Service Design as Facilitator for IoT Development

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Abstract

Purpose: This research explores how Service Design can facilitate IoT development. IoT is an emerging field in academia and practice that presents different research gaps. This study thus reviews Service Design and IoT literature, as well as looks at their intersection to contribute to current literature.

Method: This paper presents qualitative research on the use of Service Design for IoT development. A systematic literature review reveals the gaps in current academic literature on Service Design as a facilitator for IoT development. Qualitative research was conducted and the semi-structured interviews with practitioners in Service Design show how IoT development can be approached from a Service Design perspective, and how Service Design can facilitate this development.

Findings: Service Designers face new challenges when designing for IoT, thus new design tools for IoT development are presented and examined in this research. The challenges include IoT design challenges, as IoT consist of a physical, a software, and a service aspect. These different parts need to be aligned to enable value co-creation, which can be overseen by Service Designers as they are knowledgeable in stakeholder management. Also, ethical concerns arise with IoT, which Service Designers are equipped to answer, as they follow a human-centered and holistic approach.

Originality/value: Previous studies often looked at Service Design from an IoT perspective, not researching the potential that Service Design may offer for IoT development. This paper provides insights into the ways Service Design can facilitate IoT development by discussing the Service Design tools used in the design process.

Practical relevance: The findings from this research show Service Designers useful tools in designing for IoT development, also highlighting why and when these tools should be used to unfold their potential.

Limitations: This research is limited by only considering academic papers which focus on IoT and Service Design in the SLR, where one of the two topics may not be discussed as main interest. The research is further limited due to its qualitative nature.

Key words: Service Design, Internet of Things, IoT

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1. Introduction

In the last years innovation and advancements in the domains of service, technology, and the internet have been tremendous. Thus continuous change has been experienced. Currently, Internet of Things (IoT) is growing in industry and also in everyday life, as can be seen with devices such as the apple watch. These IoT devices open entirely new opportunities for innovation and challenges as well. IoT is made up of a physical device and software, and such software innovations have been a key success factor for many companies in the past years and will most likely become even more relevant in all kinds of different industries in the near future (Haller et al., 2008). This can already be seen in manufacturing companies shifting from product focused to service focused (Sayar & Er, 2018). This shift raises the need for new design processes, such as designs that are open for personalization (Porter & Heppelmann, 2014), because there are new ways to embed software into devices with IoT.

As the importance of IoT is growing, questions arise on how Service Design can help to further develop IoT, especially as competition is rising. Service design has shown to be of value for designing new services, but the question remains whether the tools known from Service Design could also enhance and support the design of IoT. Service Design could be of high value, as it is focused on creating value for users and might be able to close the gap between human and object interaction further.

Due to the emerging nature of IoT, literature is limited, and most articles are rather new, which aligns with the current interest and importance of it. Many aspects of IoT have not yet been discussed and researched from an academic perspective. Articles often discuss only a small part of the entire IoT system/landscape, but the bigger picture seems to stay blurred. However, not only is literature rather limited on the IoT side, but Service Design approaches towards IoT have not been seen in academia a lot (Hasselblatt et al., 2018). The available academic work on the intersection of Service Design and IoT is very limited currently (Korper et al., 2020), and those papers that are available seem to raise more questions than have been answered yet. In a time where servitization becomes more relevant and the focus is shifting from a product focused view towards a service oriented view, this poses to be a relevant topic for research.

The gap existing between the two topics might be caused by the novelty of the two fields, but also due to the different domains that Service Design and IoT stem from. Also adding to this gap is Data Driven Design (Trabucchi & Buganza, 2018), which poses to be very interesting for Service Design approaches. Data Driven Design offers new opportunities for designers, as it functions as an additional information source that informs the design process. However, work on the intersection of the two topics is limited (King et al., 2017). For Service Design research very different ways of designing services could come from data driven design, and the topic may gain more attention due to its high relevance for academia and practitioners.

Nonetheless, considering the limited amount of work available and the many questions and issues that should be discussed by academia, researching the former seems to be even more relevant.

IoT enabled devices also offer the chance to foster innovation and the creation of new value propositions, as valuable data can enhance the service and thus strengthen and organization

against rivalry from competitors (Porter & Heppelmann, 2014). In addition, service-based business models also show to have a more secure revenue stream (Hasselblatt et al., 2018), which can allow to put the focus more on the service rather than solely on the revenue, which can especially be relevant for companies operating in industries with high fixed costs, as these are very vulnerable to price pressure (Porter & Heppelmann, 2014). All the before mentioned also offers an opportunity for new business models that would have not been possible before (Friedrichsen, 2020). Academic literature is limited and gaps regarding Service Design tools for IoT can be seen (Shin et al., 2016).

This paper thus aims at analyzing the relationship from a Service Design perspective, and investigating how Service Design approaches can be of use for the design of IoT, focusing especially on IoT for consumer markets.

1.1 Research Objective & Question

This research aims at analyzing how Service Design can be of use for design of Internet of Things. As the intersection of the two topics is not very well researched to date (King et al., 2017), a few challenges might arise. The first issue is combining the two topics, which stem from different knowledge domains with very distinct nature. Whereas IoT can be seen as a rather continuous process, Service Design in comparison is defined as an iterative process. When looking at the possibilities that Service Design approaches offer IoT, this cannot be neglected.

Furthermore, the question arises whether the definition of Service Design as a human centered approach is still enough in a time where IoT gains popularity. It is in the very nature of IoT enabled devices to make certain decisions on their own, and thus also to make decisions for the user, which can be seen in examples of the Apple Watch and Amazons Alexa. It is likely that Service Design needs to be seen and understood in new ways, as with the use of IoT, Service Design might take a different role than it has now.

This issue of course also creates new problems to solve from an ethic and legislative point of view. As can be seen, due to the new nature of IoT and the current lack of academic literature on the topic, research that is currently conducted might raise more question than it is able to answer.

The aim of this paper is thus to get a first understanding of the possible ways that service design can influence/enhance the design of IoT enabled devices for consumers and provide a framework that designers of such devices can use.

The main research question for this paper is thus:

‘How can Service Design facilitate the design of Internet of Things?’

To structure the work, the following sub-questions are used to answer the main research question:

1. What are emerging challenges and issues Service Designers face with IoT development?
2. How do the role, approaches, and methods of Service Design change when it is applied in the development of IoT?

3. How can Service Design better address the needs for IoT development?

In section 2 of this paper the methodology used for data gathering, in this case semi structured interviews, and data analysis can be found. To answer the proposed questions this paper continues with a systematic literature review on the intersection of IoT and Service Design (section 3.1), underlining the work that has been done so far. This systematic review shows the gaps in current academic literature and thus offers a grounded start for this paper. Section 3 then continues with the general literature review, where additional literature concerning IoT, Service Design and Data driven Design are being discussed to get a more holistic understanding of the different fields and its possible intersections. The results of the interviews can be found in section 4, which is then continued by a discussion in section 5.

2. Methodology

To be able to address the research question on how Service Design can facilitate the design of IoT, it is important to first understand what has already been conducted in academic literature regarding the intersection of Service Design and IoT. Therefore, the first method used in this paper is a Systematic Literature Review (SLR). A SLR is a useful tool to answer the first sub-question through a transparent and systematic process (Følstad & Kvale, 2018). However, the SLR only covers existing knowledge in which gaps were identified (see section 3.1); semi-structured interviews were then utilized afterward to generate new insights.
Semi-structured interviews, as a form of qualitative research, allow the researcher to understand how people make sense of their experiences, and what value they link to those (Merriam & Tisdell, 2015). The key focus in qualitative research is thus understanding the researched topic from the participants perspective, often requiring inductive thinking (Merriam & Tisdell, 2015). Qualitative research is useful when there is a lack of academic literature available on a topic, the aim is thus to gather data in order to build theories (Merriam & Tisdell, 2015).
This chapter thus explains the methods used and why they were chosen, starting with the SLR in section 2.1, followed by the qualitative research in form of interviews in section 2.2.

2.1 Systematic Literature Review

The objective of the Systematic Literature Review (SLR) is to understand what has been done on the intersection of Service Design and IoT in academia preceding this work. The SLR is used to get a thorough understanding of existing work, following a methodological approach that can be replicated, to achieve transparent results (Følstad & Kvale, 2018). This step is useful and important for this research, as it helps to identify gaps in academic literature that need to be addressed and considered in this work.

Table 1: SLR Key Words

Actual Term	Service Design	Design of IoT
Narrower Term	Strategic Service Design, Interaction Design	Design of IoT Software/Hardware
Broader Term	Design Thinking, NSD	IoT
Related Term	UX/UI Design	Design of Connected Devices

Key words used in first phase of SLR, to find relevant papers

2.1.1 STEPS OF CONDUCTING THE SLR

A SLR is a structured process to analyze academic literature. This research follows the steps proposed by Xiao and Watson (2019), starting with a planning and review stage. In this first step, the research problem is formulated and a review protocol is developed. Thus the first step to conduct the SLR was to break down the main themes that are researched into their individual parts, as can be seen in Table 1.

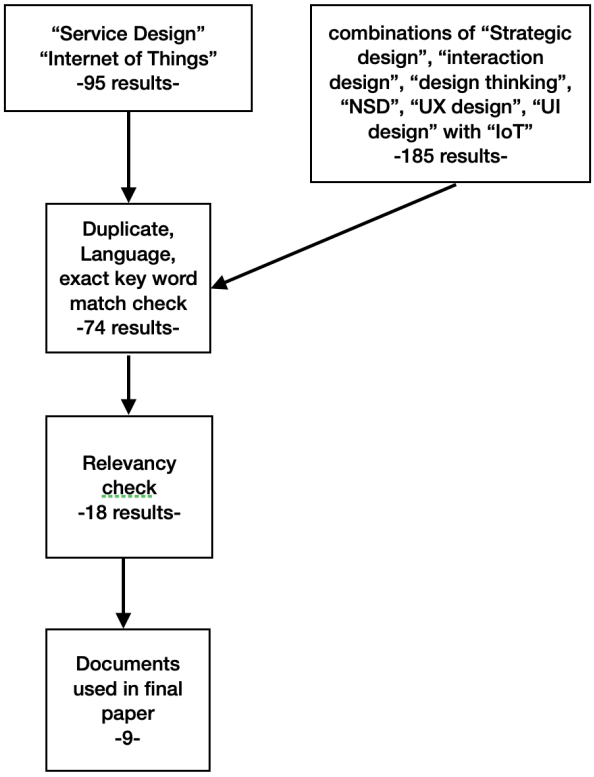

Figure 1: SLR Process

Next, the criteria developed for inclusion and exclusion of articles were developed, these will be further explained at their appropriate step. The key words identified in Table 1 were used to conduct the SLR, as shown in Figure 1. The first search was conducted using the actual key terms from the Research Question, namely "Service Design" and "IoT". Adding to this search different combinations of alternative terms for Service Design were used in combination with "IoT". The search was carried out on 'Scopus' and 'Web of Science', which resulted in 95 results after the first search. Combined with the additional key word search a total of 280 papers were found.

Next, following Xiao and Watson (2019), multiple steps were carried out to narrow down the results.

The first step was to review the title of the work, if the title is fitting to the research problem, the article will not be excluded at this stage. However, due to review of titles duplicates can already be sorted out at this step.

Then, the abstracts were reviewed, however, before reading them carefully a language check is conducted at this point, to ensure that all abstracts are written in English language and that the key words match with the search terms. Additionally, at this point it was also checked if the

articles are peer-reviewed. Thus, before starting step two only 74 articles were left for consideration.
Now the review of the abstract gives a better understanding of the relevance of the article for this work, which left a total of 18 articles to be included for the review. Step three then includes a review of the full text article. These papers were thus checked in more depth, starting by broadly looking at figures and tables, and then reading the full text. This led to the further elimination of work, leaving only nine papers relevant to this research. In the last step work was excluded due to an unfitting focus to this research.
Following Xiao and Watson (2019) these 9 papers are analyzed and the findings are reported in detail in section 3 of this article. The analysis of the SLR was also used to inform the interview process.

2.2 Qualitative Interviews

In this section, the type of study is explained and justified. The section starts with the type of study, followed by an explanation of sample selection, data collection, and data analysis.

2.2.1 THE TYPE OF STUDY

This research is based on qualitative research, and aims to obtain insights and understandings of how Service Designers deal with IoT in practice. For the purpose of this research, semi-structured interviewing was selected (Merriam & Tisdell, 2015). While there are different styles of interviews to choose from (Dunn, 2005), semi-structured interviews were the most fitting in this case. Interviews in general allow for great exchange and information sharing, as participants can share their experiences and express opinions (Creswell & Creswell, 2017). With semi-structured interviews the participant can share experiences and emerging questions can be asked throughout, but with the roughly structured questions it is still ensured that pressing questions for the specific research are answered. Based on the loosely structured questions, the interviews are still comparable during the analysis, as it is likely that similar topics have been touched on during the interviews, without compromising the depth of the interview (Flynn et al., 1990). Most importantly however, semi-structured interviews allow the participant to respond openly and share what comes to mind, and what they find important (Longhurst, 2003). This way topics that were not thought about beforehand may emerge, but be important to consider in the research.

2.2.2 SAMPLE SELECTION

To find how Service Design can facilitate IoT development, it is first necessary to understand how Service Designers approach IoT projects. Understanding their process in IoT projects may differ from traditional Service Design projects, revealing critical parts for IoT development. Thus, practitioners in Service Design who have experience in working with IoT projects were selected for this research.

In the process of finding and selecting interviewees, a total of 33 Service Designers have been contacted. The possible participants were contacted via LinkedIn and email, depending on the contact information available. As many of the contacted professionals did not reply back, the selection process took around three to four months. A total of eight participants had agreed to participate in the research; however, one withdrew from the study. Therefore, a total of seven interviews were conducted. Seven interviews is considered to be a sufficient number considering the narrow target group of Service Designers who have experience with IoT projects.

A small sample size is also typical for qualitative research. However, the exact number varies depending on the research, as it is more critical to understanding how the subjects make sense of their experiences (Merriam & Tisdell, 2015). In this case, the research was focused on understanding how and why Service Design tools were used in the design process for IoT. With a total of seven interviews sufficient information is gathered to answer the main research question, and thus poses to be enough participants, as with qualitative research no fixed number is given (Merriam & Tisdell, 2015). This research is focused on a very specific problem in an already narrow target group of Service Designers, so seven interviews is enough, especially considering the depth of the interviews. To make the results from the interviews comparable, the main criterion for choosing participants is their experience in working in Service Design, where they have done projects for IoT.

Table 2: Interview Participants

	Years of Experience with SD	**Currently works as…**	**Works in (Company kind, industry)**	**Experience with**
Interviewee 1	15 years	Service Designer	Consultancy of a big tech company	Research, Service Design
Interviewee 2	around 8-9 years	UX Designer	Design consultancy	UX Design, Service Design
Interviewee 3	13 years	Innovation Lead	Tech company	Service Design, UX, Strategy
Interviewee 4	6 years	Service Designer	University, consultancy	Service Design
Interviewee 5	8 years	Senior Service & Product Designer	Tech company, Consultancy	Service Design, Product Design, Interaction Design
Interviewee 6	15 years	Design Researcher	Design consultancy	Research, Service Design
Interviewee 7	>20 years	Experience Director	Design consultancy	Product ownership, Product management

Table 2: List of Interviewees

2.2.3 DATA COLLECTION

For this research semi-structured interviews were the data collection method of choice, given that this study is of qualitative nature. As Merriam and Tisdell (2015) found that

> "Interviewing is necessary when we cannot observe behavior, feelings, or how people interpret the world around them. It is also necessary to interview when we are interested in past events that are impossible to replicate." (p. 108).

In this research the main interest is in *how Service Designers deal with IoT projects, what process they go through, and which tools are used in the different phases*. To get answers about the former, it is of high value to discuss past projects that the Service Designers have participated in, to understand what they have done and how they experienced it. Therefore, interviews are a useful tool for data collection in this case, as it allows to so (Merriam & Tisdell, 2015).

There are a few different types of interviews that can be used for data collection. The most widely known types being structured, semi-structured, and unstructured interviews (Merriam & Tisdell, 2015). As the research aims at understanding experiences and views of the participants, structured interviews would not allow for enough flexibility. Structured interviews would also limit the possible answers, as they are very dependent on the question given by the researcher, which limits the possible outcomes (Merriam & Tisdell, 2015). Unstructured interviews on the other end are more like a conversation and can be of use when not enough knowledge about the area of study is present (Merriam & Tidsell, 2015), which is not the case in the present. Semi-structured interviews were chosen, as they allow important questions for the research to be answered, but also give participants the chance to express their views and share what they find important, thus allowing for a sufficient degree of flexibility (Merriam & Tisdell, 2015).

For the semi-structured interviews, a list of general questions were prepared (see Table 3), which was used for guidance during the interviews. The prepared questions were all open ended, to allow the participant to answer as freely as possible. The questions were also asked open ended to not influence the participants answer. As the question template was only loosely structured, most questions asked during the interviews came up naturally during the conversation and were not planned for beforehand, which is another reason why semi-structured interviews were chosen in this case (Longhurst, 2003).

The interviews were all conducted virtually through Microsoft Teams or Zoom. This was done due to the geographical distance between the participants, but also largely due to the Covid pandemic. On average the interviews had a duration of around one hour and due to conducting them online, audio recordings were made during the interviews. With the use of the audio recordings, transcripts were made of all interviews, using Otter.ai. The transcripts made by Otter.ai were then checked again with the original recording, to ensure that all transcripts are correct. The transcripts were then used in data analysis, as they enable efficient coding and comparison between the different interviews.

In Table 3 the summarized interview guide can be found (See Appendix 8.2 for full guide). The questions asked during the interviews were informed by the previously performed SLR and literature review. As the main concern of this research is Service Design as a facilitator for IoT, it was asked to discuss IoT projects performed by the participants. Especially of interest was the process the Service Designers go through in IoT projects, and which Service Design tools they use in each stage of the design process.

Table 3: Interview Guide

Purpose	Interview Questions
Introduction	Can you please introduce yourself? - Your background in and expertise with Service Design and IoT? - Your years of experience in Service Design? - How many times have you worked on IoT development projects?
Understanding Service Design and IoT	Can you give an example of an IoT project you did in your role as Service Designer? - Which part of the Service Design process did you go through within the projects? - Can you go through the different stages? - Which tools did you use? - What challenges occurred? - Which other stakeholders were involved? - Did your role change with these projects, if yes, how?
Assumptions about the future of Service Design	Do you think the Service Design tools used today are appropriate with new challenges arising from technology such as IoT? - If you think change is needed, what kind of changes in Service Design do you expect? - In what ways do you think Service Design can enable development of IoT? - Do you think your role as Service Designer will change? If yes, how?
Closing	Do you have anything you want to mention that was not talked about before in this interview?

Table 3: List of interview questions and their purpose.

2.2.4 DATA ANALYSIS

The analysis of the gathered data was done by using the transcripts from the interviews. As this research follows an inductive approach to data analysis, it uses Gioia et al. (2012). In order to achieve rigor in inductive analysis, the authors (ibid.) propose to start data analysis with 1st-order analysis. In this 1st-order analysis the researcher does not try to create codes, or categories, or anything that could influence the raw data from the interviews. During first-order analysis the researcher thus reviews the original interview recording and transcript, highlighting everything that seems interesting at this point. The 1st-order analysis is thus based on in-vivo coding, where the

exact wording of the interviewee is kept and put into its own code. This method of analysis can thus also result in a large number of 1st-order concepts (Gioia et al., 2012), largely depending on what the interviewees said during the interviews that poses to be interesting and relevant to the research.

For this research all interview transcripts were analyzed with Atlas.ti, starting by coding in-vivo in the first round to derive the 1st-order concepts. With the in-vivo coding, raw quotes from the interviews create their own code. This step is thus achieved by reading through the interviews several times and coding everything that seems interesting or somehow relevant. In this first round of coding around 200 codes have thus been created.

Following the 1st-order analysis, 2nd-order themes were created. The aim of the 2nd-order themes is to give order and structure to the 1st-order analysis, as the researcher tries to group the codes into themes (Gioia et al., 2012). During this analysis, the researcher identifies patterns, or overall themes that pose to be of interest for the research. In this specific research, a total of 28 2nd-order themes was derived from the 1st-order analysis (see section 4). These 2nd-order themes were created by manually looking through the 1st-order analysis and using color coding to make sense of the raw data that was presented. Going through this process multiple times resulted in the final 28 2nd-order themes.

The last step of the Gioia (2012) method is to bundle the 2nd-order themes into aggregate dimensions. These aggregate dimensions are overall topics under which the individual themes can be categorized. In the process of this analysis, a total of 7 aggregate dimensions was found (see section 4). Following the steps proposed by Gioia et al. (2012) offers great opportunity to think about the data theoretically, especially since the analysis starts with an open mind by coding everything in the raw data set that seems interesting or useful. By following this method the outcome is not predetermined by researchers thoughts and biases, but instead entirely reliant on the data, creating rigor in qualitative analysis.

3. Literature review

This paper aims at exploring the possible effects that Service Design can have on the development of IoT services. To accomplish this, current academic literature is reviewed, laying the foundation for a greater understanding of existing research, and overview of gaps in the literature.

To understand research gaps and the current state of research in the field of Service Design and IoT, a systematic literature review (SLR) has been conducted. The outcome of the SLR can be found in section 3.1.

After the SLR, an additional review of Service Design literature and its most relevant theories will be given in section 3.2, to address key points relevant for this work which were not accounted for in the SLR. This will then be followed by a review of IoT literature in section 3.3, to get a richer understanding of IoT adding to the SLR.

3.1 Systematic Literature Review

This section discusses the nine papers emerging from the Systematic Literature Review. The SLR is used in this place to inform the general literature review, as it presents the work that has been done in the field so far, but also offers the opportunity to identify research gaps. Those research gaps build the foundation for the general literature review, to create a holistic understanding of the topics and their intersection throughout chapter 3.
Thus, first the 9 articles will be discussed in more detail, followed by a short summary of findings and a conclusion relevant to the further research of this article.

The 9 identified papers all differ in their focus on the topic, as can be seen in table 4 (Appendix). Some of the papers focus more heavily on the IoT architecture and design (e.g. Shang et al., 2015; Ahmadon et al., 2021), while others have a higher focus on Service Design and value creation (e.g. Hasselblatt et al., 2017; Carpanen et al., 2016). The papers also show differences in the field they are written in, as some focus on manufacturing companies, others on smart homes, or are even directed at other researchers and academics in the field.

In their work, Shang et al. (2015) start by stating that the purpose of IoT applications is to optimize both business and service models, but also criticize that current literature mostly only focusses on specific parts of the whole system. For the authors, while the enabling technologies are detrimental to the success of an IoT system, more research is needed from a perspective of the whole system, to guide the design and development of future IoT. Shang et al. (2015) focusses mainly on IoT service based on Information Service; however, relevant points to this research were made. As in the past, very little work has been done regarding the design theories for IoT systems. Now service classification, coordination, and compatibility have been identified as some of the key issues to consider (Shang et al., 2015). Classification is thus necessary to understand user needs, while coordination enables an optimal system for different devices and networks, all enabled by compatibility that ensures network access.
Compatibility is also one of the key issues discussed by Bin Ahmadon et al. (2021), as end users might encounter problems when connecting their devices, as restrictions of the type of data and available capabilities can vary heavily. They propose that service designers take a closer look at this issue, as they are able to determine the suitable level of strictness necessary (Bin Ahmadon et al., 2021). Service Designers are thus emphasized to make use of the Service-oriented-Architecture (SOA), as it allows for loose coupling, interoperability, agility, and efficiency, since it allows heterogeneous components to connect and scale very flexibly (Bin Ahmadon et al., 2015). Depending on the device used, it is also worth looking at the way unconditional and conditional services are linked, to ensure optimal user experience (Shang et al., 2015).

Harvey et al. (2020) researched smart homes and found that “the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” (p.506). As they applied the Service-Dominant-Logic in their research,

they found that service innovation is a result from shared resources, which changes with the advancements in IoT, where co-creation is emphasized further (ibid..

Shin et al. (2016) take the Service Design perspective a step further by stating that Service Design is not only capable of enhancing the quality of interactions between the different stakeholders, but it does so by designing a touchpoint between the business and its customers. This way the needs of both parties can be satisfied. However, the authors argue, new design elements are needed for this, as the interactive IoT characteristics pose new challenges (Shin et al., 2016). Four design elements for IoT services were proposed, which are sensing, interactivity, expendability, and personalization, as these are the characteristics that come from IoT (Shin et al., 2016). The authors go on by determining four categories of different design elements that can be controlled by designers, which are input, output, control, and connectivity (Shin et al., 2016).

Paukstadt et al. (2019) on the other hand created a service taxonomy to understand services embedded with IoT. They distinguish between the service concept, the service delivery, and service monetization. For the service concept they found that the value proposition gains new importance and is also subject to change compared to traditional services, especially due to enhanced efficiency, value, and new offerings due to IoT, but also the visibility of a service is determined as a success factor (ibid.). They also emphasized that with IoT services, co-creation rises in importance, as the way stakeholders interact are subject to change.

Carpanen et al. (2016) applied Service Design to the creation of new IoT services in their work. With IoT enabled services new opportunities arise for higher personalization and quality of services, which also has the potential to enhance the customer relationship. However, this also means that new services are also more complex, as they not only include hardware in form of sensors and microchips, but also software and connectivity. By taking a Product Service System (PSS) perspective it becomes visible that companies can gain a competitive advantage by adding service elements to their products, however, as the PSS takes into account not only the product, but also the attached service and relationships (ibid.). The authors follow a classic Service Design approach in their research, by following the steps of inspiration, ideation, reflection, and implementation, they thus start by identifying the problem and goal, followed by understanding the customer experience. They continue with a conceptualization of the service offering, by using tools such as service experience blueprint. Based on these insights the design of the system architecture can be made using tools such as mockups and scenarios. By following this approach, rich information about users is gathered, which supports the design of the service in offering value (ibid.).

Hasselblatt et al. (2017) on the other hand focus more on the value for users, as they also identified that customers key value drivers are essential for appealing value propositions. They follow the approach from Töytäri and Rajala (2015), using four key strategic business processes that are needed for successful development and delivery of IoT services. These four processes

are: Value identification, value quantification, value communication, and value verification (Töytäri & Rajala, 2015; Hasselblatt et al., 2017). These steps help in determining stakeholder interests and purchasing criteria, to then ensure appropriate value communication and delivery (Hasselblatt et al., 2017). They thus emphasize the importance of understanding the customer, but also mention that the more complex the service, the more important this becomes (ibid.).

Tervonen et al. (2018) propose that Service Design provides tools to bridge the gap between data and actually understanding users. When using Service Design from the start, value creation and user-context understanding can be achieved based on the interactive and iterative process of Service Design (Tervonen et al., 2018). However, the authors also urge that new Service Design methods are needed to meet the challenges posed by IoT, but nonetheless Service Design already offers great use by bringing together not only designers, but also engineers and developers. Lastly, Tervonen et al. (2018) also emphasize the use of data driven design for Service Design.

The last paper from the systematic literature review is by Sayar and Er (2018), who identified antecedents of successful IoT service and system design. In total they identified six antecedents, which are: (1) communicating a well-articulated system design strategy; (2) redefining frontline employee roles and responsibilities; (3) training and recruiting service aware staff; (4) providing guidance to customers on system use; (5) aligning customer focus across the business; and (6) utilizing methods for systems thinking and creativity. Furthermore the authors found that with IoT, a new set of design principles is needed, as challenges such as personalization of service arise. However, this also means that a new level of design is needed, to seamlessly integrate design and technology, but also to create new customer experiences, which also entails that the role of customers will change. It is thus important to focus on, and understand customers throughout the whole process, and also to emphasize relationship building with users (ibid.).

As can be seen, even the few papers from the Systematic Literature Review only analyzed the relationship between Service Design and IoT quite superficially. While some papers had too strong of a focus on IoT itself, other discussed the relationship of IoT and Service Design from an IoT perspective, thus missing the point of this research, as the objective is to find how Service Design can facilitate design of IoT.

Carpanen et al. (2016) generated some very good insights into the possibilities Service Design can offer IoT design, but none of the articles analyzed the whole Service Design process in depth for each stage and looked at the different Service Design tools available. Most papers lightly touched on Service Design, and if so mostly used the approach of Multi Level Service Design (Patricio et al., 2011). This analysis shows the big gap in current literature, but the work analyzed also supports the importance of this research. Some called for new Service Design tools/ methods, as the challenges posed by IoT do not seem answered by current methods.

This systematic literature gives sufficient reason to further investigate the effects of Service Design on IoT development, also investigating the Service Design tools that can be used in each stage of the design process.

3.2 Service Design

Service Design breaks with traditional design approaches and has shown to be useful when designing for service innovation. However, it has been quite a journey to derive the current state of Service Design.

Service Design has been evolving since it was first considered its own discipline in the 1990's (Sangiorgi et al., 2019). In the recent years different perspectives influenced and shaped todays view, such as service dominant logic, or service design as part of new service development. However, voices have been raised that current Service Design and Service Design tools are not enough for the challenges posed by new technologies, such like the IoT (Shin et al., 2016; Hasselblatt et al., 2018).

In one of the early works on Service Design, Edgett (1994) found characteristics and activities performed that lead to successful services. He grouped these factors into the categories of organization, resource allocation, formalization, preliminary assessment & design testing, market research & market potential, financial analysis & project updates, market synergy, and lastly launch effectiveness. In short, Edgett found that it is necessary to know your target group from the very beginning and do extensive research on this group before starting with any other steps. He thus concluded that successful outcomes are carefully managed and do not just happen randomly (ibid.).

A few years later Edvardsson and Olsson (1996) suggested that companies do not deliver a service to customers, but only the prerequisites to service provision. This is based on the finding that each customer sees and evaluates a service differently, as every customer has different needs, wishes and expectations, all of which the assessment of their quality is different for different customers as well. Today researchers agree that companies can only deliver a value proposition, and the value and the experience that the users perceive are subjective (Wetter-Edman et al., 2014). The aim of Service Design has thus changed over the course of time. Today, its goal is to create good value propositions, which are carefully planned, as the main goal is to enhance the user experience. Different approaches to do so have been found in academia, but before looking at the different approaches of Service Design, a common understanding of the term Service Design is needed.

3.2.1 DEFINITION

A variety of definitions for the term Service Design can be found in academic literature. An early definition for Service Design was given by Mager (2004) seeing Service Design as a process of organizing and planning, which thus incorporates people, infrastructure, communication, and the material components of a service. This definition is based on the purpose of enhancing the

quality of services, by improving the interactions between the customer and the provider, but also by enhancing the customer experience when using the service (Mager, 2004).
A definition that adds to Mager (2004) was given by Dubberly and Evenson (2010), who found that service design has the means to provide services that enrich the needed qualities for an organization that bring economic and strategic value.

However, one of the most widely accept definitions for service design today is the one posed by Meroni and Sangiorgi (2011), as they define Service Design as a human centered, creative, collaborative, and iterative approach for the design of services, and especially service innovation. This definition will be leading for this thesis, as it takes into account the large network of stakeholders that can be affected and involved with Service Design, while user centered approaches are narrower and do not take other stakeholders into account (ibid.).

3.2.2 DIFFERENT PERSPECTIVES ON SERVICE DESIGN

Over time multiple approaches towards Service Design have been explored in academia. One of the early perspectives is a model from Edvardsson and Olson (1996) which consist of the service concept, the service process, and the service system. The proposed model is based on different stakeholder groups, such as customers, company staff, the organization, but also the environment (Edvardsson & Olson, 1996). They start by identifying different customer needs and how these needs are met by the content and design of the delivered service, followed by focusing on the activities that need to take place for the service to come together properly. The last step is then to describe the necessary resources to undertake the service concept.

In 2011 Patricio et al. proposed the Multi-Level Service Design (MSD), which is a rather practically oriented approach compared to others. The MSD combines different fields and designs of the service offering, which is done for the different levels of the customer experience. This approach shows that “organizations cannot design customer experiences, but service systems can be designed for the customer experience” (Patricio et al., 2011, p.183). Four steps for the MSD are proposed, which start by understanding the customer experience. Only if the customer experience is fully understood, it can be continued with the design of the service concept, which is done to understand how value is experienced by the user, so that the service is designed with customer value in mind. The next steps are then the design of the service system and the design of the service encounter, so except for the very first step, the approach of Patricio et al. (2011) shows quite some similarities with the approach from Edvardsson and Olson (1996). It should be pointed out, however, that this approach is of much higher practical relevance and emphasizes the understanding of the customer experience.

Wetter-Edman et al. (2014) showed in their work the differences between the service (dominant) logic approach and the design for service perspectives. In the service (dominant) logic, a framework is provided to gain deeper understanding of the service systems in action, which focused on how the actors integrate resources to co-create value. In the design for service

perspective on the other hand, co-design approaches are used, which leads to value co-creation during the actual design process and not only during use (Wetter-Edman et al., 2014). Next to distinguishing between different approaches to Service Design, also differences in co-creation of value have been pointed out. While often value co-creation refers to value co-creation during use of a service (Vargo & Lusch, 2004; Wetter-Edman 2011), co-creation can also be defined as something where both customer and company perceive economic, emotional, and social values (Karababa and Kjeldgaard, 2014). Literature, in general, agrees that value is co-created in use, and that organizations who provide a service to their customers act as facilitators by offering a value proposition, a configuration of resources, in a service system, where the customers and other users co-create value when interacting with the service system (Wetter-Edman et al., 2014).

Kimbell and Blomberg (2017) propose three approaches to the objects of Service Design, which are the Service Encounter, the Value co-creating System, and the Socio-material Configuration. The Service Encounter starts by understanding the experience of users when engaging with the service touchpoints during the service encounter, which is closely linked to Patricio's view. However, the value co-creating system sets its focus "on the exchange relations between actors in a service system" (p.85). This approach thus focusses more heavily on the stakeholders within the system, instead of solely focusing on the end user. The last approach proposed is the socio-material configuration, which allows to explore how the service is dynamically assembled in practice (ibid.), which again shows some similarities to Patricio's MSD due to the high practical relevance of the approach.

Finally, Stickdorn et al. (2018) summarize the main evolvements and changes that happened in Service Design from 2010 to 2017. The authors found that a change from user-centered Service Design towards human-centered Service Design has happened. This transition is especially emphasized in the work of Sangiorgi (2011), who introduced human-centered Service Design in 2011. The next main finding is that instead of a co-creative approach, a collaborative approach towards Service Design is emphasized now, with a new understanding that this is also an iterative process. Stickdorn et al. (2018) propose to look at Service Design from different perspectives, as Service design can be a process, a toolkit, or a mindset. While in the mindset the user is the point of focus, the process rather focuses on finding innovative solutions, but all three perspectives should be kept in mind when doing a Service Design project.

3.2.3 SERVICE DESIGN TOOLS

Service Design has evolved over the years, together with the challenges that designers were faced with. From a purely user-centered view to a human-centered design approach. However, the tools presented by Service Design might not be enough to solve future design problems.
Many tools are available, such as personas, customer journey maps, or prototyping, and will now be discussed, as they all follow the design approach from today's Service Design.

Personas

Personas are a tool that is often used in Service Design projects, as this creative tool offers the chance to get more knowledgeable about the different stakeholders (Stickdorn et al., 2018). Personas are basically fictional characters which are created based on information and research that has been done on the specific stakeholder group, thus the information used for the persona is based on actual knowledge and not purely fictional (Cooper, 1999; Pruitt & Grudin, 2003). Personas can vary in depth and detail, as they can be a CV-like document, but also collages or diary entries are possible option (Pruitt & Grudin, 2003). This tool offers a chance to make stakeholder groups less abstract for designers and can also be a useful starting point for stakeholder maps (Smartsheet, 2020).

Customer Journey Maps

Customer Journey Maps have proven to be a useful tool in Service Design, as they support going in depth on the journey by identifying the most important touchpoints. Knowing the touchpoints of the user with the service is essential for designing with user value in mind. This way designers know where critical interactions happen and are thus able to change or improve the design of these (Stickdorn et al., 2018). Customer journey maps can be done for all involved stakeholders; however, focus should be on the most relevant stakeholders, which often are the users of a service (ibid.).

Prototyping

In Service Design prototypes can be used to create, or stage an experience (Stickdorn et al., 2018). This can be done for designers to understand and explore the user experience with the service and thus to design for value co-creation (Yu & Sangiorgi, 2018). Prototypes can be used during different stages of the service design process, as they are useful to designers throughout the project to identify problems and improve the design (Stickdorn et al., 2018).

Especially considering IoT projects, prototypes can take on different forms, as they could be mock-ups, rough drafts, or working pieces of software. Depending on the type of the prototype designers can learn how users interact with the service, which is very valuable knowledge. With prototypes the user interaction can be tested in a safe space that allows for failure and offers the possibility to learn and improve not only the design, but also the use of resources (Yu & Sangiorgi, 2018).

Concluding, Service Design presents a wide variety of tools and methods to design for value co-creation, however, in order to adequately respond to new challenges posed by IoT and other technologies, new approaches in Service Design seem likely to be needed (Sangiorgi et al., 2015; Yu & Sangiorgi, 2018)

Considering the evolvements in IoT, it will be interesting to see which Service Design approach of the before mentioned is sufficient. Patricio's et al. (2011) practical approach of MSD might be well suited, while Kimbell and Blomberg's (2017) approach could be restricted, as the focus shifts from stakeholder interaction to human and machine interaction.

However, IoT not only poses new challenges, but it also gives designers resources. With the rapid evolvement and use of IoT big data is created, which can be used to gain further insights into different stakeholders. How data driven design plays a role will be further examined in section 3.3.5 of this article.

3.3 Internet of Things

To get a clear picture of what IoT entails, it is necessary to know what IoT consists of, what state the technology is currently in, and what IoT is envisioned to be in the future. To understand the vision of the future IoT, the issues that IoT presents today need to be taken into account, as these determine possible directions of development.

3.3.1 DEFINITION

IoT has gained quite some attention in academia in recent years, however, definitions still vary. In the most basic view, IoT can be defined as connecting physical objects through the internet (Wang et al., 2017). Yet, to understand what this means in entirety, there is also a need to define “things” and “internet”. Shang et al. (2016) define “things" as the ends of a heterogeneous network, which generate input and deliver output. Furthermore they define internet as the network that enables different objects and networks access.
For the purpose of this paper, a definition is needed where the before mentioned definitions are not only combined but are also put in perspective. The IoT is a smart connected network of objects (the things), which can communicate with each other, but also with the user, which is enabled through the internet. The definition used to guide this paper will thus be the one of Haller et al. (2008), who defined IoT as

> “A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these „smart objects„ over the Internet, query their state and any information associated with them, taking into account security and privacy issues” (p.2).

Depending on the direction of research, different purposes of IoT have been identified and emphasized. Gubbi et al. (2013, p.1646) view the main goal as enabling computers to “sense information without the aid of human intervention”. While for Haller et al. (2008) the role of IoT is to overcome the gap between the physical world and information systems. Shang et al. (2016) propose that the role of IoT is to optimize business and service models. Other purposes have also been named in literature, however, for the sake of this research the purpose proposed by Shang et al. (2016) will be leading, as this research focusses on the design of services provided by IoT.

3.3.2 CURRENT STATE OF IOT

IoT devices are often referred to as the 'things' in literature. Shang et al. (2016) define the former as the ends of the system, which are responsible for in- and output. Porter and Heppelmann (2014) go even further into detail, stating that these products consist of three parts: the physical part, the 'smart' part, and the connectivity parts. The physical parts are what can be referred to as the electrical and mechanical parts that make up the basis of the product; the 'smart' comes in via sensors, controls, and software; finally, the connectivity is achieved by ports and antennas that enable a wireless/wired connection (Porter & Heppelmann, 2014).

These IoT devices, often also called smart products, offer great new opportunities. These opportunities can be categorized in four main areas, which are monitoring, control, optimization, and autonomy (Porter & Heppelmann, 2014). These areas tend to build on each other, so that a product in the control category can control and monitor, but a product in the monitoring category can only monitor.

Monitoring can be done for the product condition, the external environment of the product, how the product operates and for the usage of a product, and alerts and notifications can be sent by the product when in use (Porter & Heppelmann, 2014). A product in the control category can have control of product functions, and thus also offers the personalization of the user experience (Porter & Heppelmann, 2014). Building on the former are products in the optimization category, which can optimize for a better product performance by service and repair functions (Porter & Heppelmann, 2014). On top of these is the autonomy category, where products have autonomous operations and self-coordinate with other systems. Furthermore, they also enable product enhancement and personalization of the product, next to self-diagnosis and service (Porter & Heppelmann, 2014).

3.3.3 FUTURE OF IOT

To advance further in IoT and overcome the challenges that the current IoT poses, some requirements were posed by Gubbi et al. (2013), such as securable, scalable, and efficient computing that is also market oriented. Gubbi et al. (2013) also address that the storage of data will be essential. To achieve these goals it is essential that developers and designers can make sense of the collected data, which in turn requires new algorithms, but also a modular architecture is proposed both for the soft- and hardware, as the future IoT requires an open architecture for interoperability (ibid.; Wang et al., 2017) As the future IoT is often envisioned as independent from the network and device, it also requires that simplicity is provided to non-expert users (Wang et al., 2017)

The future IoT should thus be modular, loosely coupled, and have globally consistent interfaces, as these features provide mixing and matching between service components, which allows for customization of services and reduced development time (ibid.).

3.3.4 CHALLENGES

With IoT, a number of new challenges may arise that need to be considered in the development. One of these challenges is the design of IoT software and hardware, as it differs from before known technologies. Also issues regarding governance and ethics may arise, as regulations and laws regarding data need to be considered in the development. Another relevant topic here is ethical design, as IoT may work with sensitive data.

Design

With IoT devices emerging everywhere, new design principles are needed (Sayar & Er, 2018). As these devices are still very new in nature, industry standards are still lacking (Wang et al., 2017). Partly due to missing standards, there are very diverse communication patterns present and thus a lack of scalable frameworks arises (Wang et al., 2017). To solve this issue of standards, an open architecture is needed to bring together such heterogeneous sources (Wang et al., 2017).

In current IoT platforms many constraints are present that hinder the development of future IoT, as at the current stage IoT is not device or network independent (Wang et al., 2017). Also, the cost of single sensor devices is still too high to connect many objects (Wang et al., 2017), which also affects the possible design ideas.

New design principles that gain momentum with IoT devices are designs that enable personalization, designs that allow for ongoing software and product updates, but also designs that achieve hardware standardization (Porter & Heppelmann, 2014).

For designers, it is also important to keep in mind that not everything that is possible to incorporate is also accepted by the customer (ibid.), which is why it might be preferable to keep close contact to users and customers during the different design phases. However, designers also face the challenge that users often are restricted in expressing their wants, as they are often unable to know what even is possible. Designers thus need to find what brings value to customers relative to cost (ibid.), sometimes without having the guarantee that it will work.

In order to design for future IoT devices that connect people and objects even further, a few suggestions have been made in academia. Wang et al. (2017) propose to use the service-oriented architecture (SOA) as a design principal that is not limited to specific technologies or WS-standards. They further go on to suggest modularity and loose coupling of components in IoT devices, as it makes reuse of certain components possible, and thus also architectural innovation. To make future IoT devices even better, they should also not be hard-coded and pre-configured from the start, as it needs to be possible to remove or add connections between objects and services while not influencing other connections (ibid.).

Governance & Ethics

With the emergence of IoT enabled devices many questions regarding governance and ethics issues arise, which are of high importance to be answered and implemented for these devices to not only work properly, but also for these devices to be accepted in the population. IoT

enabled devices offer many new ways in which data is created, but also shared among devices. These new ways require new and adapted laws and guidelines to ensure the rightful treatment of the data, which often contain sensitive information.
Moreover, issues with ethics may arise, as IoT enabled devices take over decision making, varying in extent, for humans. Especially looking at the example of self-driving vehicles, questions arise about who is liable in the case of an accident? As IoT enabled devices are rising to be more and more involved in every day decision making, such questions need to be answered.
To be able to solve for data privacy issues, future IoT devices should support distributed data accessing, processing, storage, and ownership, especially since there will be many IoT devices that will generate big real-time events where object property values change all the time (Wang et al., 2017).

3.3.5 DATA DRIVEN DESIGN

Even though this paper looks into the effects of Service Design on IoT development, it should be taken into account that with the rise of IoT and the big data these devices produce, data driven design can be of relevance when designing for IoT services. As it is not the main focus of this research, but still a relevant aspect since data driven design can influence Service Design tools, a small review of the current academic literature is appropriate.
Data is often considered a by-product of the primary product, but it can be useful in innovation processes (Trabucchi & Buganza, 2018). IoT creates a lot of data, which can be distinguished by the categories of big- and thick-data, where big data gives insights at the macro level, and thick data gives insights at an individual or group level (Griffith-Jones, 2020). Both types of data are key resources in the value creation for customers, as they both offer different kinds of insights (Griffith-Jones, 2020). Based on this data designers can learn to understand why something happens, and from that also gain an understanding of what likely will happen (Griffith-Jones, 2020). The insights derived from data can be of high value to designers, as so far unknown insights are generated. These insights also offer new opportunities for customization of services that have previously not been possible.

Next to the insights that can be generated from data, it should also be distinguished between different types of data driven design. In their work Speed and Oberlander (2016) distinguish between three types of data driven design, which are designing from, with, and by data. Designing from data is utilizing known methods from which designers can gain understanding, such as interviews, while designing with data incorporates data as a critical resource for designers to understand, to be able to design artifacts while being connected with a user, which can be done by diverse digital ethnographic methods (Speed and Oberlander, 2016). The last type is designing by data, so “when systems are designed by other systems, largely autonomously, where new products and services can be synthesized via the data-intensive analysis of existing combinations of humans, computers, things, and contexts” (Speed and Oberlander, 2016, p.9). Designing by data is the most advanced of the three approaches but is

also the least used today. Usually design from data is the standard which can be seen in industries today, while design with data can already be seen in academia. As design by data is not used yet, it shall not play a big role in this article, however, the approach should be analyzed regarding its opportunities and challenges in future academic work.

To summarize, IoT is made up of a physical and a software part, which together create the service aspect of IoT. IoT aims to fulfill different purposes, in this research focusing on enhancing the service model. Challenges may need to be overcome when designing for IoT, mainly due to a lack of standards. However, data privacy also poses to be a main concern when designing for IoT. IoT development could be enhanced by data driven design, but academia and use in practice may be advanced to different stages here.

4. Interview Findings & Analysis

Within this section the outcomes of the interviews are discussed. The detailed outcomes of the interviews can be found in Appendix 8.3. As the interviews were analyzed according to the Gioia method (Gioia et al., 2013), the different aggregate dimensions will be discussed separately. At the end of this chapter a conclusion is drawn from all findings. Everything presented in this chapter is based on the interview findings, and it does not including any information from the literature review or other sources of information. Furthermore, no conclusions are drawn at this point that exceed the interview findings.

4.1 Tools

As a main objective of this research is to find if and how Service Design can facilitate design of IoT, interviewees were asked about the Service Design tools that are used in IoT projects, also compared to more traditional Service Design projects.
There are traditional Service Design tools such as customer journey maps, service blueprints or personas, but findings from the interviews show that tools are not a focus point and that tools have to be adapted frequently to be useful to individual projects.

4.1.1 LESS FOCUS ON TOOLS

While Service Design tools are useful in many projects, the focus should not be on the tools. Service Design is about understanding and solving user needs, and while tools can facilitate these, they are not the focus point of Service Design. Tools should also not be seen as rigid, as depending on the specific problem at hand they need to be adapted and changed. As all tools have a different purpose, it is about understanding the situation and using the tools that are valuable for the cause.

4.1.2 CHANGING TOOLS

With IoT, the adaptation of tools goes even further, as the challenges faced by Service Designers also change. It can thus be useful to borrow tools from other disciplines or integrate these with the commonly known tools in Service Design. Especially, as data becomes a topic, it can be useful to create maps for data flows or integrate data in journey maps. Understanding where data comes from and the meaning behind it are important to capture in Service Design projects to fully use its potential.

> "If a customer journey map has like an extra layer that you put on top of it or something like that. I think that would be nice to have commonly used tools." (Interviewee 6)

Efforts to integrate data into journey maps have been made by two interviewees already, by developing the IoT Service Kit and the design Kit for IoT. Other interviewees referred to these two tools in a very positive way, also mentioning that they adapted them to fit their own specific needs.

Also new tools for prototyping are needed, as with IoT there is a need to prototype a use environment, where the physical and digital interact. With IoT Service Designers can also create their own tools if there is no existing one that is suited for the situation, as again, the focus of Service Design is understanding and serving user needs.

4.1.3 TRADITIONAL SERVICE DESIGN TOOLS

There are many known Service Design tools that are commonly used in practice. Often used in user research are qualitative research methods such as interviews, to get a thorough understanding of the users and their needs. Observations or ethnographic studies are also used frequently. When doing interviews or ethnographic studies, empathic listening is also of high value to get an even deeper understanding. The findings from this qualitative research then lay the foundation for the tools used in later stages of the design process.

To confirm the findings from qualitative methods, quantitative methods such as survey research are used often. Surveys allow to get answers to assumptions from a bigger sample size than interviews. Qualitative and quantitative methods thus often go hand in hand.

Journey maps are also used quite frequently in practice, as they can be used as a design tool, but also as a communication tool. Journey maps also allow to add an extra layer that may be needed with IoT, such as a layer for sensors or data flows.

A newer version of journey maps used in practice is the north star, which usually starts with a vision, from which several roadmaps that come together in end are developed. Personas and archetypes are also popular, as they can give a deep understanding of the different user groups. However, if the aim of the project is to impact customer behavior, archetypes might be used rather than personas.

Another often used tool is, of course, prototyping, which can happen in many different shapes and ways, but is often a great tool to test an idea before bringing it to market.

4.1.4 NEWER TOOLS

With technological innovation and in particular with IoT Service Designers needed new tools. Many of these new tools can be summarized as digital tools. Those are tools such as Miro that digitalize previously known tools for ease of use, but Service Designers also used entirely new tools that they created in-house in their companies. Such tools can be used to visualize user stories or do prototyping in VR. During the pandemic also new tools had to be found for user research, where things like Zoom calls or even surveys on WhatsApp were used. These also offer the possibility to do user research across borders.

There is one outstanding new tool that is used widely in the industry, called the 'IoT Service Kit' (Figure 2 & 3), which was developed by Futurice (2016). The IoT Service Kit is built like a board game, and thus acknowledges the tangibly of IoT. It has differently colored figures which each represent different things in the game, such as users or sensors. During the interviews this tool was mentioned often by Service Designers, as they use it as it is or even developed it further to fit their individual needs. The IoT Service Kit thus presents a co-creative way to explore user-centric and interactive scenarios. The way this tool is built also allows multidisciplinary teams to use it and is not limited to only designers (SDN, 2017).

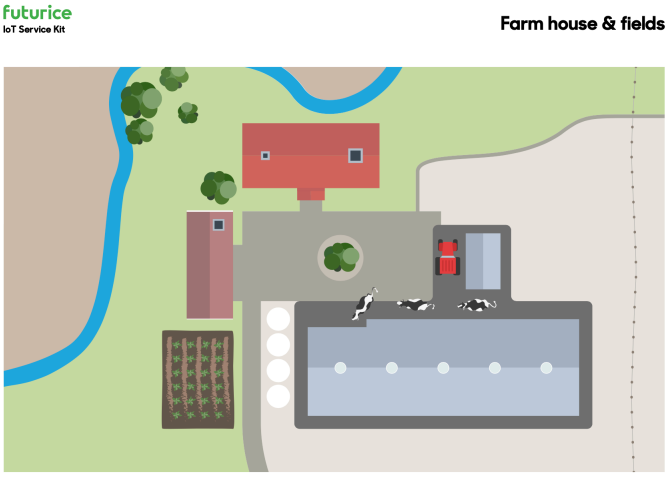

Figure 2: 'IoT Service Kit': Map (Futurice, 2016)

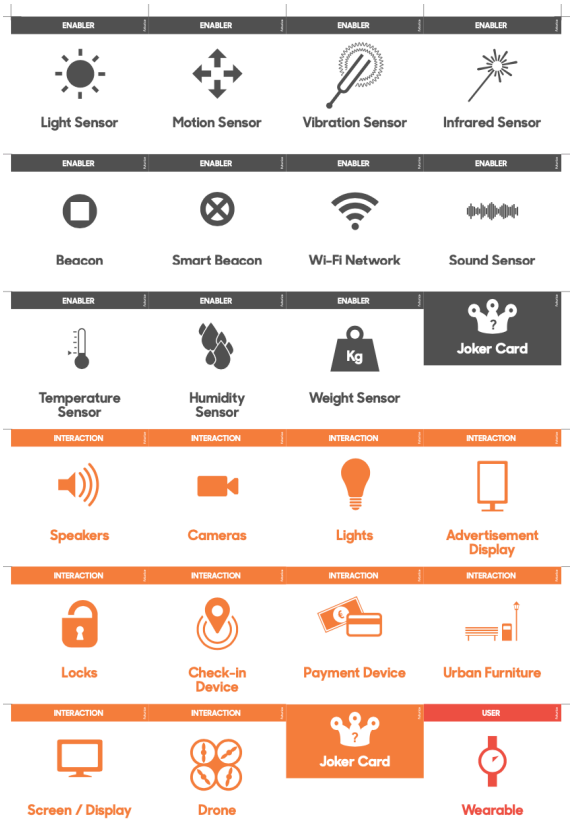

Figure 3: 'IoT Service Kit': Cards (Futurice, 2016)

Building on the ground of the 'IoT Service Kit' is the 'IoT Design Kit' (Studio Dott, 2019; Figure 4), which was created for the practitioners. The Kit is made up of five main parts which can be changed in order depending on the starting point of the project. Thus, each of the five activities can also be seen as a standalone activity. This tool is this useful as guidance throughout the design process, while the before mentioned IoT Service Kit is useful for ideation and understanding, as well as planning, of the user journey.

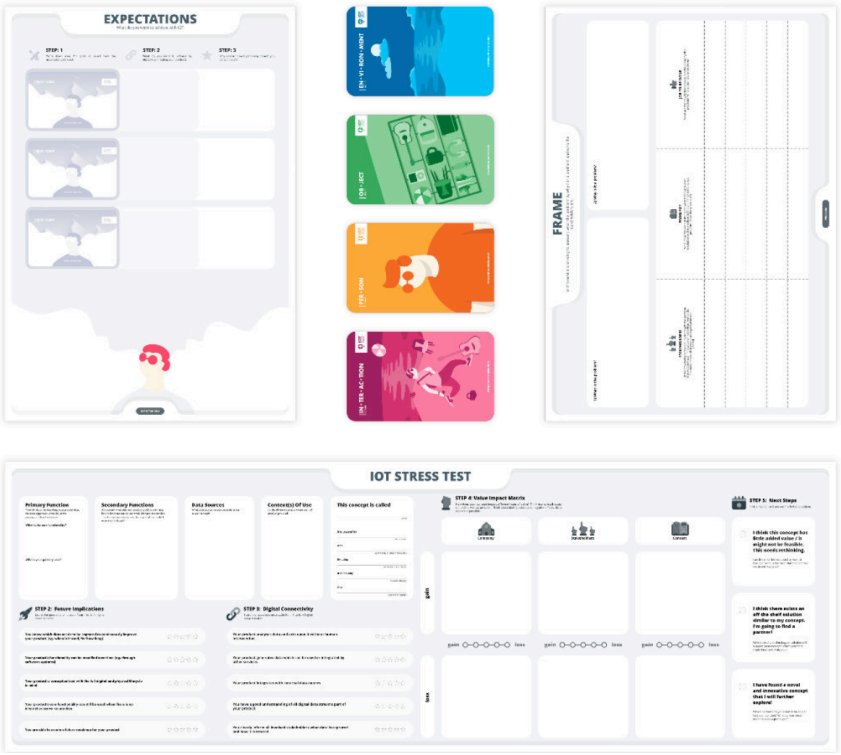

Figure 4: ‘Studio Dott (2019) IOT Design Kit’ - iotdesignkit.studiodott.be

4.2 Challenges

During the interviews, different challenges were found that Service Designers face when dealing with IoT projects. The challenges differ widely, from communication difficulties to restrictions due to regulations. All these different challenges are combined in the aggregate dimension of challenges. In this aggregate dimension seven different second order themes were identified. First these second order themes will be discussed, before drawing a conclusion for the aggregate dimension.

4.2.1 STAKEHOLDER MANAGEMENT

Stakeholder management is the first identified second order theme. When designing for IoT, multiple relevant stakeholders must be included in the process. Especially relevant in the case of Service Design projects for IoT are the Service Designers, engineers, and programmers. As IoT is made up of a physical product and software that lead to the service outcome, interdisciplinary work between the designers and engineers is highly relevant. However, in practice it can be observed that these groups often do not work aligned with one schedule, but rather siloed. This leads to several problems concerning viability and feasibility. Practitioners in Service Design thus described their ideal IoT projects to be driven by interdisciplinary teams, where all relevant stakeholders are included very early in the design process.

One reason for the discrepancy between designers and engineers is the communication, as naturally the two parties have very different mindsets and background knowledge. Finding a

common language that both parties understand is often difficult, but also offer the opportunity for Service Designers to step up and make use of the communication tools in their portfolio.

4.2.2 CLEAR COMMUNICATION

Clear communication was identified as the next second order theme. As discussed, communication between the engineers and Service Designers is one of the main issues found in the interviews.

Furthermore, communicating the importance of Service Design exercises was also found to be of relevance. Especially in technology push projects, Service Design practices tend to fall short. However, making use of Service Design tools can enhance the IoT project, as it is then more customer focused, which can enhance value co-creation greatly.

Adding to this is that Service Designers are faced with having to communicate the value of Service Design in the first place. Service designers have a varied skill set, which can sometimes be overlooked. Service Designer thus often need to use their voice to communicate why it is of value to use Service Design. This can especially be relevant in innovative projection using new technologies, such as IoT, as these often stem from a place of tech push and engineering mindset.

4.2.3 COMPLEXITY OF IOT

As IoT is made up of a physical, a digital, and a service part, different challenges arise due to this complexity. Especially for Service Designers this can be an issue, as it can be difficult to design such an interaction. A purely screen based prototype for example does not fully capture the physical aspect of IoT. The context in which the IoT is used however is one of the main aspects of IoT design. This also includes designing the environment in which the IoT is used. Also adding to this is the differentiation between different users, but also sensors and devices. IoT often requires the user to interact with a device, which in turn might interact with different sensors, thus designing the entire experience becomes complex due to the many factors that need to be understood and designed for.

4.2.4 STICKING TO THE STATUS QUO

Another challenge is sticking to the old design status quo when designing for IoT. Opportunities might be missed this way. An example for this is smart scales. Such scales would have an app that shows progress and other relevant numbers, but the interface on the scale would only show the weight. However, an app would not have been necessary if the interface on the scale would have shown things like progress in the first place. But, by sticking to the old status quo that a scale only shows the weight, this opportunity was missed for a long time, even though it might seem to be an obvious thing to do. This example illustrates how service designers can facilitate the design of IoT, as they have the tools at hand to explore new ways of doing things.

Another thing that adds to this issue of sticking to old designs is being stuck in an old mindset when working with IoT. One of these problems is understanding that IoT requires continues

testing, which is different to traditional hardware products. Next to testing also continuous software updates are often necessary, which requires continually going back to the IoT.
Another challenge for traditional engineering driven companies is thinking and designing from a user perspective. It is necessary to do user focused research, which has to be integrated in the company culture and processes. All these things may require a change in company culture, which can also lead to friction.

4.2.5 TECH PUSH

As already touched by sticking to the status quo, IoT often happens due to a tech push. Bringing technology to the market without having done user research brings its own unique challenges. Projects often fail if the user does not care for the product, so with a tech push this issue can come unexpectedly. A technology such as the IoT has to fit into the users life and create value for them. Simply bringing IoT to the market because it is a hype in the industry does not mean user needs are met. However, companies sometimes go through with such projects as they may feel like loosing an opportunity if they do not keep up with trend technologies.

4.2.6 EXTERNAL DESIGN RESTRAINTS

A few challenges for designing IoT are posed by external reasons. One part of external reasons are restraints due to regulations and laws. Some information that might be required for a service to work as designed might be confidential and protected by data laws, which in turn means that these either cannot be used or require active agreement by the user. These constraints do not necessarily make IoT unusable but depending on the context can hinder innovation. Especially in designing IoT for home security these regulations can pose many restraints.
However, as technology is rapidly developing there are also cases where none of the currently existing regulations may apply. One of these instances is blockchain. In a blockchain it is not possible to remove data, which usually should always be possible, but there are no regulations for this case, at least in the current versions of the GDPR and the German DSGVO, which makes pursuing such a technology somewhat risky.
Another external challenge is posed by cultural differences, as designers are often asked to design projects in different countries. Understanding the local culture is this highly relevant, as different cultures are also likely to respond differently to a specific IoT design.

4.2.7 TIME CONSTRAINTS

Time constraints when designing for IoT are a big challenge for practitioners in Service Design, and one of the main challenges that is often encountered.
Some of these time constraints come from unmet expectations, as it sometimes may take longer than anticipated to get in contact with the main stakeholders. Doing user research thus does not always go as fast as planned. Additionally, there are also time constraints posed by the start of the project, which is especially relevant in consultancies. Clients are not always willing or able to

spend a lot of money on consultants, so a project naturally is limited by budget and time. With such time pressure tradeoffs must be made, which can in turn pose their own unique challenges.
Additionally, unique challenges come with IoT and automation. Especially with automation, a time sensitive system may fail and lead to frustration in the user, but it may not be possible to solve this issue without human intervention. Such time sensitive issues must be designed for with IoT, but they may not always be obvious. IoT thus may in general need a bigger timeline than other projects, as there are many things that can go wrong.

4.3 Service Design as Enabler of Other Design Practices

In the interviews, participants were asked how they think Service Design will develop in the future, and how it has changed since they work in the field. All interviewees said that service design has great potential to be of higher relevance in organizations, such as being embedded more on a strategic level rather than only being used for project work.

4.3.1 STRATEGIC PORTFOLIO MANAGEMENT

Service Designers thus see Service Design as being of high value for portfolio management. Connecting Service Design to portfolio management can visualize how different things are connected, which overlaps exist and where products may even cannibalize each other. Having this overview also offers the change to connect user segments across multiple products. Good portfolio management that is user driven can also enhance the user experience. One example for this is Apple, as they have only a very limited number of devices available in each category, so the user is not overwhelmed when searching for a new mobile phone.
Having designers support the portfolio management also opens new market opportunities, as designers may find that an existing product could also solve problems of other users that were not accounted for beforehand.

4.3.2 DESIGN DISCIPLINES ENABLED BY SERVE DESIGN

During the interviews it was mentioned how Service Design could support or even evolve into system design, organizational design, ecosystem design, strategic design, and speculative design. However, as all interviewees agreed on the strategic role that Service Design can potentially have in organizations, it is important to differentiate between these different design disciplines. As most of them used a different design ‘name’ to describe this strategic importance, this finding should not be generalized in regard to the before mentioned disciplines.

4.3.3 RELEVANCE OF DESIGN IN ORGANIZATIONS

Still, Service Design should be embedded in higher levels of the organization, not only to support portfolio management and other strategic topics, but also to give design, and thus users, a voice. Service Designers are close to the users and have a high understanding of user needs and value

co-creation, thus they should be embedded in company culture and hierarchy. Only if design is taken seriously within the company, its potential can be used fully.
Service Designers are also relevant in determining a realistic cost overview, as they have a great overview of the projects they participate in. Especially with IoT many unforeseen costs can occur which could be uncovered by Service Design processes. With tools such as journey mapping and stakeholder maps, an overview and understanding are created and costs can be uncovered.

4.3.4 SUSTAINABLE TRANSFORMATION

Especially with IoT many companies experience a transformation from product to service orientation. As technology is evolving at a fast pace, it is also evolving into directions that are unexpected. This may imply that jobs that exist today are obsolete tomorrow. Such transformations can benefit from Service Designers expertise, as they can support such transformations. Making such transformations in an ethical fashion includes training employees and including them early on in the process. With automation and IoT many jobs become obsolete, but new ones open. It is thus important to manage such transformations early and with good stakeholder management.

4.3.5 VALUE PROPOSITIONS

With IoT also value propositions can change over time, as software updates enable different aspects for co-creation. This is an opportunity unique to IoT and other software driven products, however, it is also an opportunity that may be overlooked. Service Designers have a great mindset and tools at hand to explore these opportunities in adapting and changing value propositions.

4.4 Ethics

Even though ethics was not a topic that was specifically asked for in the interviews, every interviewee felt it was important to touch on the topic. Ethics in Service Design is thus important to discuss, especially since there are numerous things to consider in this debate, which are discussed in this chapter. Of course, IoT is one of the things that influences Service Design, but even more so does society. Thus topics that are important in society, such as climate change, must be reflected in Service Design.

4.4.1 DATA PRIVACY

The first ethical issue that comes with IoT is data privacy. Many people are concerned about their data, especially fearing to get hacked and having sensitive data stolen. However, not only getting hacked, but also having your Amazon Alexa or Siri listening in are concerns. These concerns are often translated to all kinds of IoT that people interact with. Often people are aware that their privacy is not always protected with such devices, and a lot of them are okay with trading their data for the convenience and value the IoT creates for them. On the other hand, there are people who would like the convenience, but are afraid of the consequences. And of course, there are also

people who do not want anything to do with this at all. It is thus the Service Designers ethical responsibility to keep these different users and their concerns in mind.
The Service Designer can thus discuss with other project stakeholders how much data gathering is essentially necessary, and how to be transparent about the gathering and usage of data with the user.

4.4.2 SUSTAINABILITY

Another topic that is raised by society is sustainability, which is especially interesting when looking at new technologies like the IoT. It is in the service designers responsibility to make the design sustainable, as the user is likely to care more about functionality and usability when it comes down to it. Furthermore, sustainability is not easily achievable with IoT, as technologies such as the blockchain or big data need a lot of energy and are often considered as unsustainable. The Service Designer's role is thus to see how to solve for a problem in the most sustainable way that is still viable, usable and feasible.
It is also important to define sustainability in this context, as sustainability goes beyond just Co2 emission. However, this discussion is not within the scope of this paper.

4.4.3 EMBEDDING ETHICS IN SERVICE DESIGN

As it has been voiced that Service Designers should act in a responsible manner with data, it seems only consistent to embed ethical design in the tools and processes of Service Design. This could for example be done by embedding ethics in well-established tools like the customer journey map, to make connections and implications to the other stakeholders and their interactions.
Service Designers can also use their role to voice concerns about ethics and data privacy to their customers. Especially concerning data gathering, as often data is gathered but not used.

4.5 Design Process

The design process of a Service Design project is highly dependent on the individual case; however, there are a few common trigger points. Some projects only aim at getting a proof of concept, while others aim at bringing IoT to market. These different aims can influence the length of projects and strategies used throughout, but also the order of Service Design phases may be changed.

4.5.1 REASONS FOR SERVICE DESIGN PROJECTS

Service design projects are done for several different reasons, two of which are either tech push situations or styling exercises. Tech push situations usually start with a technology without knowing which problem this is supposed to solve. Service Design then comes in to find a problem for this technology to solve, to be able to propose a value proposition and bring the product to

market successfully. Especially with things like the IoT tech push situations are common, as engineering driven companies want to use the new technology and bring it to market.
Styling exercises are more unusual for a project initiation, as the visual design is already set at the start of the project, which leaves less room for creative problem solving. In such a case designers are rather limited in finding opportunities to include technology to solve for user problems.

4.5.2 1ST PHASE: DISCOVERY

Traditionally service designers are likely to start their process with the first phase of discovery. During discovery the aim is to understand who the users are, which involves heavy user research. The service design process described by most interviewees is roughly oriented along the lines of the double diamond model. So really understanding the users and their needs, for this, personas and archetypes are often used tools. Personas or archetypes are carefully created based on user research done earlier in the process.

4.5.3 2ND PHASE: DEFINE ACTIONS COLLABORATIVELY

The second phase is characterized by defining the needs of users and understanding touch points between the user and IoT. This exercise is often closely linked to ideation, as it is an iterative process. Ideally all relevant stakeholders are involved in this process, to really find a well-fitting solution to the user needs. Of special relevance here is that “design can’t be top down” (Interviewee 4), so including all relevant stakeholders makes the project more likely to be successful.
The design process then continues with prototyping and again user testing, however, in practice service designers often must leave the project before this phase. Ideally, Service Designers should be included all the way through the project to make use of their skills.

4.5.4 ISSUES IN PRACTICE

Not being included in the whole process is only one of many problems that Service Designers face in practice.
Another issue adding to this is embedding research throughout the process. As Service Design is an iterative process, research should also be done continuously throughout the project. This is especially relevant for new technologies like IoT.
Adding to the research it is critical to not use unified metrics, but to evaluate each case individually based on the circumstances. Using metrics this way can be useful to get a deeper understanding of the user, which can then be validated by using qualitative research methods.

4.5.5 DESIGNING FOR IOT

When designing for IoT it is significant that different stakeholders work together continuously. Thus embedding engineers and software developers in the design process is of high relevance. Without having these stakeholders included in the process the full potential of IoT could not be used, as it is valuable for Service Designers to understand what IoT does and how it works, at

least at a basic level. It can thus also be useful to add a layer to a journey map to connect IoT and users.

4.6. Internet of Things

IoT influenced Service Design in different ways, as it raised new questions for Service Designers.

4.6.1 QUESTIONS RAISED BY IOT

One of the main concerns IoT raised is sustainability. Especially with many products coming from a tech push without sufficient user research, a lot of IoT entered the market that is not useful to customers. Thus, the question arose if pushing out IoT without user value can be considered sustainable. Service Designers are in a great place to ensure that IoT that enters the market serves a need, and thus does not unnecessarily create waste.
Nowadays it can also be asked where IoT even starts and ends, as even smartphones have many sensors and can be considered IoT. Thus in Service Design projects nowadays, IoT is often present, even if designing for something else.

4.6.2 IOT'S IMPACT ON SERVICE DESIGN

The interviewed Service Designers also mostly agree that IoT does not change Service Design. The basics of Service Design, uncovering user needs and solving them stay the same even with IoT being present. If it is decided that IoT will be part of the solution it of course brings its own unique challenges, but so do most technologies. IoT is thus seen as an enabler to solve a problem, but in itself it is not seen as a solution by Service Designers.

4.6.3 FUTURE DIRECTION OF IOT

IoT offers a broad spectrum of opportunities, however, most IoT today starts by having a device connected to an app on a mobile phone. From a user centered perspective this step is quite unnecessary, especially if the device has its own interface or can be connected to smart watches or home devices like the Amazon echo. Many things can be done by voice control or other sensors, making an app obsolete from a user standpoint.

4.7 Service Designer

With IoT the role of Service Designers changed, as they are asked to tackle new challenges, but also because new and different stakeholders are part of such projects.

4.7.1 BROADER ROLE OF SERVICE DESIGNERS

The main finding is that the role of Service Designers broadened up due to IoT. For Service Designers the scope of projects, but also the variety of projects increases with IoT.

“the things I'm being asked to do and things I've been asked to look at, and the things our company has been asked to do and been asked to look at the scope. And the range is getting broader and broader" - Interviewee 2

With IoT the scope of projects is larger, as there are more stakeholders involved and the entire environment must be kept in mind when designing. IoT is often used in day-to-day things, where new problems arise such as battery life or serving software updates. But also questions regarding connectivity come into play, as a backup system needs to be in place if IoT is used for critical infrastructure. Service Designers thus feel like they will become more hybrid in the future, also having good knowledge in an additional discipline to Service Design. As one interviewee also said:

"designers are going to be, I feel they're going to be more hybrid. And that would mean some of them may be technologists, some technologists may become designers” - Interviewee 4

One of these disciplines may be business, as Service Design has potential to be useful on strategic levels. Service Designers already have a holistic overview of stakeholder management, but other skills such as leadership could be useful to occupy. Especially since Service Designers are often a mediator between engineers and other stakeholders, such as the end users. Thus, participants also called for Service Designers importance in strategic roles, implying even more change to the role of the Service Designer.

“moving towards more strategy. So, because inherently, as these […] service designers are, they work and do and they work, they're good with stakeholder management, they understand the back end systems, they look at things in a more systemic systems thinking manner. They, I envision them becoming more influential when it comes to making decisions like business decisions, or strategic decisions, or even influencing them at the leadership level for companies. And that's because they understand the ecosystem really well" - Interviewee 4

As mentioned in sub-section 4.4, Service Designers also expect their role to have more ethical responsibility in the future.

“I think the role of the designer, and the role of any person in tech is to become more ethical about themselves and about the things that they are producing, about the impact of the things they are participating” - Interviewee 3

4.8 Conclusion

The interview findings suggest that new or adapted tools are needed to support Service Designers in designing for IoT. Even though tools are not the focus of Service Designers, they are still needed to facilitate the design process.
IoT leads to many challenges, most of which are related to communication and ethics. New or adapted tools could thus also foster these issues in the future.
The role of Service Designers has broadened due to the challenges presented by IoT, and with such challenges, now may also be the time to discuss the strategic implementations of Service Design. Unexpected topics such as ethics and sustainability came up during the interviews, as these heavily influence Service Design, while the influence of IoT on Service Design seems to be more indirect in many aspects.
The role and opportunities of Service Design tools will be discussed in greater detail in the following discussion chapter (Section 5) of this paper.

5. Discussion

In current Service Design literature, Service Design is often discussed by using projects for illustration. It is distinguished by its different stages, and the tools used in these. Even though terminology differs between authors, the basic Service Design process usually starts with discovery, followed by defining, developing and delivery. This process is highly iterative and aims to be holistic (Stickdorn et al., 2018).
Based on the interviews it was found that while the basic steps followed by a Service Design project are aligned with literature, the process is not always holistic in practice. This is especially true for those Service Design projects done in consultancy agencies. Constraints such as time and budget complicate the Service Design process and hinder it to be holistic and sometimes also iterative. Thus, it is not possible to make any assumptions on how Service Design could facilitate IoT development solely based on the Service Design process.
In the following section, the findings from the interviews will be discussed based on the literature review. How the findings add to existing literature is a main concern. Furthermore, the findings will be discussed in relation to the Research Questions.

5.1 Level of Service Design

As this research aims at finding the ways that Service Design may act as a facilitator for design of IoT, it is also useful to determine on which level Service Design is being carried out when collecting data. In literature Service Design is often researched on a project level, but Service Design may also be used at an organizational level. This paper will use the design ladder to determine the level of Service Design (Figure 5). The Design ladder has been developed by the

Danish Design Centre in 2001, and has since found use by design agencies (DDC, 2022; Davies, 2019; HEY!BRAND, 2021).
The design ladder is a useful approach in this case, as it visualizes the level of Service Design present in the different cases. Determining the level of design shall be relevant in this case, as depending on the integration of Service Design in the organization it can also influence Service Design effects on IoT. To give an example, Service Design may be used in a styling exercise, leaving the Service Designer a narrow frame to work in, while much different design could be achieved if the project was started at an earlier point in the process, giving the Service Designers more chance to influence design. In theory, this means that the earlier Service Design is involved in the process, and the more Service Design is part of the organizational culture and mindset, the more possible design outcomes there are. Thus, if there are more possible design outcomes, this can also lead to a higher use of IoT for final design.

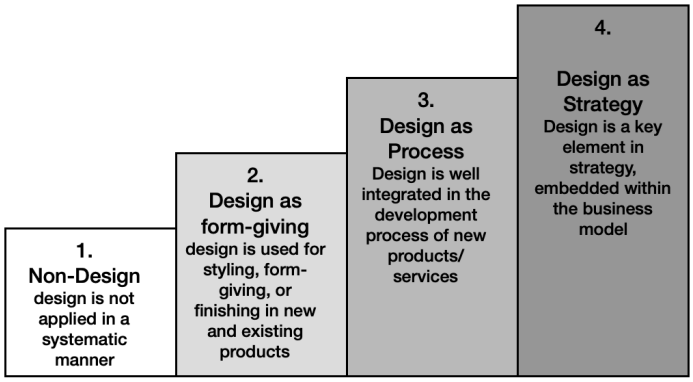

Figure 5: Design Ladder based on Danish Design

During the interviews it was found that the mentioned projects all were at different levels of Service Design, even though the lines between different levels are often not clearly distinguishable. Three specific projects discussed during the interviews were initiated by a technology push. Starting with a given technology already limits the possible design outcomes heavily, as the product itself is already quite advanced and many design aspects are fixed at this point, leaving less room for ideation. The interviews thus showed that even though in academic literature the Service Design process often starts with discovery of a problem, this is not always the case in practice. Based on the interviews, the main reason for this is the way that clients and agencies work, as clients may approach agencies when there already exists a problem.
To figure out how Service Design can facilitate IoT development, it is useful to focus on the tools used in practice rather than the Service Design process itself for now. Now, looking at the tools that were used by Service Designers in IoT projects, it can be found that mainly traditional Service Design tools were used; especially tools like customer journey maps, prototyping, but also commonly known user research practices were valued highly by the interviewees. The interviewees also argued that an IoT project is not different for them than any other project, as it does not influence what they do and how they do Service Design. Service Design always has a strong focus on the users, and aims at value co-creation, this aim is the same for all kinds of projects. Thus, in order to understand users, using traditional Service Design tools get the task done well during discovery and there is no need to further explore new tools. However, traditional tools are not always enough when actually designing IoT, especially prototyping for IoT poses to be difficult without additional tools, as IoT is made up of a physical element and a software element, which together create the service experience for the user.

5.2 IoT

While the outcomes of the interviews show that Service Designers do not approach IoT projects differently than any other Service Design project they are faced with, a few things differ compared to other Service Design projects. First, Service Designers use new and different tools additionally to the traditional Service Design tools. Second, the scope of relevant stakeholders shifts and thus also the depth of engagement with these during the design process.

5.2.1 TOOLS USED SPECIFICALLY FOR IOT

As mentioned briefly before, Service Designers still rely on the iterative Service Design process of discover, define, develop, and deliver with IoT specific projects. However, with IoT designers face a few new challenges that need to be addressed by tools previously unknown in the Service Design process. For the first stage of discovery, user centric research is conducted using traditional methods, showing that at this stage no IoT specific tools are needed.

During the second stage, needs, values, and touchpoints must be defined by the Service Designer. In this stage, tools like Miro were mentioned by participants, as it allows to collaboratively visualize the user journey. In this user journey touchpoints with the IoT Service can be mapped out on different levels of interaction. With IoT an additional layer is often added to journey maps or product service maps, as the sensors used for IoT need to be accounted for when designing the user journey. Next the IoT Service Kit, the tool developed by Futurice (2016), is also useful in this stage, as it allows to creatively discover and design the user journey, taking into account the tangibility of IoT while doing so. With the IoT Service Kit the less visible data layer is also clearly visible (De Roeck et al., 2019). The IoT Service KiT also allows for co-design by multiple stakeholders, as it is easy to understand and inviting to use with multiple parties due to its board game like character. Involving stakeholders in the design process is useful with IoT, as it allows to better understand how users interact with IoT and thus, how users co-create value.
These two tools are also of use during the third stage of development, as they allow to play around with different parts of the IoT service during brainstorming and ideation sessions. These tools solve for IoT specific challenges, as they address the tangibility and complexity of an IoT service.
Lastly, during the delivery stage prototypes and solutions are designed, which in case of IoT brings a multitude of challenges, as IoT is both a tangible product and a service. This poses to be challenging, as users may not be able to understand how the IoT works, or how it could create value.
Designers thus choose to create prototypes using AR and VR technology, as it offers the opportunity to acknowledge the tangible aspect of IoT, while simultaneously being cost efficient. Using these technologies multiple use scenarios can be designed and presented to stakeholders. Using AR and VR the user can interact with the IoT in a limited frame, but still has the chance to explore its functions and use. This also offers great opportunity to learn how users interact with the IoT, which gives new input for improving design further. Also useful in the stage of delivery is

again the IoT Service Kit, as it allows to prototype a use scenario in a tangible manner. This can especially be useful when introducing the IoT to a stakeholder group that is not technology savvy.

As seen in the SLR, literature on Service Design for IoT is limited, these insights thus give good ground for further investigation of Service Design tools for an IoT project. However, literature focusing on Service Design in general has shown many times the usefulness of established Service Design tools, which has also proven to be true when designing for IoT. Known Service Design tools are still the foundation when designing for IoT, only that those additional tools are required to account for the unique challenges IoT presents. Thus, these findings align well with existing literature, but also give reason for further research.

5.2.2 RELEVANT STAKEHOLDERS WITH IOT

Another deviation between IoT projects and other Service Design projects are the relevant stakeholders. During the interviews Service Designers mentioned that it would be useful to include end-users earlier in the design process when designing for IoT, as with IoT value co-creation is even more unique, as such services often offer a high degree for customization for the end-user. Thus, the needs of the different user groups need to be understood on a deep level to understand what options for customization need to be accounted for when designing the different user journeys.

With IoT, the collaboration between different disciplines also becomes highly relevant. In the best-case scenario, designers and both software and hardware engineers would work simultaneously and collaboratively throughout the development process. In the interviews it became apparent that this is often not the case in practice, however, the general agreement was that these stakeholder groups need to work together closely. Tight collaboration between the different disciplines can enhance the design of IoT, as designers and engineers can always find the best solution of what is feasible together. Thus, interdisciplinary work becomes even more important with IoT than it already was before.

However, to address this challenge in practice Service Designers could be more proactive in achieving this, as they are trained and knowledgeable in stakeholder management. They already have the tools and mindset at hand to overcome this separation of disciplines and can proactively work towards interdisciplinary teams. Service Designers are also the ones who can implement new workflows, as they know how to do user research, consider stakeholder concerns, and can design a process that achieves value co-creation for the engineers and Service Designers alike.
This could be a meaningful contribution Service Designers can make when designing for IoT, as they themselves are not knowledgeable in designing the IoT software of hardware, but they can ensure that those who know how to are brought together. Resource allocation is one of the strengths designers have, and thus a powerful tool to use when designing for IoT.

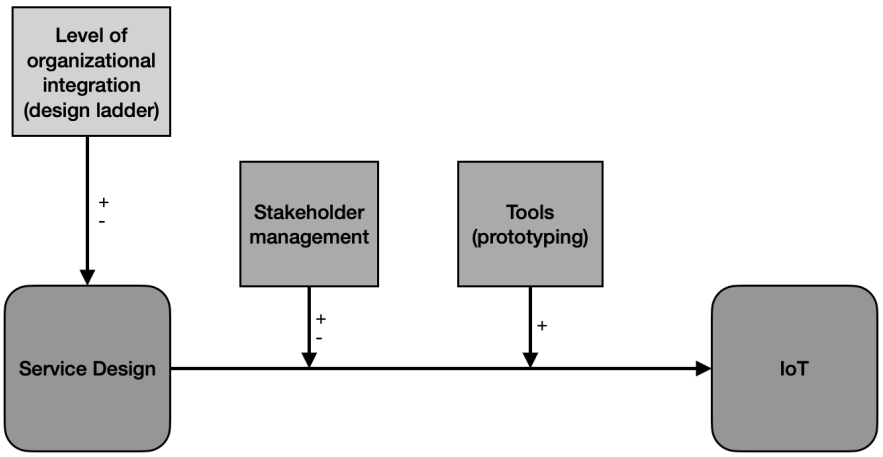

Figure 6: Theoretical Framework: Service Design as Facilitator of IoT

5.3 Future of Service Design with IoT

5.3.1 HOW SERVICE DESIGNERS EXPECT THEIR ROLE TO CHANGE

With IoT requiring a higher level of interdisciplinary work, it is also advantageous for designers to develop an understanding for such technologies. However, IoT is only one of many prominent technologies today, with things like big data or blockchain becoming more important as well. Thus, it could be useful for designers to become more knowledgeable in such fields as well. Or more generally it would be useful if designers were skilled in the main area their projects are usually based in as well. This is also backed by the interviews, as participants mentioned that it is not enough to only be knowledgeable in Service Design anymore. However, evidence from academic literature lacks in this regard and further research is needed to discover if Service Designers need to broaden their role and if so, to what degree. Nonetheless, Service Designers have experienced their role broadening up due to IoT already, which leads them to expect further changes to their role in the future.

Next to their role becoming broader, participants also called for Service Designs importance in strategic roles, implying even more change to the role of the Service Designer. There was a general consent between the interviewees that Service Designers shall become more relevant in strategic decision making in the future. Due to the nature of Service Design they are skilled at understanding the connections between different stakeholders, which enables them to identify the bigger picture and evaluate effects of possible changes to this system.

Furthermore, the designers also emphasized the importance of ethical design during the interviews, exceeding the ethical design for issues such as privacy and security with IoT, but discussing ethicality in design in general. Literature connecting Service Design and IoT so far has discussed issues concerning data privacy heavily, as it is one of the main concerns for adoption of IoT. Data privacy is also restraining possible design solutions, due to different reasons, such as concerns by users, but also data privacy laws such as the GDPR. On the other hand, Service Designers can use their knowledge to inform policymakers on how data may be used and the impact it may have, helping to increase ethical standards in data protection laws (Drew, 2018).

The emphasis on ethics also aligns well with the call for more strategic roles of Service Designers, as Corporate Social Responsibility has been a rising topic for years. Service Designers always have the user in mind when designing, which also includes that their design shall not have any negative impact on the stakeholders. As the human-centered focus of Service Design already assumes ethicality, this offers opportunity to create awareness within other stakeholders.

6. Conclusion

This research studied Service Design as a facilitator for IoT development. To do so, a qualitative study was conducted using interviews with Service Design practitioners. Findings show that Service Design may facilitate IoT development due to its nature of designing for value co-creation. However, the level of organizational integration of Service Design affects if, and how, Service Design can act as a facilitator for IoT.

New Service Design tools, such as the 'IoT Service Kit' and the 'IoT Design Kit' solve for challenges posed by IoT, as they overcome the barrier to design simultaneously for physical, service, and software aspects. These tools can have the potential to positively influence the development of IoT. Service Design further enhances IoT development by holistic stakeholder management, especially by aligning designers, product engineers, and software engineers to work seamlessly together.

In the end, IoT can be a fitting solution to many modern problems and may thus be chosen by Service Designers for the advantages it offers to the unique user needs.

6.1 Theoretical Relevance

This research adds to existing Service Design and IoT literature, by examining how Service Design can facilitate IoT development. New Service Design tools were explored in this research, adding to the existing set of Service Design tools to overcome challenges posed by IoT.

IDEAS TO EXPLORE IN FUTURE RESEARCH

This thesis also adds to academic work with new ideas that could be explored in future research. As shown throughout this work, research on Service Design and IoT is very limited today and thus this paper presents not only new findings to this field, but also gives reason to extend research.

First, this work found that Service Design approach and tools as we know them today work well with IoT, but additional tools are needed. New tools for IoT development need to overcome the challenges faced today by combining the physical, digital, and service aspect. Holistic tools that enhance alignment of the interconnected parts could be of great use. In this research the idea of integrating data into journey maps has been explored, but as the goal is not to overcomplicate journey maps, other tools may be explored in future research. Such research also offers potential for other technologies, such as big data and blockchain.

Second, it was found that Service Designers find themselves in a position where more things are asked of them than it was the case without IoT. Future research could thus explore the role of the Service Designer in more depth, as they themselves expect their role to broaden and to become more strategic. It could be valuable to research how the skills Service Designers possess might support or hinder them in receiving more strategic influence. On this note, it could also be investigated if Service Design has the potential to transform more towards system design, and if the lines between the different disciplines could blend together.
The gathered data in this work also shows how Service Design can facilitate IoT, even though more research on this question would be valuable in the future. It was found that Service Design facilitates IoT by designing with user value co-creation in mind, but this does not mean that IoT is favored over other solutions. Thus, future studies could examine the reasons why IoT may, or may not, be chosen over other solutions.
Lastly, the findings from the interviews give reason to continue research on ethical design.

6.2 Practical Relevance

This thesis is of practical relevance as it presents how Service Designers approach IoT projects in practice. Examining which tools are used throughout the different phases of the design process gives guidance to other practitioners in IoT projects.
The IoT Service KiT (Futurice, 2016) presented to be of especially high use when designing for IoT, as it overcomes challenges posed by IoT in a unique way and is easy to use in practice.
Especially relevant is the finding that interdisciplinary work between designers and engineers is of high value to the design process and thus possibly the value co-creation.
This paper also highlights the strategic role Service Designers may occupy due to the specific skills they possess.

6.3 Limitations

Due to its qualitative nature, this study is limited by its number of participants. Even though this research identified trends, additional studies with a longitudinal focus and a larger number of participants may be valuable to verify findings. Research studies focusing on the new Service Design tools presented would be of high interest as well, to verify their use in overcoming challenges posed by IoT.
As the literature on Service Design and IoT is limited, it is not clear to what degree the different Service Design tools influence IoT development. Further investigation on how strong each tool influences IoT development is thus needed. Furthermore, while this study found effects of Service Design on IoT development, it is unclear to what degree these might be positive or negative, or if they are even statistically relevant.

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8. Appendix

8.1 SLR

Table 4: Systematic Literature Review

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Shang, Zhang, Zhu & Zhou 2015	case study (cold storage monitoring) —> working out the applied utility model	IoT is not a specific network format, but rather a systemic design idea that enables all kinds of devices to and systems to work together, getting real time Information, context information as well as feedback from other working systems and finally realizing the status of coordinate working. Modern IoT service consist of conditional service and unconditional service. Three principles to design an IoT service system: service classification, coordination, and compatibility	limitations based on qualitative research, findings cannot be generalized	
Shin, Jeon, Park 2016	case study (analyze cases of an IoT based service with new design elements)	four design elements for an IoT based service: 1. sensing 2. interactivity 3. expendability 4. personalization the design elements can be used as the main goal of interactive products (IoT).	limitations based on qualitative research, findings cannot be generalized	four categories of design elements as controllable factors: 1. input 2. control 3. output 4. connectivity these four factors need to be considered in IoT based interactive products.
Carpanen, Patricio, Ribeiro 2016	qualitative research using interviews, observation, and online questionnaire for case study (development of a new smart social bike service)	The multi level service design approach can be extended to include concepts known from product service system to make it work within the context of social Internet of Things, as the current approach does not use a service design perspective. Including the service design perspective for acceptance of technologies in smart services for solving managerial problems.	developing the SIOT architecture to fit in the context	

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Hasselblatt, Huikkola & Kohtamäki 2017	qualitative comparative case method using interviews and secondary data	five strategic IoT capabilities: 1. digital business model development 2. scalable solution platform building 3. value selling 4. value delivery 5. business intelligence and measurement	results are mainly applicable to global and large manufacturers	four key strategic business processes that are necessary to develop, sell and deliver IoT solutions: 1. value identification 2. value quantification 3. value communication 4. value verification -the ability to recognize a customers key value drivers is also essential when building solutions with appealing value propositions -companies need to possess an in-depth knowledge about customers processes. the more complex the process, the more understanding required to meet customer expectations and deliver value
Sayar & Er 2018	comparative case study (of two leading manufacturers from the aerospace and trucking industry)	6 antecedents: 1. communicating a well articulated system design strategy 2. redefining frontline employee roles and responsibilities 3. training and recruiting service aware staff 4. providing guidance to customers on system use 5. aligning customer focus across the business 6. utilizing methods for systems thinking and creativity	limitations based on qualitative research, findings cannot be generalized	IoT implementations require solid product design, well executed service and system design

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Tervonen, Hautamäki, Heikkilä & Isoherranen 2018	literature review & survey research & case study	- The role of service design in the IoT context can be seen along a continuum of the further development of the service design field, where new methods are also needed in the evolution and development of new service innovations - With an organizational and systemic-level approach supporting practical methods, service design can bring together business developers, engineers and designers to build new possibilities	limitations based on qualitative research	- The role of service design related to the IoT and data mining can be seen from two different perspectives: • 1. Existing data or IoT activity: In the knowledge phase new business models or services are built, and existing ones are developed with service design. • 2. Anticipatory and interactive process incorporating service design from the beginning: Value creation and user and use-context understanding are included the process when first planning data mining or IoT solutions.

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Paukstadt, Strobel, Eicker 2019	Developing a taxonomy of smart services using literature. Demonstrating usefulness by classifying empirical objects and using cases.	9 dimensions (Taxonomy of smart services): 1. service concept (value proposition, bundle, main outcome, visibility) 2. service delivery (mode of operation, interaction between actors, main interface) 3. service monetization (Payment method, pricing model)	The taxonomy needs regular updates due to evolving field of smart services. Limited by use of website data for assessment of market-available services. Websites only provided limited information. Focus only on specific elements of smart services. Societal issues not addressed.	S-D logic also becomes more important, since the interactions between service provider and consumer are more frequent

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Harvey, Poorrezaei, Woodall, Nica-Avram, Smith, Ajiboye, Kholodova, Zhu 2020	Analysis of 13,905 consumer crafted, automated combinations of SDPs, totaling 1,144,094 installations across 253 separate service providers using the web service IFTTT.com. Exploratory network analysis used to examine the topology of the network. Interpretive coding exercise to reveal how consumers craft different styles of human-computer interaction to co-create value	SDP (smart domestic product) network is dissociative and imbalanced, with long tailed degree distribution popular services have a higher centrality across all product category combinations	IFTTT is a singe case and results should be compared across platforms. Further scrutiny required to address the demographic, psychographic, and behavioral profiles of people who connect to SDP.	A small number of channels capture a large share of installations. The SDP network exhibits long-tailed degree and weighted degree distributions. SDP classes tend to have one dominant service provider that connects to many other product classes. Services with many installations are also the most central in the network. Consumer-crafted recipes tend to connect popular channels with less popular channels. The connected smart home network has a disassortative overall network structure. SDP network connections are largely imbalanced at both channel and category level, meaning value is initiated both inside and outside the DIY smart home. Consumer-crafted combinations of SDPs are primarily motivated by utilitarian value forms and a preference for supportive human-computer interaction. When SDPs trigger themselves, recipes are primarily motivated by a failure to support utilitarian needs and thus highlight opportunities for service innovation. In the smart DIY eco-system developer and downloader agendas are aligned: Utilitarian recipe design in IFTTT meets service innovation needs in the home.

authors & year published	Method	Main finding	Limitations	other findings relevant to this research
Bin Ahmadon, Yamaguchi, Mahamad & Saon 2021	case study	**Designer**: The service designer role is to design the specification of the service. Specification includes a list of required logical devices and services, a description of the service design, and the service's data and control flow model. The designer selects the logical device or service required for the service and designs the data control flow. Register the designed documents in the marketplace and make them available to manufacturers and users.	limitations based on qualitative research, findings cannot be generalized	there exists a tradeoff between level of strictness and abstractness in specifying the service design.

The main findings of the Systematic Literature Review

8.2 Interview template

Introduction:
- briefly introducing this research, ensuring consent form was understood and asking to start recording again before starting the actual interview

General:
- Can you introduce yourself?
  - Your background and expertise with service design and IoT?
  - years of experience in service design
  - how long/how many times have you worked for IoT development projects?

Service Design and IoT:
- Can you give an example of an IoT for consumers project you did in your role as service designer?
  - which part of the service design process did you went through within the project?
  - can you go through the different stages
    - which tools did you use in each stage?
      - did they work well or did you feel limited?
      - did you encounter any problems when using a specific tool that worked well in other projects?
    - what challenges occurred in each stage?
    - which other stakeholders were involved? (internal, external etc.)
  - How did your role change with these projects?

Data Enabled Service Design in IoT Projects:
- Have you ever gotten involved in a project that is specifically about service design for data curation to redefine the value proposition?
  - IF YES
    - in what part of the service design process were you involved in?
    - can you give an overview of the project
      - go through the process
        - the different activities, tools, and challenges in each stage
    - how is understanding user needs different with machine learning projects?

- Are there any other challenges from other projects that you would like to illustrate?

Assumptions About the Future:
- Do you think the service design tools used today are still appropriate with new challenges arising from technology such as the IoT?
  - If you think change is needed, what kind of changes in service design do you expect?
  - In what ways do you think service design has limitations for design of IoT?
  - In what ways do you think service design can enable design of IoT?
  - Do you think your role as service designer will change?
    - IF YES, how?
    - How do you think you can contribute to this change?

8.3 Interview Analysis

Tables removed for confidentiality reasons