speed that human beings have never imaged before. At present, every person is unavoidably impacted by the most visible trends of being able to deal with great amounts of information, as well as being technologically enabled. Moreover, we should also be environmentally conscious, know more about economic order alternatives and have a longer lifespan on average worldwide. According to Peterson and Yoost (2015), in the business world there are at least three global megatrends that should be investigated and reacted to: demographic changes, shifts in economic power, and the proliferation of information. The interplay between these three is seen to continuously affect not only all businesses, but also our everyday lives.

The three global megatrends are elaborated one by one, starting from “demographic changes”. Within the next decade, the world’s population is estimated to be 10

percent larger. Moreover, one and often less appreciated demographic megatrend is that of the aging population. According to OECD statistics (2015), the elderly population, people aged 65 and over, was on average 15% of the total population already in 2014 in all OECD countries. This ratio has been growing annually and will result in a total of 8 million of elderly population by 2025 all over the world as estimated by the WHO. The ageing population leads to not having sufficient work force, and intensifies the challenge of retaining those workers who have up-to-date skills and knowledge (Yoost & Peterson 2015). One may ask such questions as “Who will take care of me when I’m losing self-care ability?”, “How could I keep my independent life style?”, or “Can I have a quality elderly life?” et cetera. The answers might be various, but developing a better daily living environment – one that can be easily handled has assistive technology and the safety issue considered as well as comes with an affordable price - would be the common answer.

With regard to the next megatrend “shifts in economic power”, it is a series of phenomena triggered by more and more blurred distinctions between the developed and emerging world (ibid., 35). The IMF World Economic Outlook (2014) released its forecast stating that the emerging markets continue and will continue to be the drivers of global growth, even though in 2015 the growth slowed down. An adjustment of the global economic and business activity is the transition of the emerging countries from being centers of workforce and production to customer-oriented economies to more consumption-driven ones. Inevitably, people live in a world where decisions and events in one part of the world impact on the opposite end (Cullinan 2014), which causes the dissolution of the “old orders” and many of their “traditional” assumptions about business in the international environment. This

all implies the necessity and importance of promoting sustainable development and creating shared values in consumer driven economics to pursue the global growth.

The last crucial global megatrend, “proliferation of information”, means digitalized information and that is accessible via versatile technical devices by anyone and digitalization everywhere of everything. The key factor pulling the proliferation of information is technology with its emphasis on digital products. This is driving the acceleration of innovation, interconnectivity, investment as well as business (Yoost & Peterson 2015). Business people across all sectors are seizing breakthroughs with the internet, mobile devices, data analytics and cloud computing, which transforms business and influences consumers in different geographies and cultures.

From another perspective, technology raises the expectations of consumers, which encourages them to require ever more accessible, portable, flexible and customized products, services and experiences. The negative side of a world full of abundant information is that it poses additional and usually high risks, such as breaches of security and the misuse of information. To business people, both the opportunities and the risks are worth investigating deeply. It is not difficult to understand that the ability to gather, analyze and secure data in real time has become a significant and critical competitive advantage.

When expounding these global megatrends shortly, it seems that the trends are not predictions. Instead, they are certainties affecting the everyday life at home and in business. The dynamics of life are revolutionizing products so that the results are many new, smart and connected products that have been conceptualized along with

the changing life, and the **smart home** is one of the typical examples. Porter and Heppelmann (2014) stated that, when composed of mechanical and electrical parts, products have become complex systems that combine hardware, sensors, data storage, microprocessors, software, and connectivity in many ways. These types of smart, connected products have been made possible by vast improvements in processing power and device miniaturization and by the network benefits of ubiquitous wireless connectivity, and they have unleashed a new era of business competition (Porter et al. 2014, 2).

To comprehend the object of this research, the smart home, prior analysis of its living background, business soil, future changes and challenges might be reasonable. The “Smart cities study” (Committee of Digital and Knowledge-Based Cities 2012) has released abundant papers studying smart homes from their wide adaptations to the living environment and society to further applications to smart cities. It illustrates that by being closely connected to everyday life and business, a smart home is, first, a housing environment for daily usage and, secondly, a commercial unit that business people could build for sale towards end users (ibid., 20-21). This is often facilitated with many automatic devices, such as sensors, detectors, meters, interactive machines, controllers and data processors all of which can work under one networked control system (Fatima et al. 2013).

According to Dewsburya and Linskell (2011, 249-253), one typical deployment of smart home is in the health care and social service sector where the end users are elderly people, disabled and those with functional limitations. Their households, elderly care centers and social houses are built as smart homes with the necessary

assistive technology, so that they are able to live as independently and securely as possible. There is also another typical usage of smart home in a more “trendy” way that enables end users to control and manage their home devices through a single application by connecting personal and all other possible devices to an integrated platform and server. In this situation, as Paetz et al (2011) stated, the end user is every individual inhabitant, and by equipping the smart home with such products, they wish to make their private lives more comfortable, convenient, safer as well as economically wiser in energy consumption and, thus, more environmentally friendly, in other words, smarter.

When putting it against the backdrop of the global megatrends, the smart home may probably be seen as representing many of them – a better home, smarter service housing, excellent remote working or a wise environment controller. However, one might ask whether we know exactly how to utilize a smart home and what other fields smart homes could contribute to than housing as well as whether a smart home is able to benefit consumers and the society as a broad-scale product. To find answers for these questions, an experimental journey, such as the one in this study, is needed.

1.2 Motivation for the research

In the previous section, two typical usages of smart homes nowadays were briefed: one was the assistive home unit and the other smart housing. They are respectively built for different industries: either health care and social services or home

automation and for distinct end users. To know more specifically about the status of smart home development and its market, there is a need to examine each of them.

Home units using assistive smart home technology are usually deployed by hospitals/clinics, care centers, social service houses and expert institutions targeting at elderly, disabled and functionally-limited people for purposes of better caring, serving and research. There are professional health care instruments and devices equipped and controlled by health care professionals to monitor the residents' behaviors/physiological indications and provide assistance for various physical and neurological disabilities. In Finland, using assistive technologies for elderly care houses started in 2005 with a "smart home pilot" between 2005 and 2008 by building a new kind of service model around technology to support elderly people in their living (Melkas et al. 2008). Melkas stated in her later research in 2012 that since 2008 there have been many domestics research and development projects focusing on smart homes.

Although, in general, the definitions and criteria for smart homes have varied from time to time, the "smartness" has been investigated not from the perspective of assistive devices only, but importantly also from that of aligning the customer needs and technological dimensions of smart home technology. In the field of health sciences research, some institutions, for example the Tampa Smart Home built in James A. Haley Veterans' Hospital in Florida, U.S., uses smart-home-based cognitive devices for brain-injury related rehabilitation studies. The results of this research indicate that those cognitive devices deployed in the smart home concept can play an increasingly important role in delivering rehabilitation services and become an

integral part of clinical practice (Jasiewicz J. et al. 2011). Although the above-mentioned cases have intensively focused on field-specific details, they have an interesting similarity of perspective or stance according to which using smart home by health care professionals is meaningful, helpful and important. However, the real end users' view of living in smart homes has not been clear because market analysis in this particular area is missing.

As to the smart housing part in general, in addition to its use in various professional fields, plenty of information is available via the internet, where many websites are operated by smart home providers or manufacturers. According to the European smart homes market (2015), the smart housing products can be profiled from the following perspectives:

1) The product segment comprised of security and access controls, lighting controls, HVAC modules, energy management modules, entertainment modules, home health modules, smart appliances as well as ballast and battery packs.
2) The services segment consists of installation and maintenance (setting up systems for a smart home and maintaining it in order to make the system reliable and secure to operate) and renovation and customization (remodeling the housing with automated smart home systems according to the inhabitants' requirements).
3) The major drivers for the global smart housing market are energy and cost savings, the regulatory initiatives by the European Union (EU), the increasing ageing population; and improved comfort and convenience requirements.
4) Some of the key players in this market include Siemens AG (Germany), Schneider Electric S.A. (France), ABB Ltd. (Switzerland), Ingersoll-Rand Plc. (Ireland), Tyco

International Ltd. (Switzerland), Legrand S.A. (France), Hager Holdings GmbH (Germany), Albrecht Jung GmbH & CO. KG (Germany), Control4 (US), Tyco International Ltd. (Switzerland), and Nice SPA (Italy), and even more.

5) The total European market is expected to reach $13.81 billion by 2020 at a double-digit number from 2013 to 2020 (European Smart Homes Market 2015).
6) The opportunities and challenges in the market are both crucial to business when trying to innovate the products via maintaining high performance and reliability (ibid., 7).

Marketing information is abundant in the field of smart housing, whilst the technical know-how seems to have a different presence. It could be the result of the fact that smart houses are built with all ready-made home hardware, such as single components and infrastructures. However, there is a greater need to integrate all parts into one housing and to know how to do it. Existing research concentrates on discussing the smart home architecture, data processing platforms, computing technologies, single devices/components or sometimes modules of single functions, such as, for example, lighting, security and access and home appliances. However, there seems to be a lack of integrated solutions for entire smart housing.

In addition to all above, the smart home concept has led to the introduction of “learning labs” by certain educational institutions. A recent example could be the smart home lab at the School of Health and Social Studies of JAMK University of Applied Sciences (JAMK). Since its construction was completed in 2012, the lab has been the only one in Central Finland. It has drawn many attentions nationally and internationally, not only from other institutions as a skill training lab for students in

the health care field, but also from social organizations and commercial companies due to its wide range of applications to the everyday living environment. There has been a great deal of internal discussion at JAMK about how to deal with the lab since it is now 6 years old (and technically not advanced any more) and has become too expensive to maintain. The actual argument behind this smart home lab is not about whether it should remain as a lab and still occupy the required space. Instead, the question is how JAMK could make it sustainable through much more channels of using it, for example, by selling the smart home concept and/or expertise to integrate the entire home solution towards the market.

Based on the current status analysis, the author found it fascinating that the smart home topic had rich dimensions for deepening one's learning, and for exploring for the applications of the concept in a larger scale. It attracted the author to take smart home as the study object, and to investigate possible paths of developing it in terms of real products. Ideally, the research process was also expected to train the author in constructing a theoretical base for a potential business practice, so that smart home could be also experimentally developed from a concept to possible entrepreneurial idea in the future.

1.3 Research questions and research approach

Reflecting to previous sections 1.1 and 1.2, the smart home has a good potential to be more "smarter" in line with the global megatrends, and simultaneously there are lacks of investigation for what could be wider industrial utilization and how to

transitioning the knowledge into shared benefits towards larger scaled customers - that is about making the concept to product(s).

Therefore, the research question is proposed as the flowing:

Main question - How can smart home concept be productized?

- **sub-question 1. What are the challenges in productizing the smart home?**
- **sub-question 2. How can these challenges be overcome?**

The main question covers those thinking of why smart home is named as a concept, what is the concept and why/how to productize. The sub-question 1 will discover possible factors that impact smart home being productized along with a process of productization, whilst sub-question 2 will study possible solutions towards those found factors based on current status analysis.

Qualitative Research will be applied as the approach for this research. It is mostly due to the subjective angle as Davies (2007) pointed out: describes a problem or condition from the point of view of those experiencing it, no statistical tests, more in-depth information on a few cases supported by interviews with semi-structured questions. Also time expenditure lighter on the planning end and heavier during the analysis phase (Silverman 2000) is a considerable factor to choose qualitative method.

The research approach will include interviews to experts, stakeholders and potential customer/provider in relevant fields as the primary sources; the secondary sources

through empirical studies. More details can be referred to later chapter of Methodology.

1.4 Structure of the thesis

This study will follow a structure in logic order as shown below:

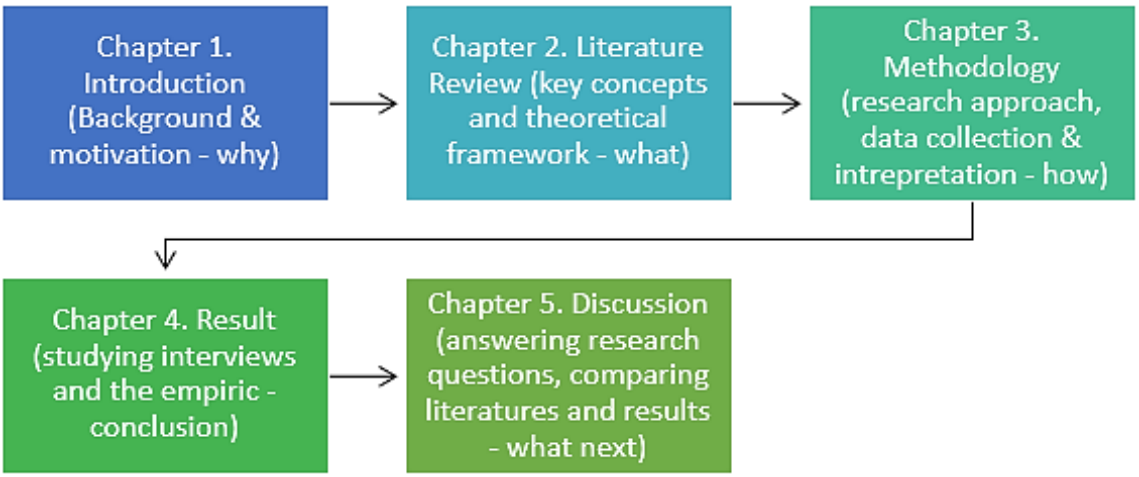

Figure 1. Structure of the thesis

Hereby, by doing all exercise in current chapter “Why this research” has been interpreted. Right after this, “What” is the next discussion.

2 Literature review

This chapter will start with key concepts of smart home, then elaborates relative literatures laid to productization and the processes, at the end describes a theoretical framework, which could be interpreted to an application of productizing the smart home.

2.1 Smart home concept

2.1.1 What is “smart home”

The definition of smart home varies to the context of where it is used. There are mainly two different ways of expression by either narrow sense or generalized sense.

In narrow sense, a smart home is more sketched as home automation or assistive domotic. It refers the use of computer and information technology to control devices and features in a home-like environment such as lighting, entertainment systems, temperature, and so on. Smart homes use the electronic networking technology to integrate various devices and appliances found in almost all homes so that an entire home can be controlled centrally or remotely as a single machine. Inside each of these machines, integrating all devices and appliances allows them to communicate with one and each other through a home controller, thereby simultaneously enabling control of various machines in preprogrammed scenarios or operating modes.

In generalized sense, smart home can be any of one “cell” that deployed with human-machine and/or machine-machine interfaced devices, with capability of monitoring and controlling automatically or remotely, as well as communication capability to other similar “cells” or the system for monitoring and controlling. An example can be the usage of sensing system for climate monitoring: deploying different sensors/detectors for temperature, moisture, soil, air, water etc., and sending the sensed data periodically to the server. Advances in wireless communications enabled multiple sensor devices to send and receive data over long distance, which promotes continuous climate monitoring as well as environment management furthermore realized in anywhere at any time necessary.

In summary of both narrow and generalized senses, the smart home could employ a general definition: **a cell with independent devices functioning into an integrated system under centralized control remotely or automatically, and able to communicate with other similar cells or command systems via shared protocols**. In this definition, a smart home is rather called as a “smart home cell” in this study to avoid the narrow understanding of a home-like only.

2.1.2 Essential elements of a smart home cell

From the discussion of smart home definition, as well as Larsen K. (2010) elaborated in his paper of “Smart home technology”, it shows clearly that one smart home cell consists of following three elements:

Firstly, **single functioning devices** which are independently operating to control each of their own functions, for example temperature, moisture, security, lighting, shielding, energy, entertainment, air quality, soil quality, water quality… and so on. They can be various sensors, detectors, meters, switches etc. able to be operated under remote or automatic control.

Secondly, **centralized control unit** of the cell, like control panels or smart mobile devices (phones, tablets or others with relative control application) which can control all single functioning devices deployed in one cell, thus an "inner" communication unit. The control is conducted via remote (Bluetooth, infrared or other RF approaches), mostly the wireless network (Wi-Fi) as the first prioritized choice.

The third, **shared protocols** interacting among one cell and 'outsiders', e.g. other smart home cells or commanding systems (control centers, data processing centers etc.), through which one cell can exchange message/data with each other and the center compatibly, thus an "inter" communication way. By this setting, a smart home cell and other similar cells can compose a programmed controlled network and be utilized in anywhere at any time with any manners commanded by one center. In another word, the protocol setting becomes one mandatory element of a smart home cell being utilized widely and wisely, for instance operated in the context of Internet of Things (IoT). These protocols need to be agreed and programmed prior to the data exchange, unless one smart home cell is designed to be in isolate running.

Based on the above, it is the time to try drawing a system view which demonstrates the smart home cell, the outsiders and the inner and inter communications, see

Figure 2. In this view, single functioning devices of one cell are demonstrated by color boxes, among which centralized control unit is shown at the middle. The inner communication inside of the cell is presented by black arrows, whilst inter communications with other cells and the commanding center by blue dual-direction arrows.

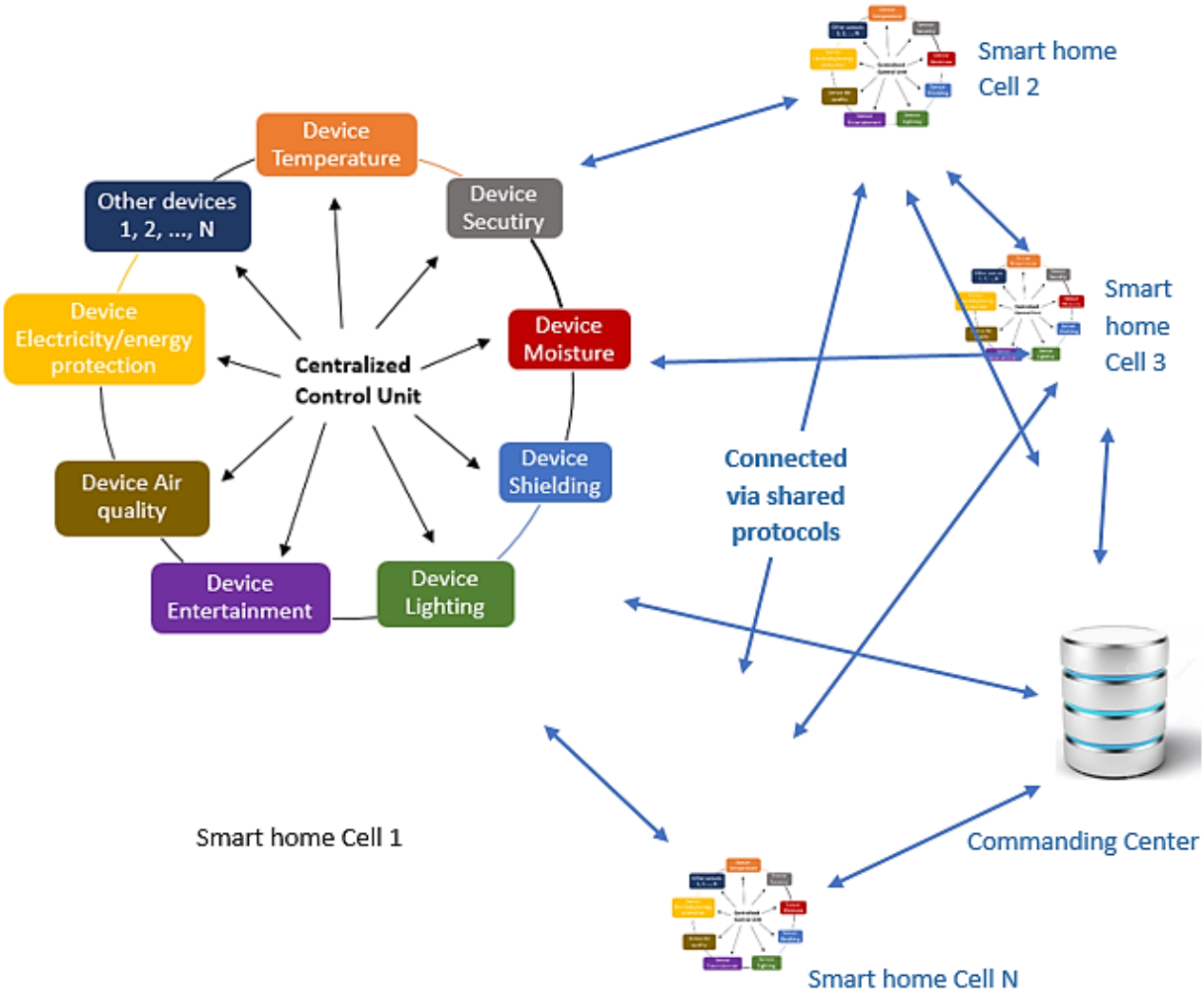

Figure 2. A system of smart home cells and commanding center

2.2 Key features of smart home

The definition and essential elements of smart home gives a view of what are key features from below four perspectives:

2.2.1 Accessibility

Accessible perspective: the smart home facility is easy to access and use due to all remotely or automatically controlled devices. Even if one ender user is not possible to control by him/herself to use centralized control unit of own cell, there is assistance control could be supported by other cells or most likely the commanding center.

Many cases of utilizing accessibility benefit can be found in those professional organizations who promote safety and functional ordinary for habitants through smart home technologies. Like a shared experience in UK (Gentry, Dewsbury & Linskell 2011), the case illustrated how the smart home designer evaluated the habitant needs and implemented infrastructures and facilities setup with a technological fit, so that the final outcome of the smart home was able to help people with neurological conditions.

This benefit of smart home is also often taken into the field of environment management, climate monitoring and in those habitat inappropriate areas, detecting devices for soil, air, water, pollution, radiation etc. are settled with centralized control units, and those units are furtherly operated under the commanding center through further centralized data processing and programming.

2.2.2 Inclusion

User-group perspective: no limitation to whom of using smart home. The age, gender, and motor ability of end users do not matter, as long as one can use the control unit of the cell, or someone else who can help to (remotely) control all devices of the cell, smart home can be employed.

A typical usage of this benefit is in health care and social service field: smart home cells are equipped for houses for elderly and disabled person who have difficulties to deal with normal activities in everyday life. In those houses, there are for instance wheelchair-compatible entrance and access, height-adjustable furniture, falling-down sensor, wearable detectors, automatic accident-alerting device, audio-controlled appliances, medicine reminding system… and remote communicator sending/receiving data to/from the central control department.

In addition to all the above, the smart home concept also helps doctors/healthcare professionals to remotely monitor person's symptoms, giving guidance for rehabilitation and make basic clinical judgment in emergent cases even those person are not at hospitals/clinics, just like Dawadia (2013) illustrated how automated monitoring and following-up of cognitive health done through smart home technologies in U.S. With assistance of smart home facilities, those person are able to live independently without compromising to the life quality.

2.2.3 Availability

Convenience perspective: always available and flexible when/where/how needed. From above two examples of environment monitoring and healthcare and social services, the advantage of convenience can be easily identified.

An example usage in this perspective is to apply smart home concept in property management area: when and how to heat/cool the building, lock/unlock the entrance, switching on/off the lighting, irrigating the garden/grass fields… all these can be operated separately within one building and monitored/further controlled by the commanding center.

More than any of those "traditional" usages, the smart home concept can be even used as a learning lab in education field to simulate healthcare, social, technological and virtual training and development environment, as Heimovaara-Kotonen E. (2014) compiled at JAMK University of Applied Sciences, Finland. When different learning situations needed, the smart home lab will be set towards corresponding situations, such as like skill training space for physiotherapy study, inpatient ward for nursing practices, disable service house for social working, and so on.

2.2.4 Sustainability

Resulted of those usages in environment monitoring (accessibility), automatic assistance to healthcare and social services (inclusion) and energy management (availability), the smart home has definitely advantages in **sustainable perspective**. According to Melvin K. Hendrix (2014), sustainability is the practice of reserving resources for future generation without any harm to the nature and other

components of it. Crosschecking this terminology with smart home definition, key elements and features, obvious commonalities can be found in between.

One interesting case of taking sustainability benefit is using smart home technologies into energy consumption control (Dütschke, Fichtner & Paetz 2011), in where consumers' perception of using smart home was studied. The study looked at consumer reactions to an energy management system which optimizes electricity consumption based on different smart home solutions. Consumers saw many advantages themselves, especially the chance to save money. Smart appliances and smart meters equipped at their homes were therefore considered to be necessary elements.

Especially when addressing it into a larger social scale, the smart home concept will be perfectly fitting into the smart city context. Under this context, as investigated in the "Smart cities study" (the Committee of Digital and Knowledge-based Cities of UCLG 2012), a city could be defined as smart when it positively performs in six areas (economy, mobility, environment, citizenship, quality of life and management), built based on a smart combination of elements (communication, infrastructure, economic development) and on purposeful and independent citizen activities (participation, education) which make sound management of natural resources. Smart home can be the basic functional component actively contributing to the smart city through its accessibility, e-inclusion, security, connectivity, promotion in education and training, transparency of management, sustainability development et cetera.

2.3 Productization

At this point, the smart home concept (definition, key elements and features) has been discussed thoroughly. To answer the question of how to turn the concept into a product, the key word “productization” must to be studied. Hereinafter the following paragraphs will elaborate the “productization” from three aspects: why, how and what.

2.3.1 Why - Customer needs driving for market-pull in product development

Firstly, in a broad view, this world has entered a period of new concepts created so rapidly that unlike any other eras since the industrial revolution, but successful new product transferred from R&D to production is a common and severe problem for organizations in whatever sizes (Brethauer 2002). There are many factors affecting on a new product developed successfully, among them the efficient development process, being faster and appropriate market propositioning, and knowing the customer and the market are essential ones. Just like Barrett (1996) addressed two decades ago that statistically 80 percent of newly introduced products failed to make a market presence after two years. Traditionally from business literature stance, market research takes a market-driven view, which is find out what the customer would like and then produce it – namely as “the market-pull approach” to innovation and productization (Trott 2005).

Secondly, in a particular view of smart home concept, finding out the most suitable process to develop products and defining “right” market and customers could be the fetal. Considering from its key features, a smart home not only makes daily routine

convenient and time saving but also provides energy efficiency and sustainable utilization of nature resources for the society, benefits of a smart home can be endless. Therefore, smart homes have already started attracting the stakeholders in the market including architects, developers, device manufacturers, service providers and infrastructure builders.

A particular example in Europe market is used to further elaborate this topic. According to European smart home market report (2014), the specific market of smart home in home automation area is expected to grow at a decent pace for many years. In this area, the smart home technology offers prospects of significant improvements in the living standards of elderly, infirm and disabled who without automated demotic activities currently so that may otherwise be totally reliant on home care. These benefits can only be realized if the technology becomes affordable and accessible to those who need it the most. Thus, deep understanding of this portion of customers and their exact needs as well as affordability would become the crucial driver of this market, product segmentation and then corresponding product development process.

2.3.2 How to productize - the process of New Product Development (NPD)

Over past 30 years, in management literatures there are enormous attentions and theories introduced and discussed concerning the concept of new product development (NPD). In Trott's (2005, 383) opinion, the actual development of new products is the process of transferring business opportunities into tangible products.

A commonly presented linear NPD process among large amount of theories could be described as this model:

> Idea generation => Idea screening => Concept testing => Business analysis => Product Development => Test marketing => Commercialization => Monitoring and evaluation (ibid., 398)

However, thinking of the “why” as discussed in earlier paragraph, customer needs as the core market-driven factor has to be prioritized when choosing an appropriate NPD process for smart home product developing, and that is essentially a market/customer-focused process.

According to Brethauer (2002, 35), a new product entering the market with a marked advantage over the competition will soon deteriorate with no-longer-product-advantage. To maximize product quality, productivity and profitability to protect against the deterioration, a “Robust Design and Product” process was elaborated through introducing progressive tools from two aspects: focusing on product design and focusing on product transfer. In the following, the authorwould interpret these two toolboxes by a compressed summary:

• Toolbox A. When focusing on robust product design

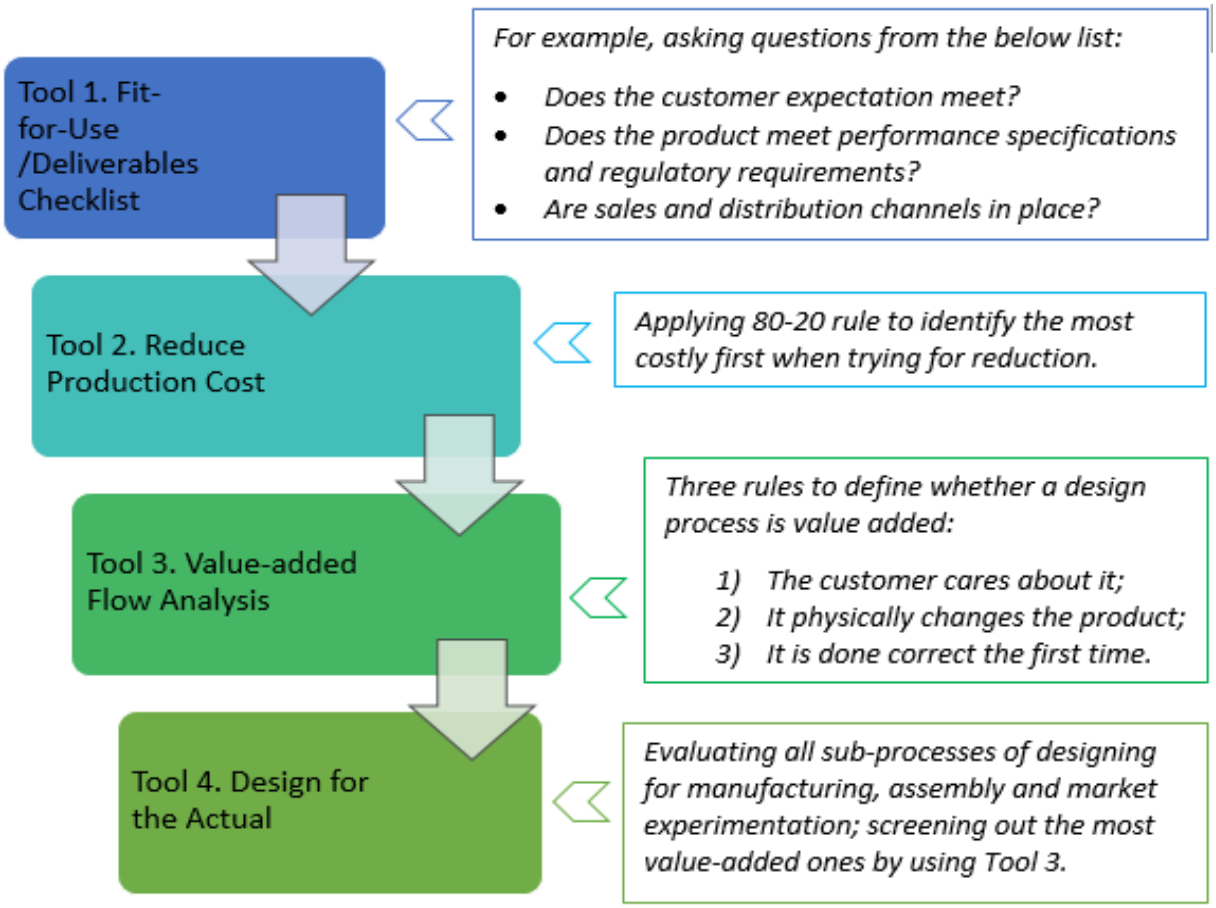

Figure 3. Tools of Robust Product Design for NPD. Source: Brethauer (2002, 35-45)

By following of above tools step-by-step, a “complete” product can be outlined and ready for next steps to go through the transfer process.

• Toolbox B. When focusing on robust transfer process

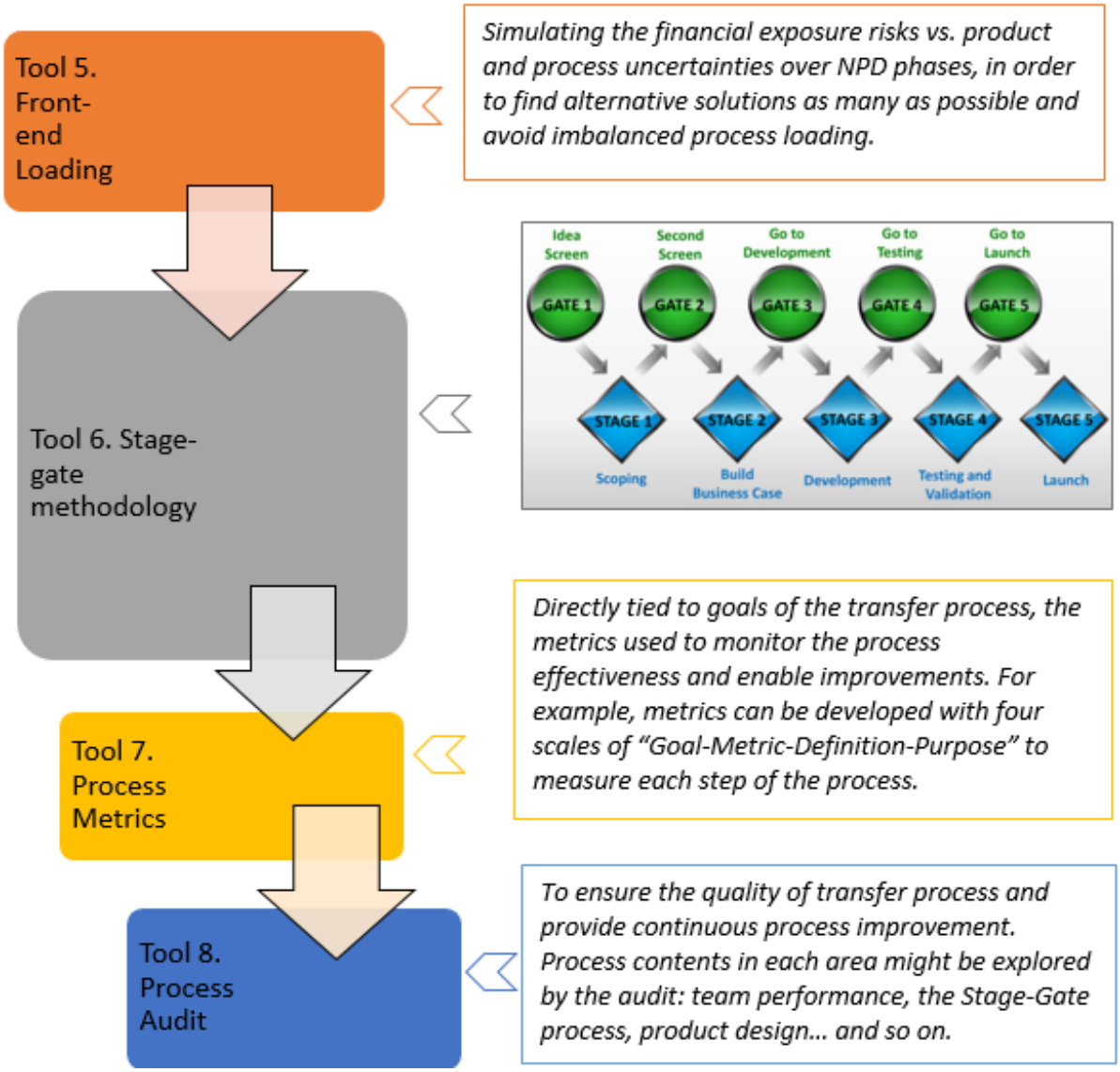

Figure 4. Tools of Robust Transfer Process for NPD. Source: ibid., 45-60.

Once above tools are followed progressively, a whole process from the design to product transfer is theoretically recognized robust.

All introduced tools in the above were referred from one of enormous NPD process guidance, none of them shall be a bible for any NPD in real life, neither for the smart home productization. However, this elaboration may indicate that by using a

successful new product development process, these benefits could be expected (ibid., 3-4):

- A competitive advantage;
- The ability to respond to customer needs;
- An increase probability of profitability and total quality;
- Decreased cycle time to introduce a new product to market;
- A continuously improving product development team.

2.3.3 What to be considered during productizing - managing of product portfolio

After discussions on the reason and process/tools of productization, next step naturally goes to “what is more must be considered for productizing smart home”?

- Considering from product structure aspect, how to define different levels of product items - components, hardware versions, software releases, product family, configuration, assembly and packing?
- Considering from whole life cycle aspect, how to define the product roadmap, to manage variants, to design maintenance and warranty term?

To cover all necessary elements of the productization, meaning centralized management of the processes, methods, technologies, resources, financial, risks, and even changes, the product portfolio management (PPM) hereby must be included.

Standing on pursuing a profitable product solution’s viewpoint, Tolonen, Harkonen and Haapasalo (2014) specified that the product portfolio management can be treated as a platform resulting in strategic product and release road maps, in order

to enable successful and constant incremental and architectural solutions. PPM aims at cost effective renewal of product portfolios by adding new products to the portfolio, enhancing and modifying the existing products meanwhile removing non-competitive ones (ibid., 174).

A visualized model (see Figure 5.) outlines clearly the framework of proposed PPM governance: the entire PPM is constructed by vertical and horizontal sub product portfolios, through which vertical portfolio presents the product structure levels in commercial and technical portions, whilst the horizontal presents four phases of product life cycle. Product portfolio renewal requires strategic PPM over vertical and horizontal sub product portfolios. Ideally, the horizontal and vertical portfolio renewal would occur in balance and synchrony with new product introductions, as well as old product ramp downs.

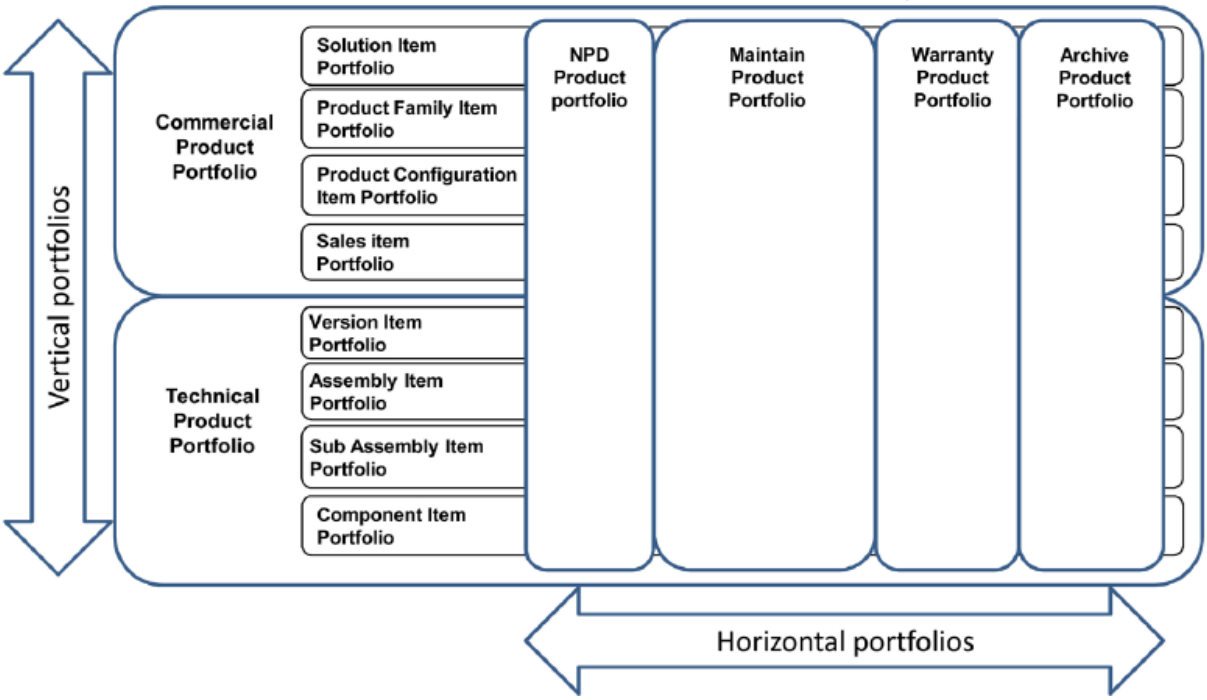

Figure 5. The ideal framework for Product Portfolio Management (Tolonen et al. 2014, 180.)

The framework draws a thorough matrix of what need to be considered during an entire product life cycle, even though none of listed sub product portfolios will be discussed in this study. For the topic of developing smart home product, know-what of the PPM framework would be valuable enough to catch the ideology essentially.

2.4 Theoretical framework

In summary of previous paragraphs, detailed NPD process with progressive tools and matrix-structured PPM framework have been revealed. Although they are filtered out from vast literatures as the most likely appropriate one to guide the productizing smart home concept, still both of NPD process and PPM framework are rather complicated to follow. Thus a clear and simplified version of them is necessary.

2.4.1 Why product development funnel

A tool developed by Harvard Business School professors Wheelwright and Clark in early 1990s has been recognized as the renowned and popular model to improve NPD process, namely the “development funnel”. In many literature documents, the development funnel is seen as a variation of the Stage-Gate process but strongly emphasizing on the need of generating product related ideas, and later on narrowing those ideas down quickly when the product development process proceeding alone (Von Stamm 2008, 58-61).

According to Katz (first released via blog of “Innovation Excellence” in 2011), the development funnel icon has been in use for several decades as a visual depiction of

the NPD process. It works well due to its true implication of NPD being a refinement process, which takes us from the earliest stage – with numerous of fuzzy ideas and fuzzy thinking – to the final stage of new product launch.

Looking back to our topic in this study, applying the idea of productizing the smart home into the funnel model turns to be an appropriate thinking.

2.4.2 The proposed development funnel to be embraced

At the stance of Von Stamm (2008), the development funnel encourages one to adopt an integrated approach to NPD, instead of making decisions on individual new product itself – that is an advance to take the organization wide perspective. Here the organization could be a company that operates the NPD processes, or an entrepreneur team that expects to transfer R&D knowledge into new products. In this viewpoint, a new interpretation of key factors of the development funnel would be drawn in the Figure 6:

- **Capability assessment and forecasting** – the current and future product capacity and their developments as analyzed by the organization, investigation of efficiency in current processes and technologies.
- **Market assessment and forecasting** – the analysis of existing customers to identify needs and areas of improvement, analysis of competitors, as well as a trend analysis to capture the direction of the industry.
- **NPD goals and objectives** – developing a set of specific measures and targets for key product portfolio criteria, including strategic fit, revenue and profits,

customer fit, new product performance criteria, new product introduction objectives, target setting for entering new market segment etc.

- **Product portfolio management** – a set of criteria regulating which product (features, structures) to be selected and resources to be allocated correspondingly. This part has extremely strong link to the organization's overall strategy.
- **NPD process management and execution** – the definition of appropriate stages and gates that a target new product must pass through. The Stage-Gate process is rather a tool during the NPD process management and execution stage.
- **Post-NPD learning and improvement** – in theory a happy ending of the whole funnel to close the "loop", so that funnel output could be reviewed by crosschecking with organizational strategies. Lessons learnt and improvement actions to be generated during this stage to ensure the quality.

The new drawing of development funnel covers NPD process, PPM consideration, marketing factor and overall organizational strategies. Its new outlook is not same as the original by Wheelwright and Clark (earliest use in 1992), but it is much more informative, referable and practical when an organization needs to start thinking of developing a new product – just like now this study trying to productizing the smart home concept. By these reasons, this development funnel would be proposed as the suitable model to guide the smart home productization, as well as being the theoretical framework for the study.

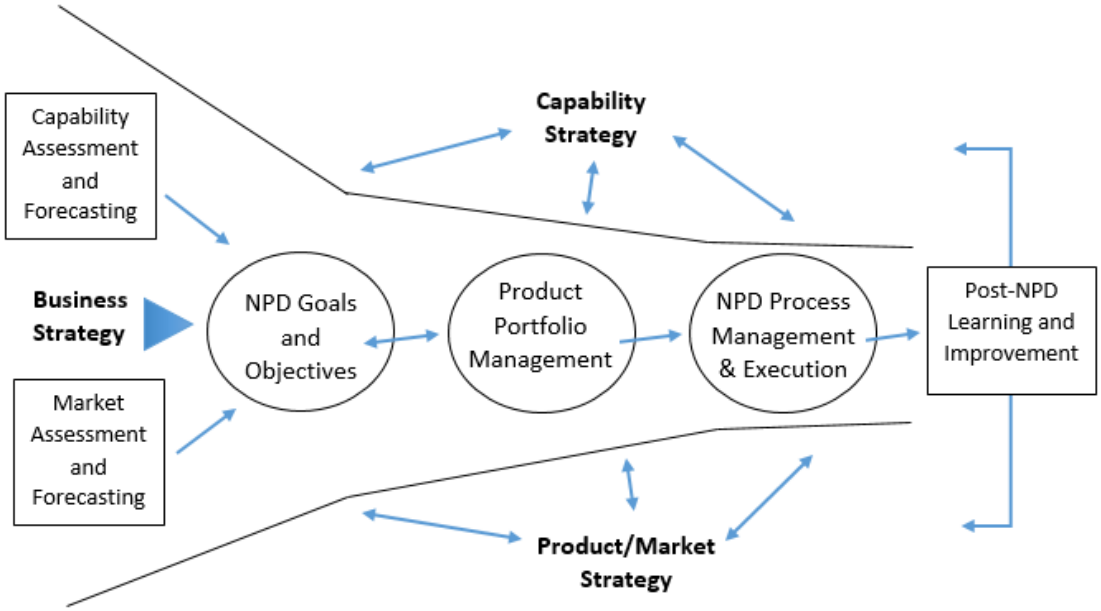

Figure 6. the proposed Development Funnel. Source: Von Stamm (2008, 58).

To furthermore illustrate this funnel, in additional to those six key components, there is a simplified way of interpretation: a firm business strategy is the key throughout an entire process of new product development, alongside the capacity strategy and product/market strategy keep continuously functioning to shape the implementation of business strategy at each process stage. Tuning of capacity and product/market strategies are necessary to do through Post-NPD improvement actions, by which the shaping function to the business strategy is expectedly more effective.

All the above mentioned illustrations of chosen theoretic framework provide a map for later works of this study, which is a mapping of collected data.

3 Methodology

As addressed in Chapter 1, the research question of this study is to find solution for productizing the smart home concept, which includes two parts of the answer: what are the challenges in productizing the smart home, and how can these challenges be overcome? In this chapter, the procedure and tools chosen for carrying on the empirical study are described.

Briefly, this study employed a qualitative research approach supported by inductive approach for data analysis. Interviews were used to collect primary sourced data led by semi-structured questions, and the interviewees were selected from those belonging to either the concept designer of smart home solution or the entrepreneur of commercializing smart home based products. The narrative data from interviews were transcribed and grouped into different categories according to the theoretic framework presented in the end of Chapter 2.

3.1 Research strategy

Choosing qualitative research method for this study was triggered by the characteristic of the research objective: seeking answer for productizing smart home concept. In Myers's (2013) opinion, a qualitative researcher may typically ask questions like what and how. In this study, the author asked from a viewpoint of own experiences when little is known, and related to understanding some aspect of social business life in order to generate the answer, which expected as texts or words rather than numbers, as data for analysis - this characterizes a qualitative research method (Patton et al. 2002). By using qualitative method, the author had an easier

start to explore the phenomena around smart home, then gradually dived deeper into and approached some understandings to the objective.

According to Mack et al. (2005), qualitative method is typically more flexible – it allows greater interaction between researchers and study participants. In this particular study, the method enables to adopt semi-structured interviews composed by open-ended questions, for gathering individual answers of participants' experiences in smart home design and productizing trials, through which the challenges and overcome idea were able to be revealed.

Corresponding to the qualitative method with a purpose of finding "what" and "how", the study employed an inductive approach when analyzing individual data collected from interviews. This manner matches with the inductive reasoning as pointed by Myers (2013). All data was classified into six categories according to the pattern defined by chosen theoretic framework – the proposed Development Funnel. After mapping those categorized data into the Funnel, rough answers to the research question started outlining.

The qualitative research method does not require many resources of participants and much time, a small scale of participation may fulfill the need to carry out the study (Ben-Eliyahu 2014). However, in another hand, the method also has typical criticisms such as too small data samples to necessarily represent the broader participation; the findings lack rigor and naturally might be biased by the

researcher's own opinions in some extent (Patton et al. 2002). This study was not an exceptional to avoid those commonly seen shortages, but by following related literatures while making progresses with the awareness was still a meaningful research practice.

3.2 Data collection

Interview was chosen for data collection by this study, and obtaining narratives during the interviews was planned. As Bui (2014) addressed, narrative interviews are in-depth with specific features, and the influence of the interviewer in narrative should be minimal. Through this manner, rich information was able to be gathered from comparatively small scale of interviews.

The author selected two interviewees to reach the narrative purpose:

Mr. Toni Pekkola, Finnish citizen, working eight years as Project Engineer and Project Manager in R&D Department, School of Health and Social Studies, JAMK University of Applied Sciences. He has experience in design smart home lab for his organization to be used as multi-functioning training lab for JAMK students, and involves in many R&D projects such as digitalization in education, assistive technology, smart community et cetera. In those areas, Mr. Pekkola also acts as keynote speaker or panel discussion host at international forums or seminars of for instance digitalization and smart city several times during recent 3 years.

Mr. Jun Wang, a Chinese entrepreneur living in Beijing, China. He has professional background in engineering and business management fields, and been operating different kinds of companies in recent ten years covering trading, internet technology, finance, and consultation services. Lately Mr. Wang has invested in co-funding a new company focusing on smart home conceptualization and smart products used for households in Beijing area, his cofounders were representatives from engineering university, telecommunication operator and marketing experts.

Both interviewees were chosen mainly because of individual life experiences in either design or commercializing smart home concept. In addition to this, the author knows separately each of them well in working life or privately already long time, which was an important fact helped the interviews committed and implemented based on personal trusts.

A structured way to perform the process of obtaining narrative interviews is introduced by Muylaert et al (2014):

Table 1. Main phases of the narrative interview. (Source: ibid., 3)

Phases	**Rules for the interview**
Preparation	Exploring the field; formulating exmanent questions.
Initiation	Formulation of the initial topic for narration. Use visual aids.
Main narration	No interruptions. Only non-verbal or paralinguistic encouragement to continue telling the story. Wait for signals the end of “coda”.
Questioning	Only question: What happened then? No opinion or attitude questions, no arguing on contradictions, no ask of Why. Go from exmanent into immanent questions.
Small talk	Stop recording. Only question allowed is Why? Make note immediately after the interview.

By following this structured process as much as possible, two of interviews were conducted for the study:

- Interviewer: the researcher-self of this study
- Preparation from end of May to middle of July 2017:
  - Making two documents, one in Chinese and anther in English to present the research objective, the research question, theoretic framework and proposed interview questions;
  - Sending these two documents separately to interviewees via email, and asking their intention of participation to interviews;
  - Communicating of proposed interview questions and the manner of conducting interviews: where, when and how;
  - Agreements between interviewer and each interviewee separately upon the principles of how to use interview data.
- The first interview was on afternoon 25th July 2017, 15:00 – 16:30, at one hotel room in Chaoyang District, Beijing, China, towards interviewee Jun Wang. Language used was Chinese for both verbal and noting.
- The second done on afternoon 9th August 2017, 13:00 – 14:00, at one meeting room of Dynamo Building, JAMK University of Applied Sciences, towards interviewee Toni Pekkola. Language used was English for verbal, and English/Chinese for noting.
- As agreed with each of interviewees separately, the way of recording interview narration was as the following: the interviewer made notes by pen and paper while talking and recording during interview occasions; interviewees wrote own

answers of each question afterwards in Word-format files and sent to the interviewer. Two files were received: on 3rd August from Wang in Chinese and 19th August 2017 from Pekkola in English. Audio records kept by the interviewer only to be used for further crosschecking according to written answers from interviewees.

Interview questions were constructed according to the pattern of theoretic framework: in total 12 open-ended questions were formulated around those six components of the Development Funnel. Among them, there was few questions made slightly different towards Chinese and Finnish interviewees, when considering their different experiences and country contexts. Details of all questions are referred to Appendix 1.

3.3 Data analysis

In this study, the data to be analyzed was narrative – words, phrases, sentences collected from interviews, which consist of interviewees' perception of smart home concept, strategies of smart home business and product/market, and their implementation processes of design or commercializing smart home concept as well.

Narrative analysis was used to deal with interview data. In Myers' point of view (2013), this analysis would be a useful tool for small amount of interviews with in-depth approach to study interviewees' personal experience. In general, the analysis process can be illustrated as examining raw data -> reducing them to themes through

coding and recoding processes -> representing the data in figures, tables and narratives in a final research text (Understanding Narrative Inquiry, 2016, 188). This study roughly followed the process.

Suggested by Muylaert et al (2014), analyzing the narrative interviews recommends to gradually reduce text, and to deal with condensation of meaning and generality. In this study, the author performed three steps starting from a data screening: crosschecking between the audio records of interviews and the written answers from interviewees, to achieve narrowed range of data for next step; transcribed screened data into written format and used this new written one for analysis. In this step, the part of original data collected in Chinese was translated into English. The second step was using those wordings from the theoretic framework as key codes to filter all texts in the transcribed file, so that further reduced amount of texts sorted out by the close relevancy to the research objective. The third step was grouping: classifying those relevant texts into six categories that patterned the Development Funnel:

1) Capability assessment and forecasting
2) Market assessment and forecasting
3) Goals and objectives setting for NPD
4) Product portfolio management
5) NPD process management and execution
6) Post-NPD learning and improvement

These categories were also perceived as classification variables, or alternatively the qualitative variable or the categorical variable (O'Rourke 2008, 5) that were studied by this qualitative research.

As a brief wrapping up of the abovementioned data analysis process, below visual illustration is presented by the researcher:

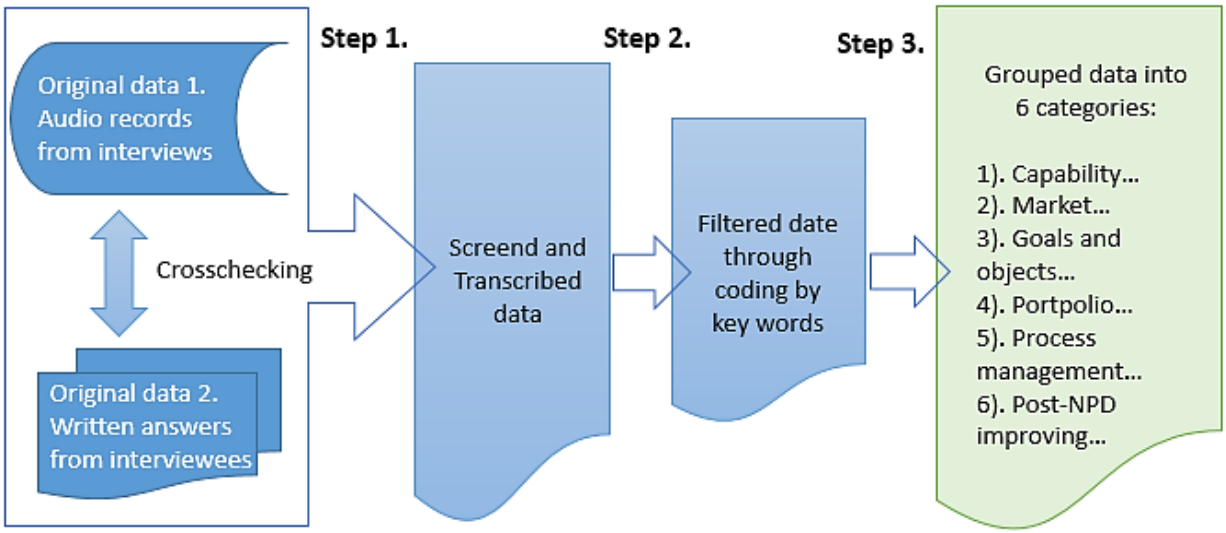

Figure 7. Data analysis process employed in the study

3.4 Verification of the findings

In qualitative researches, methods used are more subjective than in quantitative research and there are no statistical analysis and numerical calculation included (Brink 1993, 1). From this perspective, Golafshani (2003, 7) further stated that the validity and reliability are conceptualized as trustworthiness, rigor and quality in qualitative researches.

Validity in research is concerned with the accuracy and truthfulness of findings (Le Comple & Goetz 1982). Morse et al. (2002, 2) indicated that the criteria in a qualitative research to ensure "trustworthiness" are credibility and fittingness (Guba & Lincoln 1981), which are corresponding to internal validity and external validity

that often applied for quantitative studies. In this study, these two parameters can be interpreted as the following:

• **Credibility** is to make the results generalized by the study shall be self-explanatory and able to answer the research question: how to productizing the smart home concept. Around the terms of smart home and productization, literature investigation was done prior to empirical examining and a new product development related funnel module was chosen as theoretical framework. In later phase of primary data collection, an interview procedure was designed through careful interviewee selection, and interview questions were structured based on the pattern of theoretical framework. The framework was also used as the target module when mapping out sorted interview data, so that results produced after data analysis were expected to examine the development funnel.

• **Fittingness** implies that the study's findings can be generalized in other contexts. This was attempted mainly due to choosing of the theoretical framework in more generic extent - when perceiving the smart home as a new product, its productization could be served as a process of new product development, and then the way of finding solutions for this process could be generalizable. So to say, to those extents of new business development situation, such as productizing new products, services and technologies, the findings from the study might be an example for referring.

According to Golafshani (2003), the reliability is concerned with the consistency, stability and repeatability as well as the researcher's ability to collect and record data

accurately (ibid., 7-8). It means the extent of a study to consistently generate same results by repeated examining rounds. In term of this study, the reliability's dimensions are evaluated by auditability and confirmability in line with the terminology from Morse et al. (2002, 3):

• **Auditability or dependability** is asking whether the findings be reproduced by another researcher. It depends on reliable data sources and appropriate data collection techniques used in this study. In previous sections of this chapter, the author has explained the consideration and process of in-depth interview with open-ended questions done.

• **Confirmability** or objectivity means the possibility to support other researchers achieving same findings from the same data. Corresponding to the chosen data collection method in this study, the author used narrative inquiry to analyze the data. Prior to the analysis began, interviewees' intervention - by providing own answers in written format rather than only the author transcribing from audio records - was invited as a joint participation to the processing, so that interpreting data objectivity could be attempted.

The above was claimed from the researcher's individual aspect, which can be impacted by the individual own perception. Concerning the researcher's ability and skill in any qualitative research, Patton (2001) held on an opinion that the reliability is a consequence of the validity in a study. Sustained by this standpoint, firstly concentrating on building the validity in this study perhaps to be the essential.

To improve the validity and reliability of qualitative researches or evaluation of findings, Golafshani (2003) suggested to consider the triangulation as a typical strategy. Patton (2001) explicated the use of triangulation is to strengthen a study by combining methods, that refers to using several kinds of methods or data in qualitative research methods. In this study, the approach of triangulation can be interpreted as a data triangulation - utilizing various sources of the data. The following was the researcher's argument of the variety:

Firstly, the primary data was collected from the interviews, in where different original data samples were generated: one by researcher's transcribing of recorded audio and another provided straight from interviewees' own written answers;

Secondly, selection of the interviewees was a consideration of avoiding homogeneous in primary data source, through which different kinds of data obtained from distinguished experience of business life in distinguished markets.

It was one try to achieve comparatively valid and reliable results, when no triangulation in research methods engaged in this study.

4 Research results

As Chapter 3 introduced, narrative data was collected through two in-depth interviews and inductive reasoning was used for trying reveal of answers to the research questions. In this chapter, results of the empirical study are described.

The first interviewee, Mr. WANG, held on a stand of an entrepreneur from China market aspect and shared his story from year 2014 to 2016 as being one of co-founders to conceptualize and construct a startup aimed at smart home products. Other co-founders of that startup were one telecommunication company and one university of industrial engineering in Beijing. He did not succeed in running the startup after 2016, whilst he has been a CEO of one technology company having experiences of managing nine sales projects in ICT field since 2004. Although currently not investing in smart home related business, Mr. WANG did not conceal his interests to review those moments when he and his co-founders were analyzing the marketing and planning for their products. He spent more than half of interview time to talk about the “failure” of the startup, that made the interviewer had clues to catch his answer to challenges of smart home productization.

The second interviewee presented another aspect of the smart home. Mr. Pekkola started his story by arguing how could be defined as “smart” and what shall be a “smart home” from technic point of view. Then he briefed those years around 2011-2013 when designing and involving in building a lab for his employer, JAMK University of Applied Sciences, based on smart home concept. Major builders of the

smart home lab were companies providing hardware of smart home related products, such as special designed furniture, sensors, switches, cameras, and measurement equipment. After that, he told about his lessons learnt from participated international forums and seminars concerning the development of smart home concept and products. In his opinion, though the smart home lab was not a real product sold to a consumer, Mr. Pekkola believed the way of building and using the lab reflected to the marketing value: the lab gave a real-scenery to the market that how actual smart homes should work.

In next, detailed results will be presented in a pattern of the theoretical framework – by six categories of the Development Funnel.

4.1 Capability assessment and forecasting

Current status and problems

From Wang's point of view, most of smart home products in China market are homogeneous in mainly three function types: wearable health products; remote control of household hardware; and single-function robots like floor-sweeping robot. They mainly focused on integration of sensors and switches. These types of products were made of existing features through imitation, without cutting-edge technologies, and less innovation. There were no unified product standard and no open interface protocols in the industry, and manufacturers competed heavily to each other – this caused the fragmentation of products and weakened the compatibility and applicability of products.

In comparison to China, Finnish smart home has an “integrated” profile, one smart home includes embedded products and functions so that it performs as one full scenery in indoor environment. From Pekkola’s aspect, the critical challenge was concerning the terminology of “smart”, he sees that different person has different interpretation in different period alongside with the technology development. A smart home built in last year might not be smart in next year anymore. This challenge was so fundamental, that it caused problems in design and constructing of smart home. Because of the dynamic of being smart, the assessment and forecasting of smart home capability has been difficult.

Solutions

Both Wang and Pekkola turned to believe that finding the “right” product positioning was the key. An example proposed towards China market was to concentrate on the fit product, i.e. avoiding choosing single functioning products, but focusing on the capability of integrating single functioning products into a dynamic system. The fit product was proposed having a combination of: (1) knowledge of utilizing key smart home hardware, (2) a set of solutions for a full scenery environment with all function integrated hardware, and (3) a selection of data services based on cloud computing. The smart home capacity would be seen as integrated solutions and data services oriented.

Moreover, since the “smart” is a dynamic term, the real value of smart home product would stay in the design and integration – being capable to become “smarter” then shall be the essence of building smart home capacity. Keeping awareness of new

technology development and upgrading the technique to using the up-to-date facilities is an important basis of the essence.

4.2 Market assessment and forecasting

Current status and problems

Although having a vast market behind, Wang regretted that Chinese smart home industry has not growing into a scale that has probability to match with the market potential. One reason was too many similar products in the market without "intelligent" characteristics. For example, most of products were built on mobile applications' basis and rely too much on human's pre-setting and operating, it is difficult to find actual smart homes being able to handle simple daily-life tasks at home or in hospitals as a human being, which was actually one typical scheme of employing smart home solutions expected by the market. This presented a serious problem of unsuitable market assessment and forecasting prior to the production.

Pekkola shared his viewpoint that the Finnish smart homes have been facing the same difficulties as the worldwide companions. Similar to China market, the biggest problem in market forecasting was the gap between product features and market expectation. In another word, it was the difficulty caused by defining customer. The customers of smart home are changing all the time in recent years, they (individuals, families, organizations, or business companies) all declared that some kinds of smart home products needed.

Solutions

Wang stated that to find out the demand or expectation of market to products, one special suggestion to China market was investigating the national strategy and regional government policies of, for instance, promoting smart home or artificial intelligent products. In China there is a wording of “guiding market needs”, Wang said, that illustrates a reality of marketing tactic: starting from a deep analysis of the strategy and policy, seizing the indicated direction by government, then defining marketing around the direction. He believed building a stable relationship with local government should be helpful to approach a right marketing outreach.

The recommendation of Pekkola was to prioritize finding right customer as the first issue before other steps of productization – the customer makes decision to smart home. Then marketing assessment and forecasting shall be done around that customer segmentation. He expressed an example to support that idea: comparing with last decade, most of us are living in smarter homes than ever. The technology development is so fast and involved deeply in daily life, it leads to the reality that “living in new buildings constructed with smart home technology has become self-evident”, according to Pekkola. This might give one approach from knowing the customer to understanding the marketing.

4.3 Goals and objectives setting for NPD

Current status and problems

In his story of the smart home startup, also combined with his observation from some of his competitors in that entrepreneurial period, Wang rarely saw the overall

planning properly done for new product development. Most of companies in that field concentrated to compete in producing hardware in order to make more visible outcome of R&D works, thus large amounts of investment spent quickly in early entrepreneurial stage. In Wang's word, it was an expenditure "of endless single product R&D". Often the R&D investment and amount of new hardware created from R&D phase were seen as key indicators of NDP, which caused a problem of neglected goals and objective settings.

Pekkola talked this from an aspect of Finnish expertise in innovation and technology development. Started being well known of mobile technology and technology development from 1990's, Finnish strength in manufacturing has moved to other countries during last decades. Nowadays wellness technology is a rising area of Finnish expertise, but developing new technologies towards everyday-life products is comparatively slow. Particularly in terms of smart home, "there are still only few companies, when speaking about situation in Finland and Europe, which are concentrating on smart home technology". That indicated a problem of how NPD goals and objectives were formulated responding to technology evolvement. He concerned that the R&D institutions and NPD teams were in danger of being left behind if lack of rapid and constant development and upgrade of technologies.

Solutions

Wang and Pekkola had distinct thinking to solve the NPD goal-setting problem. Wang believed in two approaches: one was "direct" path - focusing on defining main market segment and the competitors, let the need shape the NPD goals. Another

was a “roundabout” way - to employ a set of standards to smart home industry through introducing relevant practices from outside (for example imported from advanced countries), then using the standardized process to guide goal-setting and NPD process in China. As stated in 4.1, lack of standard was one big challenge in smart home industry. Wang supposed that who firstly adopting ready standards and promoting for a widely domestic use of standards could be the one occupying an upstream of the industry.

Pekkola commented more on a view of designer’s stand: the ultimate goal of smart home development is to be a smarter home instead of being smart. The smart home needs under constant development; from technology development perspective, it is never smart enough. To reach this kind of development, there should always be different kinds of technology providers who work in co-operation with the settings for smart home goal and objective.

4.4 Product portfolio management

Current status and perceived challenges

Wang and Pekkola both found out the effect of product portfolio management was one of consequents resulted from the capability assessment/forecasting and goal/objective settings for NPD. Impacted by the current situation as presented in 4.1 and 4.3, the portfolio management of smart home products had a challenge to be in high quality. In WANG’s case of his co-founded startup, failed in managing the portfolio for new smart home products was the fatal. In addition, the technology development exists rapidly every day. Pursuing technology upgrade for maintaining

product portfolio has been very costly and endless. How to reach a balance of R&D investment and return was always challenging to manage the product portfolio.

Solutions

For smart home concept and its products, planning the portfolio has to base on a clear positioning of product core – whether strong in new technology upgrading or user experience optimizing. Wang gave one example from entrepreneur's viewpoint: if a company sketched a scheme of portfolio factors for new smart home product development as shown below (Figure 8), then the company's portfolio management should have priorities and processes defined to develop either those components in left side (product features) or pursue those features listed in right side (user experiences). Indicated in 4.1, Wang wished a smart home with core capacity in integrated solutions and data services oriented, thus its portfolio management should prioritize, for instance, the development of value-adding applications for smart home data, in order to gain a better user satisfaction.

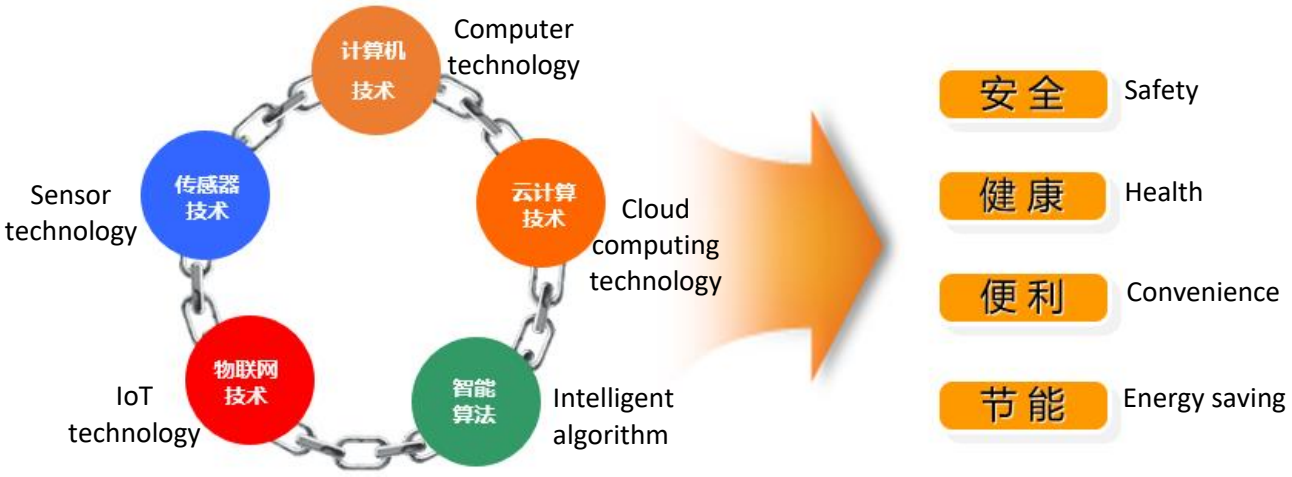

Figure 8. An example: what a portfolio management should be considered by the smart home startup company. Source: Wang (from the interview in August 2017)

Pekkola believed that a good portfolio management was an essence of smart home product productization, managing the portfolio could solve fundamental problems. He expressed his dream of an “ultimate” solution to conquer smart home challenges: concentrating on how to not rely on technology or artificial manners. That is not pursuing leading edge technologies; instead, always seeking better ways to solve real-life problems for the customer would be the right principle.

4.5 NPD process management and execution

Current status and perceived challenges

General situation in the management and execution of developing smart home products was lack of clear process and no related standard for guidance. Wang observed many products were produced in very short periods by using ideas and concepts copied from each other, the speed seemed being a preferable indicator. During entrepreneurial stage of his startup, WANG recalled that the team who operated NPD and the payer of NPD were from different founders, distinct ideas to smart home products and markets had negative effects on NPD process. It resulted in inappropriate allocation of NPD funds, or insufficient direct expenditures in NPD process that finally became the direct reason of the startup’s failure.

Pekkola recognized finance problem as the first direct challenge also, when summarizing his notes from past processes of developing smart home. The next he pointed out the data security, user privacy, and the prejudice against new technologies were worth mentioning as factors leading to finance problem. One

proof was from his latest experience in working for smart home development at JAMK University of Applied Sciences (JAMK). Pekkola noticed smart homes have been typically designed for assistive technology presentations, and usually initiated in R&D projects and built up during certain years of funding period. Although still administered by their owner organizations, once those projects ended, the process of smart home development was usually on a minimum level due to the lack of external funding.

Solutions

Because of no personal practices in NPD management and execution, Wang stated that he did not have much thought of the solution. Only factor he would comment was from an aspect of human resource' allocation, which was finding right members to take care of NPD. The right member meant those from entrepreneurial team who knew the positioning of product and market, and had influence to the product portfolio management. He stated that building a right resourced team was one of roles startup founders should take care of.

Pekkola's suggestion was mainly towards the organizations who manage the smart home development as R&D project and own the smart home. The organizations have to be willing to take risks of investing in new solutions and able to be the first ones in the market. Particularly those originations, such as his current employer JAMK, have their advantages to be the "one" enduring afore risks: comparing with basic research institutions, higher education institutions in applied fields own more strengths of transiting the technology to productivity.

4.6 Post-NPD learning and improvement

Current status and perceived challenges

In Wang's case of his smart home startup, there was no post-NPD learning process (the startup died after first round of NPD). Nevertheless, he expressed a general impression of two main problems seen in his past NPD processes in ICT fields. Firstly, the post learning was done too quickly, the improvement was hard to be made effectively enough; secondly, the improvement suggestions were often perceived as too costly or taking too long time to gain sufficient returns, therefore rejected. So to say, the timing or speed has been a key word to NPD in ICT field, WANG speculated that smart home industry shares this character.

To Pekkola, currently smart home producers seemed not too eager to ask anymore "what makes it smart" after having one smart home. He said the challenge of post learning and continuous improvement was more like a self-questioning about mega trend of technology evolvement. Examples can be "where is the real cutting-edge of smart home technology?" or "in the future, which solution might be more smarter for customers – adopting technology based smart home solutions, or turning back to relying on human being's services especially for those situations occurring in families and social services?". Those pending questions affected on the post-NPD learning and improvement because directions were never clear enough.

Solutions

Considering the specification of smart home product such as rapid renewing of technologies, Wang had an opinion that post learning and improvement shall be more based on the directions driven by market demands or policies. Similar interpretation as described in 4.2, he also recommend to utilize the post improvement as a tool to make next products guiding the market demand. If recapping from the failure of his smart home startup, Wang said his consideration of improvement was actually to transfer own lessons learnt into “project works”. He explained, employing existing smart home technologies to extended fields outside of home environment, for instance in elderly care places, hospitals and clinics, schools, and rehabilitation centers, so that those tested smart home solutions in various sceneries could generate valuable inputs to future productization.

Pekkola responded it after his self-questioning about technology evolvement. He said the main change to each round of post NPD improvement should be the transformation from smart home to a smarter home. Similar to Wang, Pekkola believed that nowadays the focus is not only at homes but also in smart living areas, communities, cities and also in transportation. The real improvement of smart home solution should be connected to these new areas of interest, in that way the benefit of smart home can be enlarged to the society.

4.7 Summing up to answer the research question

To summarize above separately described records, following table is the place to put all results into a nutshell shown as Table 2:

Illustrated by Table 2, main challenges and solutions to productizing smart home concept are presented upon six factors of the Development Funnel. Corresponding to the idea described in Section 2.4, the Development Funnel was a framework to identify the new product development process. Now situating smart home productization to the NPD process evaluated by six factors of the Development Funnel, the research question could be answered:

"*How can smart home concept be productized*" - resolved by two parts:

- Firstly, "*What are the challenges in productizing the smart home*" – answers are extracted around six factors (referred to the middle column of Table 2).
- Secondly, "*How can these challenges be overcome*" – solutions are summarized corresponding to each factor as in the last column of Table 2.

Table 2. Challenges vs. solutions of smart home productization

Factors	Current status and challenges	Solutions
1) Capacity assessment and forecasting	Fragmented products with homogeneous features, poor compatibility and applicability; Dynamic perceptions of "smart" led to difficulties to assess and forecast the product capacity.	Finding the "right" product positioning: integrated solutions and data services oriented; keeping awareness of new technology development and renewing of technique to using the up-to-date facilities in design.
2) Market assessment and forecasting	The gap remained between product features and market expectations; big difficulty caused by defining the customer.	Investigating related national strategy and regional government policies to assure the direction for "guiding market needs"; focusing on customer segmentation, then assessing and forecasting the corresponding market around the certain segment.
3) Goals and objective settings for NPD	Too much R&D investment spent in early stage for single function products; slow product transfer comparing to technology evolvement; lack of rapid and constant development and upgrade of technologies.	Starting from market positioning to let the need shape the goal/objective; introducing a standardized process to guide goal-setting and NPD process; instead of a smart home, adapting the ultimate goal as being smarter, and searching different kinds of technology providers for this goal-setting.
4) Product portfolio management	Low quality of portfolio management - pursuing technology upgrade for maintaining product portfolio being very costly and endless, difficult to reach a balance of R&D investment and return.	Managing the portfolio based on a clear positioning of product core capacity - prioritizing to optimize holistic user experience and to not lean on new technologies or artificial manners.
5) NPD process management and execution	Inappropriate allocation of NPD funds, or insufficient direct expenditures in NPD process; other finance problem caused by data security, user privacy, and the prejudice against new technologies.	As for a startup team: finding right resource to take care of NPD, who knowing the positioning of product and market, and having influence to the product portfolio management. As for the organizations who own the smart home: building the willingness of risk taking to invest in new solutions and the readiness of being the first ones in the market.
6) Post-NPD learning and improvement	The lessons learnt defined too quickly to be effective or too costly to be adopted in improvement; directions of improvement not clear enough for smart home when connecting to the megatrend of future technology evolvement.	Justifying the improvement according to the directions driven by market demands or policies; transferring the smart home to a smarter one as the important principle; applying the learnt smart home technology to extended fields than in home environment to enlarge the effect of improvements.

5 Discussion

In previous chapters, started with a briefing of this rapidly changing era, the author discussed how the most visible worldwide megatrends - such as being information rich, technologically enabled, and more aged in average – cause revolutionizing of products and development of new conceptualized products becoming common and important to business life. As an example of those newly conceptualized products, Smart home was chosen to be the research object with the aim of studying how to properly productize it. Although mostly used for home automation and assistive technology, the smart home concept could be applied to many other situations once key features matched. To develop smart home towards fitting products in different needs, NPD process combined with PPM was introduced essentially, and the Development Funnel (Von Stamm 2008) was the theoretical framework guiding the trial to find main challenges and solutions of smart home productization. The study used qualitative research approach for the empirical: in-depth interviews with semi-conducted questions were done. Results of the study was analyzed based on collected narratives and presented in Table 2. Recalling the background of this study introduced in Chapter 1 and the literatures reviewed in Chapter 2, the author would give a further elaboration in this chapter.

5.1 Reflecting upon the research question

According to theoretical framework of this study (see Figure 6), factors “Capability assessment and forecast” and “Market assessment and forecast” belong to the area of where “Business strategy” influenced; whilst factors “NPD goals and objectives”,

"Product portfolio management" and "NPD process management and execution" compose the affecting area of "Capability and Product/market strategy". In contrast with the results came out from Chapter 4, the research question can be also explained in an extracted way as the following:

"**What are the challenges of smart home productization**" – In business strategy influential area, product positioning (fragmented products with homogeneous features, poor compatibility and applicability), customer definition and product capacity forecasting (the gap remained between product features and market expectations) are main challenges. Affected by capability and market/product strategies, the crucial challenges are too high investment in R&D before the products being competitive enough in the market and low quality of product portfolio management. Yet in Post-NPD phase, the cost-speed balancing for product improvement is a key challenge too.

"**How to overcome those challenges**" - corresponding to the business strategy part, focusing on customer segmentation (fine classification), concentrating on integrated system schemes for smart home, and aligning the business direction with related national and regional development policies are the most recommended ways. To the functioning area of capability and market/product strategies, suggested solutions are adapting the ultimate goal of smart home as "being smarter", prioritizing to optimize holistic user experience (instead of leaning on new technologies or artificial manners) and keeping it as the core capacity of smart home products. Finally, at the Post-NPD

stage, decision making for product improvements might be mostly epitomized as to apply a principle of “pursuing the smarter”.

In author’s opinion, the above presented challenges and suggestions to overcome are commanded mainly due the nature of smart home: new market segmentation driving new product using new technologies and changing with rapid evolution. Growing market need of smart home products lays on technology development and application of new technologies, while the technology application demands clear product positioning, adequate investment and efficient processes of new product development and portfolio management. Although “smart” and “new” technologies are relative terms, and smart home is an evolving concept in the context of technology progressing, aforementioned challenges and solutions to productizing smart home seem not tied to the timeliness. Finding out suggestions like focusing on integrated system schemes and to optimizing user experiences through pursuing the “smarter” is the core value to question. This may lead to one hypothesis, that in such cases as new technologies’ productization, the similar kind of challenges and solutions as from smart home could be referred.

5.2 Comparing the results with the literature

In this study, reviewed literature surrounding “productization” is in three aspects: market-driven product development, process of NPD and PPM.

To the first aspect, the study found that smart home was referred to the need/requirement for a new situation or solutions needed by quality daily life, which came from the market place. The need is identified by customers and proved by market reports, however the expectation to smart home products seems be interpreted in different ways and not very easy to be fulfilled. The result from interviews certified the market-pull principle in developing smart home products, but there was also an advice to try fulfilling market needs through another way: starting from national or regional strategy/policy investigation and alignment, designing product accordingly, then developing the products to guide the market needs. This advice occurred when the entrepreneur interviewee suggesting how to overcome challenges in smart home productization, in researcher's opinion, that can be due to his lesson-learnt of balancing between product proposition and customer expectation for relatively "technology-intensive" products (Trott, 2005).

In the NPD process literature, this study adopted the guidance mainly from Brethauer (2002) which covers the complete process of transformation of a market opportunity into a product available for sale. Two focuses on product design and product transfer process are matching with overall situations of productizing smart home concept, according to the results revealed by interviews in this study. However, the fore one is recognized more critical than the latter: central aspect of developing smart home products shall be the design focus. The ideas of "Fit-for-Use" checking and "Value-added flow analysis" were emphasized. Furthermore, a "Front-end loading" principle to assess the financial risks vs. product development

uncertainties is worth to note, since it is a necessary threshold to be kept in mind before rushing into turning smart home design to product transfer.

Earlier literature in PPM suggested that PPM as an entity has a role in managing existing product portfolios and their renewal based on commercial and technical portfolios as collaboration between business and engineering teams in all organizational levels (Tolonen et al. 2014, 181). The referred framework of PPM governance model in this study (see Figure 5) provides possibilities to enable effective product portfolio ownership and management, which has larger scope and more comprehensive contents than the actual found during this empirical study. The interviewees admitted that they did not manage to do proper PPM governance, the smart home designer was not involved in commercial portfolio management, and the entrepreneur had limited involvement in technical portfolio. The unsuccessful in PPM was mostly because of weak cooperation between business and R&D teams at whole organization level, and also generally lack of know-how of PPM.

5.3 Implications

After answering the research question, this is to discuss main implications of findings in practical and in managerial to whom running or planning to run smart home business.

From business strategic aspect, to strengthen the marketing assessment and forecasting, a “guiding market needs” approach could be suggested. That is to firstly investigate related regional strategy, government policies or growth reports with regarding to smart home market dynamic, and then accordingly define new technology adoptions and product portfolios in order to assure that smart home products may direct the market movement. This seems going against to normal principle of from studying market needs to developing products for fulfilling needs. But, in some extents, it may indicate other possibility of smart home productization, which is probably driven by technologies instead of market needs.

From capacity and product strategy aspect, to enhance the goals and objective settings for NPD, it is recommended to introduce an industrial standard to standardize smart home products and hence benefit to the process of smart home product development itself. The expected industry standard would include such key specifications as definition of smart home products, interfaces with other products, data security standard and so on, which is able to be commonly recognized and adopted by the majority involved in the market. It is believed also that who introducing the standard first, the earlier opportunity to gain more beneficial could be expected.

From Post-NPD improvement aspect, a different idea than improving smart home product itself is suggested. If applying those learnt from smart home development process to extended fields in addition to home environment, it might be an approach

to enlarge the effect of improvements. Given examples are to employ some home products and development process in smart living areas, communities, cities and also in other fields like transportation. The real improvement of smart home should be connected to these new areas of social interest, in where the benefit of smart home can be enlarged to the whole society.

The implication to the team managing a smart home startup: finding right resources responsible of NPD from the stage of goals and objectives setting. Ideally the person should have competence knowing the positioning of product and market, and influencing to the product portfolio management. It is critical because the resource(s) expected to be multi-professional in not only technology and R&D, also in implementation of R&D and even marketing. If particular person is not possible to find, then the management team has responsibility to define most fitting process on whole organizational level to assure NPD.

Last but not the least, the implication to those organizations who has smart home product already: forming the willingness of risk taking to invest in renewing solutions or technology updates. As discussed early, “smart” is relative and the smart home concept is dynamic corresponding to the evolving of technologies and market. Following existing products or slowing in product upgrading would cause obstacles to keep competitiveness. Managers have to build up the readiness of being the first ones in the market.

5.4 Limitations of the research

As a result of overall self-reflection on this study, the author perceives two major limitations in whole research process.

The first one is conditioned by the broadness or ambition of research object. Smart home is a phenomena having dynamic definitions, in this study it was targeted by a widespread research question while not given a clear delimited scope to the research context. This increased difficulties to obtain a holistic browse on the related literature and keep to updates, also brought more challenges to achieve a comprehensive empirical data collection.

The second limitation is the coverage of interviewees' representativeness. In this study there were two interviewees, one representing entrepreneur with failure in smart home startup and another representing smart home designer. Although both interviewees gave full supports to provide narrative details and answer research questions through in-depth interviews, the natural shortage of success stories from real business life in smart home company was not avoidable.

There is one observation worthy of attention: this study was concentrated in "object" of smart home phenomena - the concept, product, processes and even the target customer and market. It did not cover the "subject" part: the person and person's teams making smart home products and developing smart home businesses. No doubt that results coming out from this study shows great

importance of all the “object”, nevertheless, people as the main body of any activities is one un-ignorable factor to objects. For instance, finance managers in smart home companies, R&D heads of smart home design, project leaders of product transfer and portfolio management processes are all key person influencing to the smart home productization.

The self-reflection was also made particularly in correspondence to validity and reliability of the study. After a methodological illustration in Chapter 3, the author would come back to those measurements once more.

- **Internal validity**: in this study, results given in Chapter 4 are able to answer the research question of how to productize smart home concept, the challenges of productization and solutions to overcome those challenges are self-explanatory. Details can be referred to Table 2.
- **External validity** is to measure the generalizability of findings. This study demonstrated a trial: conceiving the smart home as a targeted product, so that its productization can be processed by new product development procedure; next, choosing “Development Funnel for NPD” (Figure 6) as the theoretical framework to make the framework in a generalized context. To such extents as development situations requested by new products/services/solutions, which are driven by innovation and technology adoption, the author would propose that following the way demonstrated in this study may generalize similar kind of findings.
- In the author’s attempts, **Reliability** is assured by methodological approaches during the study. Examples are using reliable data sources and appropriate data

collection techniques, as the author could do. However, in earlier statement of the second major limitation of this study, the primary data sources are considered limited. The author conducted in-depth interview with open-ended questions as a compensation to the limit, however, when other researchers select different interviewees or increases amount of interviewees, reproducing of the findings perhaps may become questionable.

- **Objectivity** is corresponded by the method chosen for data collection and analysis, which is the narrative inquiry in this study. Interviewees' intervention was planned together by the author and interviewee selves prior to the analysis began – after interviews, interviewees provided own answers in written format in addition to the researcher's transcripts of audio records only. This joint participation to the data processing helps to interpreting data objectivity, also gives the possibility for other researchers trying to have same findings from the same data.

5.5 Recommendations for future research

Nowadays new technologies and innovations are developed very fast, updates on technology adoption has been quickly substituted. Researches in smart home related has an unavoidable impact factor: the timeliness. This particular study is not concentrating on the concept or technical specifications of smart home; instead, it is more process-oriented discussion. However, along with the rapid technology development and market evolvement, the smart home related study needs review and renewal too. Future researches could be considered from four aspects.

The first is to respond to the research limitation caused by wide-ranging objective whilst comparatively inadequate primary source data. A further research could be done through supplementing interview data collected from enlarged number of interviewees, who will represent the group of successful smart home entrepreneurs. Also another continuation of this study might be to add a focus on “people”, who involved in smart home business, into the research context with an aim to clarify the people impacts in different phases of smart home productization.

The second is about effectiveness of market driven product development, which has been intimated in this study already. Trott (2005) has discussed striking the balance between new technology development and market focus, and finding out the correct time to ignore the customers (ibid., 458-466). Extended by this smart home study, a future comparison is interesting of mentioning: in contrast with the “traditional” product development driven by marketing, is a technology-push approach of new product development more fitting for technology-intensive products, like smart home?

Thirdly, from new technology adoption point of view: what will smart home go if newest technologies like artificial intelligence (AI) and robotics widely used in daily life? Corresponding to incessant evolution of new technologies, defining the very cutting-edge of “the” new technologies, or the exact real expertise of smart home solution becomes more difficult. The future day may approach soon, when most of our daily life is supported by enormous manners that rely on enormous new

technologies. By then will the human being and human-contact manners be the most rare and valuable among all of cutting-edge technologies?

The fourth is tied to deepening study of the essence of smart home: who/what makes decision for smart home? How will the future technology development affect the nature of smart home? This topic is to use smart home as a case, studying the implication in bioethics trigged by new technology adoption of AI: where shall the boundary be drawn for artificial technologies supported smart or intelligent, so that the ethical limit of human-being will not be destroyed?

These newly raised questions are composed based on smart home discussions, but not limited to smart home only. Like the second study possibility explained, future researches can be encompassed around technology-intensive products, services or innovations. In the researcher's opinion, making further studies is therefore a likely implication of smart home productization study extended in academic.

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Appendices

Appendix 1. Interview questions

Towards the Finish interviewee

1 How do you see the general status of smart home in Finland –

1.1 Where is Finland's technical position of smart home technology, in Europe?

- If possible, how about of worldwide?

1.2 What are typical examples of utilizing smart home concept in Finland?

1.3 Do you think there is a space to develop the concept and utilize it better in Finland?

- If yes, what could be better and why?

- If not, why?

2 How do you see the future development of smart home concept –

2.1 Technically, what could be a likely roadmap of smart home development?

2.2 How would you foresee the market needs of smart home-based utilization, within e.g. coming 2-3 years from now on?

2.3 What could be possible new products based on smart home concept?

2.4 What are most critical factors to build these new products?

e.g. infrastructure, engineering/manufacturing level, data security, R&D efforts, marketing analysis, decision making process and so on…

2.5 What would be your suggestions to Finnish organizations for the future development?

Towards the Chinese interviewee

All interview questions were translated into Chinese. The interview was conducted/recorded in Chinese, later the transcription and analysis were done in English.

1 How do you see the general status of smart home in China –

1.1 In your opinion, where is China's technical position of smart home technology?

1.2 What are typical examples of utilizing smart home concept in China?

1.3 Do you think there is a space to develop the concept and utilize it better in China?

- If yes, what could be better and why?

- If not, why?

2 How do you see the future development of smart home concept –

2.1 How would you foresee the market needs of smart home-based utilization in China, within e.g. coming 2-3 years from now on?

2.2 What could be possible new products based on smart home concept?

2.3 In China market, which new products do you think could be the most/least successful? And why?

2.4 What are most critical factors to build probably successful new products in China?

e.g. infrastructure, engineering/manufacturing level, data security, R&D efforts, marketing analysis, decision making process and so on…

2.5 What do you think that you could do for the future development?