THE FUTURE OF WASHING AS A SERVICE IN A CIRCULAR ECONOMY

MASTER THESIS

INTEGRATED PRODUCT DESIGN

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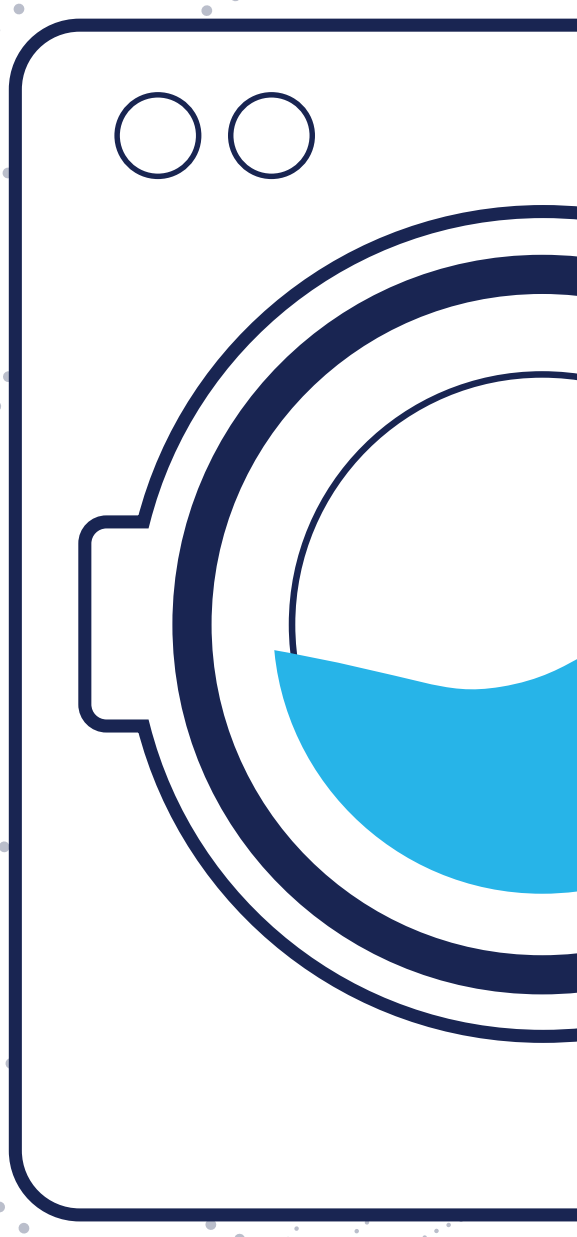
Clients

THE FUTURE OF WASHING AS A SERVICE IN A CIRCULAR ECONOMY



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Nilesh Nahar

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Love,
Nilesh

Do not go gentle into that good night.

EXECUTIVE SUMMARY

Bundles is a Dutch startup that is working on developing circular propositions by offering products on a subscription model. Bundles already offers high-quality Miele washing machines on a "pay per wash" model to consumers. However, high lifecycle costs hinders the competitiveness of the business. This high cost is a result of the product (washing machine) and service (subscription model) not being developed in tandem with each other. The current washing machine is not designed for the Circular Economy (CE) and not designed for multiple use cycles.'

CE, Digital Technologies and Product Service Systems

Different academics point out that digital technologies creates opportunities for circular propositions (e.g., Ellen MacArthur Foundation,2016; Pagoropoulos et al., 2017; Bressanelli et al., 2018). The connection of products through the internet enables them to sense their own and their environments status, process this information and interact with their users. These capabilities help service providers to extend the useful life of products, maximise the utilisation of products, loop products through additional use cycles, regenerate natural capital from their products, and make sure these products are used efficiently. Bundles currently, uses a smart plug to connect their devices to the internet which generates little insights for users and the service.

Washing machines that last forever

Through the knowledge of the condition and status of a WM, PSS can increase the useful service life of the WM eternally by enabling lifetime extending strategies like maintenance, service, refurbishing and remanufacturing .
With washing machines, proactive service and maintenance is important for the service life of a washing machine. Users are critical stakeholder in enabling proper maintenance and service as if they do not participate in the service and maintenance process, the actions do not succeed. Fogg (2009) describes in his behavior change model three elements needed for a behavior to occur – Motivation, Ability and Trigger. If a person has high motivation to do an action and the ability to do it and triggered in the right way, the action will occur.

Design Solution

The result of this design project is a User Interface framework for enabling easy and efficient maintenance and service of the WM. The concept looks at the different faults and maintenance actions for a washing machine and describes three different states of a WM.

Green State – Most desired state where the machine is functioning perfectly and does not require any user action

Yellow State – A state where the functionality is intact but the machine requires maintenance action to be done

Red State – A state when the functionality is seized due to a fault and requires a service action to fix it.

The concept also looks at the transitions between the different states and what casues them and what action is needed to bring the machine to the green state.
On the basis of the different actions, and a behavior change model that is aimed at motivating users and giving them the ability to carry out the maintenance and service actions, a UI concept is generated.

This concept brings together Digital Technologies enabling circularity in a PSS.

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INTRODUCTION

CHAPTER 1

INTRODUCTION

In this chapter, the origin of the assignment behind this master thesis will be explained. First, some understanding of the important concepts of the assignment will be discussed. Next, the assignment itself will be presented. Finally, the approach used during this design project will be presented.

1.1 Background

Today, there is a shift in the consumption of products and services towards mindful and sustainable consumption. Initiatives in sustainability are coming from all parts of society:

Consumers have become more critical (Nielsen, 2018; Unilever, 2017) on the sustainability of the products that they buy;

Governments are introducing more rules and regulations on Sustainability (Dutch Government, 2016; European Commission, 2018);

International organizations like the United Nations (UN) are advocating member nations to adopt the Sustainable Development Goals (SDGs) (United Nations, 2015);

Financial Institutions like Green Investment Banks are being setup to facilitate private investment into sustainable start-ups and initiatives (OECD, 2017);

Manufacturing companies are now actively integrating sustainability principles into their businesses (Bonini & Görner, 2011).

This push is also supported by a shift from the traditional, linear economic model of 'make-use-dispose' towards Circular economy (CE) (Ghisellini, Cialani, & Ulgiati, 2015). The Ellen MacArthur Foundation (EMF) defines four strategies to create value in a CE calling them as CE Value drivers - Extending the use-life of products, increasing the utilization of products, looping and cascading products through additional use cycles and, regenerating natural capital (EMF, 2016). This is illustrated in the well-known CE model

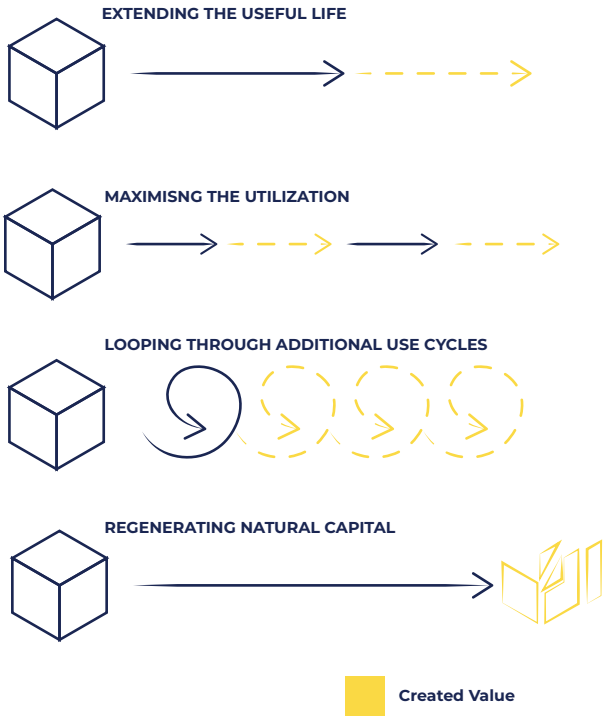


Figure 1.1
Circular Econovmy Value Drivers

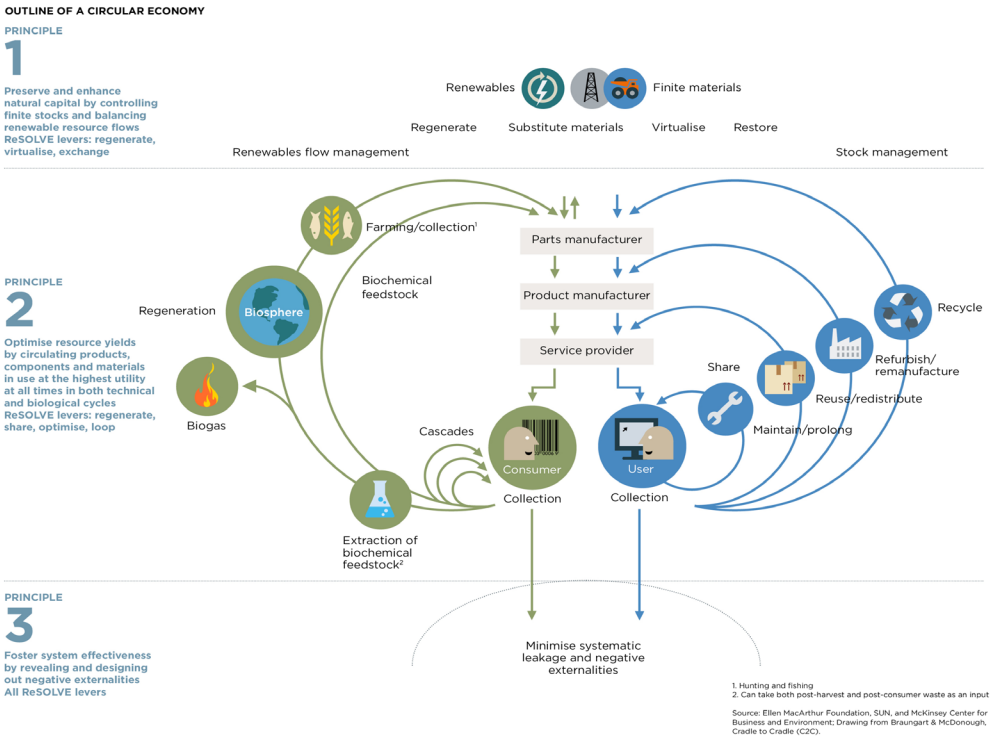


Figure 1.2

Outline of Circular Economy EMF (2015)

proposed by EMF (fig 1.1)

For the business community, the shift towards sustainability is coupled with the emergence of new business models (N. Bocken, Short, Rana, & Evans, 2013). With products finding it difficult to be differentiated on the basis of price, functionality, and quality (Pine & Gilmore, 1998), traditional industrial companies are focusing on servitization. Companies are now progressively offering allied services like maintenance contracts alongside the traditional selling of products. These offerings are giving rise to new business models called Product-Service Systems [PSS] with the intent of enhancing their competitive position aided by service provisions (Kamp & Parry, 2017; Tukker, 2015).

The world is also currently witnessing the third wave of IT Revolution with the emergence of technologies associated with Industry 4.0 (Baur & Wee, 2015; Porter & Heppelmann, 2014). These digital technologies are seen as an enabler of the circular economy (Antikainen, Uusitalo, & Kivikytö-Reponen, 2018) and servitized business models (Suppatvech, Godsell, & Day, 2019). This is through incorporating sensors and actuators in products which are expected to boost productivity, enable new business models and enable products to become a strategic asset for value creation (Bonini & Görner, 2011; Mckinsey Global Institute, 2015). With this shift in the industry and consumer dynamics, durable consumer goods are one of the focus areas for such a transformation(Ellen MacArthur Foundation, 2015).

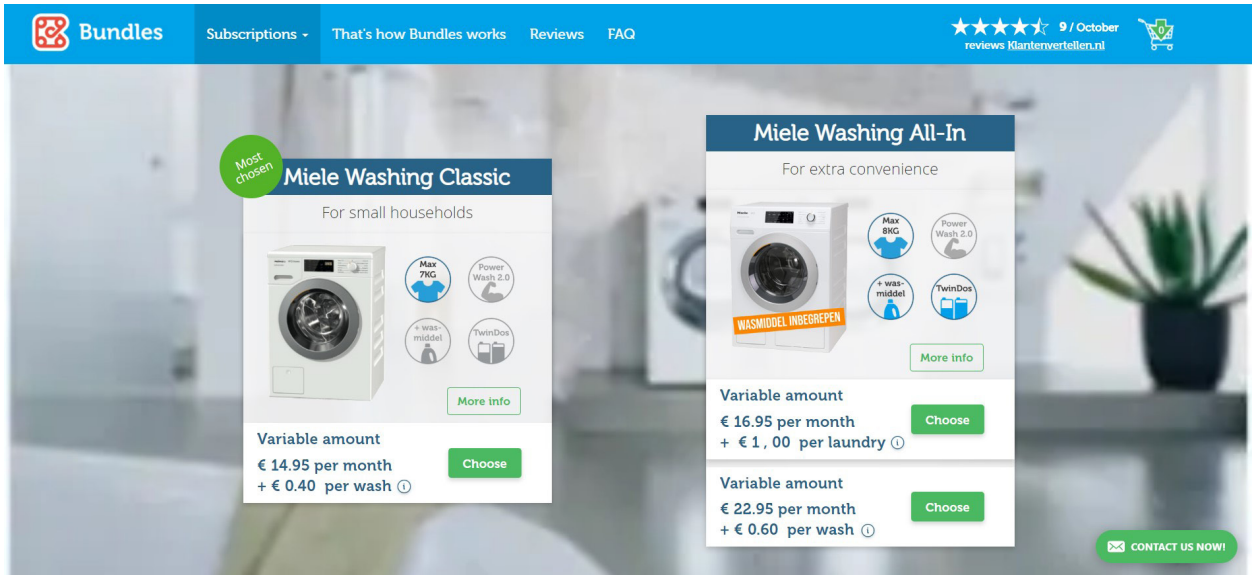


Figure 1.3 Subscription plans for Washing machines by Bundles

1.2 Bundles and the Circular Economy

Bundles, a startup founded in 2014 based out of Amsterdam and Miele, a renowned manufacturer of durable consumer goods have been collaborating in contributing to the transformation towards Circular Economy with products like washing machines, coffee machines, tumble dryers and dishwashers.

Bundles offers a PSS for washing machines amongst other durable consumer goods. As a part of this PSS, Bundles offers high-quality and highly-efficient washing machines (manufactured by Miele) to customers on a subscription model. Bundles procures off-the-shelf washing machines (WMs) from Miele and installs the WM at the residence of the customer. The company offers a pay-per-access and pay-per-use subscription model where the users pay a monthly access fee and a per-wash charge.

Bundles retains the ownership of the WM and are responsible for the installation, maintenance and repair of the machine. This is aimed at making the laundry experience of users hassle-free. The customers also have the flexibility to terminate their contract at any time. On termination, the WM is picked up by Bundles and sent for reconditioning where the machine is evaluated and then cleaned and repaired for it to be reused by another user. Bundles tracks the wash usage statistics by retrofitting the washing machine with a smart-plug which translates power usage patterns into wash statistics. This data is then uploaded to the cloud where it is used by Bundles for invoicing and also the data is visualized on the Bundles App for the customers to look at usage statistics.

Bundles aims to contribute to the Circular Economy through its service offering. They achieve this by increasing the service life of washing machines by taking responsibility of the maintenance; by reusing the washing machine multiple times and; by handling the End of Life (EoL) processes of the WM like recycling, refurbishment.

1.3 Assignment

This project is focused on redesigning a future Product Service System for washing machines which is fully integrated in the Circular Economy in which the role of digital technologies is explored towards this transformation. Furthermore, to identify the limitations and opportunities availed by a fully Circular PSS. The demands from the service (stakeholders) and the product (design) that are required for implementation.

1.4 Approach

This project's approach consist of five phase: discovery, analysis, vision, development, validation.

During the first phase, the Discovery phase, the broader context of the project is explored. This phase is followed by an analysis phase where the company and context of the current system are analyzed. As an input for the analysis, the following sources were looked into:

1. Bundles and Miele's promotional materials (websites, brochures, presentations) were used to gain insights into their strategy, their current service offering and initiatives with sustainability;
2 Visit to Miele Headquarters, production facilities and Design center in Guthersloh, Germany and Interviews (semi-structured) with eight employees from different departments to understand the manufacturer side perspective on new business models, and potential challenges and opportunities with transforming towards Circular economy
3. Visit to Vonk en Co (logistics partner) to gain insights into the logistics and refurbishing processes of the current service offering
4. Literature review to get insights into the drivers and barriers for PSS, CE and Digital Technology
5. One semi-structured interview with co-founder of Bundles (Wouter Buijze) to understand the company structure, vision. Also the service-provider perspective and the workings of the current PSS and the various bottlenecks and problems with the system.
6. Analysis of 300 customer reviews of Bundles on www.klantenvertellen.nl to get insights into common pain points with the service
7. Analysis of results from a conjoint study on the current service carried out by Bundles and Bloom (a data analysis company);

The results from the analysis are then used to describe the current context of the system. The insights from the analysis are then used to generate a vision for the future state of a circular PSS. On the basis of this, the design goal and design focus are defined
The next phase, development involves rethinking the washing machine by looking it through different lenses like circularity, digital technology, servitized business models leading to generating a concept for the realizing the future vision for the circular washing machine ecosystem.

The solution space is explored and on the basis of that a design direction is chosen.

Then ideation is done to generate a framework for UI and on the basis of it the final concept is made.

The validation of the final concept and the limitations of the process are discussed. This is done through interviews with Bundles and Miele. Final conclusons are stated followed by recommendations and then a personal reflection on the process is also done.

PART 1

DISCOVERY

CHAPTER 2

COMPANY ANALYSIS

A company analysis was done by carrying out desk research, informal interviews with two employees of Bundles and nine employees at Miele, Germany. This chapter summarizes the two companies, Bundles and Miele by their vision, mission and ambition. It gives an insight about the service offering, target group, business strategy and their efforts in relation to the assignment.

2.1 Bundles

Bundles (fig 2.1) is a start-up founded in 2014 in Amsterdam. Their motto is "The Best products as a Service". They provide customers high quality appliances on a subscription model. Their value proposition for customers is
Convenience – no initial investment needed to buy high-end washing machine;
Comfort – responsibility of maintenance and repair with Bundles;
Flexibility – the possibility to terminate the contract at any time;
Efficiency – Use of highly efficient Miele washing machines leading to the reduction of water and electricity costs.

2.1.1 Vision

The vision that Bundles is driven by:
A circular world in which companies create better solutions, which are accessible for everyone and materials are preserved for the next generation. Bundles aims to realize a systemic change towards a circular economy by collaborating with manufacturers to offer a high-value experiences to everyone and optimize their value chain through smart technology.

2.1.2 Target Group

The main customer segments for Bundles is urban households and these are focused on the basis of purchase arguments: low purchase investment, sustainability, the flexibility of contract and service.

Figure 2.1 Bundles Logo

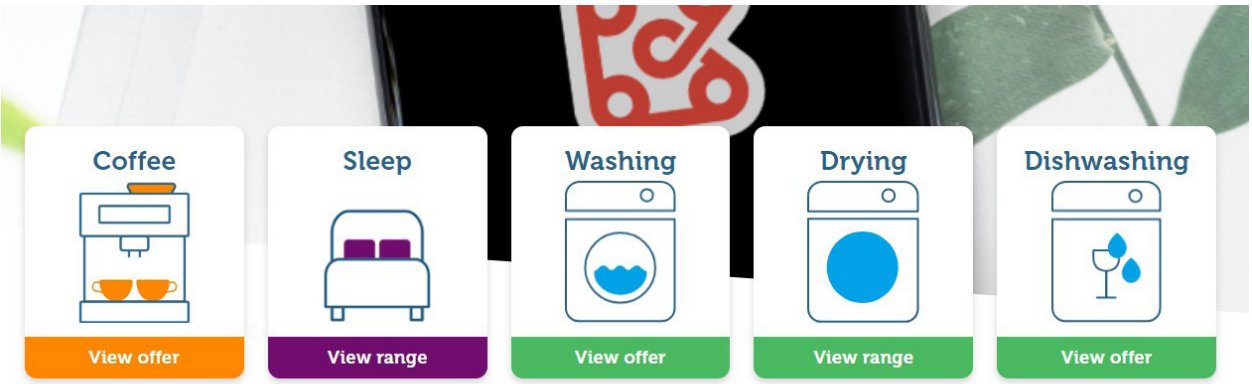


Figure 2.2 Product offering of Bundles

2.1.3 Business Strategy

Bundles partners with brands manufacturing high quality products to facilitate the transition towards a circular economy. Three main benefits which are offered by Bundles to the strategic partners are:

- Developing an environmental and financially sustainable business model.
- Targeting a wider consumer base that would otherwise (financially) not be able to buy the product.
- Setting up a direct interaction channel with customers.

2.1.4 Product Offering

Bundles currently offers products over five categories on a subscription offer: Washing machines, Tumble dryers, Dishwashers, Coffee machines and beds (fig 2.2)

2.1.5 Service Offering for Washing Machines

The essence of the offer is a high-quality machine, with a carefree service at a pay per access and pay per use subscription model. Users pay a fixed monthly amount for access to the machine and an amount per wash for every wash they undertake.
The services that are included are: delivery, installation and operational support and logistics on the termination of contract .
Through the mobile app, social media and newsletters, customers are motivated and stimulated to use the machine in the right and optimal way.
The WM is retrofitted with a connectivity kit which consists of an IoT plug between the socket and the power cord, and a bridge that is linked to the internet modem of the customer.
Consumables are offered in an additional subscription. The offered brands are selected on the basis of sustainability aspects: Seepje (100% nature-based), Miele (automated dosing to reduce over-usage), Ariel. The detergent is automatically and periodically delivered at home for free. The customer benefits from automated stock refill, consistent fair price, no need to carry bulk packages.

Figure 2.3 Explanation on how Bundles service works

2.1.6 Current Efforts in Sustainability

Bundles wants to be an enabler of the circular subscription business model and therewith help create a more sustainable and profitable business model that has a positive impact on our planet. For Bundles, this impact and profitability comes from:

High-quality products
Bundles only offers Washing machines of high-quality (Miele manufactured) and believe that the path to being sustainable is to use products that last longer and are made of high-quality materials

Highly efficient products
With 70-90 percent of the total energy footprint of a WM caused during the use phase, Bundles offers (Miele) WM which are highly efficient and are enabled with technologies like Twin Dos automatic detergent dispensing system that doses the right amount of detergent for every load which helps with reducing water and detergent consumption and reduces machine wear

Smart appliances
Bundles connects the machine with a smart plug that monitors energy usage and enables algorithms to recognize opportunities to decrease consumption.

Smart Usage and maintenance
Bundles offers a web application that provides tools to select the right wash program and also provides personalized tips and also monitor the appliance performance to prevent any functional problems

Smart use and reuse
By providing WM on a subscription basis, Bundles offers its customers free breakdown service an`d the flexibility of terminating the service on which, the machine is then reconditioned to be made available for another user thus extending the use life of the machine.

Collaborator for Circular Economy
Bundles aims to offer a circular service by easing the repair, reuse, refurbish and recycle of WM with a close collaboration with industry partners (Miele) and the customers.

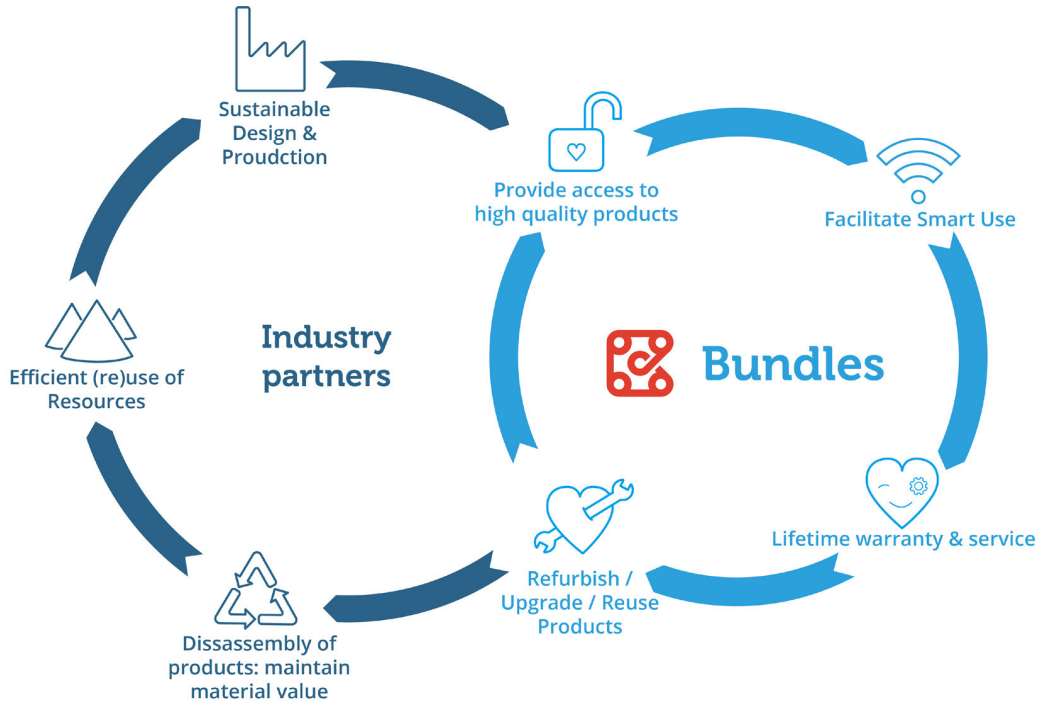


Figure 2.4 Bundles Sustainability Vision

2.1.7 Bundles and Digital Technologies

Bundles retrofits it washing machines with a smart plug that is connected to the power inlet to the WM which translates the power consumption patterns into number of washes and uploads that data to the cloud. This wash data is used for invoicing and also displayed on the Mobile and web-application provided to customers by Bundles. The mobile application also provides users with troubleshooting and a guide for choosing the right wash program alongside general washing tips and tricks.

2.1.8 Future Vision

The future aspirations of the company were explored through an interview with the co-founder of Bundles, Marcel Peters. Bundles aspires to:

1. Besides Wasbundles, Bundles wants to enable manufacturers and entrepreneurs who aspire to revolutionize other product categories using a circular subscription (product as a service) business model.
2. Extend the level of collaboration with the entire value chain/loop including manufacturers, data-analysts, refurbishers, customer engagement and logistics companies.
3. Asserts that this should become the basis for getting the business model at a scale and adoption level where it can compete with the linear business model.

2.2 Miele

Miele is a German brand and manufacturer of high end domestic and commercial appliances founded in 1899.

Figure 2.5 Miele Logo and Motto

2.2.1 Vision

The vision of Miele is "to become the most sustainable company in the industry". They go by the motto of "**Immer Besser**" which translates to "**Always better**".

2.2.2 Company Structure

The company is fully family-owned company which is being run by the fourth-generation of the two founding families owning and running the company.

The company generated a turnover of 4.1 bn EUR in 2017/18. It is headquartered in Gutersloh, Germany since 1907. The company is run by the Executive Board of the Miele group consisting of five executive directors with equal voting rights. These include two Executive Directors who act as representatives of the owner families, as well as three Executive Directors with divisional responsibility, who are not associated with the families.

The company is c1omprised of the following segments:

Miele & Cie. KG
The main holding company is Miele & Cie. KG which handles the central administration, manufacturing plants and subsidiaries in Germany.

Miele Beteiligungs-GmBh
Sales subsidiaries and international plants and participations

Imperial-Werke Ohg
A wholly-owned subsidiary of Miele & Cie. KG with plants in Bunde and Arnsberg

Steelco Group
Majority stake in Italian medical technology company, Treviso.

Miele Venture Capital GmBh
A Subsidiary (100 percent) of Miele & Cie. KG based in Gütersloh which focuses on start-up funding in the fields of Smart Home and Industry 4.0.

2.2.3 Current Efforts in Sustainability

Miele has been the pioneer in making products that are of high-quality and highly energy-efficient. 99% of all washing machines sold my Miele achieve highest energy-efficiency category of all washing machines available on the market. Miele focuses on durability of their products. They test machines to last upto 20 years. They also acknowledge Circular economy as the way forward for a sustainable world and are taking steps in the direction of making their products more circular through pilots and testing new business models (Section 2.2.8). Miele was placed first in the Sustainability Image Score by an online survey by ServicePlan Group in 2011 (Miele, 2019).

2.2.4 Product Offerings

Miele offers a wide range of washing machines based on the customer group and requirements. These machines are categorized into three different segments :

1. Domestic Washing Machines
2. Semi-Professional WMs
3. Commercial (Professional) Washing Machines

Domestic Washing Machines

Miele offers high-end domestic washing machines with a tested service life of 10,000 hours (5000 cycles) which lasts for 20 years when used 5 times a week. Their maximum capacity ranges from 7-9 kgs. They offer different variants with options like automatic detergent- dispensing , special wash programs (PowerWash, SingleWash), WiFi connectivity enabled etc.

“Little Giants” - Profi@Work Washing Machines

Miele also offers Professional grade washing machines (tested service life: 20000 hours/ 10000 wash cycles) in the physical footprint of domestic washing machines. They are nicknamed as “Little Giants” (fig 2.7). These are targeted at small-businesses with higher washing needs than domestic users like hairdressers, day-care centers.

These WMs have limited number of wash programs as these customers often use the same set of programs. Their longer service life compared to domestic washing machines is attributed to use of highly durable components and sturdy construction.

Commercial (Professional) Washing Machines

To cater to large commercial laundry requirements, Miele offers professional washing machines (fig 2.8) with drum capacity ranging from 7 to 32 kgs. They are highly customizable to suit different applications like hospitals. The construction of these WM are made of highly durable materials and sturdy to deliver a tested service life of 20,000 hours/ 10,000 washes. These WM are designed with ease of repair in mind and are often sold in tandem with service and maintenance contracts. The wash programs are also adapted and pre-programmed to the needs of the customers. They also offer WM for highly-specialized application like hospitals for hygienic operations.

Figure 2.6 Domestic Washing Machine

Figure 2.8 Commercial Washing Machine

Figure 2.7 “Little Giants”

2.2.5 Innovation in Laundry Technology

Miele is renowned for innovation in laundry technology. They are directed at higher efficiency, better wash quality and longer service life of washing machines. Some notable innovations are:

Load Recognition

Miele washing machines have intelligent automatic load recognition. This system analyzes the actual load and uses just as much water and energy as is required for the optimum washing result.

EcoFeedback

Miele washing machines with EcoFeedback function give you an accurate indication of the actual energy and water consumption (Fig 2.9). This way you always have full control over the costs. Before starting the program you can request a forecast of the consumption of the selected program. At the end of the program, the exact consumption data is displayed, depending on the load.

TwinDos

TwinDos is a two-stage automatic detergent dispensing system(fig 2.10). The TwinDos system will automatically dose the correct amount at the ideal time during the washing process.

CapDosing

Capsules suited for special textiles via the detergent drawer. The washing machine then automatically doses the contents at the ideal time during the washing process.

Honeycomb Drum

The web-like surface structure of drum forms a honeycomb structure that creates a thin film of water between the drum and the laundry. This results in laundry gliding gently and protects the fibers perfectly. The smaller, smoothly polished shouldered holes in the walls of the drum are also gentle on textiles and prevent pilling and laddering.

Figure 2.9 Miele EcoFeedback

Figure 2.10 Miele TwinDos System

2.2.6 Service Offerings

Along with selling devices, the company also offers allied services for the products. They offer the Miele Coffee Care package, which is an add-on service while buying a coffee machine from Miele. This takes care of the maintenance, repair and upkeep of the coffee machines (Miele, n.d.-c). They also offer solutions for shared laundry for student and starter homes by helping set up a launderette in a common space along with providing the IT solution for availability of machines, reserving a machine, monitoring the wash progress and payment for the wash. (Miele, n.d.-a)

Miele also runs a service named Miele Laundry Club (Fig 2.11) which picks up your laundry from home and washes, irons and steam your clothes and delivers them to your doorstep. (Miele, n.d.-a)

The Miele Professional division also offers Annual Service contracts to its customers which takes care of annual maintenance, service and spares in case of break-downs and ensures uptime. (Miele, n.d.-c)

Miele NL also offers a special financial lease solution for procurement of Miele commercial washing and drying equipment in cooperation with ABN AMRO Lease. This gives customers the access to new equipment without any capital investment. (Miele NL, n.d.)

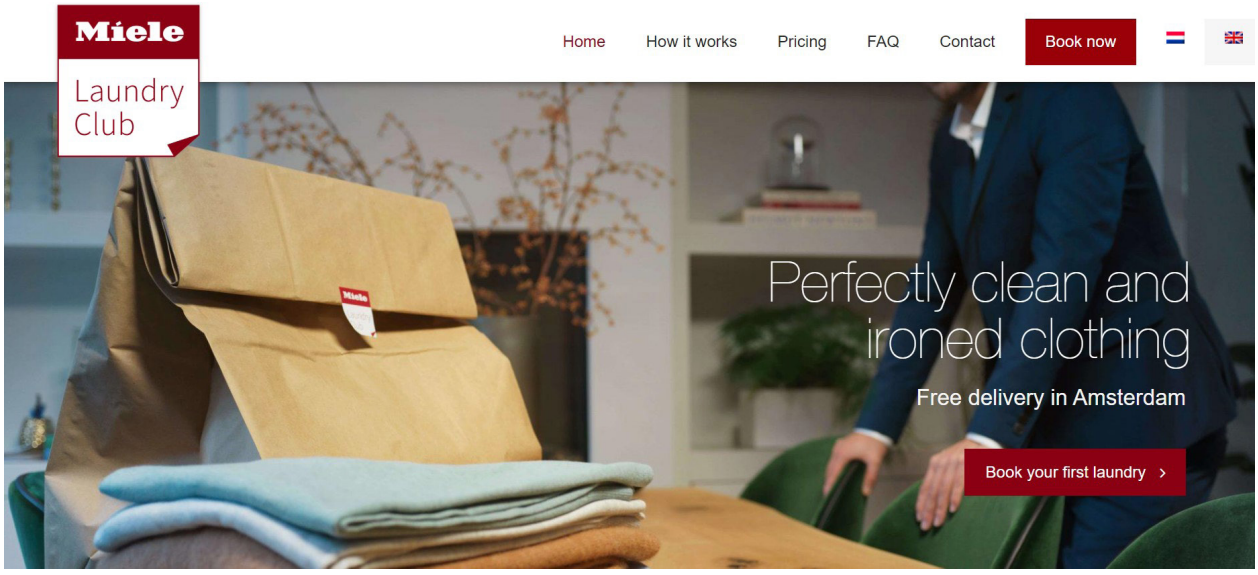


Figure 2.11 Miele Laundry Club

2.2.7 Current Circular Economy Efforts

Miele has been engaged in consultations with organizations, interest groups, representative of the EU commission, European Parliament on Circular Economy. Miele has also been registered in the public transparency register for interest groups in Brussels since the end of 2015 for easier consultations (Miele, 2019). Miele is also a part of the Circular Coalition - a partnership of customers of Renewi, a waste management company who support the transition to a circular economy (Renewi, 2017).

The company also took a step towards circular economy by initiating an arrangement with Coolrec, an electronics goods recycling company to extract cast iron coun ter weights (fig. 2.12) in old Miele washing machines to be returned to the factory for recycling (Coolrec, n.d.)

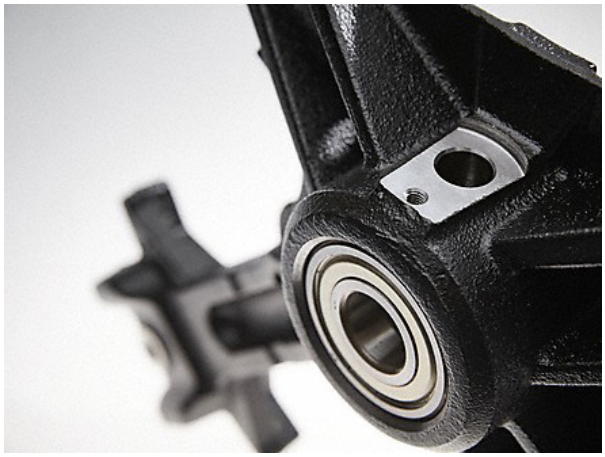


Figure 2.12 Cast Ireon Counterweights

2.2.8 Previous experiences with New service-based Business Models

Miele has been exploring and supporting new business models internally and through strategic partnerships. It has promoted the development of innovative business models that are sustainable through Miele Venture Capital which was established in 2017. It aims to promote projects with promising start-up companies in areas such as digital marketing, smart home and industry 4.0.
Miele has been running multiple initiatives with PSS for washing machines with focus on leasing instead of buying. Their cooperation with Bundles is one of them. They also introduced a rental mode for washing machines in a pilot project in Germany named BlueHorizon (CE Electro, 2018).

In 2018, Miele carried out the “Shared Laundry Room” project in the Netherlands to investigate and document the advantages of the pay-per-use model. The result: the number of wash cycles carried out – and with it the amount of water and energy consumed – in a shared laundry room was 47 percent lower than when residents had their own appliances (Miele, 2019).

2.2.9 Miele and Digital Technologies

Miele has been pioneering the integration of digital technologies into products under the Miele@home initiative. Under it, 500 network-enabled domestic appliances have been vested with new capabilities to give customers more flexibility, convenience, quality of life and security (Miele, 2019)

In 2017, the Competitiveness Symposium, an in-house event by Miele focused entirely on digitalization. Around 200 specialists and managers from Miele plants took part in lectures on the subjects of digital products and customer-centric business models, industry 4.0 and smart collaboration (Miele, 2019). With Miele@Home, users can monitor the progress of the wash and also remotely switch on and off the WM. For easier integration of Miele devices into third-party application, Miele released an API (Application Programming Interface) in August, 2018. This API grants secure access to device data through its Miele cloud service after user authorization.

From the perspective of the product, the washing machine is equipped with multiple sensors. They are:

1. Max lateral drum deflection sensor (Limit Switch) - For vibration detection
2. Water level indicator
3. Temperature - NTC Sensor
4. Power usage sensor
5. load sensor
6. Door lock sensor
7. Moisture sensor

These are currently used for the wash functionality of the washing machine and has no feedback loops attached to them that relay information to users except in the case of faults.

Figure 2.13 Miele@Home Application to control washing machine

Figure 2.14
Earliest models of
Miele Washing Machines

2.2.10 Company Visit Insights

A visit was made to the headquarters of Miele in Gutersloh, Germany to understand the perspective of Miele towards the current Bundles PSS and the future of new business models. A total of 9 informal meetings were undertaken (Full Report in Appendix B) with representatives of different departments at Miele. The main insights from the visit are:

1. Miele sees a higher value proposition with a connected washing machine but not fully aware of the opportunities arising out this connected system.
2. There is already a beta public API available for 3rd party applications which can be used by Bundles to access machine data.
3. As manufacturers are responsible for the recycling of old washing machines, Miele recognizes that there is higher value in having only Miele machines back for recycling instead of a heterogeneous mix of machines as it will be a clean stream.
4. Miele recognizes Bundles role as an enabler of reverse logistics of Miele machine for effective End of Life (EoL) treatment.
5. The condition of the machine cannot be solely based on the number of cycles it has run, similar to how the odometer of a car isn't truly representative of what road conditions the car has ran those miles. There has to be a more holistic approach to it and IoT can be an enabler.
6. The weight of the clothes does not determine the water, detergent and power usage. It depends on the material-mix of the load as each material has a different rate of water absorption.
7. During the production of the washing machine, data of components and their quality parameters are collected and stored but not used after the machine leaves the factory floor.
8. Miele is interested in exploring different business models but concerned about the viability and risks of cannibalization of primary sales. They consider Bundles as a good pilot project.
9. All parts and sub-assemblies are marked with QR-code during production which is used to map durability test results to the part or sub-assembly.

Key Takeaways

Both Bundles and Miele have a similar vision for the future of washing machines and sustainability. But their areas of focus are different. While Bundles wants to deliver value through offering services of whom a high qulaity product is a part of. Miele, has been focusing on making the product durable and highly effienct. Miele has slowly started to venture int oexploring new business models as it acknowledges the trend towards the service economy.

Technology can be seen as a major focus point for both the companies, with Bundles basing its business on a software platform and Miele working on its Miele@Home smart home initiative. Both the companies see the potential of aconnected washing machine and its value creation potential. There is a need for alignment of these efforts to unlock the opportunites it holds.

CHAPTER 3

LITERATURE REVIEW

A desk research was carried out to review the literature on the three domains relevant to this project- Product Service Systems, Circular Economy and Digital Technologies. Also explored, is the inter-relations between the three domains. The outcomes from the desk research has been summarised in this chapter. These findings are then used to analyse the current system of Bundles in Chapter 5.

3.1 Product Service Systems (PSS)

Since the mid-1990s, researchers dealing with sustainability and business have concurrently looked at PSS. The argument is that the shift of focus on the final needs of the user's wants rather than the product itself would enable the easier design of need-fulfillment systems with significantly lower impacts (Tukker, 2017). Management literature has almost unanimously suggested product manufacturers integrate services into their core product offerings. The rationale behind this is the economic benefits - higher revenue from an installed base of long-life products, relatively higher margins in services than products, and resistance of services to the cycles of capital investments; secondly, there is a higher demand for services from consumers and thirdly, the competitive advantage services offer (Oliva & Kallenberg, 2003)
There is also a push important actors in civil society, business and government to move towards resource-efficiency (Tukker, 2015).
The European Union (EU) has therefore designated resource-efficiency as one of the flagships of its Europe 2020 strategy (European Commission, 2011). The United Nations (UN) has also pushed for sustainable resource management as illustrated in the Sustainable Development Goals (SDGs) Number 12 which is aimed towards "sustainable management and efficient use of natural resources" (United Nations, 2018).
For the business community, the interest in PSS grew as the realization arose that in most markets, products are all similar and of high quality and product differentiation is limited. The design and manufacture of products could no longer be a source of differentiation and competitive advantage. To weather this sheer price competition, firms have to offer integrated solutions, allowing them to improve their position in the value chain, increase their innovation potential, and enhance the value addition of their offering (Pine & Gilmore, 1998).
Servitized Business models (BMs) has been acknowledged as one of the key enablers of CE paradigm into companies (Bressanelli, Adrodegari, Perona, & Saccani, 2018). Often mentioned in literature are the examples in the mobility sector are car sharing offerings where providers don't sell cars but offer turnkey solutions through a servitised scheme

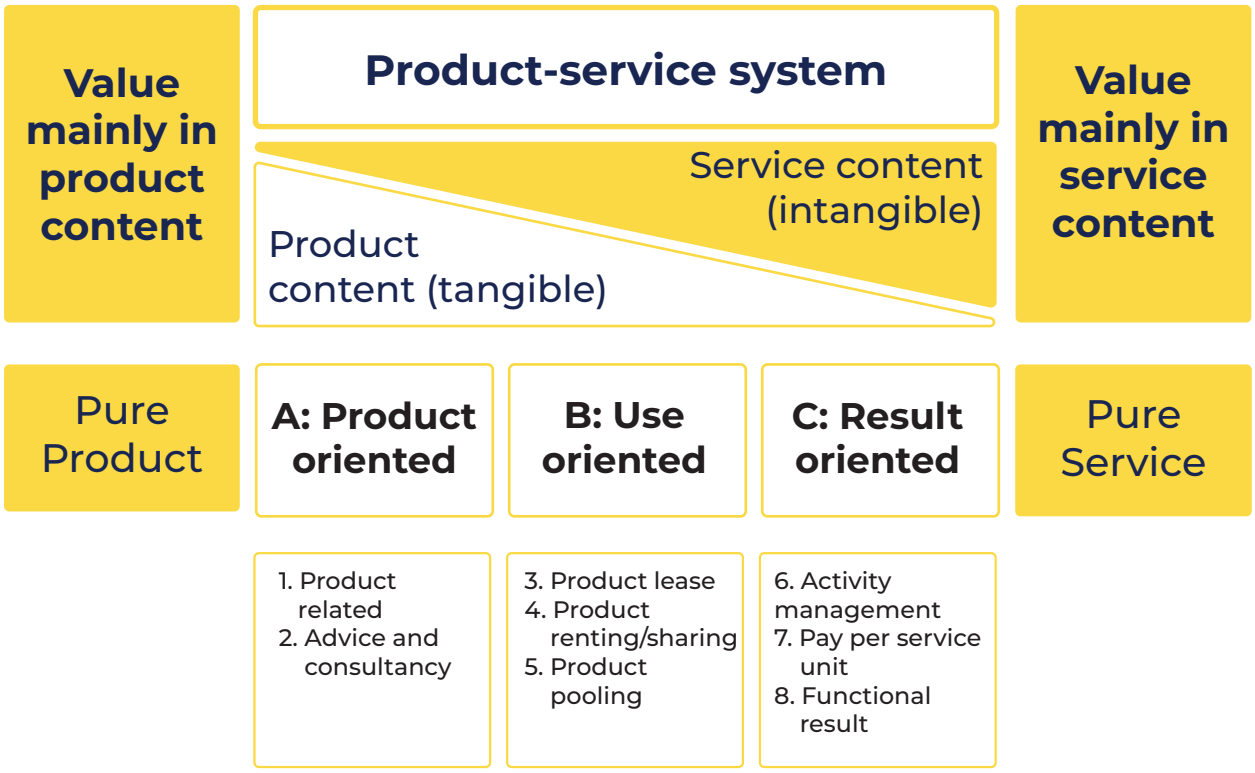


Figure 3.1 Different types of Product-Service Systems (Tukker, 2004)

(Cohen & Kietzmann, 2014). Car2go is a practical example of a Business-to-consumer (B2C) car sharing BM, where cars can be used and left at any place within the city area, and users are charged with pay-per-minute fee. In line with the ambition of CE to decouple economic growth and resource use (Ghisellini et al., 2015), many authors take cognizance of PSS being an effective instrument to move from a product-oriented business to a service-oriented one (N. M.P. Bocken & Short, 2016; Ellen MacArthur Foundation, 2013a; Tukker, 2004).

3.1.1 Definition

Tukker (2004) defines a PSS as "an integrated bundle of products and services which aims at creating customer and generating value".

3.1.2 Characteristics of PSS

PSSs can be classified into three main categories: product-oriented, use-oriented and result-oriented (See figure 3.1).

Product Oriented PSS

Product-oriented PSSs are still linked to the product with the product ownership staying with the user. In this category, only a few services are added to the product.

Use Oriented PSS

In use-oriented PSSs, although the product is still central, the ownership stays with the service provider as in the example of leasing or renting models.

Result Oriented PSS

In result- oriented PSSs the product as such is not central anymore but the focus is on the result or function of the product.

With the focus shifting from selling the product and delivering the result becomes the prime focus of PSS, products and consumables that take a part in providing the service, become cost factors. This also shifts their business focus towards cultivating a long term relationship with their customers. Rust, Moorman and Bhalla (2010)(Rust, Moorman, & Bhalla, 2010) propose a new business development perspective and new business metrics as presented in Figure 3.2
Hence, there is an incentive for firms in prolonging the service life of the products by making them cost- and material-efficient and also to re-use parts as much as possible at the end of the product's life. These can lead to the minimization of materials-flows in the economy while maximizing service output or user satisfaction (Tukker, 2015), thus fulfilling the aim of CE to decouple economic growth from resource use.

Figure 3.2
New business metrics by Rust et al. (2010) for a long-term customer centric business perspective

3.1.3 Challenges to PSS

To make a product-service system a success, there is a need to move from a goods-dominant (GD) logic to a service-dominant logic (Vargo & Lusch, 2007). In order to do so, multiple challenges need to be tackled. Nudurupati (2013) defined eight different challenges product based companies face (fig. 4.3): Incorporating the customer perspective, redefining the interface, the pricing of their offerings, the design of PSSs, the supply network, the organizational architecture, the performance measurement and the cultural transition.

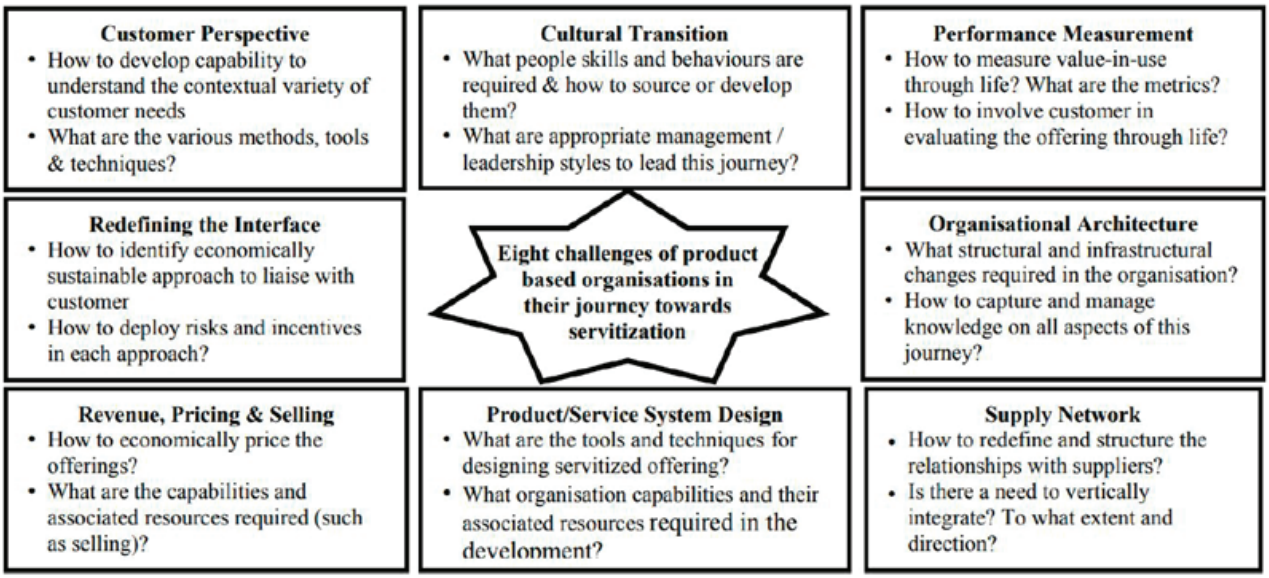


Figure 3.3 Challenges of PSS Nudurupati et al. (2013)

3.2 Circular Economy and PSS

The current industrial economy is sustained by readily available raw materials and energy at a relatively low cost coupled with cheap labor with no priority nor the need to recover the used materials or energy. This results in a 'linear economy' or the 'take, make, dispose' model. This dominant economic model of today relies heavily on large quantities of resources and energy, which are both readily available but increasingly expendable (Ellen MacArthur Foundation, 2015). These linearly produced products, on disposal, are discarded without substantial recovery of materials. It is estimated that of all waste generated in Europe in 2016, only 57% was re-used, recycled or composted (Eurostat, n.d.).

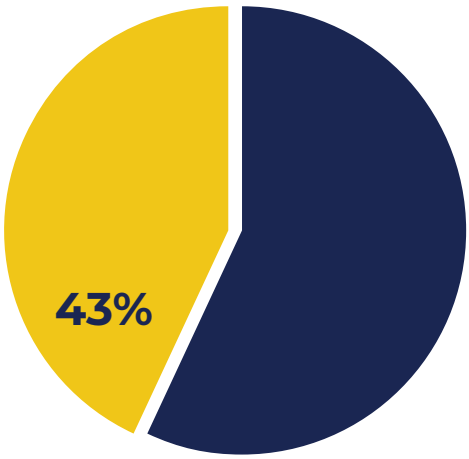
With the global population stated to reach 9 billion by 2050, the consumption of natural resources is estimated to triplicate in the coming years (Ellen MacArthur Foundation, 2013b). Leading to an undue impact and pressure on natural resources triggering resource scarcity, supply shocks, price volatility, and political instability (OECD, 2001) and shall have an even greater effect on environmental problems.

In the face of these detrimental impacts of the linear economy model, there is a search of a 'better hedge' and an industrial model that decouples revenue from material consumption: the 'Circular Economy' (Ellen MacArthur Foundation, 2013a). Studies show that the application of CE principles may increase the European Gross Domestic Product (GDP) by as much as 11%, with a net benefit of EUR 1.8 trillion by 2030, with savings on material costs up to EUR 1 trillion (Ellen MacArthur Foundation, 2019). This decoupling of revenue from material consumption can be achieved through the creation of new strategies for different stages of the lifecycle of products, for example, designing products that last longer, or reused and recycled easier; the servitization of products.

As mentioned earlier, PSSs are seen as the way towards fulfilling user needs with less resources consumptions and lower impact. PSS are considered a positive approach towards CE (Tukker, 2015).

Only 57% of all waste generated in Europe, reused recycled composted

Source : Eurostat



3.2.1 Definition of Circular Economy

Circular Economy aims at being an alternative to the linear economy with the goal to "decouple global economic development from finite resource consumption" (Ellen MacArthur Foundation, 2015). Different definitions have been explored in the literature to outline CE goals, characteristics, and principles (See Table 3.1).

Author	Definition
Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2013a)	An industrial economy that is restorative by intention; aims to rely on renewable energy; minimizes, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design
Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015)	An economy that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles.
Mentink, 2014	An economy with closed material loops.
Scott, 2013	A concept used to describe a zero-waste industrial economy that profits from two types of material inputs: (1) biological materials are those that can be reintroduced back into the biosphere in a restorative manner without harm or waste (i.e: they breakdown naturally); and, (2) technical
Geissdoerfer, Savaget, Bocken, & Hultink, 2017	A regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling.
Accenture, 2014	In a Circular Economy, growth is decoupled from the use of scarce resources through disruptive technology and business models based on longevity, renewability, reuse, repair, upgrade, refurbishment, capacity sharing, and dematerialization.

Table 3.1 Defininitons of Circular Economy

3.2.2 Principles of CE

Ellen MacArthur Foundation (EMF) has been a crucial actor in the dissemination of the CE concept by engaging business, government and academia in its augmentation. EMF proposes the butterfly diagram which captures and illustrates the three core principles of CE applicable to both technical and natural cycles (See figure 3.4) (Ellen MacArthur Foundation, 2015).

The second principle states that resources can be optimized by circulating products, components, and materials through different loops that ensure the highest utility at all time (EMF, 2013) These looping strategies described in the diagram offer new opportunities for value creation that do not require new manufacturing of products but the continuous flow of materials (Nancy M.P. Bocken, de Pauw, Bakker, & van der Grinten, 2016). Hence, the loops where products, materials, and energy are being shared, maintained / prolonged, re-used / redistributed, refurbished/ remanufactured and recycled are paramount for the propagation of the shift towards a CE. Also noteworthy is that, the smaller the loop, the higher value of the product is preserved, e.g. reuse of a mobile phone vs recycling of mobile phones (Ellen MacArthur Foundation, 2013a)

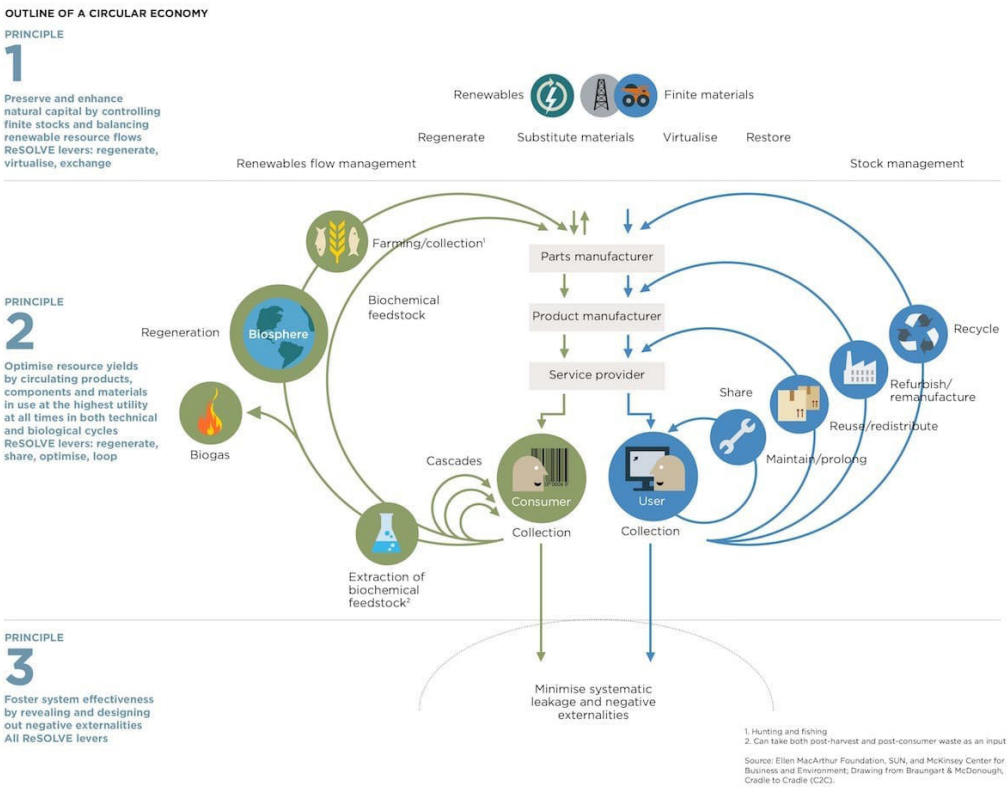


Figure 3.4 EMF Butterfly Diagram for Circular Economy

The distinguishable factor with the current, linear system is that the value of products is kept as high as possible rather than destroying it after use (fig 3.5)

For companies, a CE results in the following opportunities (Ellen MacArthur Foundation, 2015)

- **New ways to generate profits**
- **Resilience of Supply**
- **Demand for new service models**
- **Improved customer relationships**

The Value Hill represents the rise and fall of value of a product through its lifetime.Figure 3.5a shows the value creation in every step of the value chain as it rises from pre-use till the use phase. At the end of the use phase, as the product dropss in the value chain, the value of the product and subsequently resources is decreasing again. Maintaining value instead of destroying it is where circular propositions are more profitable and effective than linear propositions.

In order to keep this value as high as possible, the loop has to be closed and circular strategies are need to be in place for all downhill activities through - repair/maintain, reuse/redistribute, refurbish/ remanufacture and recycle (Achterberg, Hinfelaar, & Bocken, 2016)

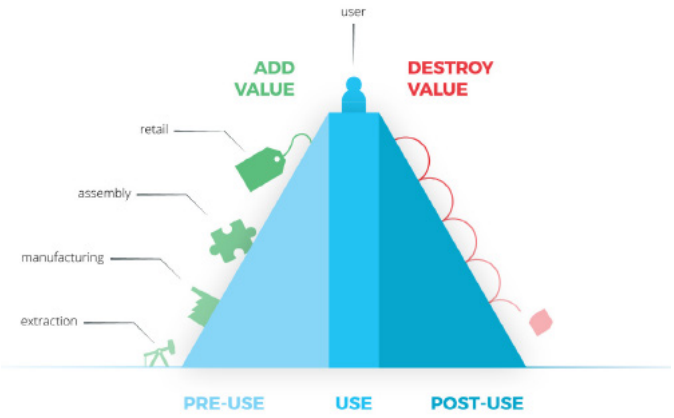


Figure 3.5a Value Hill in a Linear Economy(Circle Economy, 2018)

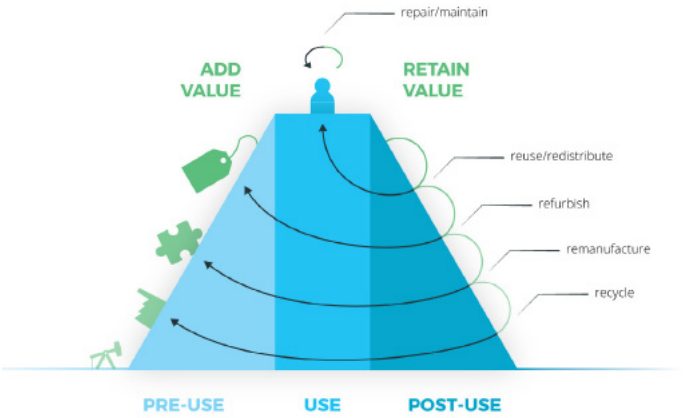


Figure 3.5b Value Hill in a Circular Economy(Circle Economy, 2018)

3.2.3 Challenges of Circular Economy

Ritzen and Sandstrom (2017) defined multiple barriers for moving towards a Circular Economy.
They have been categorized under five categories: **Financial, Structural, Operational, Attitudinal and, Technological barriers**.

These are similar to barriers as defined by Kirchher et al. (2017). Figure 3.5 gives an overview of the different barriers per category.

Bet et al. (2018) state that product-based industries have problems in envisioning the complete product life-cycle, because they look at their own company rather than considering all the stakeholders in the chain:

> "*As one can imagine, material chains may be closed in many different ways, making a circular economic system a very complex network compared to the traditional linear system. As a result, making a transition from a linear to a circular economy poses a very complicated paradigm shift, demanding a lot of knowledge from the many involved stakeholders and close cooperation between them. Even though a lot of valuable scientific research and professional expertise on circular economy is available, this knowledge often does not find its way to the relevant stakeholders, leaving many opportunities to accelerate the transition to circular economy untaken.*"
> (Bet & Truijens, 2018)

Financial	Measuring financial benefits of Circular Economy
	Financial profitability
Structural	Missing exchange of information.
	Unclear responsibility distribution
Operational	Infrastructure/ Supply chain management
Attitudinal	Perception of sustainability
	Risk aversion
Technological	Product Design
	Integration into production procsses

Table 3.2 Categorisation of barriers to CE (Ritzen & Sandstrom, 2017)

3.2.4 Circular Product Design and the PSS

The shift towards CE requires a strategic level of business model innovation and product design to happen in tandem with each other (Nancy M.P. Bocken et al., 2016).

Guidelines for product design have been created by researchers to fit the Circular Economy (Van den Berg & Bakker, 2015). Fig 3.6 and 3.7 show the Circular Product Design Vision and a summary of Circular Product Design guidelines, both of which are to be used as a reference during the (re)design of the product in the PSS.

Figure 3.6 Circular product design vision. (Van den Berg & Bakker, 2015)

make it	future proof	for endless performance and adaptability
with design for	disassembly	to allow
easy	maintenance	for optimal performance
modular design to	remake	products
and optimizing for	recycling	at end of life

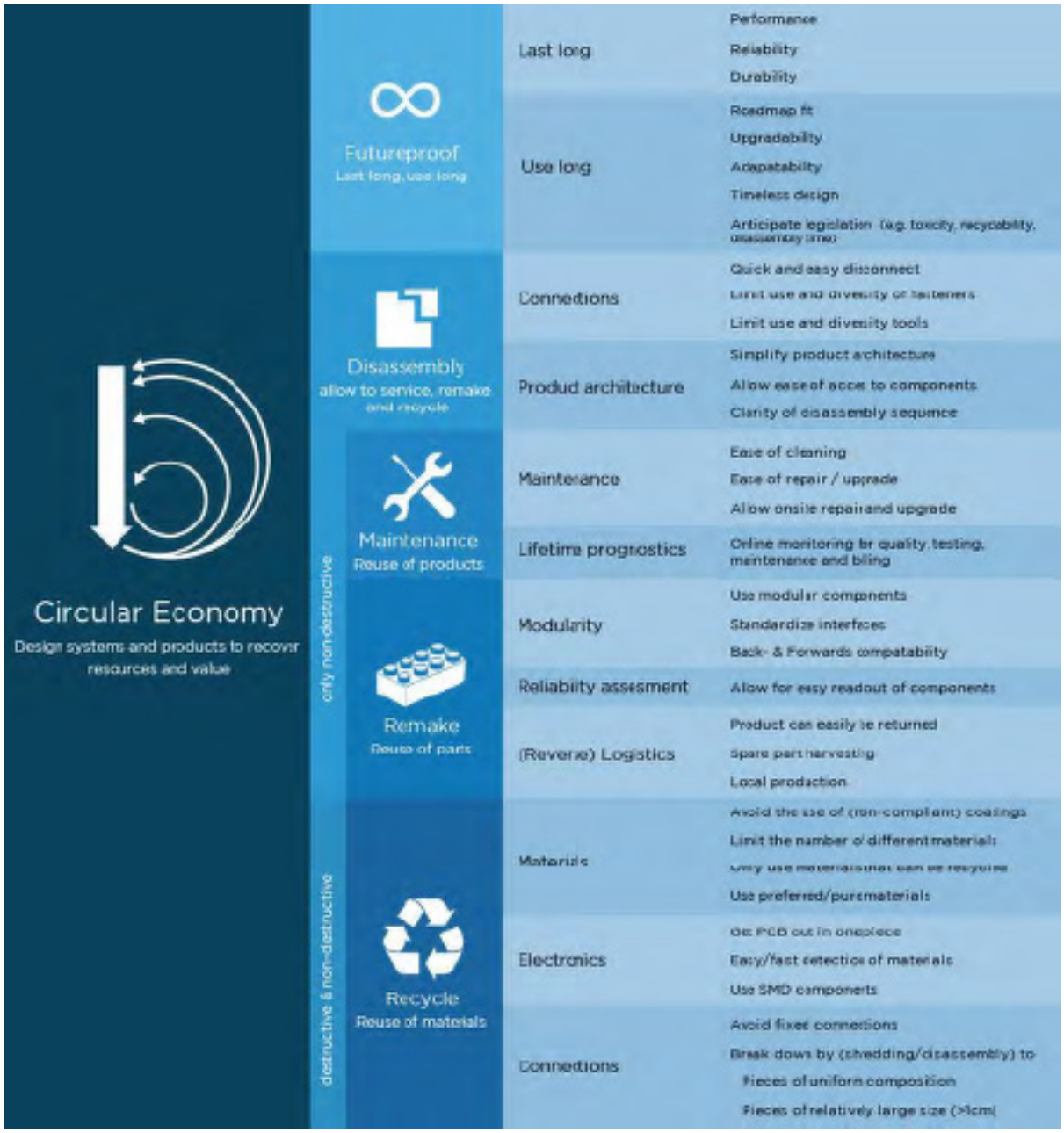


Figure 3.7
Circular product design guidelines
(Van den Berg & Bakker, 2015)

3.3 Digital Technology in PSS and CE

The first three industrial revolutions came about as a result of mechanization, electricity and IT (Kagermann et al., 2013). Over the past 50 years, twice has information technology radically reshaped competition and strategy; we are now standing at the brink of a third transformation.

The first two waves gave rise to huge productivity gains and growth across the economy. While the value chain was transformed, products themselves were largely unaffected. This third wave is characterized by the rise of technologies of Industry 4.0. This next phase of the digitization of the manufacturing sector is driven by four disruptions: **the staggering rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing** (Baur & Wee, 2015).

Two concepts that have recently captured the attention of scholars and practitioners: the Circular Economy (Ghisellini et al., 2015) and the Internet of Things (IoT)(Porter & Heppelmann, 2014). The adoption of IoT has been seen as an enabler of the Circular Economy life-extending activities like maintenance, reuse, repair, remanufacturing and recycling (Ellen MacArthur Foundation, 2015). This is a result of building visibility and intelligence into products and assets such as knowledge of the location, condition, and availability of assets. This is furthered by the fact that there is a key shift in business models moving towards Products Service Systems (PSS) where the focus shifts from selling products to leasing, renting and sharing products (Antikainen et al., 2018).
The Internet of things are now transforming products into complex systems that combine hardware, sensors, data storage, microprocessors, software and connectivity giving rise to a myriad of “smart, connected products”. These products offer expanding opportunities for new functionality, higher reliability, and higher product utilization. That being said, “Internet of Things” is not truly representative of the full implications and opportunities of these smart products as the internet is simply a mechanism for transmitting information (Porter & Heppelmann, 2014). IoT technology allows entities to collect a large amount of data which is usually called Big Data. Given their volume, variety, velocity, and veracity, Big Data cannot be analyzed using traditional database techniques, but require specific Analytics to leverage software and data mining processes, in order to identify patterns in the data and make predictions. Thus, Big Data combined with Analytics are usually seen in literature as a valid approach to enable a better decision making (Pagoropoulos, 2017), which can positively advance the shift towards CE by feeding sustainability-oriented decision-making processes with the required information. Furthermore, Big Data and Analytics are required in the provision of advanced services such as preventive and predictive maintenance (Bressanelli, Perona, & Saccani, 2017). For the sake of convenience and simplicity, all the different technologies are bundled into Digital technologies in the context of this project.

Literature has pointed out the potential benefits that companies may gather from servitized BMs, such as strengthening customer relations, creating higher barriers for competitors, and generating new and resilient revenue streams (Baines & W. Lightfoot, 2013; Spring & Araujo, 2017); it also notes the

great challenges implied, since servitization requires fundamental changes in the way of delivering value and dealing with customers and stakeholders. In this context, the role of new digital technologies that constitute the backbone of the fourth industrial revolution, has been indicated as “disruptive”. In fact, these technologies are radically reshaping the way companies deliver existing services, enabling the introduction of servitized BMs into companies and facilitating the transition towards CE (Bressanelli et al., 2018). It is clear from literature that the implementation of Digital Technologies will help overcome some of the PSS and CE challenges described in Section3.1.3 and 3.2.3.

3.3.1 IoT Capabilites

Porter & Heppelman (2014) propose four basic capabilities of connected products: Monitoring, Control, Optimization, Autonomy.

Monitoring
Use of sensors and data to monitor products’ condition, usage and external environment.

Control
Software embedded in the product that enables the control of product functions and the personalization of the user experience.

Optimization
Monitoring and control capabilities enable algorithms that optimize product operation and use in order to enhance product performance and allow predictive diagnostics, service, and repair.

Autonomy
Autonomous product operation and self-coordination of operation with other products and systems, self-diagnosis and service.

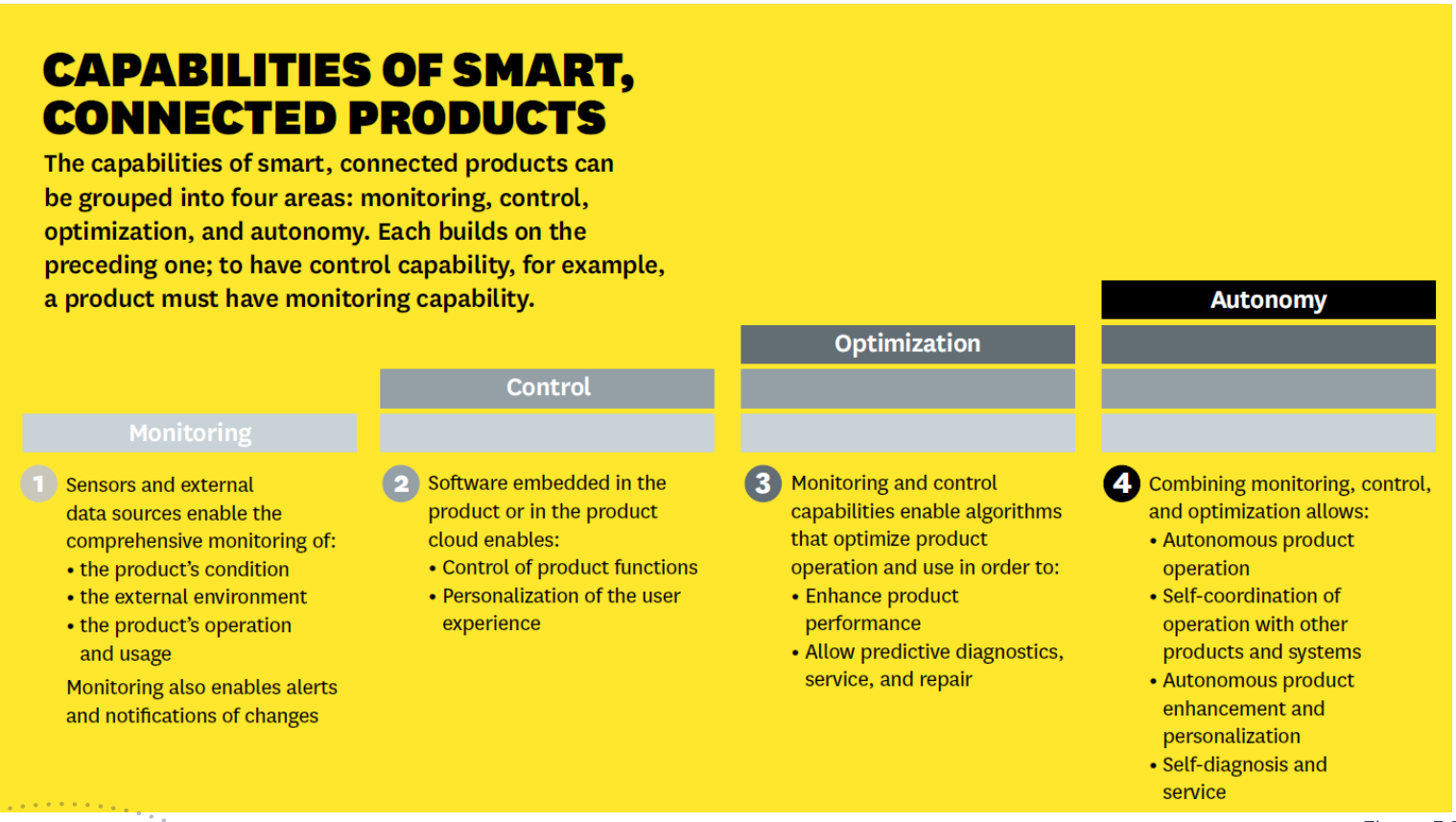


Figure 3.8
Capabilities of Smart, Connected Products (Porter & Heppelman, 2014)

3.3.2 Challenges to Digital Technologies and CE

Section 3.2.3 elaborates about the barriers for moving towards CE which also hinder the gained benefits of digitalisation. Currently, one of the major barriers towards implementation of the CE are problems related to information (Wilts & Berg, 2018). When studying the role of digital solutions in the CE, often, the issues related to data integration are ignored. This is however a central issue, as it is not necessarily known how to use data to support the transition from less linear and more circular business models. For business applications, data integration is an crucial part as it combines individual information sources with the business goals of the involved stakeholders and their application in daily business (Pagoropoulos, Pigosso, & McAloone, 2017). According to Lieder & Rashid (2016), an important gap in literature while evaluating Circular Economy is that most studies neglect the business and economic perspectives.

While looking at the integration of digital technologies in the PSS, it is important to look into the business implications of such integrations despite the added benefits in delivering new value propositions.

Key Takeaways

Digital Technologies are seen as an enabler of the Circular Economy and Product Service Systems as a positive approach towards CE.

Both PSS and CE comes with its own set of challenges which requires design interventions at a product level, a system level and also attitudinal changes.

CE is not only an approach towards sustainability but also opens up opportunities to offer new value propositions to all stakeholders.

PART 2

ANALYSIS

CHAPTER 4

CURRENT PSS

In this chapter, the context of the current PSS offered by Bundles is explored and analysed by conducting interviews with Bundles, a visit to the logistics and refurbishment centre at Vonk.

4.1. Stakeholder Analysis

A stakeholder analysis was carried out to understand the different relationships between the stakeholders of the current service offering of Bundles. The primary stakeholders in the system are explained below. Fig 4.1 shows the stakeholder map with the primary stakeholders in the central circle and the secondary stakeholders in the periphery. The different exchanges between the stakeholders are also illustrated.

Bundles (Service Provider)
Bundles is the core service provider in the PSS and is the focal point of all the interactions between the different elements of the service. They are aggregators of services arising out of the collaboration with partners to deliver value to their customers.

Miele Germany (Manufacturer)
Miele is the manufacturer of the washing machines that are being offered in the PSS. Their relationship with Bundles is transactional with Miele selling washing machines to Bundles in exchange for monetary compensation.

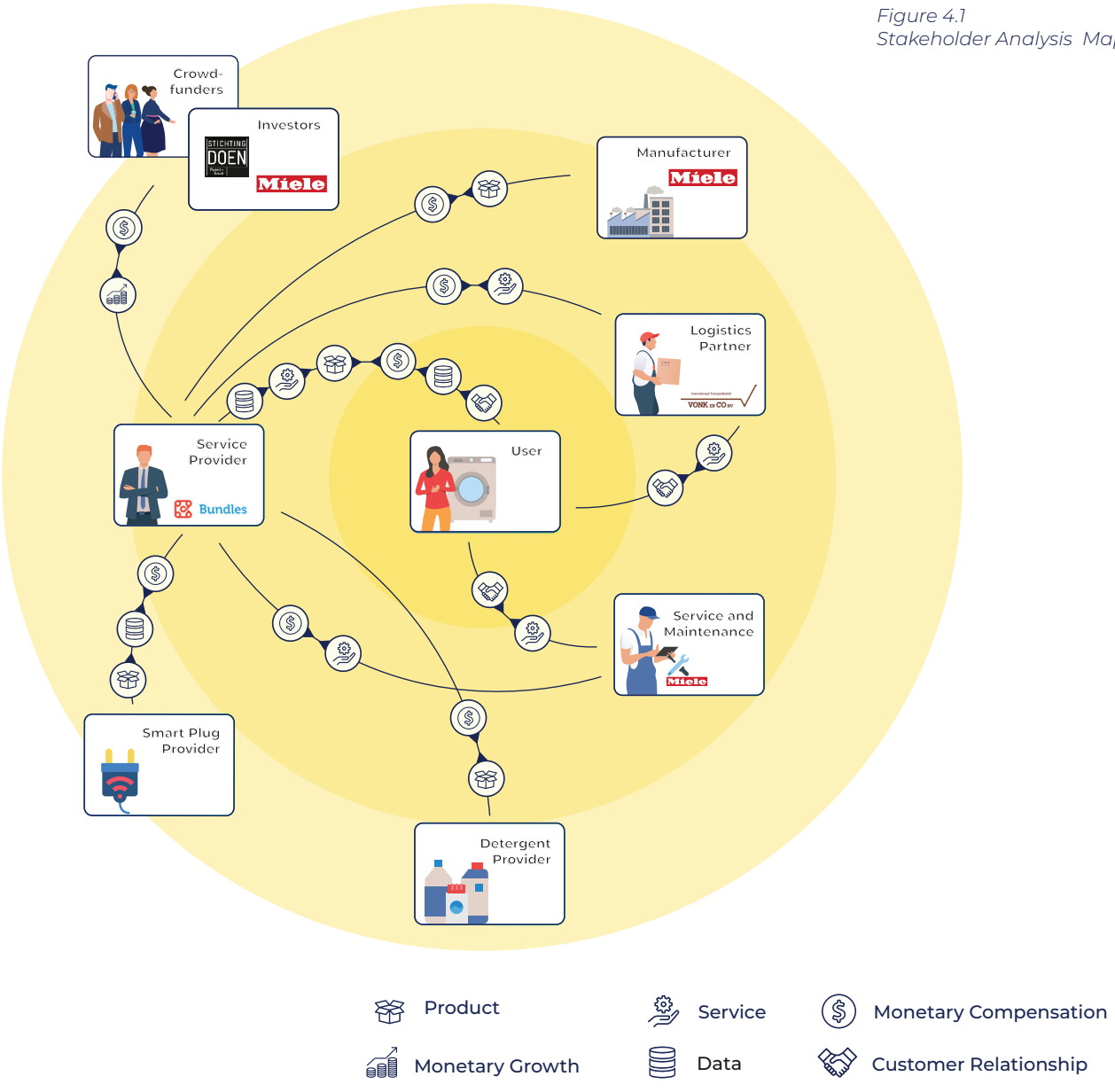
Vonk en Co (Logistics and Refurbishment Partner)
Vonk en Co is the logistics provider for Bundles and is responsible for the delivery and installation of WM and also the reverse logistics of WM when customers terminate contracts. They also take care of the reconditioning of used machines to prepare them for reuse. This reconditioning involves cleaning the machine and making small cosmetic repairs. In case of extensive internal repairs, they call upon Miele Service to fix it who visits the warehouse to fix the machines. Bundles has rented a dedicated space at the warehouse of Vonk for the refurbishment and storage of machines.

Miele Service (Repair Partner)
Miele NL Service network is the repair partner for Bundles. They service the WMs in case of breakdowns and Bundles bears the costs of the servicing. They also carry out reconditioning of the used washing machine in case extensive repairs are required.

User

The User pays a monthly subscription fee to get access to the WM and the services offered by Bunles. The user can reach Bundles for any support via phone or email. They are also provided with information on the phone and web application (Sec. 3.1.4) where they can check their invoices, usage statistics, wash advice and quick troubleshooting measures.

Figure 4.1
Stakeholder Analysis Map



Limitations

1. The partnership between Miele and Bundles is very transactional in nature. For Miele, Bundles is just another customer.
2. Miele has no direct relationship to the customer and is seen merely as the manufacturer of the product.
3. There is no flow of usage data of machine back to Miele which can offer new opportunities for Miele to build relationships with customers.
4. The information provided to the users on their usage is limited to number of washes and does not show how they can improve their washing behaviour.
5. There is a lack of information for the service personnel while trying to diagnose faults and often requires laborious manual diagnosis.

Wishes

1. The designed concept links the machine directly to the network which can establish a higher fidelity data link between all the primary stakeholders – Bundles, Miele and the user which can give rise to new value creation opportunities.
2. The designed concept improve customer relationship with the service provider.
3. The designed concept help users improve their washing behaviour.

4.2 Business Model Canvas

This section will look into how Bundles operates as a company, and explain the company's business model using Bocken et al.'s (2014) Business Model Framework with comprises of three aspects: Value Proposition, Value Creation and Delivery, and Value Capture. (Fig 4.2)
The business model of the washing machine service offering of Bundles is summarized using the Business Model Canvas (BMC) as shown in figure 4.3

Value Proposition

This is concerned with the product and service offered to customer segments and how to maintain a continued relationship with the customers.
For Bundles, the target customer segment is Urban households. Their value proposition for customers is to provide access to high-quality and highly energy-efficient (Miele) washing machines at a low cost and also provide a hassle-free and sustainable laundry experience.

They maintain their customer relationships through their customer-care helpline, through regular emails and by providing feedback and insights on the BundlesApp.

Figure 4.2
Business Model Framework
(Bocken et al. (2014)

Value Creation and Delivery

Bundles delivers on the proposition of providing access to high-quality machines by partnering with Miele to provide machines which are rated with an A+++ energy efficiency label. They provide access to these machines by providing them on a pay-per-access and pay-per-wash subscription model without need for a high initial investment from the customer. They aim to make the Total Cost of Ownership (TCO) of a washing machine through the Bundles service lesser than that by buying a washing machine.

Bundles deliver on a hassle-free laundry experience by taking responsibility of the installation, service of the machine in case of a fault and also reverse logistics of the machine if the customer decides to terminate the service. They provide a customer-care helpline and a mobile application to assist customers with any issues or concerns.

Bundles also provide detergent along with the subscription by monitoring the washing behavior of customers and predicting the detergent use of the machine and shipping a detergent refill before the customer runs out. For this, they have retrofitted the machines with a Smart-plug which records power-usage patterns and translates the data into wash data. They have partnered with Proctor & Gamble to develop the algorithm that analyses the detergent use.

For a sustainable laundry experience, Bundles provides customers information and tools on the BundlesApp that gives customers tips and information of how to wash with the optimal program and how to maintain the machine. The BundlesApp also gives customers insights into the usage of the machine in comparison to the average Bundles customer.

Bundles delivers on the sustainability promise by refurbishing machines which return on termination of service by the customer and reusing the machines for a new customer.

Value Capture

Bundles has a recurring revenue stream arising out of the monthly subscription pay-per-access fee and the pay-per-wash fee that customers pay. They also add to the revenue stream by promoting subscriptions of other product categories offered by Bundles.

The cost base for Bundles arise from the capital investment into procuring machines, logistics, the smart plug and warehousing. There are also lifecycle costs as a result of servicing the machine by Miele service, refurbishment by Vonk. There also administrative costs from customer service, financing costs and web hosting charges.

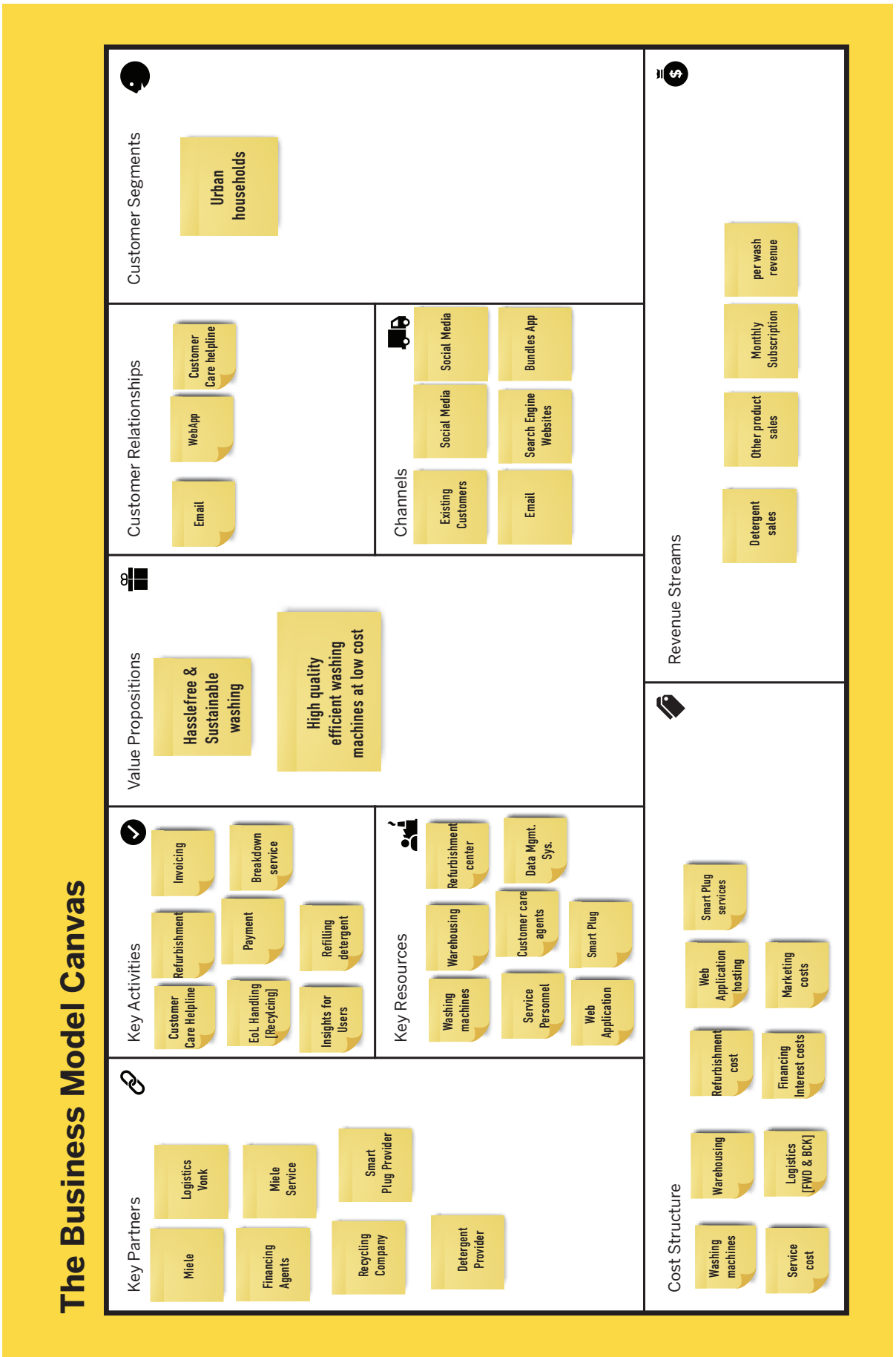


Figure 4.3
Business Model Canvas of Bundles

Limitations

1. The high capital investment required for purchasing the washing machine is detrimental to the scalability of the business.
2. Most key partners have a transactional relationship with Bundles. These increase the cost of running the business
3. The lifecycle costs due to refurbishment are high (discussed in Sec. 4.1.4) leading the subscription price to be higher.
4. The administrative cost of running the service is high due to the involvement of multiple stakeholders requiring constant coordination and the lack of automation of these processes.
5. While the revenue is recurring and a major component of it fixed, as the business grows, the costs of repair and refurbishing will increase as the machines gets utilized more.

Wishes

1. The designed concept reduces administrative cost of running the PSS.
2. The designed concept to reduce the cost of repair and refurbishment.
3. The designed concept increases collaboration with key partners.
4. The designed concept unlocks new revenue streams and value creation for users.
5. The designed concept strengthens the value proposition of the service by improving customer satisfaction and becoming more sustainable

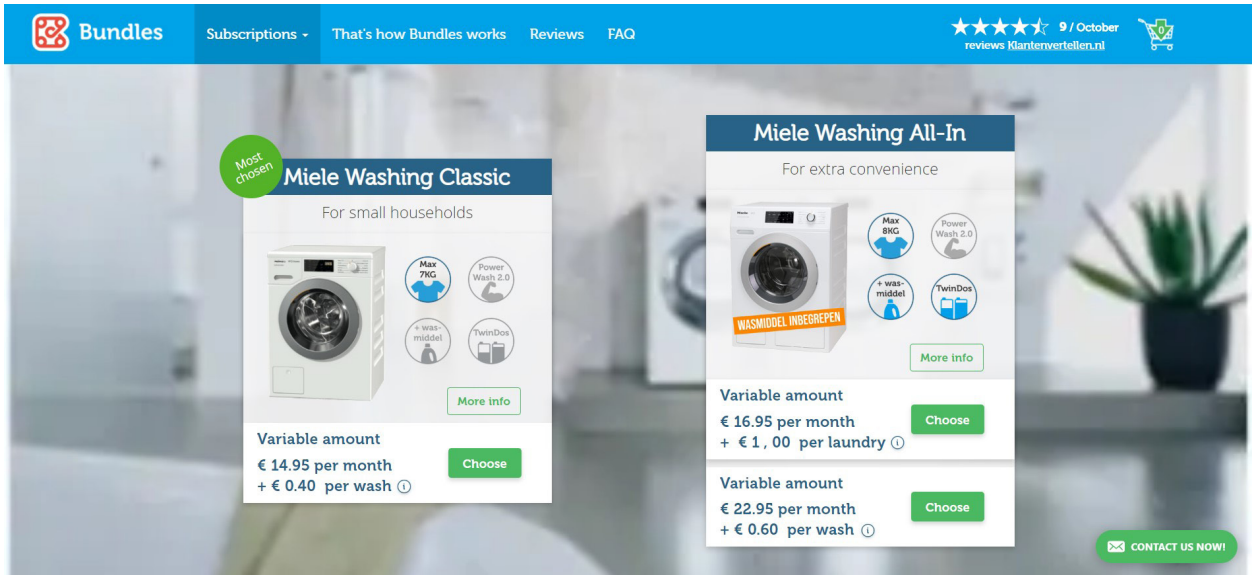


Figure 4.4
Bundles Subscription Plans

4.3 Subscription Types

Consumers have the option to choose from two types of machines (Fig 4.4)

1. **Miele Classic Washing Machine :**
   This is aimed at small households with subscription not including detergent supply and automatic detergent dispensing

2. **Miele All- In WM**
   This is aimed at higher customer convenience. With this subscription, Bundles also supplies the detergent and the machine has an automatic detergent dispensing system installed.

The subscription has two cost components a fixed pay-per-access component and a pay-per-wash component which is charged on the number of washes done by a user.

4.4 Bundles App

Bundles provides a mobile and web application to its customers where the users can access information about all the products provided on a subscription model (fig 4.5).

With washing machines, the application provides the following features:

Wash Assistant

A tool to get advice on which wash program to use based on t the type of laundry.

Stain Pointer

A section for tips and tricks on how to handle tough stains.

FAQ Section

This section contains information on quick questions users might have with using the washing machine and also tips with disruptions, faults and maintenance.

Your Subscription

This section displays information about the subscription of the users and the invoices of their usage.

Insights

This section displays the insights of the usage of the machine by the users. The user can check the number of washes and compare to their own average or the average of all Bundles users.

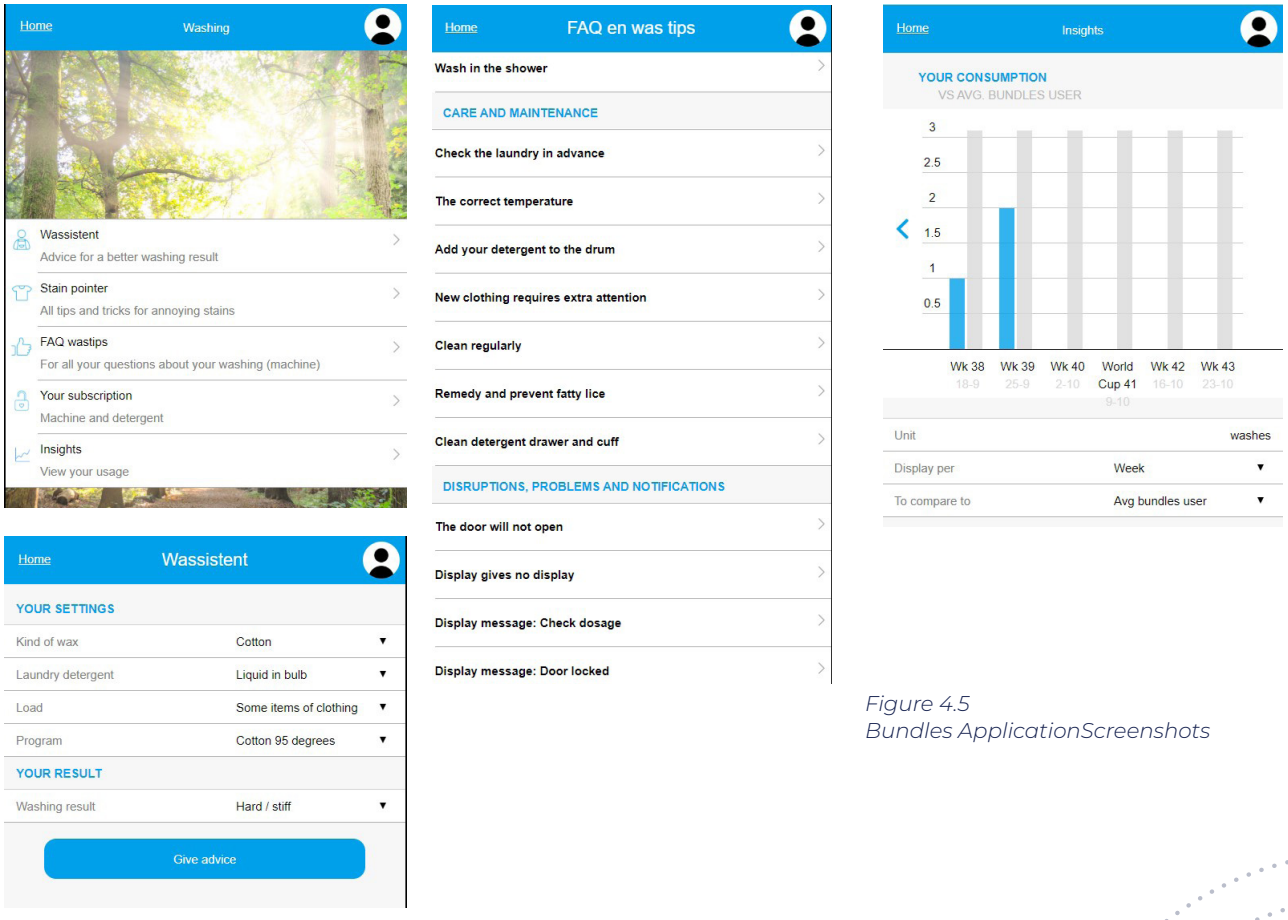


Figure 4.5
Bundles ApplicationScreenshots

Limitations

1. The application merely provides information about the service to the users barring the wash assistant.
2. The application does not bring about any user engagement with the service or the service provider.
3. The user cannot control or monitor the function, status or condition of the machine.
4. The insights are barely useful to influence user behaviour and practices.

Wishes

1. The designed concept be able to monitor the condition of the machine
2. The designed conept provide users with more control over the machine
3. The designed concept make user interaction more intuitive
4. The designed concept generate actionable insights and show insigts of environmental benefits.

4.5 Service Offering

The different actions and interactions in the journey of the user in the service, starting from discovering the service to the termination of service were mapped. Fig 4.6 shows the different parts of the customer journey and the interactions between the different elements in the system facilitating the journey in the frontstage and in the backstage as well as the pain points experienced in the different parts. The journey of the current PSS is divided into three phases – **Pre-use phase, Use phase and Post-use phase.**

4.5.1 Pre-Use Phase

This phase is the part of the customer journey is focused around discovering the service and the process of purchase of the subscription service. The different steps in this phase are:

Discovery

This phase of the journey involves the customer discovering Bundles as a potential option for procuring a new washing machine. Here, promotional emails are sent to potential customers to appraise them of the service. Search engine ads are also displayed when customers search for relevant terms. This leads them to the website of Bundles.

The backstage processes involved in this phase includes identifying potential customers and carrying out targeted marketing.

Information

On finding the website, the customer can view information about the service offering like the different subscription plans, benefits of service, terms and condition and the reviews of existing customers.

The backstage process involved with this phase involves Bundles developing the content of the website and prepare the subscription plans.

Purchase of Service

On deciding to opt for a subscription with Bundles, customers fill in the required details. The website automatically checks the address for availability of service in the area and then redirects the customer to the payment portal and provides confirmation of the order via the website and email.

The backstage processes involved in this phase includes providing the form for customers to fill in their details, to define the service area for customers to know if their address has service availability, to provide the payment portal and to send the confirmation emails on successfully signing up for the subscription service.

4.5.2 Use Phase

This stage of the journey starts with the delivery and installation of the machine and subsequent use of the machine by customers to do laundry. The different stages of this phases are:

Delivery and Installation

On confirmation of the order, in the backstage, Bundles first checks its inventory at Vonk for a reconditioned machine. If it is unavailable, a new machine is ordered from Miele. An e-mail is sent to the customer which contains a form that the customers need to fill in (Appendix D). This form collects information relevant for the logistics and installation of the machine (for example - what kind of building does the machine needs to be installed, if there is a water supply point at the place, etc). This information is passed on to the logistics and installation partners, Vonk en Co. Vonk (logistics partner) then contacts the customer to schedule an appointment for delivery and installation. The installation is then carried out by Vonk who also configures the connectivity kit containing the smart plug. Customers then receive an welcome email (Appendix D) with relevant information and also the credentials to access the Bundles mobile and web application (Section 3.4).

Use (Wash)

This stage involves the process of use of the machine by the customer to wash the laundry. The users load the laundry, select the wash program, add the detergent and start the wash. The users are provided with the wash assistant on the Bundles app to get advice on selecting the best wash program. For users with the Miele All-in subscription plan (Section 4.3), through TwinDos (Section 2.2.5), the machine automatically detects the kind of load and dispenses detergent automatically.

The smart plug, which is retrofitted to the washing machine, then converts the power consumption data into number of washes and uploads it to the database.

This conversion of power usage data to wash is done using an algorithm software by Bundles. This wash data is then used by Bundles for invoicing purposes.

This data is also used to generate insights on the washing behaviour of users and displayed on the Bundles

application.

For the subscribers of the Miele All-In plan, the detergent is included in the plan. The data transmitted by the smart plug is also used to predict the detergent use using an algorithm developed with Proctor and Gamble, a famous detergent manufacturer. When the system detects that the user might be running out of detergent soon, Bundles drop-ships detergent refills to the customers in advance.

Maintenance and Repair

If there is a malfunction with the machine, the customer can firstly troubleshoot the problem using the Bundles App which holds information for troubleshooting issues. If they aren't able to solve the issue, the customer contacts the Bundles customer care helpline to reports the problem. Bundles then raises a service request with Miele Service. Miele then contacts the customer to schedule an appointment. Miele technicians then visits the customer and fixes the fault in washing machine. The cost for the service are paid by Bundles.

Painpoints

1. The customer needs to manually enter the load information in the app to get the optimal wash program.
2. Smartplug records only power consumption and indirectly calculates number of washes. No data on type of wash program, water consumption is collected.
3. There is no regular maintenance done on the WM during the use phase of the service.
4. The breakdown is only detected after the customer informs Bundles while the repair cost is borne by Bundles.
5. With the amount of data collected from the washing machine indirectly being limited, a limited number of insights and statistics available to the users.
6. With customers with the Miele All-In subscription plan, the machines are equipped with the Twin-Dos automatic detergent dispensing system. Users stop using the system after the free refill of detergent runs out. The reason for not using the system is the lack of smell in the detergent and the high cost of refills.
7. By the analysis of reviews of customers of the Bundles service on www.klantenvertellen.nl, it was noted that customers find that the delivery window given by Vonk was too wide which lead to missed deliveries and the customers ended up getting charged 89 EUR for missing the delivery.

Figure 4.7
Bundles Refurbishment Center at Vonk

Figure 4.8
Refurbished Machines storage sleeve

4.5.3 Post-Use Phase

This phase of the service involves the journey of the machine after the user terminates the subscription. This includes the the procedure of termination of the service, the reverse logistics to bring back the machine to Bundles and the subsequent process of reconditioning (refurbishment and service) of the machine to prepare it to be reused by another Bundles customer.

The user terminates the subscription by sending an email to Budles. On termination, Bundles initiates the process of pick-up of the used machine which is done by Vonk. Vonk contacts the user to schedule a pick-up appointment and then picks up the machine from the customer. The machine is then brought to the warehouse of Vonk. The warehouse has a dedicated space rented by Bundles where the reconditioning is carried out (fig. 4.7).

Here, the machine condition is assessed and a personnel from Vonk carries out basic cleaning and minor cosmetic repairs on the machine. In case the machine requires major internal repair, a Miele technician is called to fix it. The reconditioned machine is then stored at the warehouse (Fig 4.8) for it to be reused for another customer.

Painpoints

1. The assessment and inspection of the used machine is done visually.
2. While usage data of the machine is collected and a service history is recorded, this data is not used for the refurbishment process.
3. The most common repairs that happen during refurbishment is the replacement of the inner seal as it is either dirty or worn out (fig 4.11) and customers accepting refurbished machines often complain about the condition of the seal. The cost of this replacement it about 160-180 EUR.
4. The other major replacement is the Twin-dos automatic detergent dispensing system which gets clogged due to non-usage of the system by the previous customer causing the liquid detergent to clog the tubes. The service cost of replacing or repairing it is between 180-270 EUR (fig 4.12).
5. The other repair that is carried out often is the body panels which often need to be drilled for double-standing washer-dryer combos installation.

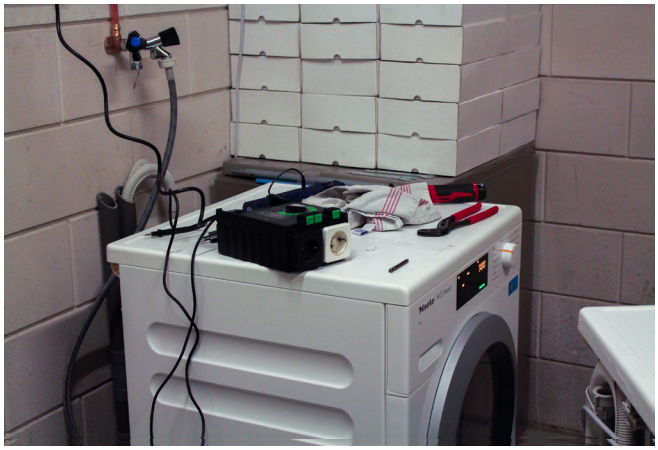


Figure 4.9
Used machine being repaaired by Miele Service

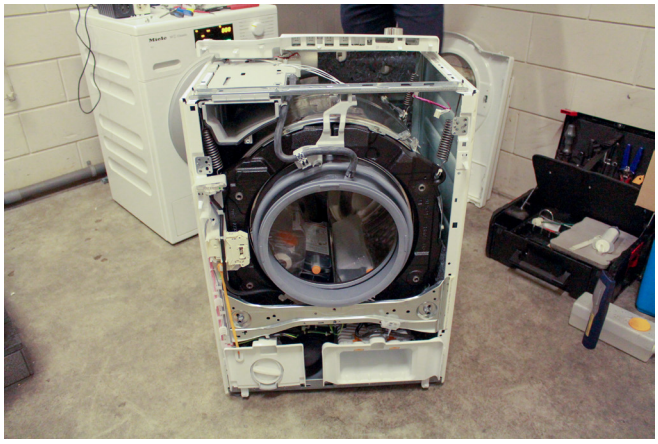


Figure 4.10
Used washing machine in repair

Figure 4.11
Degraded inner seal of used washing machine

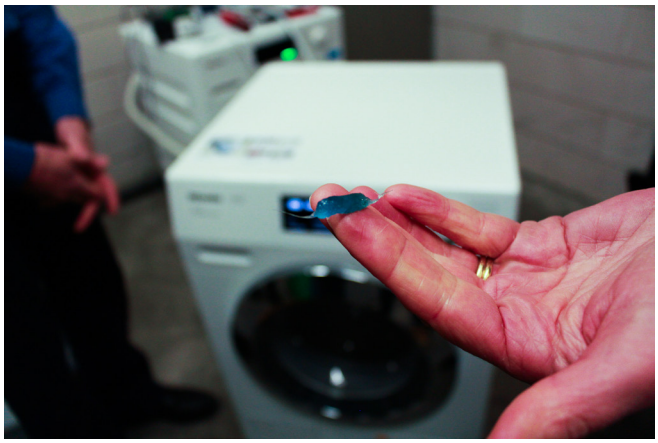
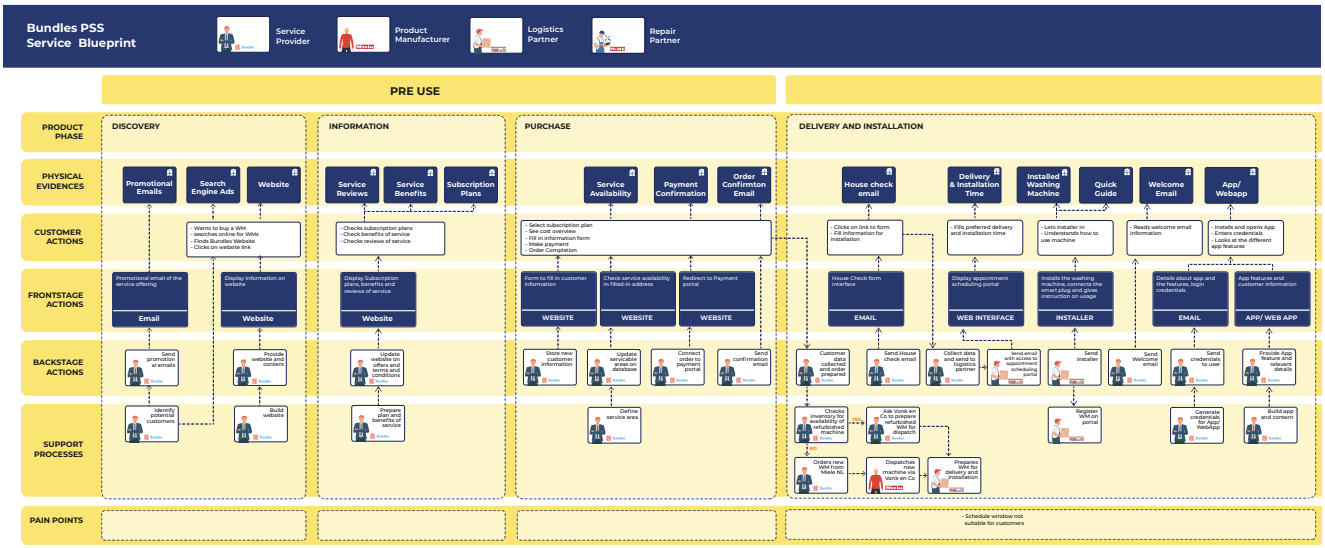


Figure 4.8
Chunk of removed hardened detergent clogging the tubes of Twin-dos system



Wishes

1. The designed concept can reduce the lifecycle costs
2. The designed concept could collect the service history of the machine
3. The designed concept could enable regular maintenance of the machine
4. The designed concept reduce the total cost of owndership of the machine
5. The designed concept improve collaboration between the stakeholders
6. The designed concept make it easier for repair and service of the machine.

4.6 Bundles Users

Bundles currently have an installed capacity of 2000 washing machines. The users of the service are categorized on the basis of age groups, geographical location, buying argument and credit score (Appendix C)
A conjoint study was conducted by Bloom, a data analytics company and Bundles in 2018 to analyze data of the customers, their usage data to generate insights on customer segments, usage behavior, buying arguments, product portfolio and clustering and segmenting of subscribers (Appenix C).
Some of the key insights from the study are :

Customer Segments

1. 63% of Bundles' customer base is aged below 45,
2. The 46-55 age category brings in the highest average monthly revenue,
3. 36% of the customers aged 46-55 have multiple contracts for other products, compared to only 16% of the customers aged 18-25,
4. Clients aged 46-55 are least likely to have a pay-per-wash subscription.

Usage Behavior

5. At least 17% of customers who pay per wash are most likely better off with a pay-per-month contract,
6. From all customers, those below 35 years old have churned most often
7. With increasing age, the main buying argument shifts from 'flexibility' to 'comfort / service,
8. For pay-per-wash customers, 8-10 washes per month is most frequently observed,

Buying Argument

9. Despite the clear environmental mission of Bundles, sustainability does not seem to be the most important buying argument for most customers,
10. Flexibility is, with 36%, the most important buying argument for customers below 35 years old,
11. Across all customers, 'Comfort / Service' is the most popular buying argument and is correlated with the highest revenue per month,

Product Portfolio

12. Miele Classic (cheaper plan) quickly grew in share after its introduction in Feb 2017, indicating there was a customer need for a lower-cost mode,

Key Takeaways

Despite Bundles' key mission being sustainability and CE, customers are attracted to the flexibility and comfort proposition offered by the PSS. The average number of washes of customers is 8-10 washes which shows that the utilization of the machine over the nominal contract period of 5 years is much lower than the actual service life of the machine.
The growth of Miele Classic plan (cheaper) shows that there is a need for segmentation in offering on the basis of price and features.

4.7 Survey on Washing Practices and Behaviour

An online survey was carried out to understand the washing practices and behaviour of users. A total of 175 respondents filled the online survey.

4.2.1 Survey Questions

To better understand how users wash their laundry and how aware they are of the upkeep of the machine, the following questions (Appendix D) were answered by the users:

1. What age group they belong to and what is the composition of their household?
2. What kind of laundry setup do they use – private/shared/by hand
3. How many loads do they wash per week and when?
4. What kind of detergent do they use and how do they add it?
5. How do they separate the load and how do they select the wash program?
6. How important is the length of the wash and how often do they use the longer ECO wash?
7. How often do they clean their washing machine and if they use the cleaning program for cleaning the washing machine?

4.2.2 Results

About 49% of the respondents were aged between 25-40 which corresponds with the target segment of Bundles and 46% of the respondent were aged between 18-24.

The median for the number of people per household was 3 showing that the respondents live in relatively small households. About 78% of the respondents use a washing machine installed at their home similar to the setup Bundles offers and 18% of the respondents use a shared washing machine at a Laundromat or a coin-laundry.

The average number of washes is 2.5 washes per week which translates into an average service life of 38.5 years for a Miele machine offered by Bundles which is almost 3 times that of the average lifetime of a washing machine as found out by Tecchio et al. (2019)

Most respondents do their laundry when that have a full load (58%) and when they find the time to do it (56%) and only 10% of the respondents have a fixed day of the week when they do the laundry which shows that there isn't a routine attached to washing practice by the respondents.

About 60% of the respondents use liquid detergent followed by 19.5% of them using powder detergent with 62% of all respondents adding an approximate amount of detergent for the washes. This shows potential for Bundles and Miele to increasingly work on the automatic detergent dispensing system for added value to customers and better washing results.

It can be seen that 66% of the respondents selects the washing program based on the kind of the laundry and 31% use the same wash program for all washes. The focus should be on ensuring that all users are able to effortlessly choose the right wash program based on the type of load. This is something that Bundles offers through its wash assistant feature in the BundlesApp (Ch.4.1.4) and Miele through its Miele@home mobile application (Miele, n.d.-b).

50% of the respondents almost never clean the washing machine and only 9% of the respondents clean their machines on a monthly basis. Many respondents even commenting if the washing machine is required to be cleaned and even if they did know, they weren't aware of how to do it. 67% of the respondents also are unaware of a cleaning program available on machines and another 19% don't use it at all. This can be seen as synonymous to why a lot of parts degrade and have to be replaced on refurbishment by Bundles.

Wishes

1. The designed concept increase user awareness of machine use and maintenance.
2. The designed concept accomodates different washing habits and give users feedback on their practices

CHAPTER 5

THEORETICAL ANALYSIS

This chapter discusses how the findings from the previous chapters relate to the literature review as discussed in Chapter 3. First it will show how Bundles fits into PSS and the challenges it face. Followed by, whether Bundles' circular effort are in line with CE as described by literature and if there are opportunities that haven't been taken. It also shows the different efforts by Bundles with Digital technologies and what opportunities it can take to improve the service.

5.1 Bundles and Product Service Systems (PSS)

Here, Bundles was related to the literature of Product Service Systems. The categorisation of Bundles in the PSS ecosystem and the challenges faced by Bundles are explored

5.1.1 Bundles – The category of PSS

As described in Section 3.1.2, PSSs can be classified into three main categories: product-oriented, use-oriented and result-oriented (See figure 3.1).

Bundles offers a PSS which lies between Use-oriented and Result-Oriented PSS. They charge a fixed-amount per month for access to the washing machine and a variable per-wash component which depends on the number of washes the customers use.

Miele on the other hand mostly offers product-oriented PSS through service contracts and in some cases use-oriented PSS in the case of commercial washing machines (Section 2.2.6).

5.1.2 PSS Challenges and Bundles

With Bundles, the challenges with implementation of the PSS were researched in the context of this project to identify potential risks and design opportunities. With relevance to the project, four challenges were selected that contribute to requirements of the solution space:

Supply Network

The transactional nature of the relationship between Bundles and Miele poses a challenge to the successful delivery of the PSS. Given that Miele has a strong influence over the Product-side and Bundles has a strong influence over the Service-side of the PSS, a strong collaboration between the two is required for the development and implementation of a successful PSS (Vezzoli, Ceschin, Diehl, & Kohtala, 2015).

Performance Measurement

With the value of the WM during the different parts of the lifecycle estimated approximately, based on visual and functional appearances (Section 4.5) and no concrete way to track the value of the product is a challenge for the Bundles PSS. Metrics for performance of assets in the PSS will help with value delivery and

also decision-making at different lifecycle stages in the service system.

Product/Service System Design

With Bundles using off-the-shelf WMs from Miele and use of existing logistics and service networks with minimal modification is a challenge for the scalability of the PSS. There is a need to look into the dedicated design of the products and the services associated with the system to maximize benefits for both the user and for the PSS.

Redefining the interface

Currently, the users and Bundles do not have an optimal platform to keep the customer engaged and also build a relationship with the customers. The Bundles App (Section 4.4) has limited functionality and is restricted by the fact that the machine is not connected to the internet. The app only displays wash advice and number of washes. There is a need for looking into redefining this interface between the user and the service.

Key Takeaways

1. The current service and product were designed and developed independently of each other. Literature shows that a true collaboration between Miele and Bundles in the development and delivery of the different elements of the PSS could allow the PSS to be successfully implemented and allow the alignment of product and service requirements.
2. There is a need to track the value of the assets (WM) in the PSS in the different lifecycle stages to enable better decision-making contributing to the increase the service life of the product in the system and the actions needed to achieve them

5.2 Bundles and the Circular Economy

As mentioned in Section 3.1.2, PSSs are seen as the way towards fulfilling user needs with less resources consumptions and lower impact. PSS are considered a positive approach towards CE (Tukker, 2013). Bundles through its business model and PSS offering is one such use-case towards Circular Economy (EMF, 2018).

As can be seen in figure 3.4, there is value creation in every step of the value chain as it rises from pre-use till the use phase. At the end of the use phase of a product, it can be seen that each drop in the value chain, value of the product and subsequently resources is decreasing again. Maintaining value instead of destroying it is where circular propositions are more profitable and effective than linear propositions.

In order to keep this value as high as possible, the loop has to be closed and circular strategies are need to be in place for all downhill activities through - repair/maintain, reuse/redistribute, refurbish/ remanufacture and recycle (Achterberg, Hinfelaar, & Bocken, 2016).

5.2.1 Circular Efforts of Bundles Circular Economy

As discussed in Section 4.1.5, Bundles adopts circularity in order to reuse a machine to offer to as many customers as possible before the EoL of the machine. Table 5.1 summarizes the efforts by Bundles towards CE and the limitations of these efforts as identified in Section 4.5.

CE Strategy	Effort	Limitations
Repair/ Maintain	Bundles aims to prolong the life of the machine by providing a high-quality long lasting product by Miele and a service to repair it alongside.	No regular maintenance of the machine happens during use phase.
Reuse/ Redistribute	Bundles reuses and redistributes the machine till it reaches EoL..	User acceptance of used products; Washing machine not designed for multiple use-cycles.
Refurbish/ Remanufacture	Bundles, at the end of every use cycle – refurbishes the machine for a new use cycle.	Product not designed for such process and often laborious and expensive for Bundles.
Recycle	Bundles picks up old machines of new customers and sends to recycler. Bundles also reduces the amount of waste generation by using high-quality machines.	Bundles disposes used machines through regular channels where the waste stream is not homogenous and contains other machines as well.

Table 5.1
Bundles and CE Efforts

5.2.2 Challenges of Bundles in a Circular Economy

Based on the current context of the Bundles PSS as discussed in Chapter 4 and the CE challenges discussed in the literature review, the challenges faced by Miele and Bundles were analysed and are shown in Table 5.2.

Type of CE Challenge	Miele	Bundles
Financial	• Costs of implementing new systems to incorporate reverse flow of materials • Potential cannibalization of primary sales	• Capital expenses for one-off purchases of equipment which pays off over a long duration • High transactional cost in the process of looping
Structural	• Lack of overview of developments in CE • Newness to new BMs away from traditional selling of goods	
Operational	• Given the large size of the company, there is a lot of inertia to quickly move towards CE	• Tedious manual processes affects scalability
Attitudinal	• Requires rethinking of current processes which might be difficult to harmonize over all departments • Requires all departments to work in tandem to realize it which might be difficult	• Not enough clarity about true benefits of the CE which shows some resistance towards full adoption
Technological	• Not enough know-how on how to convert data into actionable insights • Products not connected to the manufacturer post-sale • The products not designed for the CE	• Limited data on condition of the machine available • Decision making is not automated and done manually

Table 5.2
CE Challenges faced by Bundles and Miele

5.3 Digital Technology in PSS and CE

5.3.1 Current System and IoT Capabilities

Porter & Heppelman (2014) propose four basic capabilities of connected products: Monitoring, Control, Optimization, Autonomy.

From a product perspective, the washing machine is equipped with sensors which can be used for monitoring the condition of the product and the usage but is not being used for in the WasBundles ecosystem. With no access to the data generated by the machine, Bundles uses an external device, the smart plug to monitor the usage of the machine. This data is also being used for invoicing and providing basic insights into the users washing behaviour.

The system does not utilize the other three capabilities – Control, Optimization and Autonomy. Enabling them can improve the experience of the users and also increase the sustainability of the system.

Analysis Conclusion

While the partnership between Miele and Bundles is very strategic and key to the business, it is still very transactional in nature. This becomes a barrier to improve the circularity of the ecosystem. For Bundles, currently the cost base is quite high owing to high financing cost and high lifecycle expenses. This is because the service is designed around the product while the two need to be developed in tandem. While the value proposition offered by Bundles is in the direction of sustainability, the company is not able to fully deliver on the promise and there are a lot of missed opportunities to reinforce the proposition. This is can be attributed to the lack of data integration. While there is data being generated and collected at different parts of the system and by different stakeholders, there is a lack of aggregation of data with most of it being scattered through the system. At a stakeholder level, there is also not enough knowledge about how to translate the data into insights that can add intelligence to the systems as a whole. The project should aim at finding a way to bring these data points and sets together, harmonise it and create actionable insights that have a positive impact.
The washing machine itself by design is not made for the circular economy nor for multiple use-cycles that the PSS demands. Also, there is no system for proactive maintenance of the machine despite being one of the important looping strategies in CE. The system also lacks an active system to drive user washing behaviour.
The lack of awareness of the condition of the machine can be seen as one of the biggest barriers to unlocking opportunities and also tackle the existing limitations and challenges faced by Bundles. The project should try to explore how to overcome this barrier and enable system awareness of the machines and subsequent actions to deliver quality, impact and experience for the Bundles customers.

PART 3
VISION

CHAPTER 6

DESIGN VISION

This part describes the vision of the project leading up to the Design Goal. This is done by showing how a fully circular PSS would look like enabled by digital technologies. Based on this vision for the future, a design goal and the design focus is formulated for the solution space.

6.1 The Future Smart Circular PSS for Washing Machines

Based on the findings of the analysis phase, it can be seen that extending the use-life is one of the preeminent strategies for a more sustainable and circular PSS for washing machines and technology can help bring about the implementation of these strategies. On the basis of the this, a future vision for a Washing machine is drawn up incorporating the Circular Economy value drivers mentioned in Section 1.1 .

This is done by looking at the WM through the three different lenses – Circularity, Product Service Systems and Digital Technologies. Each of these lenses helps to realize the structure of the sustainable ecosystem.
The first lens of Circularity is focused around making the WM more circular through the Circular product design vision shown in Chapter 4.2.5. This is to make the product design of the Washing machine more suitable for life-extending activities like proper use, repair, maintenance, refurbishment and remanufacturing.

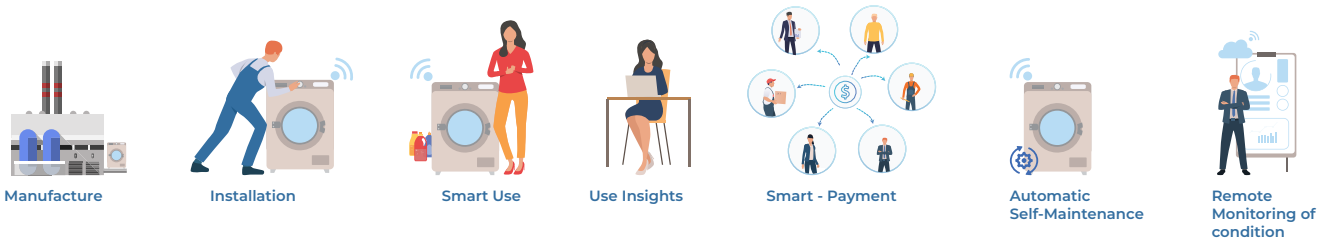


Figure 6.1
Future Vision for Smart Circular PSS for Washing Machines

The second lens is that of Product-Service Systems. This looks at the washing machine through a service-dominant logic. This gives rise to a systemic structure behind the lifecycle extending activities with the involvement of the different stakeholders.

The third lens is that of digital technologies which empanels the product with sensors and data collection capabilities; and the system with data analysis capabilities which enables the different lifetime extension activities to take place.

The result is the conceptualization of a Smart Circular PSS for washing machines. (fig 6.1) The vision includes a set of activities that occur at different stages in the lifetime of the washing machine service (Pre-use, During Use and Post-Use). The activities are as follows :

Smart Installation

The installation process is done with the aid of sensors to make sure that the machine is installed in a proper manner and precautions are taken to ensure that no fault occurs due to improper installation like high vibrations and imbalance.

Smart Use

The washing program is optimized to the load with the optimal amount of detergent, water and power being used. This helps reduce the overall wear and tear of the components in the machine.

User Insights

The users have access to the use statistics and washing behavior to nudge them towards better washing behavior and optimal utilization of the WM. For example, if they are overloading or underloading the washing machine.

Smart Payments

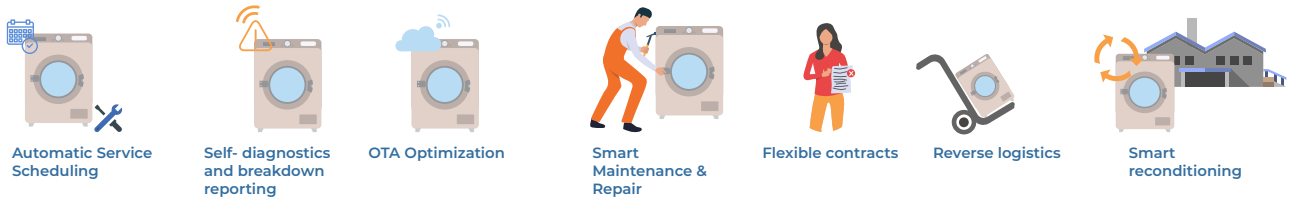
As it a multi-stakeholder service, the respective shares of their revenue are already paid for through a smart micro-payment system.

Automatic Preventive Maintenance

The WM automatically runs self-maintenance actions like high-temperature cleaning washes, rinsing the detergent tubes. It also informs the users when they need to perform certain activities.

Predictive Maintenance

With the WM being connected to the network, the service-provider can monitor the condition of the machine and through data populated over the machines in the field, can predict faults and breakdowns and can take predictive action to tackle possible downtime.



Self-Diagnostic and Reporting

Being equipped with sensors and diagnostics tools, the WM can diagnose faults and communicate the same to the relevant stakeholder to ensure quick and proper service and repair.

Over-the-Air (OTA) Optimization

With the WM being connected to the manufacturer, it can receive updates to the firmware and also based on wash data, can optimize wash program tailored to the users without any user intervention.

Smart Repair

In case of a breakdown, the WM is repaired by the service personnel who has access to the WM data and can plan service more efficiently and enable the use of refurbished parts and components. Consequently, the service provider can better plan the service thus reducing costs and unplanned downtime.

Flexible Contracts

The user retains the freedom to cancel the contract with the service provider or also request a change in service or product. For example, if the living status of a user changes, the user can request a machine with a larger capacity.

Smart Reconditioning/ Refurbishment

If the user chooses to terminate the service, reverse logistics infrastructure is in place to transport the machine to a reconditioning center where the machine can be reconditioned to make it fit for reuse by another customer.

All these different activities in the system is aimed at extending the useful service life of the washing machine. And as this is a design vision, it can be seen as the most ideal solution and does not necessarily imply it is all possible in one system. As the project is focused around the strategy of increasing the service life of the washing machine, the strategy is taken to the extreme. For the sake of posterity, this extreme strategy assumes that the different activities in the future vision increases the useful service life of the washing machine to eternity. This leads to the conceiving of an eternally lasting washing machine. For the scope of the project, important aspects like recyclability and energy efficiency are ignored.

This future vision for an eternally lasting washing machine is intended to detach the ideation process away from the current product and system and helps setup a context for conceptualization of design solutions.

6.2 Design Goal

Based on the analysis and the vision of the future of Washing machines, the following design goal is formulated

“To Design a Product Service System for a Washing Machine with an eternal service life in a Circular Economy”

6.3 Design Focus

With the context of the project and the time available, the project scope was further narrowed down to focus on the designing the system to facilitate easy and efficient service and maintenance of the washing machine.

Maintenance and Service are chosen as the focus firstly because, it is recognized as important strategies for the extension of the service life of the washing machine (Boyano et al., 2017; Prakash, Dehoust, Gsell, & Schleicher, 2016). Secondly because, analysis shows that there is minimal maintenance activities in the current system and the service costs increase the lifecycle costs significantly.

PART 4

DEVELOPMENT

CHAPTER 7

IDEATION SETUP

This phase of the project involves the development of concepts for the design goal. This is done by first defining the solution space, the user experience vision and the requirements and assumptions for the system, the architecture of the washing machine and its relation with the different maintenance and repair actions.

7.1 Solution Space

To kick-off the development phase, the solutions space is first explored by looking at the different kinds of maintenance strategies and its application to washing machines. Similarly, the different faults in the washing machine are also explored. Apart from this, behavior models were investigated to find a framework that supports users to perform the maintenance and service actions. This helps establish a base for the ideation process.

7.1.1 Types of Maintenance Strategies

Literature points out three different kinds of maintenance programs (Swanson, 2001):

Proactive maintenance

Proactive maintenance is a maintenance strategy whereby breakdowns are avoided through activities that monitor equipment deterioration and undertake minor repairs to restore equipment to proper condition. Proactive maintenance includes Preventive and Predictive maintenance which reduce the probability of unexpected equipment failures.

Preventive maintenance is often referred to as use-based maintenance. It is comprised of maintenance activities that are undertaken after a specified period of time or amount of machine use. This type of maintenance relies on the estimated probability that the equipment will fail in the specified interval

Predictive maintenance is often referred to as condition-based maintenance. Within which, maintenance is carried out in response to a specific change in the condition of the equipment. Under predictive maintenance, diagnostic tools are available to measure the physical condition of equipment such as temperature, vibration, noise, lubrication and corrosion. And when one of these reach a specified level, work is undertaken to restore the equipment to proper condition.

Reactive Maintenance

Under reactive maintenance, equipment is allowed to run until failure. On failure, the equipment is repaired or replaced. Within reactive maintenance, temporary repairs may be made in order to return equipment to operation, with permanent repairs put off until a later time

Aggressive Maintenance

An aggressive maintenance strategy goes beyond efforts to avoid equipment failures. It seeks to improve overall equipment operation. Within this, maintenance may participate in these improvements through involvement in efforts to improve the design of new and existing equipment.

For the scope of this project, proactive maintenance is chosen to be investigated further as there already existing protocols and practices for the same.

7.1.2 Proactive Maintenance for Washing Machines

In the study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency", Bundgaard et al. (2015) include improving possibilities for maintenance and repair under "resource efficiency". In the preparatory study for the revision of "Ecodesign and Energy Label for household washing machines and household washer-dryers", Boyano et al. (2017) reports that maintenance and repair are very important for the durability of the WM. For washing machines, the following actions have intuitive effects on durability (Alfieri, Cordella, Stamminger, & Bues, 2018):

- To clean the filter on a monthly basis;
- To clean the pump;
- To clean surfaces, including door gasket and detergent dispenser drawer;
- To carry out hot washes every couple of months for avoiding build-up of detergent;
- To use of descaling agents in case of very hard water.

7.1.3 Faults in Washing machines

Alfieri et al. (2018) and Tecchio et al. (2019) analyze the failures of washing machines and what are the components behind the failure of the WMs.

Most failures in washing machines occurs at the following components :

1. Electronics
2. Shock absorbers and Bearings
3. Door, door hinges and seals, door locking assembly
4. Carbon Brushes
5. Circulation/ Drain pump

They go on to further investigate the cause behind the failure of these components. Table 7.1 shows the connection between machine usage conditions, user actions and the different components whose durability are affected.

Machine Usage conditions and user actions	Major affected Components
Unlevelled Washing machine	Shock absorbers, Bearings, Carbon Brushes
Incorrect Loading	Shock absorbers, Bearings, Carbon Brushes
Overdosage of detergent	Door seals, hinges
Not regularly washing using High-temp wash	Door, door hinges and seals, door locking assembly
Door closed between washes	Door, door hinges and seals, door locking assembly
Not regularly cleaning filters and hoses	Circulation/ Drain pump

Table 7.1
Correlation between machine usage conditions and major affected components

Washing machines are capable of diagnosing certain faults and are currently displayed through fault codes on the display of the washing machines (Appendix E). Table 7.2 summarizes the different faults and the possible causes and remedies to rectify the fault.

Fault	Causes	Remedy	Effect on Machine Functionality
Temperature Sensor (NTC) Short Circuited	Component Failure	Replace Sensor	Machine continues to run with cold water
Temperature Sensor (NTC) Open Circuited	Component Failure	Replace Sensor	
Water Intake	Water Supply Shut	Check water supply tap	Machine stops functioning
	Intake filter clogged	Clean inlet filter	
	Low onsite pressure	Check pressure	Wash program takes longer
	Problem with solenoid valve	Repair	Machine stops functioning
Water Drainage	Drain filter clogged	Clean drain filter	Machine stops functioning
	Drain hose blocked	Clean hose blocked	
	Problem with drain system	Check and Repair non-return valve, drain pump, hoses	
Hot water Intake	Water Supply Shut	Check water supply tap	Machine continues to run with cold water wash
	Intake filter clogged	Clean inlet filter	
	Low onsite pressure	Check pressure	
	Problem with intake solenoid valve	Repair	
Excess Foaming	Over-dosage of detergent	Proper dosing of detergent	Additional Rinse cycle
	Machine not draining	Check drain pump	Machine stops functioning
Heating	Problem with Heating circuit	Check heating circuit	Machine continues to run with cold water wash
Electronics	Failure of control and/or power electronics	Check/Replace	Machine stops functioning
	Communication fault with Display Module Interface	Check connections between modules	
Pressure Sensor	Analog Pressure Sensor Failure	Check/ Replace pressure sensor	
Tachogenerator	No signal from drive or main motor circuit	Check for faulty components	
Water Path Control Unit	Faulty Water Path control unit	Check/ Replace components	
Door lock is jammed	Fault with Door lock sensor	Check/ Replace components	
Float valve activated	Internal Leakage	Check for leaking component	

Table 7.2
Fault Analysis for Washing machines

7.1.4 Behavior Change Models

Bundles provides washing machines under the “Pay-Per-Use” business model, which is a sufficiency-based business model. The environmental impact reduction potential of the pay-per-use business model is evident (Tukker, 2015). Bocken et al. (2018) presents how the business model in general already changes people’s behavior positively. The current system relies more on the business model and strategy level to influence positive washing behavior by users.

Maintenance and repair seen as important for increasing the durability and the useful service life of the WM and from the analysis of the different maintenance actions and service (Section 7.1.2 and 7.1.3), it can be seen that the users needs to perform these activities.

With the service provider contractually responsible for the service and maintenance of the washing machine, there is a need for a mechanism that encourages users to undertake the required service and maintenance action and requires a behavioral change in users for it to be successful.

The Fogg Behavior Model (FBM) is one such psychological model that identifies factors that control whether a behavior is performed. Fogg (2009) defines three factors that influences user behavior – Motivation, Ability, Triggers.

In brief, the model asserts that for a target behavior to happen, the user must have sufficient motivation, sufficient ability and effective triggers to carry out the intended activities. The model goes on to say that these three factors must be present at the same instant for the behavior to occur.

Fig 7.1 visualizes the FBM as a graph with motivation on the Y axis and ability on the X axis. The ideal behavior requires a high motivation and ease in carrying out a behavior. The triggers to these succeed to the top of the action line.

Fogg further goes on to elaborate on the different elements of three factors- ability, motivation and triggers.

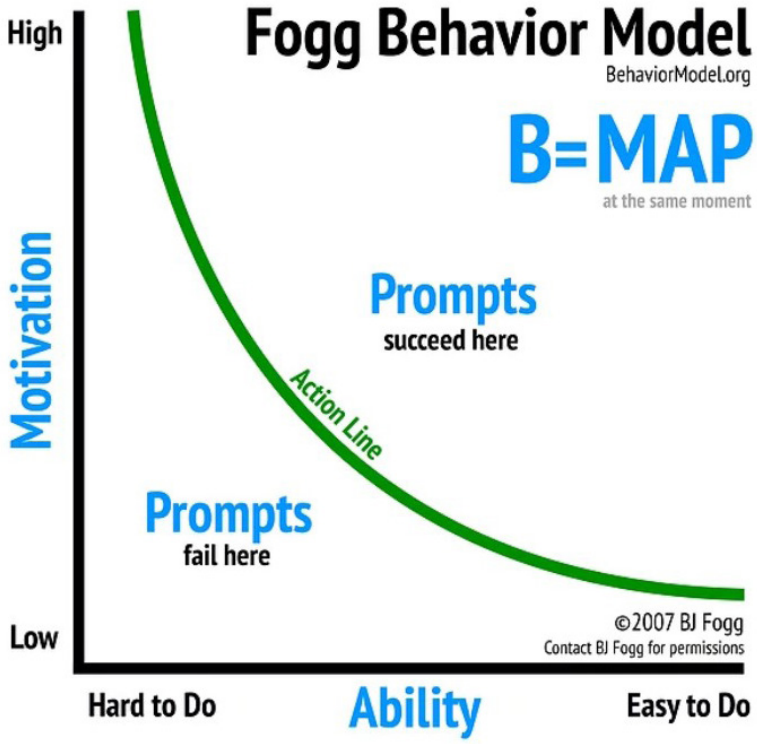


Figure 7.1
Fogg Behavior Model (Fogg, 2009)

Elements of Motivation

Pleasure/ Pain

The immediate results of carrying out a behavior can be motivation through pleasure or pain

Hope/ Fear

This dimension is characterizes by the anticipation of an outcome which can be something positive- Hope or the anticipation of a bad outcome.

Social Acceptance/ Rejection

This motivator is a social dimension where the outcome warrants either social acceptance and the motivation to avoid social rejection.

Elements of Ability

Time

The target behavior's time requirement affects the ability to do the task

Money

A higher ability is seen when the target behavior costs less money especially if there is limited financial resources

Physical Effort

The target behavior should be simple and require minimal physical effort to carry out.

Brain Cycles

If the required behavior requires a lot of thinking, it reduces the ability to carry out a task compared to a task that requires less thinking.

Social Deviance

If a task requires the user to go against social norms and normal practices, the ability to do the task reduces.

Non-Routine

If the target behavior requires the user to move away from a routine, activities may be found not to be simple and reduce the ability.

Types of Triggers

Spark as Trigger

This type of trigger is aimed at motivating the user to carry out a certain behavior and is usually sent in tandem with an element of Motivation.

Facilitator as Trigger

This type of trigger is aimed at improving the ability of the user and guiding the user to carry out the intended activity.

Signal as Trigger

This type of trigger is intended as a reminder to carry out the target behavior when the person is sufficiently motivated and has sufficient ability to carry out the activities.

Ryan & Deci (2000) in their Self-Determination Theory describe two kinds of motivation – intrinsic and extrinsic. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable while extrinsic motivation refers to doing something because it leads to a separable outcome. While extrinsic motivation can be used as a boost to get going, but in the long run, intrinsic motivation works better (Ryan & Deci, 2000). Therefore, the design intervention can begin by building extrinsic motivations such as incentives or punishments for users. Thereafter, it will be necessary to build the intrinsic motivations for the sake of a long-term user engagement.

In the context of the maintenance and service of the washing machine, the designed solution should encapsulate these factors to facilitate users to carry out the required activities effectively.

7.2 Design Direction

On the analysis of the solution space, it can be seen that there is user involvement with the service and maintenance of the machine. In order to achieve the goal of an eternally lasting washing machine, users behavior needs to be changed to carry out the different activities required for extending the service life of the washing machine. This requires them to be motivated sufficiently and be given the ability to carry out the various maintenance and service actions. This lead to the design direction to be chosen as designing the User Interface (UI) for facilitating the proper maintenance and service of the washing machine in order to extend its lifetime eternally.

CHAPTER 8

IDEATION

This chapter looks at the ideation process to first setup a vision for the UI and then generate a framework for the conceptualization of the user interface by mapping different scenarios of maintenance and service.

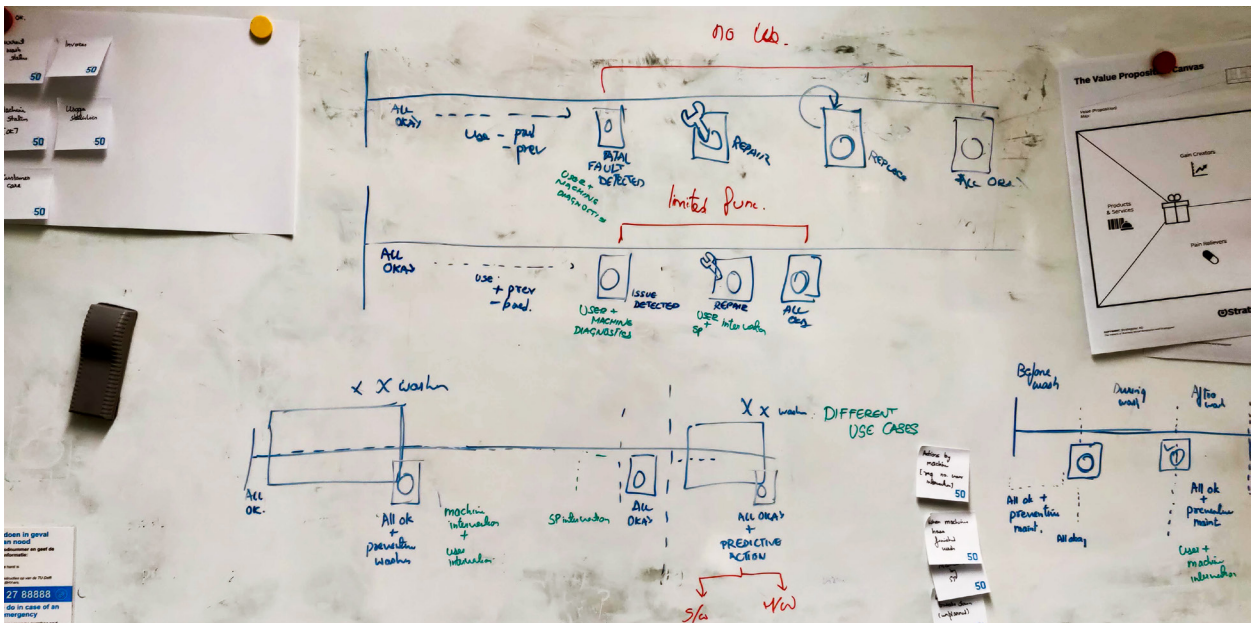
8.1 Brainstorm

The different maintenance activities and the different faults and corresponding service actions are explored in the solution space (section 7.1.2 and 7.1.3). On further introspection, it was seen that these different faults and maintenance actions occur at different times in the service life of the washing machine.

A brainstorm was then carried out by placing the different actions and occurrences on a timeline of the use-phase of the washing machine.

It can be seen that there are there are some faults that can be solved by users while others require a service personnel to repair it. There are also faults that can be avoided through maintenance actions and some that can be predicted and fixed before failure.

Figure 8.1 Brainstorm session



8.2 UI Vision

Here, the vision for the User Interface is defined. This helps to later evaluate the concept and see whether the UI concept fulfils the goal of the UI vision.

The overarching goal for the UI is that “The UI must support the extension of lifetime of the washing machine through effective and efficient maintenance and service”

Apart from this, some other sub-goals are also defined. They are :

1. UI should motivate users to carry out maintenance activities,
2. The UI should give users the ability to carry out different maintenance actions and also aid them to carry out the initial prognosis before requiring service provider intervention,
3.. The UI should trigger the users to carry out the required activities to fit into the normal routine of the user and should not be very disruptive.

8.3 Scenario Mapping

Scenarios for three different faults and the reason behind the occurrences were explored and the different activities that can be carried out to avoid these faults were investigated. The scenarios were chosen rationally to encompass all the different aspects of the service and maintenance process.

The three different fault scenarios that were explored are:

1. Degradation of inner seal of door
2. Failure of Heating element
3. Fault with the water inlet

8.3.1 Scenario 1 : Degradation of inner seal of door

The degradation of the seal can be caused by the following reasons (Fig 8.2) (P. Tecchio, Ardente, & Mathieux, 2016):

1. Foreign objects
2. Door left closed after wash
3. Not cleaning seal after wash
4. Overdosage of detergent
5. Normal wear and tear
6. Not regularly doing a high temperature wash

These causes were then clustered according to the maintenance strategy that can help in avoiding them.

These maintenance strategies occur at different points in time and have different frequencies. For example, some preventive maintenance actions like leaving the door after wash, cleaning the seal and removing any foreign object can be done right after every wash.

Another preventive action like regularly using a hot water wash is something that is done periodically. While the normal wear and tear can be tackled through predictive maintenance where data about the condition and usage of the washing machine can be used to plan the replacement of the seal before failure occurs.

With the functioning of the washing machine, the washing machine can be continued to be used normally without any significant effect on the performance of the machine.

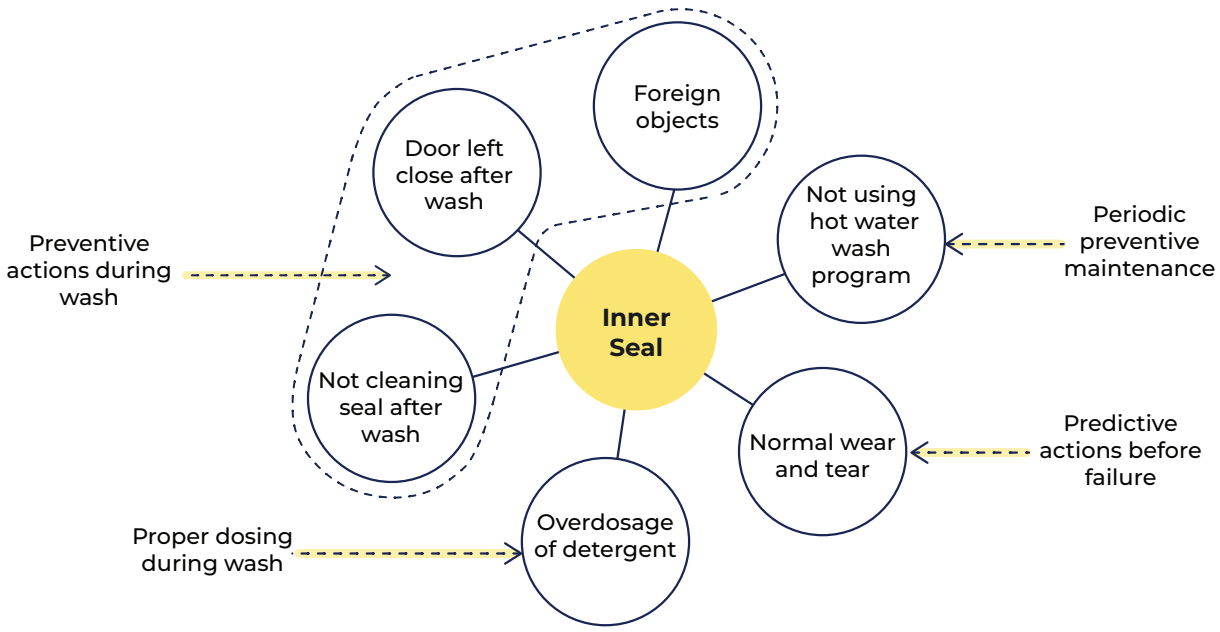


Figure 8.2
Scenario brainstorm for degradation of inner seal

8.3.2 Scenario 2 : Failure of Heating System

With the failure of the heating system, it can be traced to component failure. And the only remedy is to replace the failed component. This replacement requires the Service provider to perform the service of the machine.
With the functioning of the machine, it can be seen that the machine still continues to run with the functionality of carrying out a high-temperature wash disabled.

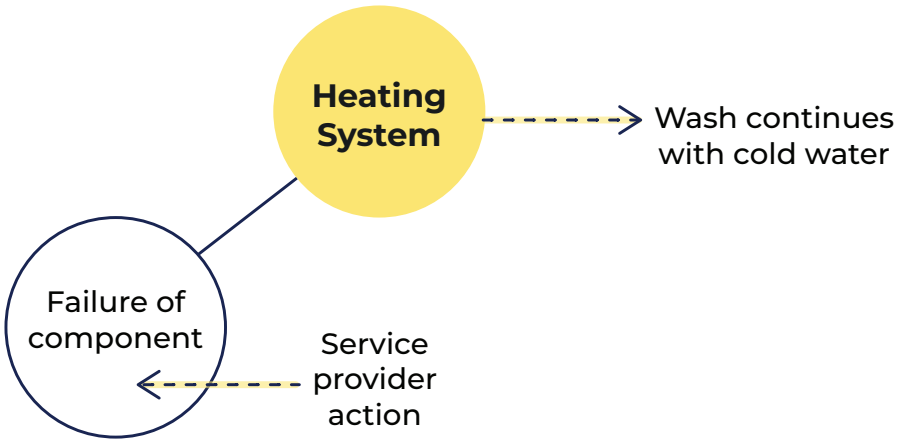


Figure 8.3
Scenario brainstorm for Heating system failure

8.3.3 Scenario 3 : Water inlet fault

With the water inlet fault, the fault occurs due to either external factors or internal faults. The causes behind the fault are:

1. Water inlet tap is closed off
2. The inlet filter is clogged
3. Low water pressure at inlet
4. Problem with the inlet valve

The fault can be avoided by carrying out regular cleaning of the filter and if the fault occurs, it can be easily rectified by the user and if that does not rectify the fault, then the service provider needs to perform a repair action.
The fault causes the machine to seize operations and becomes non-functioning.

With the three scenarios, it is worthy to note that each scenario firstly has a effect on the functionality of the machine. The scenarios also show that there are different interactions involved. Sometimes, the user needs to interact with the machine or with the service provider.

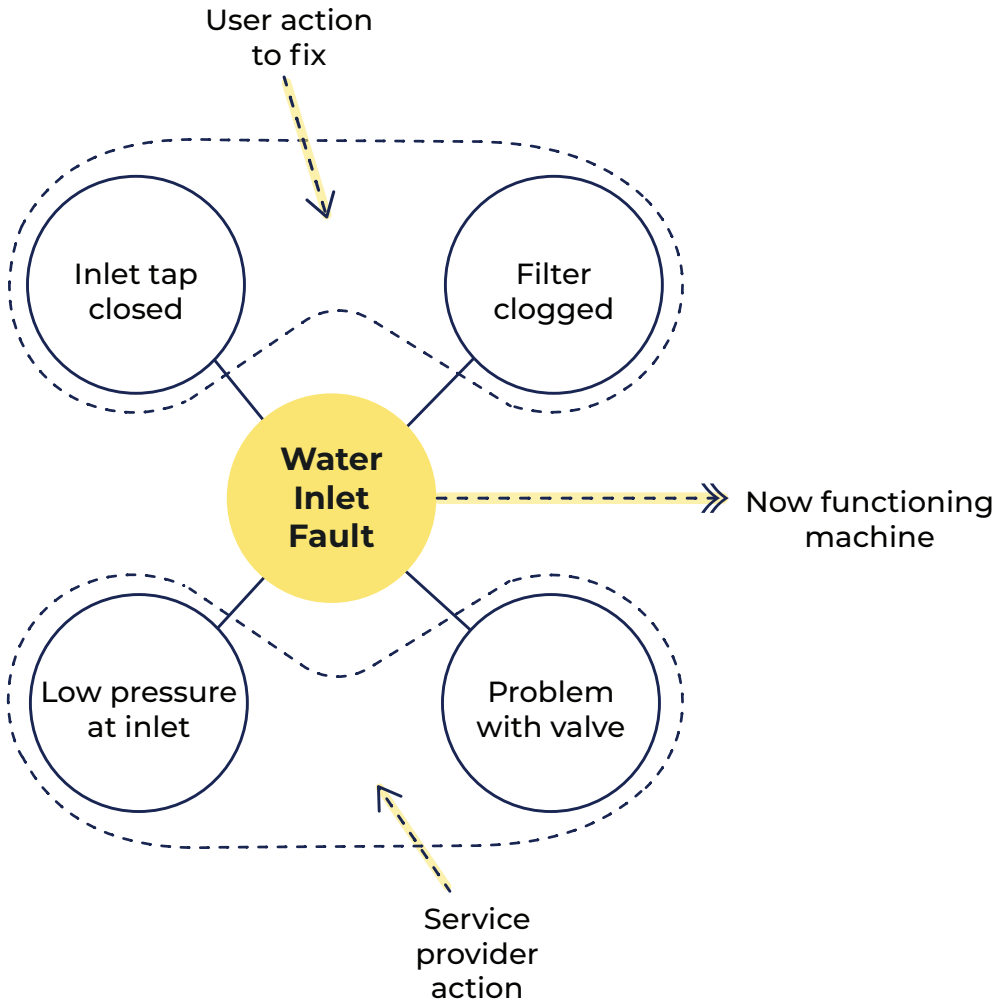


Figure 8.4
Scenario brainstorm for Water inlet fault

CHAPTER 9

USER INTERFACE FRAMEWORK GENERATION

This chapter builds on the findings of the ideation to generate a framework for the generation of the User Interface.

9.1 Machine States

Based on the scenarios as illustrated in Section 8.3, it can be seen that the WM has different states and it transitions from one state to the other due to the occurrence of a fault or the need for a maintenance action. On performing the action or rectification of the fault, the machine transitions back to its original state.

From the scenarios and the brainstorm, three states of the machine are identified. They are:

Green State

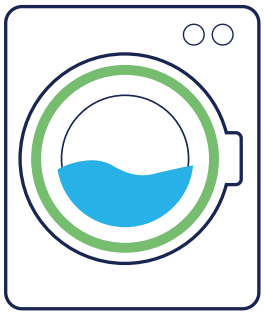
In this state, the machine is functioning normally and does not require any user or service provider attention. This is the most-desired state for the washing machine.

Yellow State

In this state, the machine is functioning normally but requires either an maintenance action by the user, the machine or the service provider.

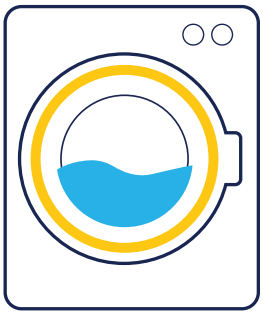
Red State

In this state, the machine cannot be used by the user for washing or has limited functionality. This state requires a service action to be carried out to restore the functionality



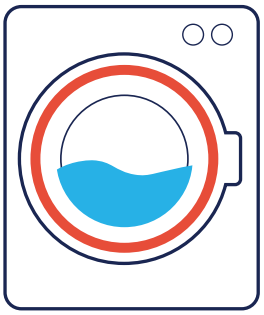
Green

All okay



Yellow

All okay + Maintenance Action Due



Red

Non- Functioning Service action reqd.

Figure 9.1
Machine States

9.2 Machine State Transitions

After defining the different states, the transitions between the different states were explored. The different state transitions that were explored are :

- Green to Yellow State
- Green to Red State
- Yellow to Red State

Apart from these state transitions which are dependent on the use-cycle of the washing machine, there is also a use-cycle independent action. This includes hardware and software upgrades to the washing machine which are dependent on the development cycle of the manufacturer. This action can occur at any stage and brings about improvement to the performance and quality of the WM while also extending the life of the machine.

Fig 9.2 visualizes the different state transitions in the WM with the arrows showing what action causes the transition.

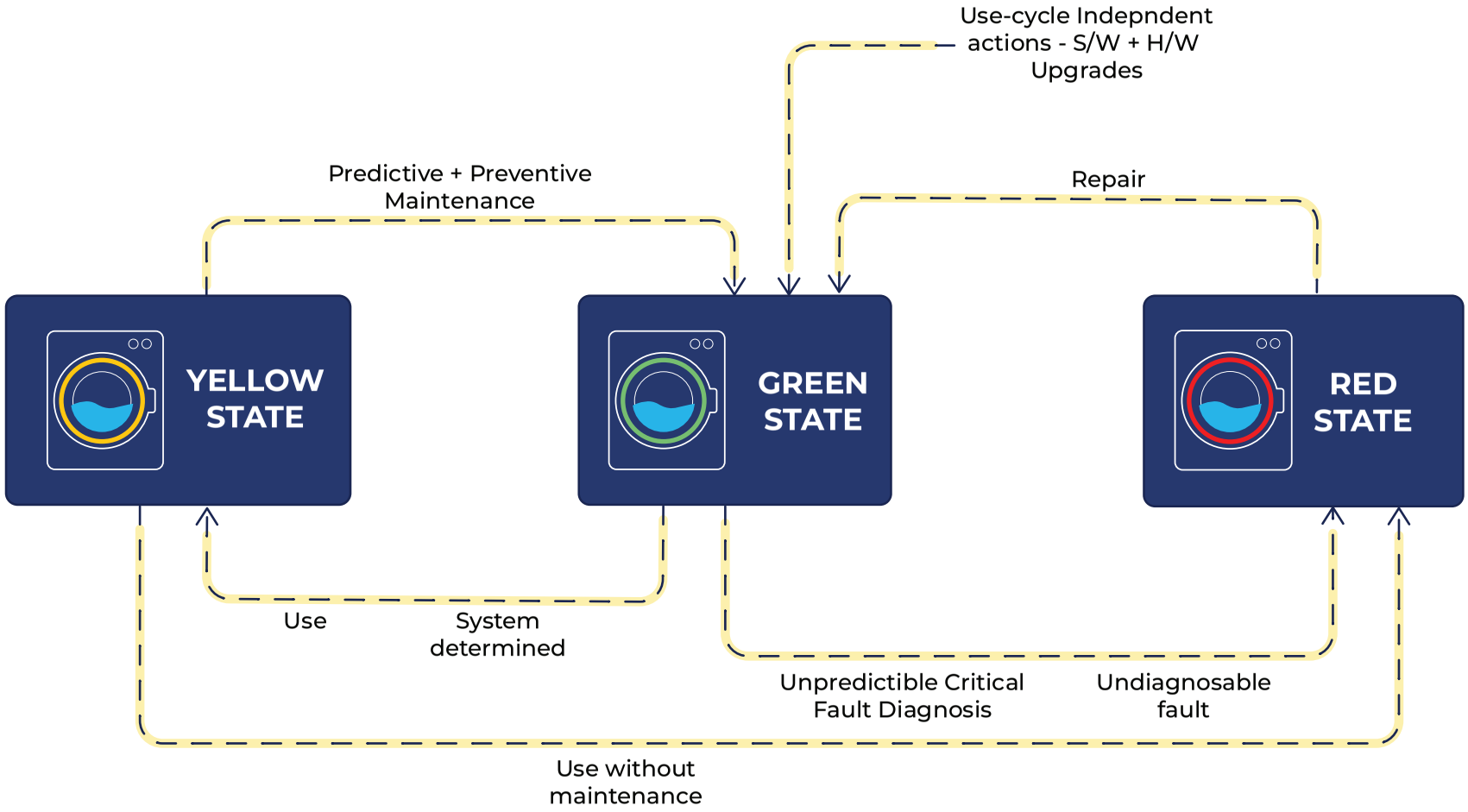


Figure 9.2
State Transition
Diagram

9.2.1 Green to Yellow

The machine transitions from Green to Yellow when it has preventive and predictive maintenance actions due as a result of the use of the washing machine. The transition back to green occurs when the maintenance action is carried out. As seen in Section 8.3, these maintenance action occur at different instances and at different frequencies. This kind of transition occurs at four different instances. They are :

1. **Before every wash**
   This includes preventive maintenance actions that have to be resolved before the commencing of the wash program as washing with these actions due might be detrimental to the durability of the machine.

2. **After every was**
   These maintenance activities are due right after every wash that the user has to carry out to ensure that the machine is maintained well. These include activities like cleaning the seal, letting the door open after use, removing any foreign objects.

3. **Periodic Maintenance Actions**
   The machine requires to undergo preventive maintenance actions periodically to avoid degradation of the machine. These activities include cleaning filters, having the machine carry out a self-cleaning cycle etc.

4. **Condition-based system recognition (Predictive Maintenance)**
   This occurs when the system recognizes from machine data if a certain component is starting to show signs of failure and requires a repair/ replacement action before eminent failure.

Loop	Cause	Remedy
Before Every wash	Unlevelled Machine	Levelling the machine
	Imbalance in load	Redistributing the load
After Every Wash	Preventive Maintenance actions	Cleaning the seal
		Leaving the door open
		Removing foreign objects
Periodic Maintenance	After every 30 washes	Clean inlet filter
		Clean drain filter
		Automatic Self-cleaning by WM
Predictive Maintenance	System recognized	Replacing of the component by Service Provider

Table 9.1
Maintenance Loops

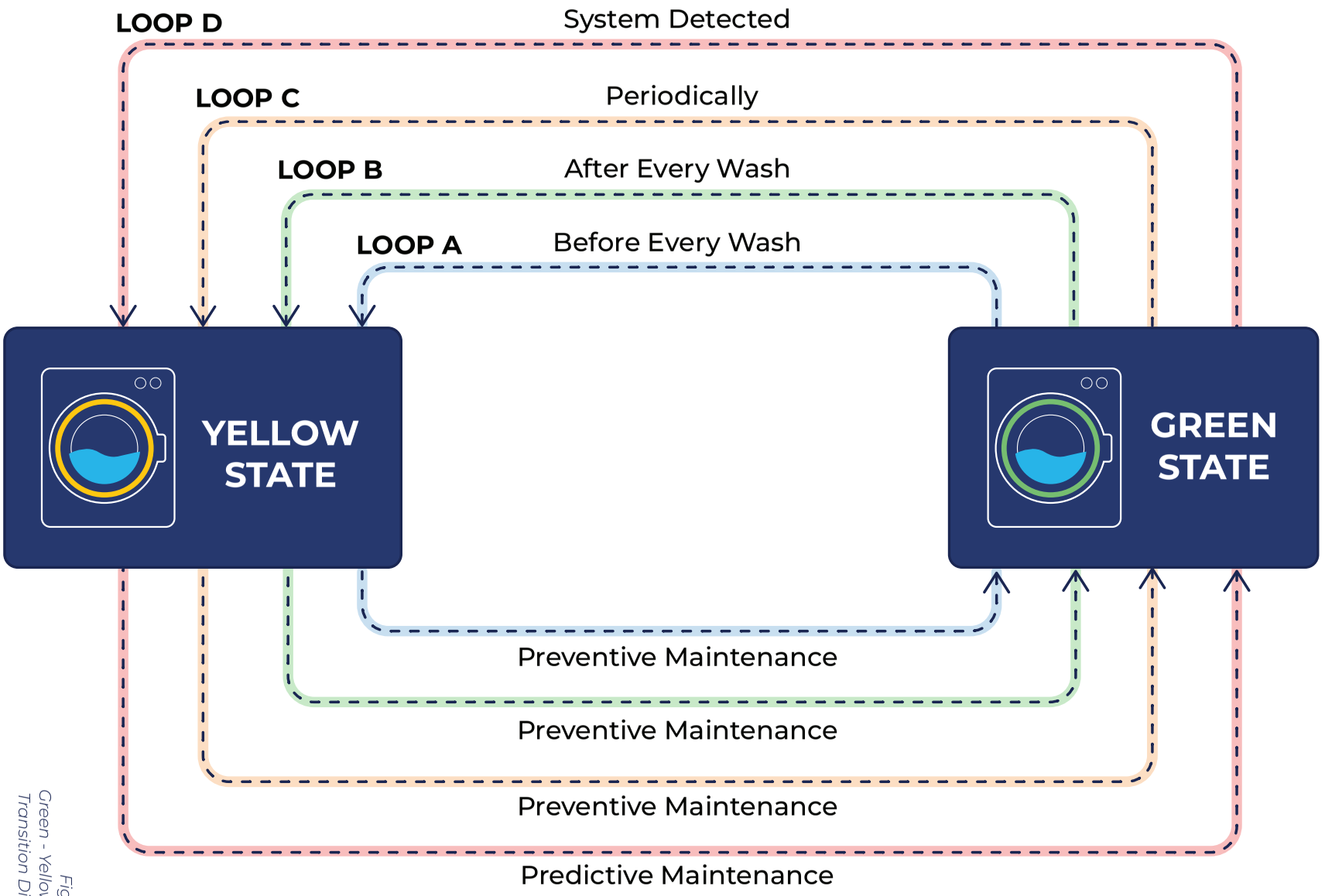


Figure 9.3
Green - Yellow State Transition Diagram

Table 9.1 summarizes the different actions that cause the transition from Green to Yellow state and the corresponding activities that bring it back to Green state

9.2.2 Green to Red

The machine transitions from Green to Red state when following things occur:

1. When the machine diagnoses an unpredictable critical fault which causes the machine to become non-functional. Within this transition, the fault can be rectified either by the user or through a service action carried out by the SP.

2. When the machine diagnoses an unpredictable non-critical fault which causes some functionality of the machine to be lowered and it requires a service action by the service provider to fix the fault.

3. When the user encounters an undiagnosable fault or physical damage to the machine and reports the problem to Bundles.

Table 9.2 summarizes the different faults that cause the transition from Green to Red state and the corresponding activities that bring it back to Green state

Loop	Cause	Remedy
Non-Critical Fault diagnosis	Temperature Sensor Failure	Replace failed component
	Heating system Failure	Repair/Replace system
	Hot water intake	User action
Critical Fault diagnosis	*Heating system Failure*	*Repair/Replace system*
	Hot water intake	*User action*
	Faulty Drain system	Replace/ Repair valve
	Water Inlet Fault	User Action/ Repair/ Replace
	Water path control unit	*Repair/ Replace*
	Electronics	Repair/ Replace
	Tachogenerator	Repair/ Replace
	Pressure Sensor	Repair/ Replace
	Door lock	Repair/ Replace
	Water leakage	Repair/ Replace
Undiagnosable fault	*Power failure*	Repair/ Replace
	Water Leakage	Repair/ Replace
	Network failure	Repair/ Replace

Table 9.2
Fault modes

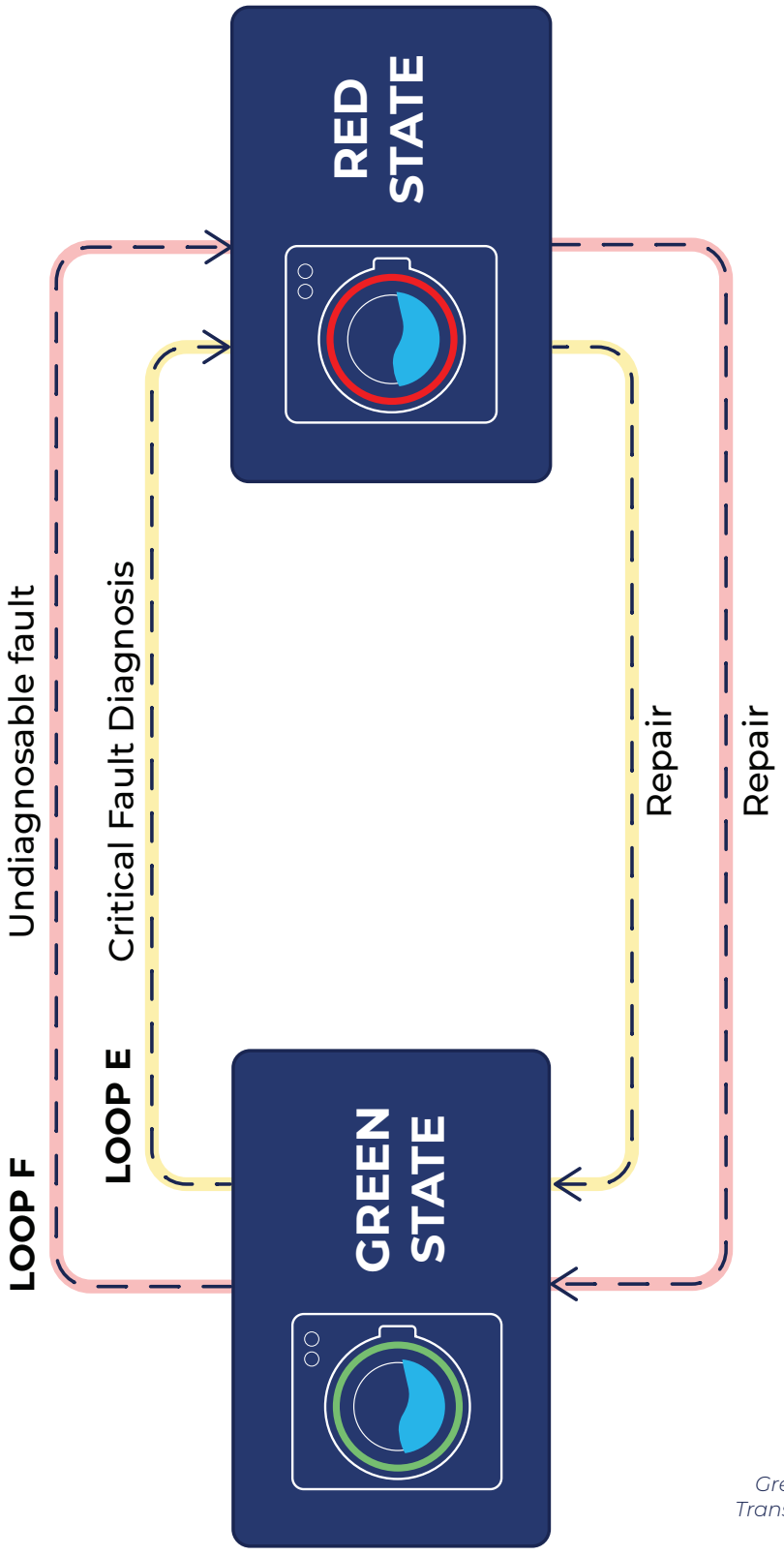


Figure 9.4.
Green - Red State
Transition Diagram

9.2.3 Yellow to Red

The machine transitions from Yellow to Red when the user continues to use the WM without carrying out any of the maintenance actions which would eminently lead to critical failure of the machine causing it to seize operation. In this case the machine has to be repaired to bring it back to the green state.

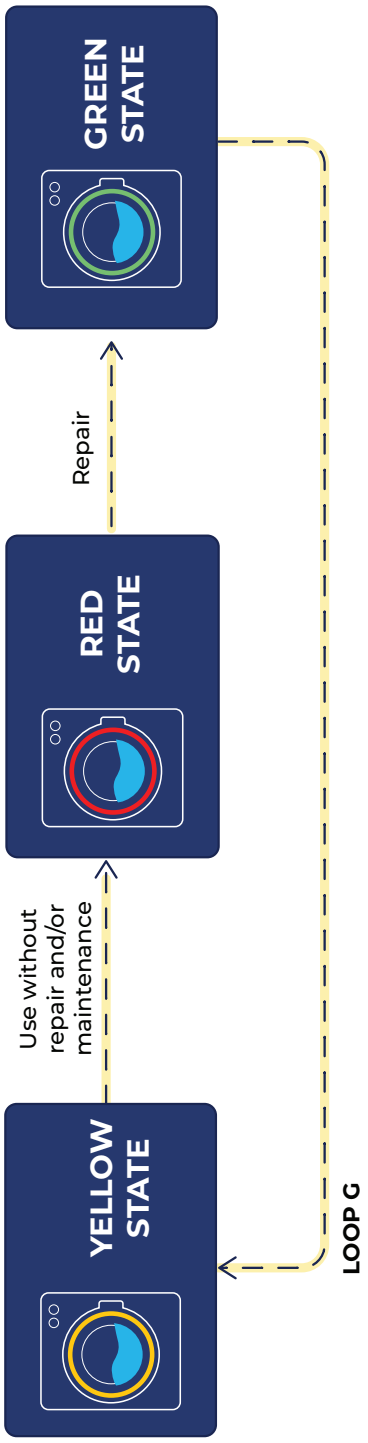


Figure 9.5. Yellow - Red State Transition Diagram

9.3 Behavioral Aspects

Looking at the different state transition loops, faults occurrences and rectifications, and the different maintenance actions and keeping in mind the goal of motivating and enabling users to carry out the required maintenance and service actions, a behavior change model is proposed for the customers of Bundles. This is based on the Fogg's behavior model described in Section 7.1.4.

The different elements of model applied to the user interface for Bundles are:

Motivation

Pleasure : Showing positive impact of doing the required action.
Ex: Savings in water consumption from proper usage of detergent.

Pain : Denying access to use the machine if critical action is not carried out.
Ex: User not allowed to wash unless they carried out a maintenance activity.

Hope: A reward system for carrying out an action.
Ex: Free wash or free detergent for regularly carrying out maintenance action.

Fear: Showing the negative impact of not carrying out an action.
Ex: Bad wash result if an action is not carried out.

Ability

Physical Effort and Brain Cycle: Guide users through the process of doing an action and make actions more intuitive.
Ex: A digital guide on how to clean a filter.

Non-Routine: Bind maintenance actions to the normal washing routine.
Ex: Ask user to do a task right after removing the laundry

Trigger

Spark : Show impact of good behavior to motivate good behavior

Facilitator: Provide visual tools and aids to help users carry out an action.
Ex: Animation or video of a maintenance activity

Signal : Notify users of pending and impending actions.

9.4 Information Architecture

Using the different state transitions, a brainstorm session was carried out to generate the information flow during the transition to set a base for the UI to be developed. The information flow was made by taking the different faults and maintenance actions described in Section 7.1.2 and looking at what information is required to facilitate the different actions.

These information flows were further refined and visualised to get the information for each loop in the state transitions to get the final Information Architecture(IA)(Appendix E)

The IA was then used to generate wireframes for the User Interface between the user and the WM.

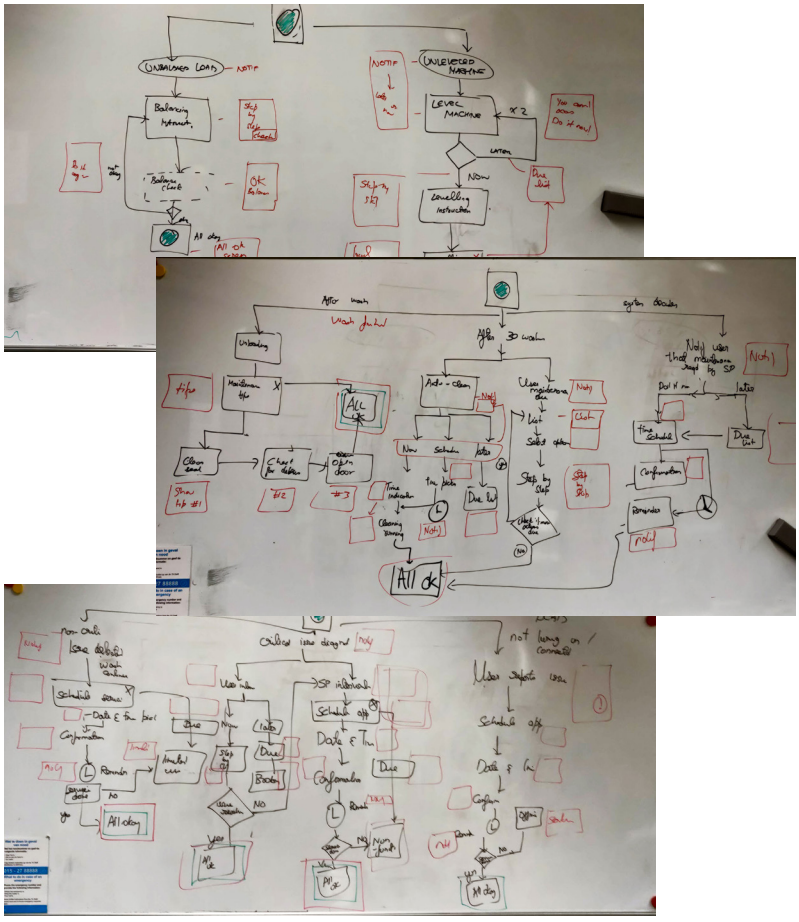
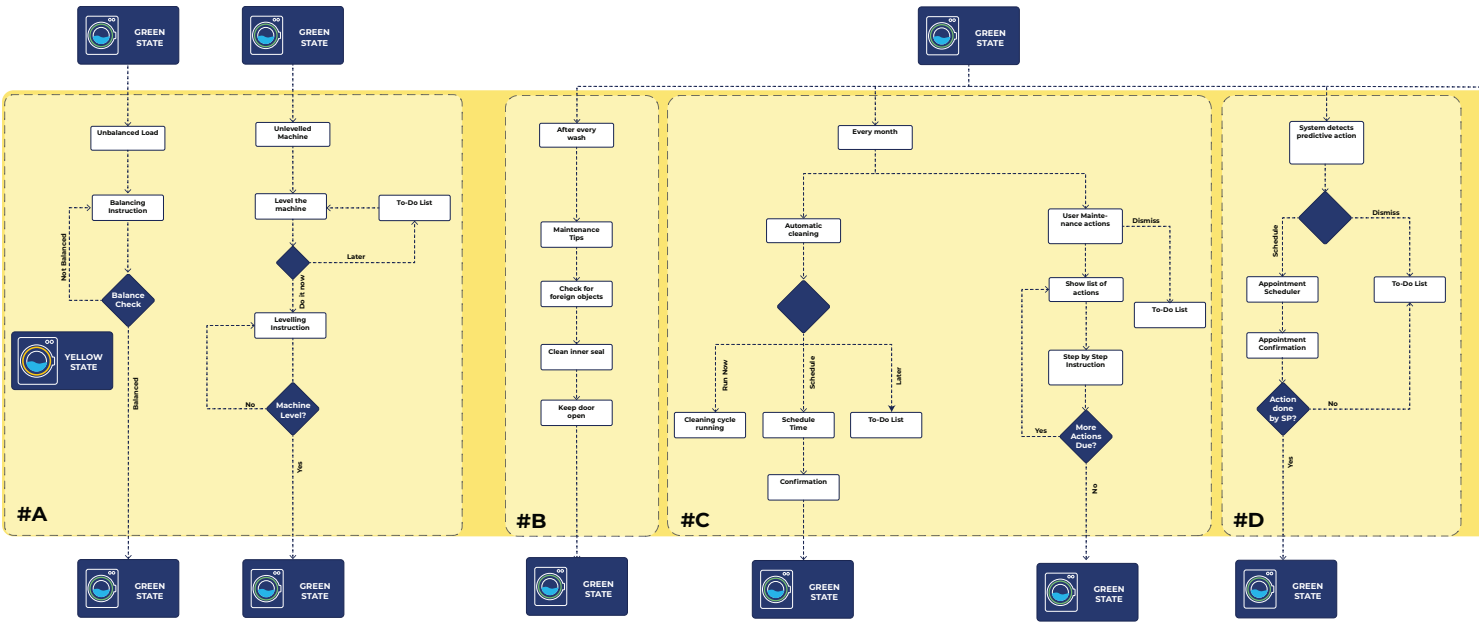
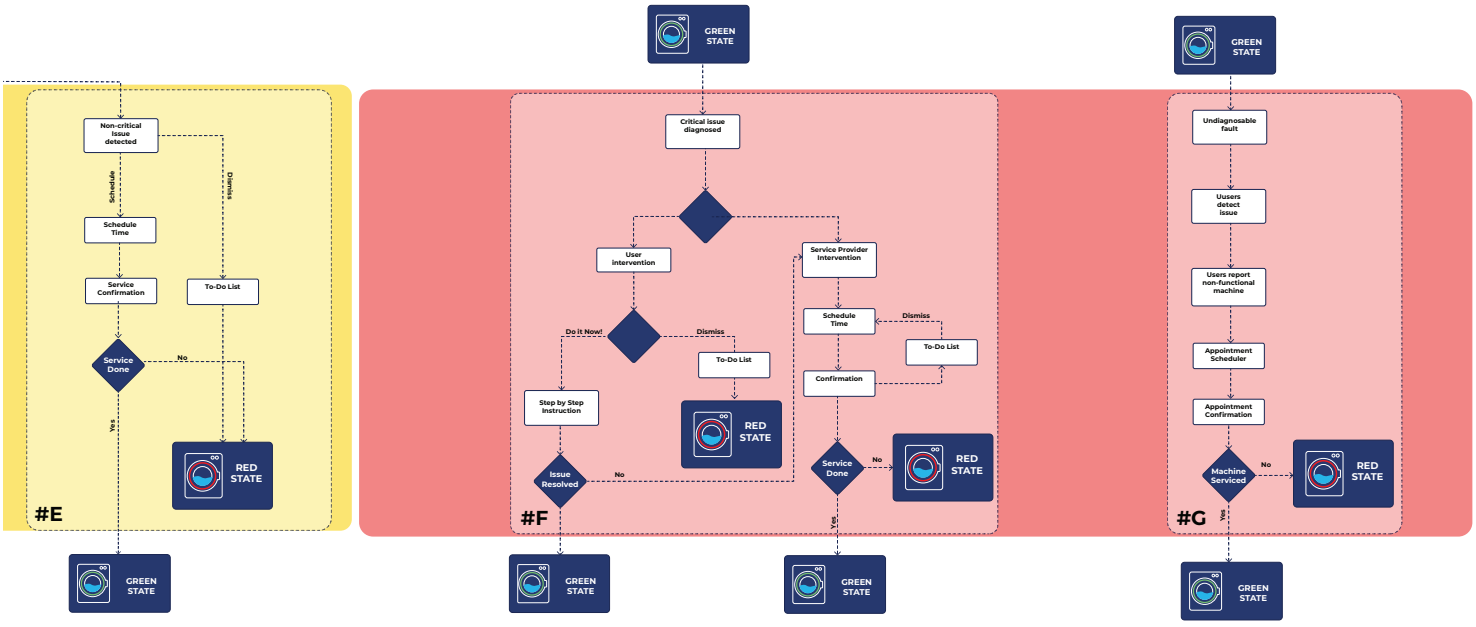


Figure 9..6
Architecture framework brainstorm


GREEN STATE
GREEN STATE
GREEN STATE
Unbalanced Load
Balancing Instruction
Not Balanced
Balance Check
YELLOW STATE
Balanced
Unlevelled Machine
Level the machine
To-Do List
Later
Do it now
Levelling Instruction
No
Machine Level?
Yes
#A
After every wash
Maintenance Tips
Check for foreign objects
Clean inner seal
Keep door open
#B
Every month
Automatic cleaning
Run Now
Schedule
Later
Cleaning cycle running
Schedule Time
To-Do List
Confirmation
User Mainte-nance actions
Dismiss
Show list of actions
To-Do List
Step by Step Instruction
Yes
More Actions Due?
No
#C
System detects predictive action
Dismiss
Schedule
Appointment Scheduler
To-Do List
Appointment Confirmation
Action done by SP?
No
Yes
#D
GREEN STATE
GREEN STATE
GREEN STATE
GREEN STATE
GREEN STATE
GREEN STATE


Non-critical issue detected
Schedule
Dismiss
Schedule Time
Service Confirmation
To-Do List
Service Done
No
Yes
RED STATE
#E
GREEN STATE
Critical issue diagnosed
User intervention
Service Provider Intervention
Do it Now!
Dismiss
To-Do List
Step by Step Instruction
Issue Resolved
No
RED STATE
Schedule Time
Dismiss
To-Do List
Confirmation
Service Done
No
RED STATE
Yes
#F
GREEN STATE
GREEN STATE
GREEN STATE
Undiagnosable fault
Uusers detect issue
Users report non-functional machine
Appointment Scheduler
Appointment Confirmation
Machine Serviced
No
RED STATE
Yes
#G
GREEN STATE

9.5 Wireframing

For qucikly prototyping the UI for the different loops, paper wireframes were sketched. This wireframing of the user interface was done for two different interfaces. One is the interface of the mobile application that is provided as a part of the PSS offering. The other is the interface present on the WM.

9.5.1 Information distribution on different interfaces

For designing the interface and sketching the wireframes for the two different interfaces, the following model for distribution of information was used:

1. If the interface requires interaction between user and the washing machine, the primary display for the interface is taken as the machine interface.
2.. If the interface requires interaction between user and the service provider, the primary display for the interface is taken as the mobile application.

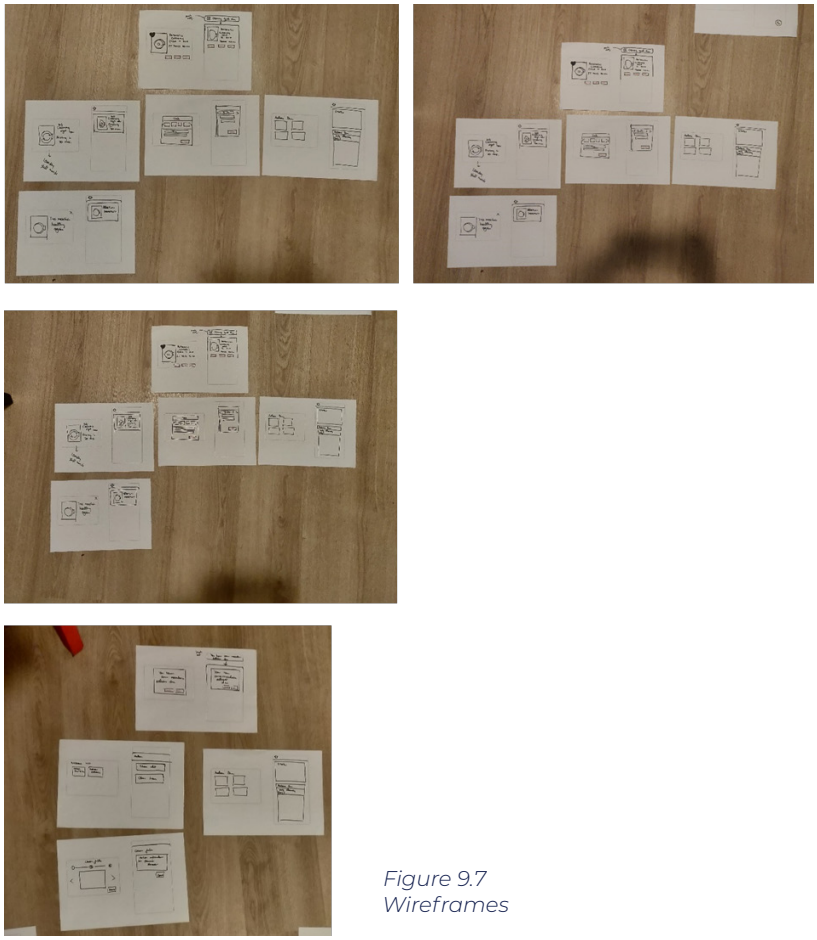


Figure 9.7
Wireframes

9.6 User Interface Framework

The differerent elements of the wireframes were then clustered into different categories. This is done to harmonize the different UI elements and form a structure for the UI flow.

Based on the clustering, the UI elements can be divided into the following types:

Status elements

These UI elements displays the status of the WM or the status of any operation in progress or planned,

Information elements

These UI elements provide contextual information about the action, steps or notifications,

Action elements

These UI elements are where the users have to perform some actions in order to perform a task, get feedback or provide input.

Each interaction between the user and the machine should have the different elements to provide the best intended user experience (Section 8.2) Fig X.X provides an example of a wireframe for a notification for the machine to carry out a self-cleaning program and the different UI elements in the wireframe.

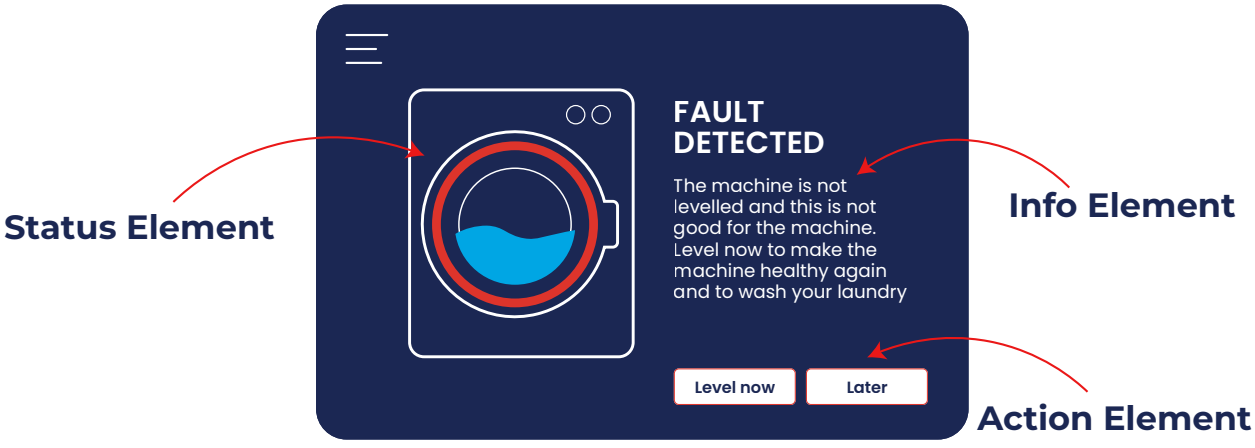


Figure 9.8
UI Framework

CHAPTER 10

UI CONCEPT GENERATION

This chapter looks into the generation of UI concepts incorporating the IA and the UI framework for the different maintenance and service actions described in the Machine state transitions.

10.1 UI Concept Generation

For generating the UI concept, a fictional user journey is imagined with different activities like maintenance actions, faults and use of the machine occurring to simulate the different actions required. These fictional actions correspond to each of the state transition loops (Section 9.2)

The different activities that occur in this user journey are:

1. Unlevelled machine before a wash
2. Preventive maintenance after the wash
3. Machine Self-Cleaning program due after 40 washes
4. Periodic maintenance due after 30 washes
5. Predictive maintenance action to replace the motor at 8500 washes
6. Drain system fault during wash
7. Pressure sensor fault before wash
8. Water leakage detected

For generating the UI concept for each of the activities, the process is as follows

A. Look at the different steps for the activity in the Information Architecture
B. For each step, decide where (on which user interface) the information is displayed and how,
C. Consider the behvioral aspect for any influence,
C. For each step of the activity fill in the UI Framework table (Table 8.1) to understand the interaction required
D. Prototype the UI concept

Status Element	
Information Element	
Action Element	

Table 9.3
UI Framework Table

10.1.1 Example of an Unlevelled Machine

In this part, an example of an unlevelled machine is taken and the different steps in the generation of the UI is illustrated.

Step A

Information Architecture for Loop A

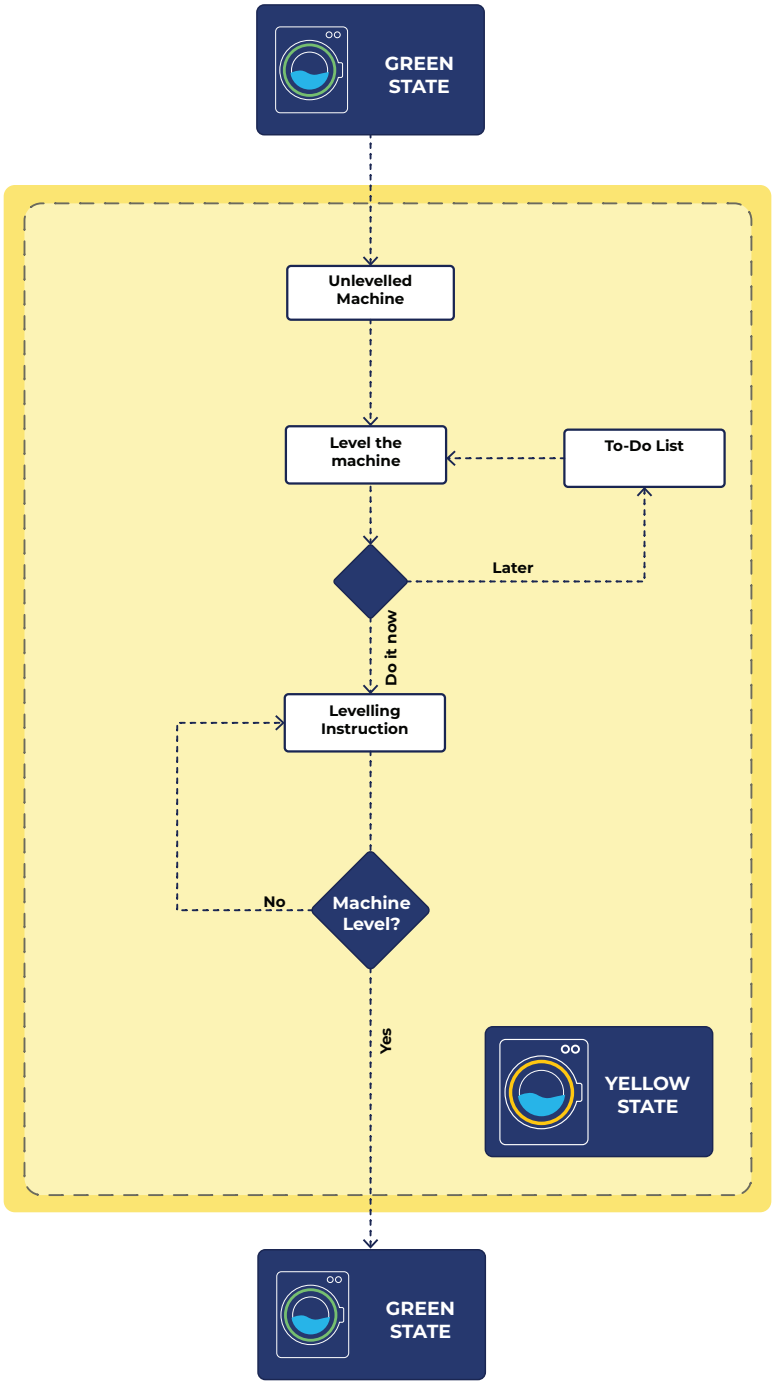


Table 9.9
Information Architecture of Loop A

Step B

The different steps in the activity and the information distributions are :

1. Detection of Unlevelled machine : **Push notifications on app and machine interface**
2. Level the machine? : **Popup on machine**
3. If yes, levelling Instructions : **Levelling instructions on machine**
4. Levelling guide tool : **Levelling guide tool on machine**
5. Levelling confirmation : **Popup on machine and phone**
6. If no, todo list : **Added to todo list on phone and machine**

Step C

From the fault analysis (Section 7.1.3), it can be seen that an levelled machine causes damag to the bearing and the spring dampners. Hence, users must be discouraged from using the washng machine if it is unlevelled and also be given the right motivation, ability and trigger to level the machine before they wash. The UI can enhance the ability of the user to carry out the levelling action by giving them the right prompts and information.

Step D

For each step of the activity, the UI Framework table is filled to understand the interaction required

Step 1 : Detection of Unlevelled machine

Status Element	Change of status to Yellow state
Information Element	Machine is Unlevelled
Action Element	Level now or Later button

Step 2a : Levelling instruction

Status Element	N/A
Information Element	Instructions on how to level
Action Element	Next or go back

Step 2b : To-Do List

Status Element	Yellow State
Information Element	Actions due
Action Element	Perform Action

Step 3a : Level guide tool

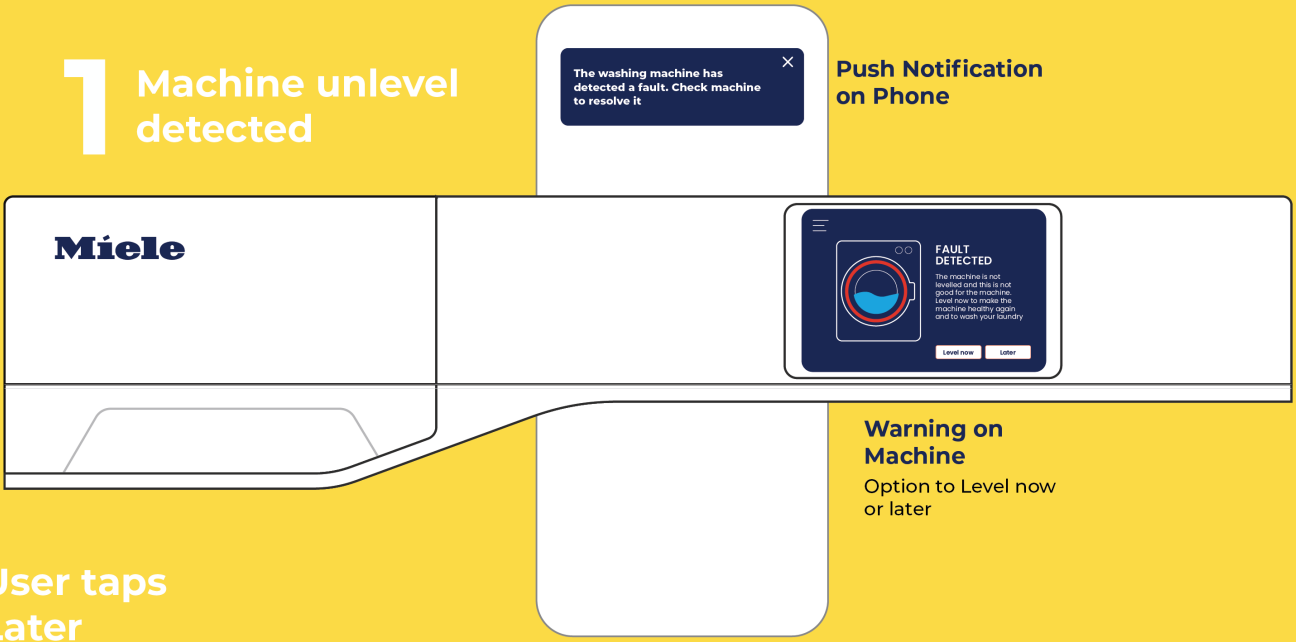
Status Element	N/A
Information Element	Digital level visualisation
Action Element	Check

Step 4a : Levelling confirmation

Status Element	Green State
Information Element	Machine now level
Action Element	Dismiss

UI Flow for Unlevelled Machine

1 Machine unlevel detected



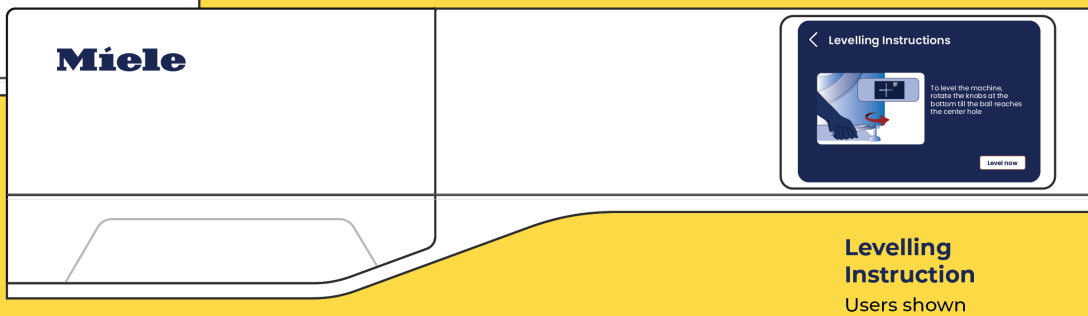
Push Notification on Phone

Warning on Machine
Option to Level now or later

2b User taps Later

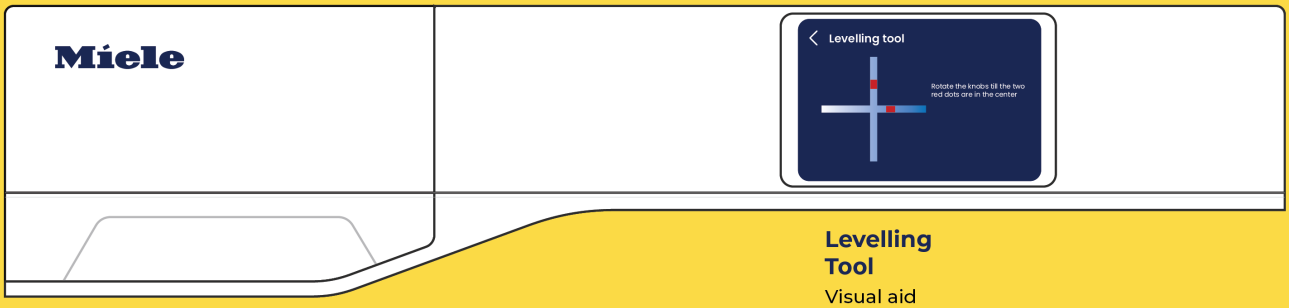
To Do List
Task added to to-do List

2a User taps level now



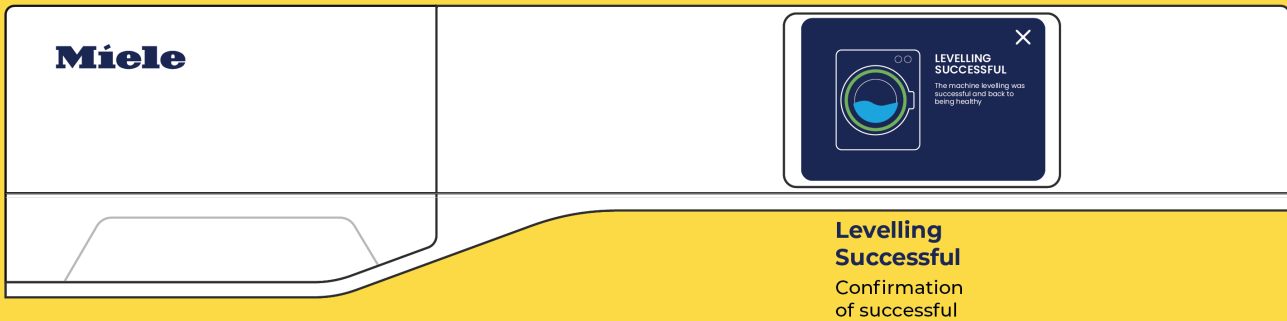
Levelling Instruction
Users shown how to level machine

3a User uses tool



Levelling Tool
Visual aid to help users level machine

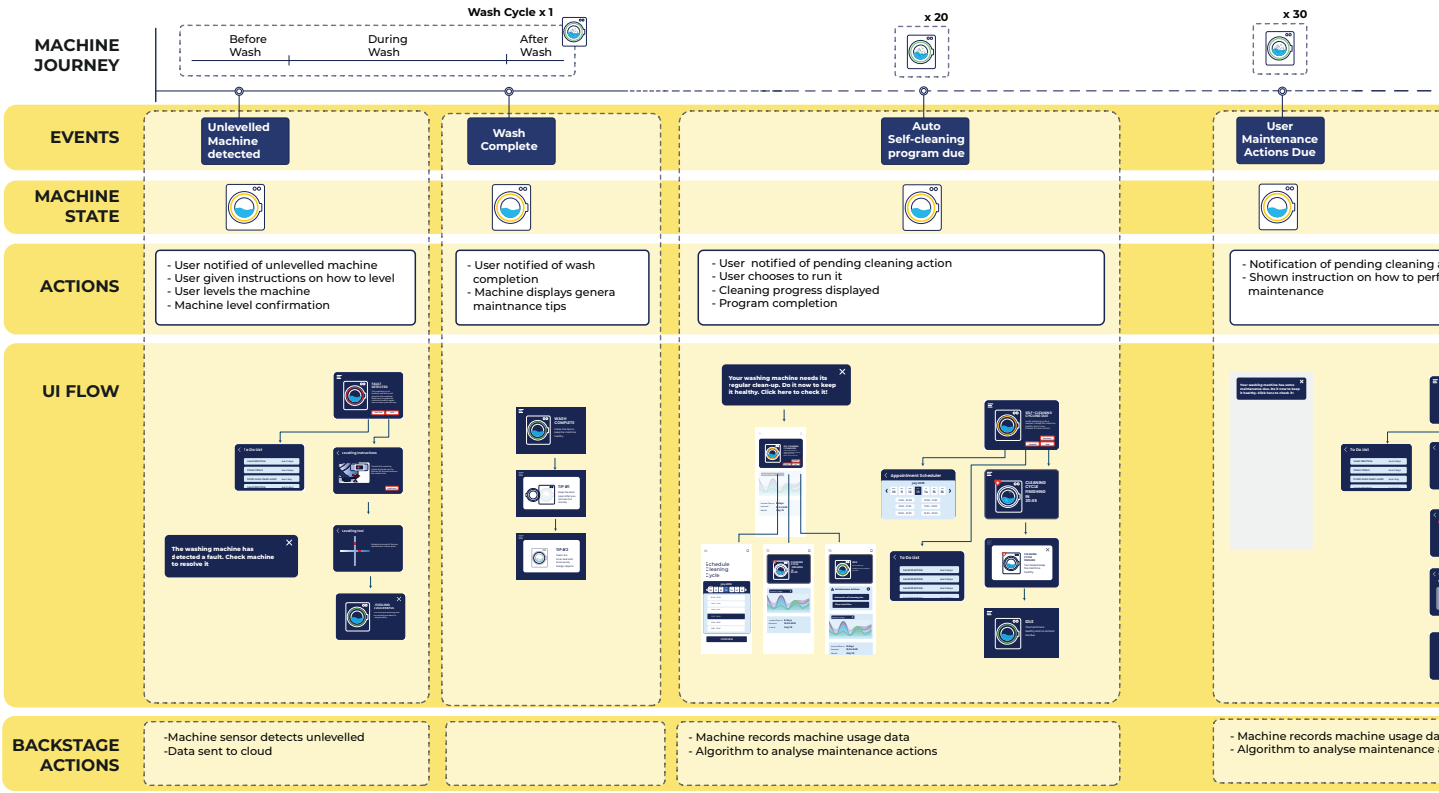
4a Machine levelled

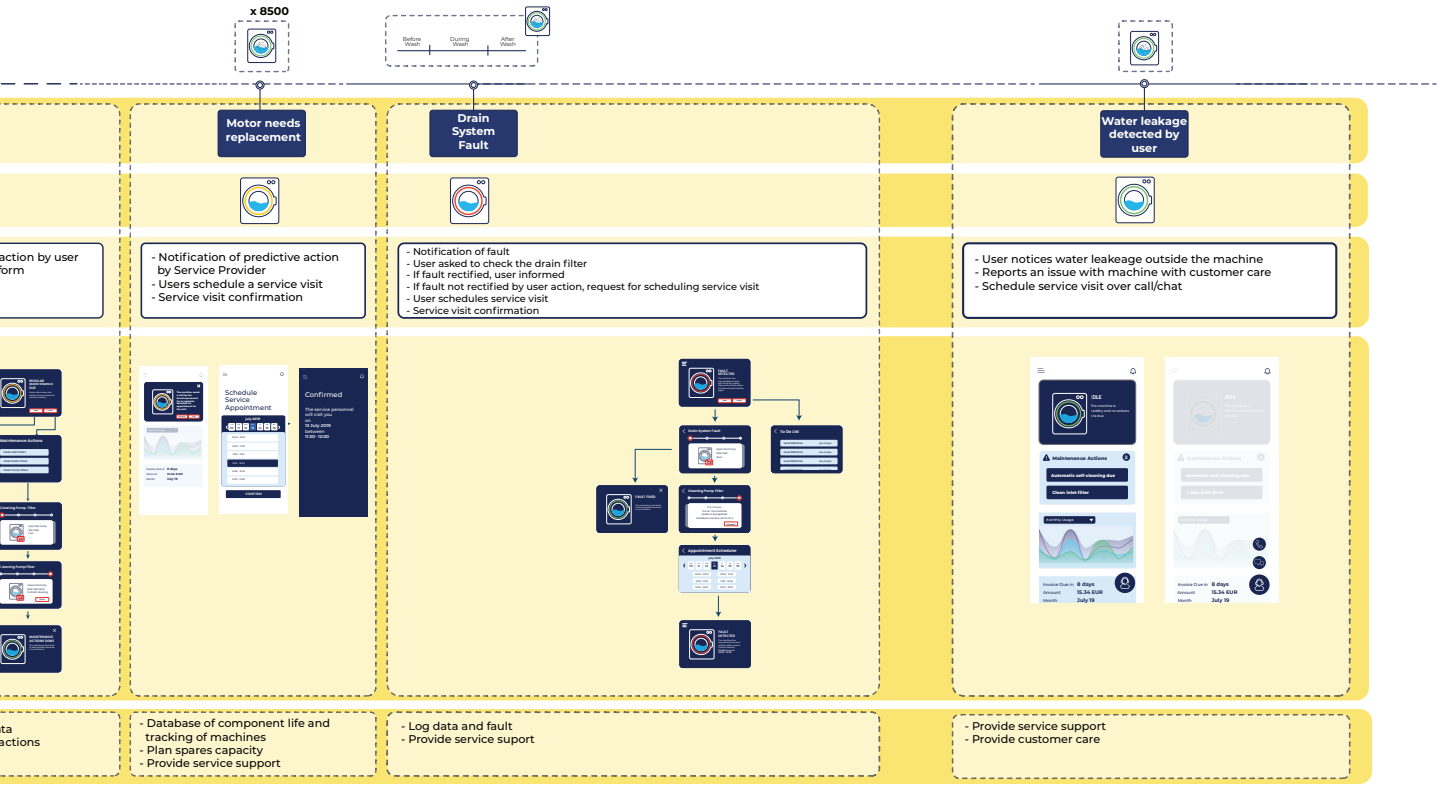


Levelling Successful
Confirmation of successful levelling

10.2 Final Concept and Blueprint

Here the final concept with the UI is presented on the timeline of the lifecycle of the WM. Alongside the UI, the backstage processes with the Service Provider are also illustrated.




x 8500
Before Wash
During Wash
After Wash
Motor needs replacement
Drain System Fault
Water leakage detected by user
- Notification of predictive action by Service Provider
- Users schedule a service visit
- Service visit confirmation
- Notification of fault
- User asked to check the drain filter
- If fault rectified, user informed
- If fault not rectified by user action, request for scheduling service visit
- User schedules service visit
- Service visit confirmation
- User notices water leakeage outside the machine
- Reports an issue with machine with customer care
- Schedule service visit over call/chat
Schedule Service Appointment
Confirmed
Maintenance Actions
Automatic self-cleaning due
Clean Inlet Filter
- Database of component life and tracking of machines
- Plan spares capacity
- Provide service support
- Log data and fault
- Provide service suport
- Provide service support
- Provide customer care

PART 5

VALIDATION

CHAPTER 11

CONCEPT EVALUATION

To evaluate the desirability, viability and feasibility of the final concept, interviews were held with five employees from Miele and the co-founder of Bundles. During these semi-structured interviews, the concept was first presented using a demo phone application with the different interfaces of the concept.

Desirability : Do the stakeholders want this?

The employees from Miele recognized the consumer trends moving from quantity to quality, from price to value. Miele sees itself changing from selling to providing services (like Bundles) and that having such an UI which gives users the ability and convenience to carry out maintenance is a win-win for both customers and Miele because customers have higher convenience and the washing machine runs longer. One employee predicts that the general term “luxury” will shift from technical (product) superiority towards usability and software. He adds that the UI will help adapt to the shift.

When asked specifically about the desirability of the concept for Miele, an employee of Miele cautioned that the UI concept has technical desirability but lacks business desirability. But the UI does have some low hanging fruits which are worthwhile to explore. The employees also found in their experience, the user acceptance of changes in behavior to be difficult.

The Bundles employee recognizes that they have the data regarding usage but there is a lack of a UI based on the data that show the right kind of insights because Bundles does not want to hassle their customers. The employee also comments that many of their customers are happy to see the impact of their good washing behavior (ex. Reduction in power consumption over washes) but still a majority of customers are keen at looking at the impact from a cost perspective and that there is more need for a correlation of impact of usage to the service costs. The employee also finds the design concept consistent with the future vision of Bundles and a Miele employee sees the design concept as a way to get direct access to customers and build a stronger relationship with the users.

On inquiry about the system of rewards and punishments, Bundles employee finds the rewards and punishments important and sees a potential to reduce costs of running the service because of proactive maintenance and service of the machine and eventually sees that the prices of customers might reduce making it even more competitive to primary sales of machines. A Miele employee indicated that Miele is already working on concepts like predictive maintenance, self-diagnostics, OTA optimization and smart repair but lack a UI to bind all the activities into a single platform and that there is potential in the design concept. Apart from being implemented in machines that are given out on a subscription model, it can also be added to the UI of washing machines sold in primary channels.

Viability : Should Bundles and Miele do it?

The interviewees from Miele thought that the viability of the design concept lies in exploring the economic benefit versus the investment required as many of the actions requires changes to the product and the current market size does not afford a big investment to justify the move. An interviewee from Miele was questioning the business case behind the concept despite seeing the added value to the brand and the business.

The employee from Bundles commented that there is a need for Bundles subscription model to differentiate itself from traditional rental models. And that this requires users to take responsibility in the upkeep of products requiring a change in the mindset of the users. The design concept is seen as a positive step in that direction. The interviewee also warned against the risk of improper implementation and that the model needs to be tested before full fledged implementation.

Feasibility : Can Bundles and Miele do this?

The interviewees from Miele all stated that this concept was technically feasible while the economic feasibility would require some research into it. An interviewee mentioned that concepts from the designed solution are being implemented in Coffee machines and with washing machines, they are taking steps towards the same. With a lot of the washing machines not having the connectivity setup, the employee from Bundles saw it as issue in implementation. The employee also said that the design concept was aligned to the business case of Bundles which is nudging and triggering customers to wash more sustainably. He also highlighted that with the current technology and context, Bundles has been able to present a sound business case for subscription models to Miele and that Miele needs to actively look into developing products for these new business model.

An interviewee from Miele mentioned that the smart homes department at Miele is already developing solutions for predictive maintenance, smart repair, OTA updates, diagnostics and condition monitoring for washing machine. They never thought about the UI for these actions and that the concept adds to the feasibility of the other concepts they are working as well.

Conclusion: What’s next?

The employees indicated that they were, parallel to this project, working on similar concepts. They indicated that they are going to develop these further using the insights gained in this project. This means that designed solution will probably not be implemented exactly as it is designed right now, but insights will be used.

CHAPTER 12
CONCLUSION

This chapter provides provides the concluding statements of the design project alongside the value the design project brings and the limitations faced during the project.

The goal of this design project was to design a PSS for an eternally lasting washing machine in a circular economy.

The design concept fairly captures all the different aspects of the design goal. The UI concept is designed within the context of a PSS infrastructure. And the UI concept is designed to trigger the motivation and ability of users to undertake life-extending strategies on the washing machine. The UI concept enables connectivity of the washing machine which is seen as an enabler for CE.

Value of the design concept

The validation by the stakeholders show that the concept has potential for the current context and creates impact for people, planet and, profit

People Increasing user convenience and ability

Planet : Supplementing lifetime-extension strategies for the washing machine

Profit Reducing the lifecycle cost by proper maintenance and service of the machine

Limitations

The project has a few limitations and these limitations arise from the scoping of the project.

With the scope of the project at the start of the design project being focused on the system design and this had an implication that there wasn't sufficient qualitative or quantitative research carried out on the users which might have an impact on the desirability of the concept, especially the Fogg behavior change model applied to this project.

CHAPTER 13

RECOMMENDATIONS

This chapter provides some conclusions on the project in the form of next steps and insights for Bundles and Miele that go beyond the scope of this graduation project and recommendations for further research.

For Bundles and Miele

Set up a data integration plan

Both Bundles and Miele need to evaluate the current data stream and harmonize it and then work together to define metrics and insights relevant to the user but also for PSS business intelligence

Explore UI options for other parts of the User journey

While this project is focused on service and maintenance, Bundles should explore the UI for the other parts of the user journey in the service to create more value for the customer.

Work to get direct connectivity to all washing machines

Bundles should work with Miele to develop a retrofit connectivity module to directly access data from machines that do not have network connectivity and look to eliminate the SmartPlug

Get machine access through Miele API

Bundles should start to develop their software platform to collect machine usage data through the Miele API as this will bring new insights for Bundles and their customers

Further Research

User Acceptance of Behavior Change Models

For the UI to have a positive impact, the system relies on the behavior change models to shape user behavior. For this, their acceptance of the model is vital and if the model is not accepted, it can have a negative impact on the usage of the products.

Economic Impact maintenance and Service actions

Quantitative research is needed to investigate the economic impact of maintenance actions. This will help build a business case for the new UI system as it requires changes to product and systems.

The right triggers for motivation

For driving intrinsic motivation towards service and maintenance, there are triggers required. With the right triggers, users will be motivated to perform actions. It is important to research which triggers drive users to good wash behavior.

Structure of Reward and Punishment System

A well balanced reward and punishment system will provide users the right motivation to perform actions. This requires the research on the viability and feasibility of reward systems and also look at different types of rewards – tangible or intangible.

CHAPTER 14

PERSONAL REFLECTION

This chapter contains a reflection on some of my personal experiences during this project.

Process

In the beginning of the project, I religiously applied methods in my approach to the project but wasnt fully able to convert methods into inights and a design direction. While I was continuously going through with this approach, I forgot to stop and introspect on the material that I already generated and use it for my next step. I rather accumulated an excessive amount of information that led to an overload.

In this process, I was unable to build on a strong design criteria which otherwise would have benefitted me at a later stage.

Scoping Issues

Throughout the project, I followed the double diamond approach but at the end of every milestone, I was unable to pinoint and scope down the focus I wanted to take. On introspection, I realised that this was because my personal ambitions from the start of the project never gauged down and I continued to chase the idea of making it the best project ever. Apart from this I found it difficult to manage my time and keep up with the planning. with misjudging of the amount of time a task would take.

Main Takeaways

The process of doing this project helped me recognize my strengths and weakness as a design professional but also helped me implore on my personality. I learnt the need to prioritize, have a concrete plan and the idea of the kind of outcome of the task that I am doing. I hope to work on those shortcomings of mine and work to be a better designer.

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