Laundry Podium PDE Major Project 2021

Improve User Experience and Lessen Environmental Impacts of Laundry

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CONTENT

DISCOVER *Background // Research*

DEFINE *Analyse // Concepts*

DEVELOP *Prototype // Technology*

DELIVER *Final Concept // Storyboard // Assembly // CAD*

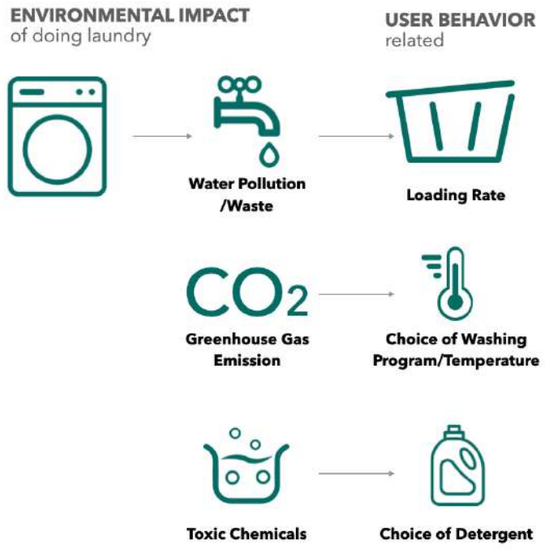
SUMMARY

Background

Clothes cleaning is a source of various environmental impacts, including water pollution, greenhouse gas emissions and potential toxicity impacts, which depend greatly on user behaviors, such as loading rate, choice of washing program and detergent. An optimization choice of operations made by users can not only reduce associated environmental impacts but also improve user experience.

What is it about?

This product/service should improve the overall experience of people using the launderette as well as lessen the environmental impact. To achieve that, it needs to be found out whether there is an optimization choice of users washing operations that can not only increase efficiency but also reduce associated environmental impacts. How much more efficient or environmental friendly can it be exactly? Is there a trade-off between these two goals?



Who is affected?

Customers are the top concern. Each family type differ widely in the energy and water consumption when doing laundry, that's why they need to be categorized carefully during the research.

Other stakeholders like hosing sectors, service providers and local governments may have the initiatives to improve the service and protect the environment.

Customers

- Cohabiting with/without Children
- Single with/without Children

People who are actually going to use the service

Service/Product Providers

- Profit-oriented service companies
- Renting, leasing and pooling commercial service companies
- Manufacturers of equipment and products

People who may have the motivation to improve service

Housing Sectors

- Housing organizations/ service providers
- Construction companies
- Utility providers

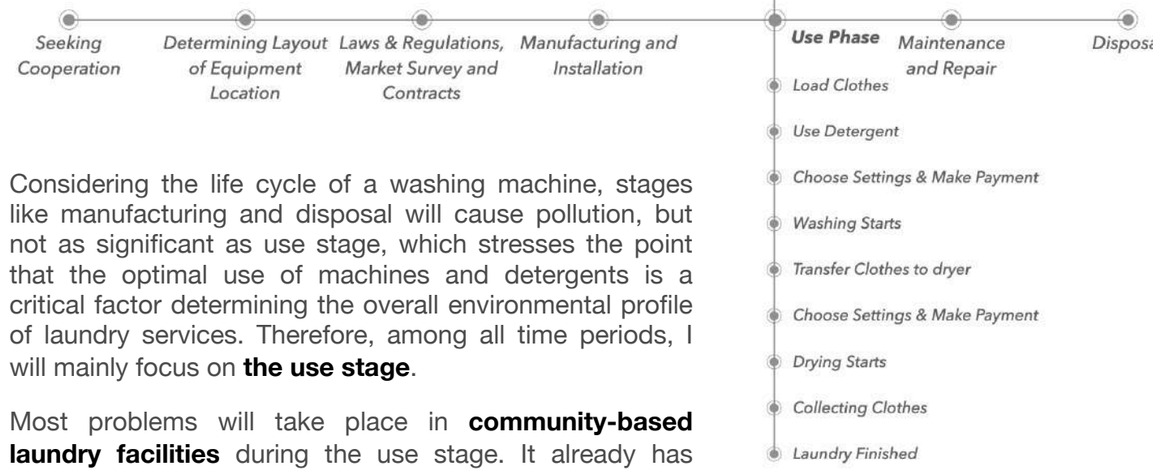
People who may have the motivation to save energy

Local Government

- City planning authorities
- Authorities responsible for social services
- Environmental Protection Agency

May have the motivation to protect environment

When/Where does it occor?



Considering the life cycle of a washing machine, stages like manufacturing and disposal will cause pollution, but not as significant as use stage, which stresses the point that the optimal use of machines and detergents is a critical factor determining the overall environmental profile of laundry services. Therefore, among all time periods, I will mainly focus on **the use stage**.

Most problems will take place in **community-based laundry facilities** during the use stage. It already has lower environmental impacts and benefits for users. Also user tends to **sort clothes at home** before going to the launderette.

Why care about it?

Value for Customers

More Efficient

Less Complicated

Value for Environment

CO2 *Reduce Energy Consumption*

Reduce Water Waste

Reduce Toxic Chemicals

Value for Business

Save Electricity Bills

Attract More Tenants

Desk Research

Factors identified as relevant

Impacts – the relative environmental impacts of washing, drying, ironing and dry cleaning

Consumer behaviour – the frequency of washing, cleaning practice, convenience, time restrictions, comfort, cleanliness, extent of clothes soiling and fashion

Technology – type of fabric, appliances, detergent and dry cleaning process

Legislative and market initiatives – current status and future developments of EU and UK legislation and initiatives

Improvement Measures

Wash at 30°C to be encouraged as there is an existing trend and further adoption would reduce environmental impacts significantly

Development and validation through independent LCA analysis of detergents with reduced environmental impacts. **A concentrated detergent product has been shown to have a lower impact** than a less concentrated detergent across a range of environmental indicators.

Increasing spin drying efficiency of washing machines to reduce mechanical drying would reduce energy consumption.

The upcoming review of the **international standard on clothes labelling (ISO 3758)** provides an opportunity to influence both manufacturers and consumers, through **encouraging manufacturers to standardise clothes care label terminology** and **simplify guidance for consumers to promote good practice to achieve environmental benefits**. The label should be positioned to be clearly visible to consumers, as stakeholders expressed concern that clothes care labels are currently placed in locations where they may not be noticed and hence are less likely to be used.

Primary Research

	Preparation		**First Arrival: Washing**				**Waiting Stage I**	**Second Arrival: Drying**			**Waiting Stage II**
ACTIONS	 Sorting Clothes	 Bring Basket & Detergent	 Loading Clothes	 Using detergents	 Open the App & add Funds to balance	 Scan the QR code of the machine	 Confirm Payment in the App	 Choose Washing Program & Press Start	**39”** Go Back or Stay and Wait	 Collecting washed Clothes from the Washing Machine	 Loading Clothes into the Dryer	 Scan the QR code of the Dryer Machine	 Confirm Payment in the App	 Choose Drying Program & Press Start	**50”** Go Back or Stay and wait (50 mins)
					Choose Settings & Make Payment					**Transferring Clothes**		**Choosing Dryer Settings & Making Payment**			
THOUGHTS	Sort clothes according to fabric type and color shades to avoid damaging finer fabrics and accidentally mixing colors.	Choosing organic laundry detergents is better for skin and the environment.			Many launderettes nowadays accept mobile payment to adapt to the trend of cashless society. As a result, mobile applications have been implemented to deal with the payment and some controlling of the washing machine.		Washing in hot water also carries a carbon cost that exponentially increases with the age of the machine. If it’s not in perfect condition at all times, it will take more energy to run.					Washing and drying a 5 kg load of laundry every two days creates nearly 440 kg of carbon dioxide emissions in a year. Most of that energy is used up in the dryer cycle.			
PAIN POINTS	Sorting clothes is frustrating	User may forget to bring the detergent	Dropping	Don't know what amount of detergent should be used	During this stage users' attention is jumping between the machine interface and the app, which causes confusion.		Don't know what washing programme should be chosen		Go back middle-way to move the clothes from washer to dryer. Clothes may get throw out if not	Clothes may fell to the ground when being transferred		Which QR code represents which machine? That is not clear			The third visit in one washing process

Customer Persona

Richard

Living Condition: *live alone in a student apartment*
Employment Situation: *student, unemployed but fulfilled*

Age:

young — *elder*

Educational Standards:

low — *high*

Personal Financial Situation:

bad — *good*

Possibility to own a Washing Machine:

low — *high*

User Analyse

Factors of building the persona and why they matter

Socio-economic status:

Employment situation - One adult present at home all day(unemployed) tend to wash more

Education - People with higher education tend to wash less

Personal financial situation - In many tenant associations the users of shared launderettes are often charged a flat rate independent from the frequency of use. In this way all members of community share the costs of energy, water and facilities.

Personal lifestyle:

Age - Older people tend to wear cloth longer and then wash them with higher temperature and with full machine. Younger generation separates cloth in many fractions and does not usually fill the washing machine, but usually washes with lower temperatures (NUTEK 1994). So the total energy use is approximately the same

Types of household - Families with children will have the largest resource consumption.

Place to live - Larger living space wiil increase the possibilty to own a washing machine.

Possibility to own a washing machine - those families owning washing machines often use public launderettes to save time and the nuisance, as well as for practical reasons, e.g. for washing larger items such as carpets, pillows, etc.

Summary of Issues

Washing in communal launderettes provides an energy saving potential in the order of 30% only due to the use of more resource efficient professional equipment.

Energy efficiency increases along with the size of machines

CBS have a strong role in shaping consumption patterns and a certain potential in reducing associated environmental impacts.

Environmental Gains

Save time and nuisance

Machines in the launderette have larger capacity

Laundry with staff can provide better service like ironing and folding

Customer Gains

To wash larger items like carpets and pillows in the launderette

Customer Jobs

To minimize pollution

Environmental Jobs

Environmental Pains

Washing in hot water also carries a carbon cost that exponentially increases with the age of the machine.

Washing and drying a 5 kg load of laundry every two days creates nearly 440 kg of carbon dioxide emissions in a year. Most of that energy is used up in the dryer cycle.

If a bunch of clothes are not sorted right, it's impossible to use a specific washing program to achieve any environmental goals

Laundry equipment is not filled to maximum loading capacity

Customer Pains

Go back middle-way to move the clothes from washer to dryer. They have to come to the laundry three times in the entire process.

When loading and transferring clothes in launderettes, small items like socks are easily to slip out and fall on the ground

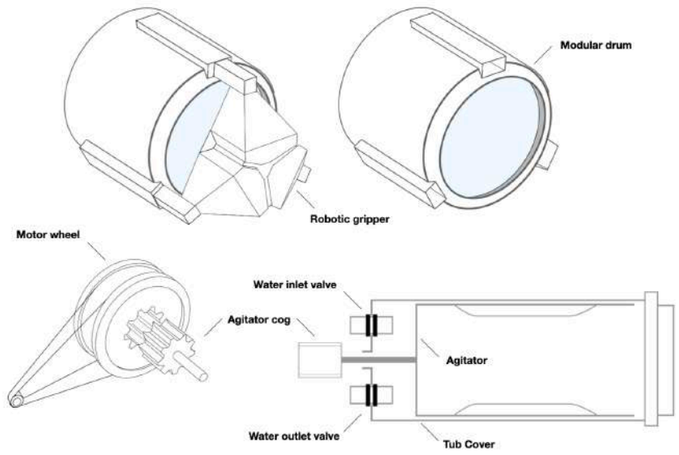
Sorting by them self is troublesome, and requires knowledge

It's difficult to check inside of the drum to see whether there's any clothes left

To wash clothes once or twice a week (80 loads per year, about 2 hours a week)

To minimize energy and water waste

Concepts



Concept Descrption

Concept 1

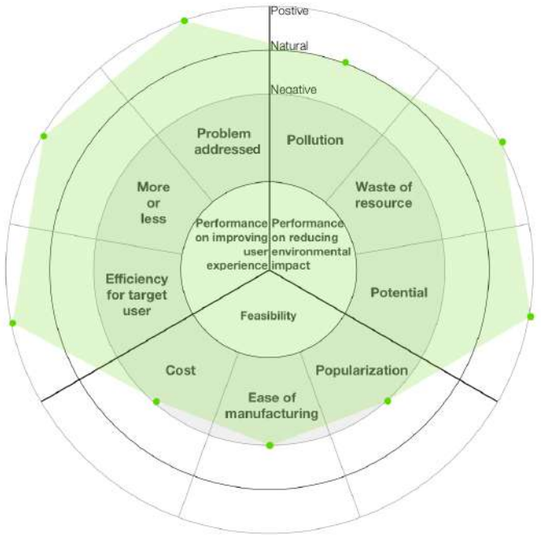
Redesigning current washing machines and dryers and implementing modular drums, which is a unit that carries a bunch of clothes, transferred by a robotic gripper.

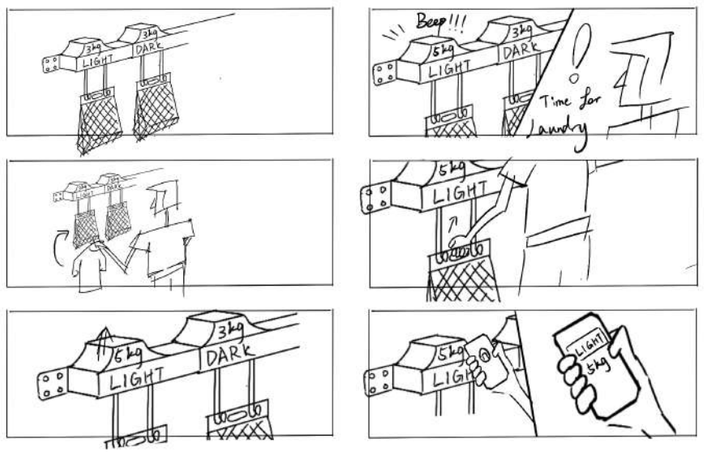
The modular drum can be inserted into washing machine or the dryer by the robotic gripper, the agitator cog is fixed to the wheel and water inlet/outlet valve is connected. After the washing process is done, the modular drum can be transferred from washing machine to dryer, and moved aside when drying is done.

Users can leave their clothes in the launderette as long as they like without occupying any machine. They don't have to come back middle-way to dry clothes, neither do they have to collect their clothes the very same day.

Evaluation

This concept has spotted a vital problem of the waiting gap between washing and drying in the launderette and if this can be realized, the problem can be fully addressed. However, building a robotic gripper system in every public launderette can be insanely expensive and difficult, which makes it impossible to be popularized by stakeholders. ✖





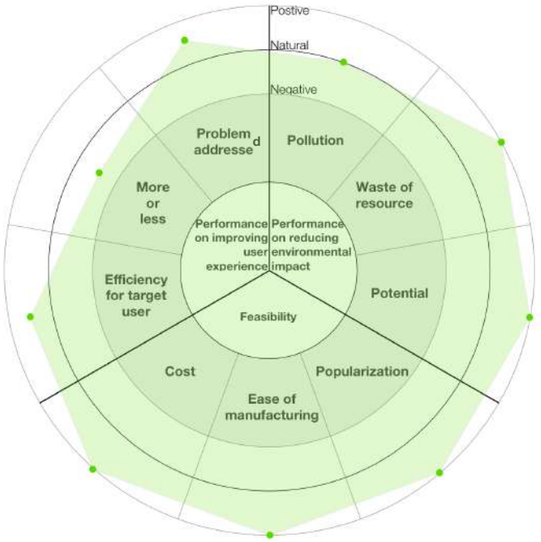
Concept 2

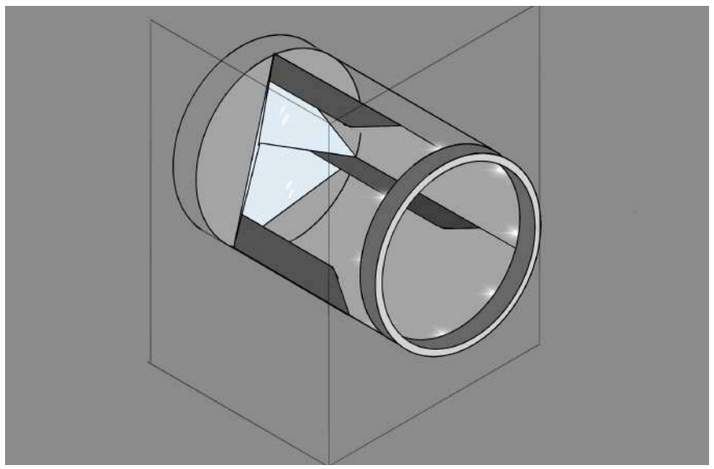
This product is a laundry hanger with force sensor, laundry bags and NFC function. User store their laundry in the product. When the weight of one type of laundry reached the maximum capacity of the washing machine, user will get reminded to do the laundry.

User can use their smartphone to hit the NFC panel on the product, and informations include laundry type and weight will be transferred to the phone. Then user can take out the laundry bag and go to launderette.

In the launderette, after throwing the laundry bag into the machine, user can hit the machine with their smart phone again to tell the washing machine what washing program to run and it will charge automatically.

This concept has addressed a problem of small items like socks slipping out during loading the washing machine. It also saves user from solving permutations of the washing program and washing temperature. Furthermore, It makes sure that every time people do the laundry, they can fill the maximum loading capacity of the machine to save energy. It's not very costly and easy to popularize among families. ☑



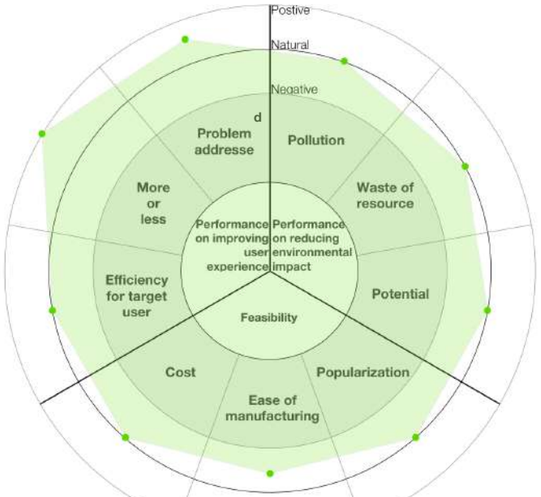


Concept 3

It is a newly designed drum of washing machine and dryer. Mirror reflection is implemented at the bottom of the drum to provide a vision inside. A light band is hidden behind the rim of the drum and will be turned on when the drum lid is opened.

With some lightings behind the rim of the drum, users can see inside of the drum with mirror reflection at the bottom, in which way they don't have to struggle with checking left items inside the drum.

This concept focused on the problem that users find it difficult to check inside of the drum to see whether there's any clothes left. It's an inexpensive solution to implement mirrors and lightings to the drum. However, it did not address the environmental problems in laundry, which is one of the main purposes of this project. ✖



First Prototype

The first prototype is made base on existing laundry storer with 3 removable fabric bags and metal frame. Three separated NFC tag is embedded on each basket. Laundry bags are tied on the edge of the baskets, and can be threw directly Into the washing machine.

Weight changes are detected after user put their cloth in

Once user gets the notification from the product, he can take the laundry bag out of the basket and tighten up its rope

Information (weight, type and color) stored in the tag will be written and user can collet that through their phone with NFC function

Feedbacks

Usability

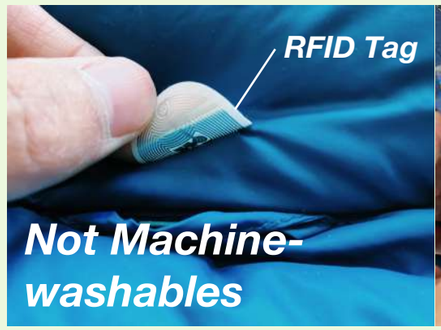
- It's hard to fix the laundry bag tightly on the edge of basket. The bag will be dragged downward due to the friction when user loading clothes.
- When user tried to take out the bag, the basket will also be drag out as it's not fully fixed vertically.

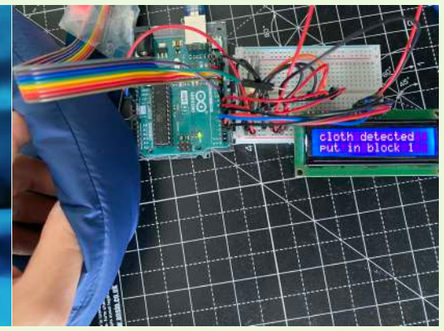
Reasonability

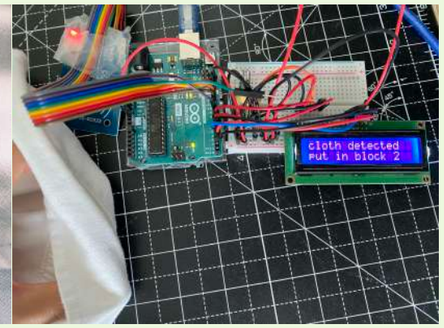
- Users still need to do the sorting on their own, and three baskets are way too few to achieve optimal sorting.
- Three NFC tags will make the architecture of the system dispersive, also too much touch points may cause confusion.

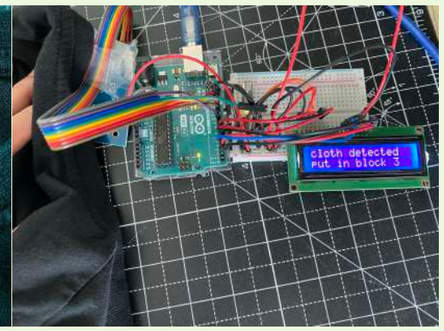
Second Prototype

After examining feedbacks from the first prototype, two iteration directions was raised for further development. First iteration direction is providing a better use of RFID technology (NFC is a subset of it). In the previous tests, users still have to do the sorting on their own. **What if the product can detect the type of the clothes to be sorted, and guide user to put in a basket** to achieve optimal sorting, which is solved also by program. This can be achieved through long-range RFID technology.

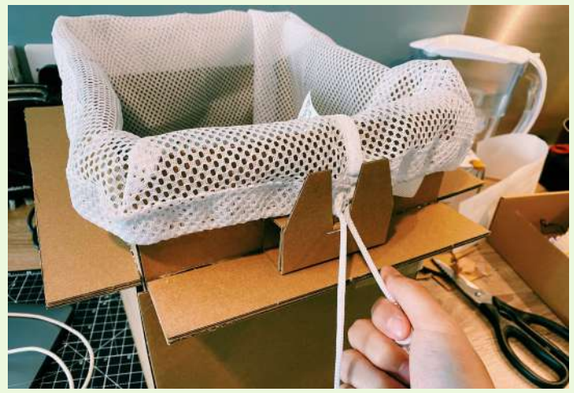


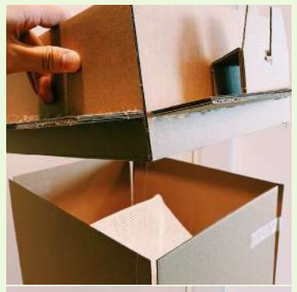


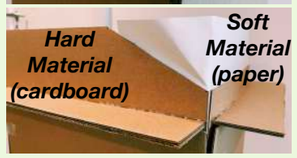




Second iteration direction is providing a better fixing and packing mechanism. This can be achieved through a specially designed basket lid which allows user to quickly pack the bag inside. The following prototype was made to test whether the mechanism would work or not.







Conclusions

GOOD & BAD

RFID is suitable in this scenario and do help improve the sorting experience. The tag used is flexible and easy to be embedded in clothes. The easy-packing mechanism works because the soft material behind will bend over when user pulls the rope, and it does make packing easier.

The read range of the RFID chip (MFRC522) used is poor, only 5cm maximum. User has to pick up every cloth separately and put the tag very close to the reader, which makes the process tedious and troublesome. **The read range of the RFID chip must be improved.**

Optimal Sorting

This product will guide user to sort their clothes in a better way. Therefore, how many laundry baskets needed to achieve that goal should be decided. This figure also have a huge impact on the final format of the product.

How exactly should laundry be sorted? **Factors affect laundry sorting include color, temperature, delicate or not, machine washable or not and etc.** Most of these information can be found on care labels behind clothes. However, strictly following care labels will lead to thousands of permutations and combinations , which is impossible in practice. Therefore, some similar features should be considered as one to simplify the problem.

First of all, since the main purpose of this product is to help user do laundry with washing machine more easily, those clothes that cannot be machine washed should be sorted out at the very beginning. This information can be stored in one bit.

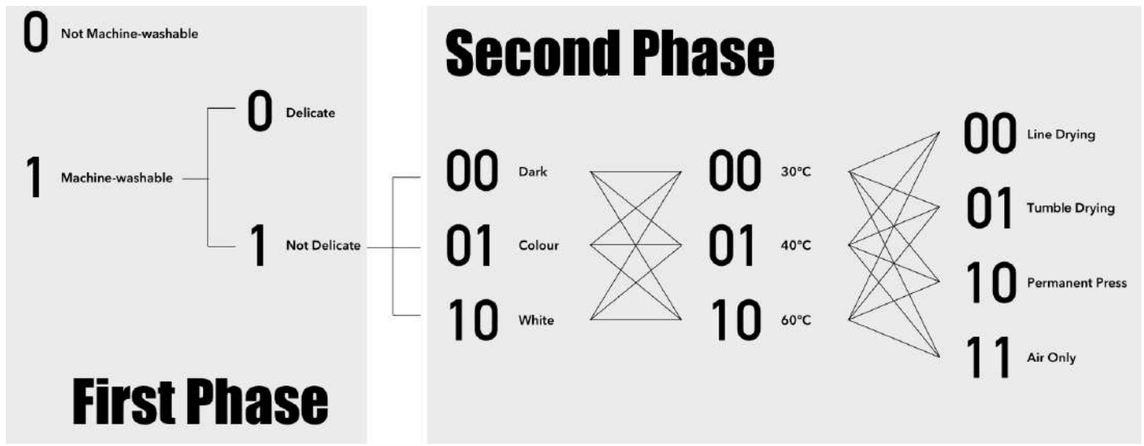
Delicate clothes should usually be treated separately with lower spin speed, lower temperature and specialized detergent. Thus they should be the sorted in a separate basket. This information can also be stored in one bit.

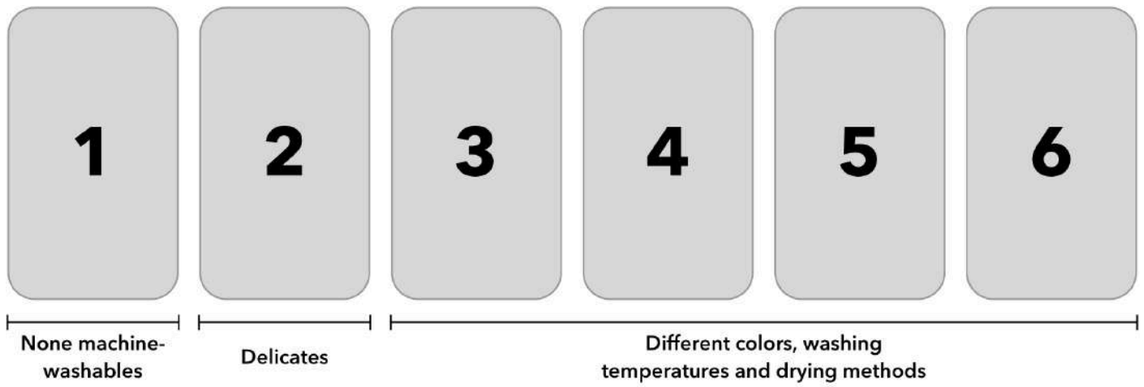
The remaining clothes will be further sorted by color (Dark, lights and colors), washing temperature(30°C, 40°C and 60°C) and drying method (line drying, tumble drying, permanent press and air only). Each type of information requires 2 bits to be stored.

An encoding mechanism is developed to illustrate how clothes are sorted in this system, which can help further development. According to the sorting method above, one byte is enough to represent any laundry type of a specific piece of cloth. First bit for machine-washable or not, second bit for delicate or not, the third and forth bits for colors, the fifth and sixth bits for laundry temperatures and the last two bits for drying methods.

Assuming that none-machine washable clothes and delicates each takes one laundry sorting basket, how many more baskets need to sort out the remaining clothes? From the encoding mechanism, the maximum possible number of laundry sorting basket needed can be calculated as below: $MaxBasketNumber = 2 + 3 \times 3 \times 4 = 38$

38 baskets are way too much for daily sorting. To reduce that figure, a model is built to anticipate how many clothes will a person need to wash every week and how many piles should that number of clothes be sorted into. According to probability calculated, a conclusion can be drawn that **6 baskets (1 for none machine-washable clothes, 1 for delicates and the other 4 for the remaining) is enough for the user scenario.**

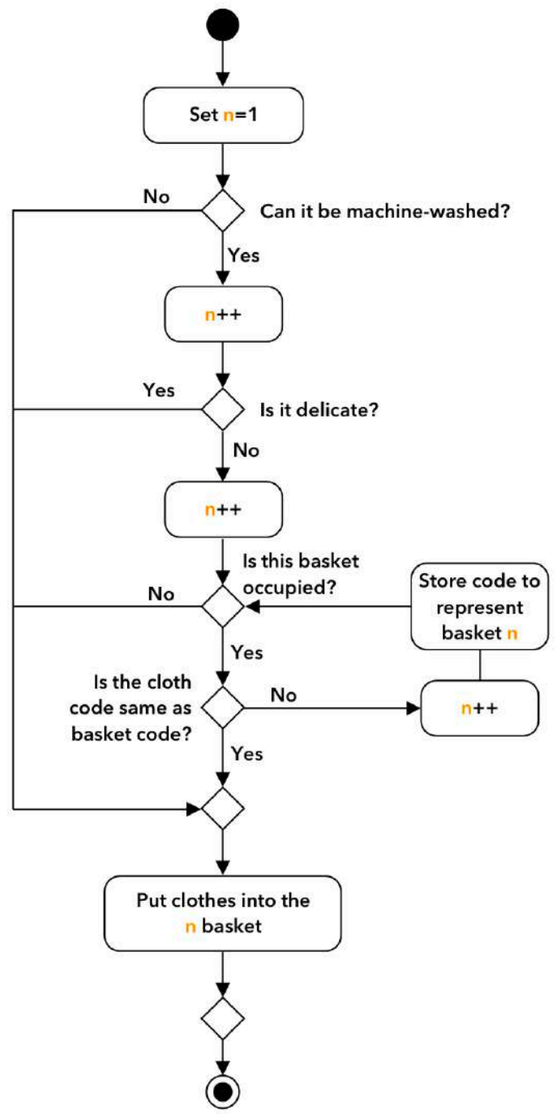




Activity Diagram

This activity diagram is drawn for the use case of **deciding which basket should the detected cloth be sorted into.** This is developed based on the encoding mechanism.

In this diagram, natural number n is used to represent the number of baskets. If the cloth doesn't belong to the first two categories, the program will enter a loop of checking whether the next basket is empty or it's not but having same sorting code with the cloth.



Final Concept

This product is called ***Laundry Podium***. Like a conductor conducting a band, this product can lead user to sort their clothes in an optimal way, give notifications when a basket is full, and transfer information to user's smartphone to help later washing program choice in launderette.

Product & Service	Gains Creators	Pain Relievers
Auto choice of washing program and payment	More convenient for user to use launderette and make payment	
A clear guidance of laundry sorting	Materialize the potential in reducing impact of CBS	
A design of easy-packing mechanism		
A encoding system to achieve optimal sorting which can protect fabric and save resources		It saves people from solving the permutation of the washing program and washing temperature.
Quick interaction through NFC among Laundry Podium, smartphone and washing machine		It makes sure that every time people do the laundry, they can fill the maximum loading capacity of the machine. In this way water and energy can be saved.
		No more dropping of small items with the laundry bags.

Main Design Features

Double RFID System

RFID stands for Radio Frequency Identification and is a non-contact technology that are broadly used in many industries. NFC stands for Near-field Communication, which is a subset of RFID. In this product, both of this two technologies are used for different purposes. RFID reader is used to identify tags on clothes for it has longer range of communication, while NFC reader/tag is used to transfer information to smartphones.

Vicinity Sensor

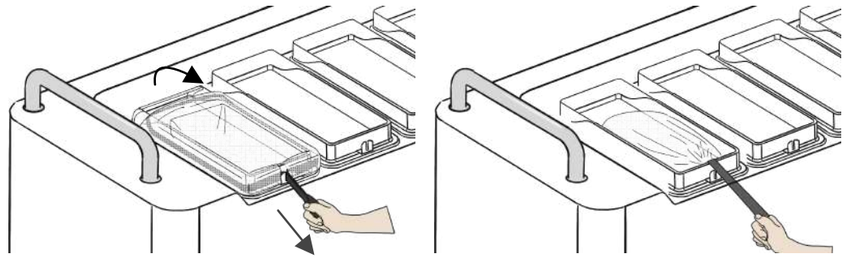
- Used to identify tags on clothes
- Usually can provide a reader range longer than **15 cm**

Proximity Sensor

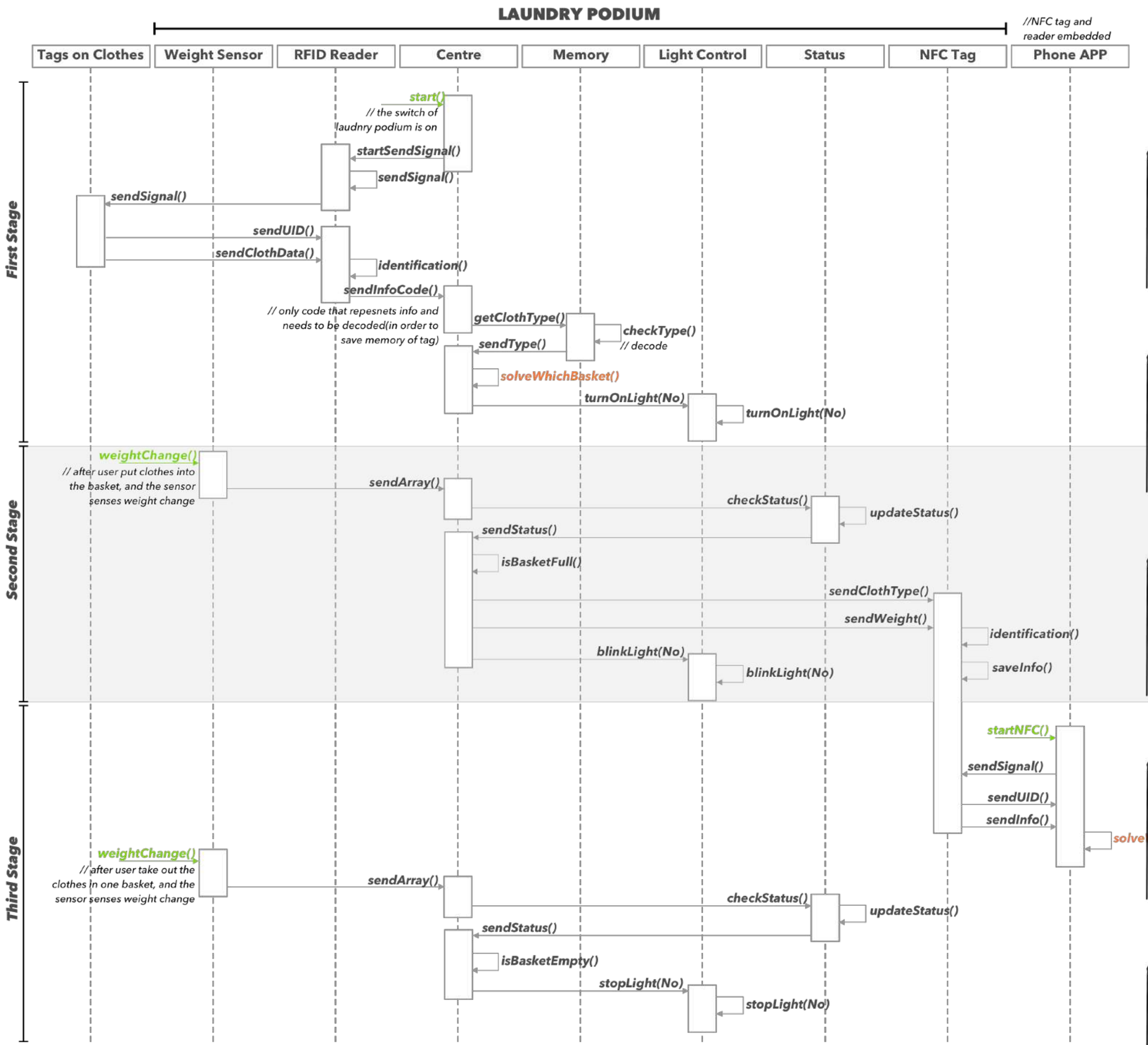
- Used to transfer cloth information to the smartphones
- Usually can provide a reader range longer about **5 cm**

Laundry Bags & Easy-Packing Mechanism

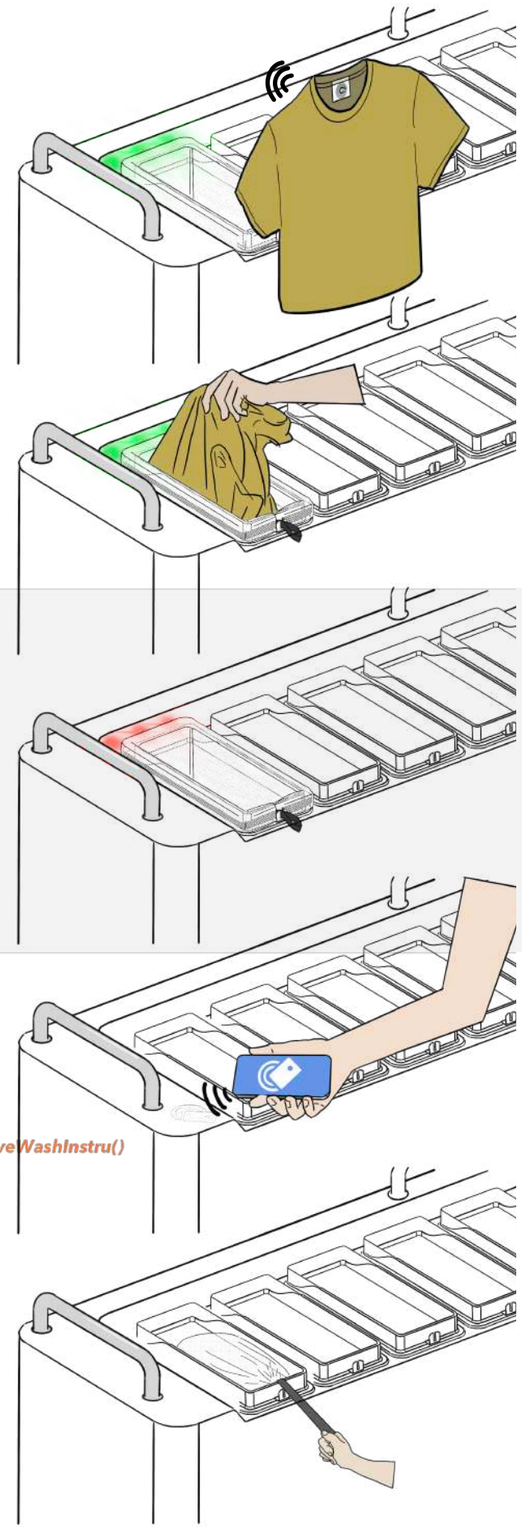
There is an laundry bag in each basket, which can be taken together and throw directly into washing machine to save the user having to bend when loading clothes. The easy-packing mechanism allows user to simply pull the rope in front of the basket and the soft material behind will bend over so that the mouth of the laundry bag will be tightened.



Sequence Diagram



Storyboard

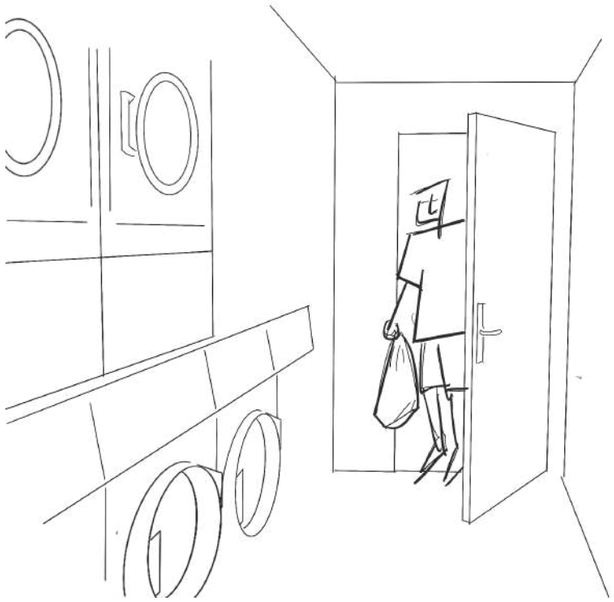


When user bring a cloth close enough to the Laundry Podium, it will detect the tag embedded on the cloth and solve which basket should that cloth be loaded in. Then the green lights at the corresponding position will be on to guide user.

When the weight reaches the maximum capacity of the washing machine, the Laundry Podium will again send notification through red-lights to tell user it's time to do the laundry.

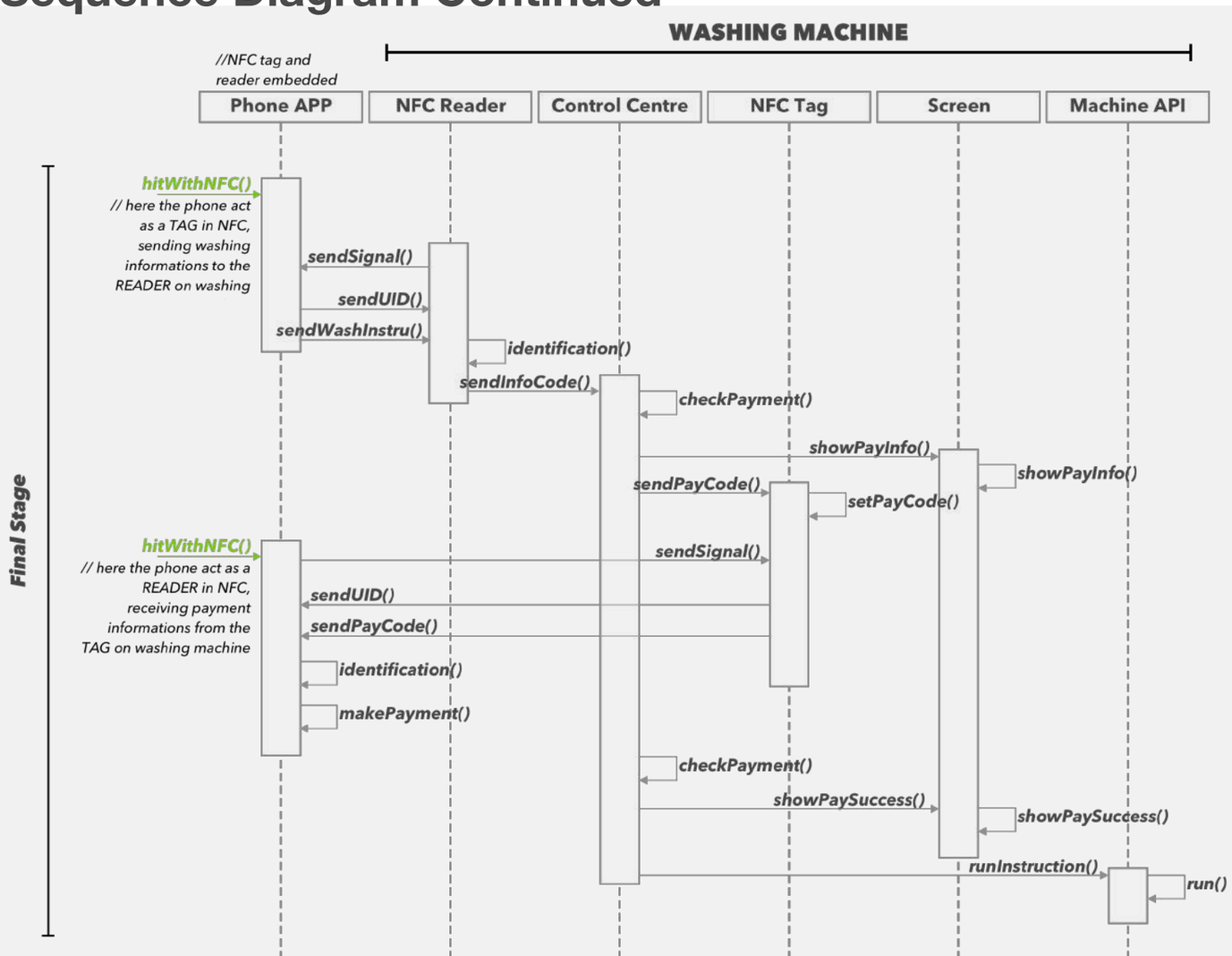
User can collect the information about color type, fabric, weight etc of the basket to be washed through NFC with smartphone. User can then pull the rope in front of the basket to tighten the bag and take it out for laundry.

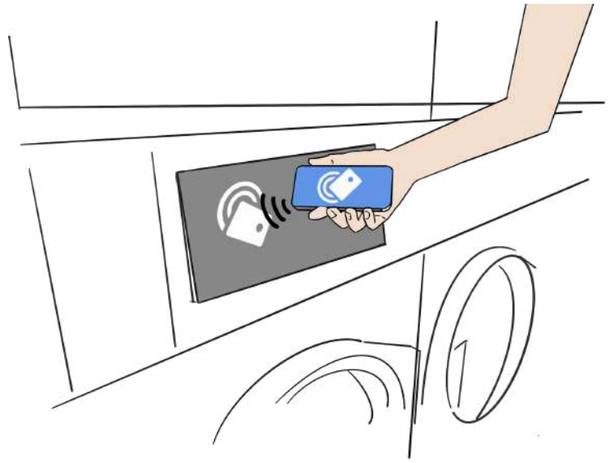
Storyboard Continued



User can bring the laundry bag to the launderette and throw it directly into the washing machine. In this way he/she can avoid dropping of small items during loading or transferring to dryer.

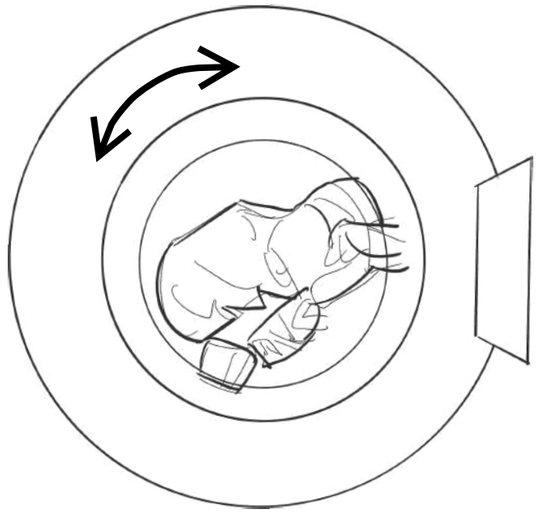
Sequence Diagram Continued





By getting information from the smartphone through NFC, the washing machine can solve the optimal program to run and how much does that program cost. By displaying the payment information on the screen, user can hit with their phone again to make payment.

Once the payment is made successfully, the washing machine will display the 'payment successful' information on the screen and start to run.



Outer Shell

- Manufacturing method: sheet metal
- Manufacturing detail: Rounded corner (R=5cm) applied to avoid tearing

Inner Basket

- Material: ABS Plastic
- Manufacturing detail: Draft angle of 1° applied to both sides to help removing of the mold. Sharp corners are avoided to prevent stress concentration.

Integrated Circuit Level

- Components included:
  - Logic Board
  - LED Screen
  - NFC Reader/Writer
  - NFC Tag
  - Battery
  - LED Lighting
  - 2xLong-Range RFID Reader

Rubber Bushing

- Material: Rubber
- Function: fastening

Handle

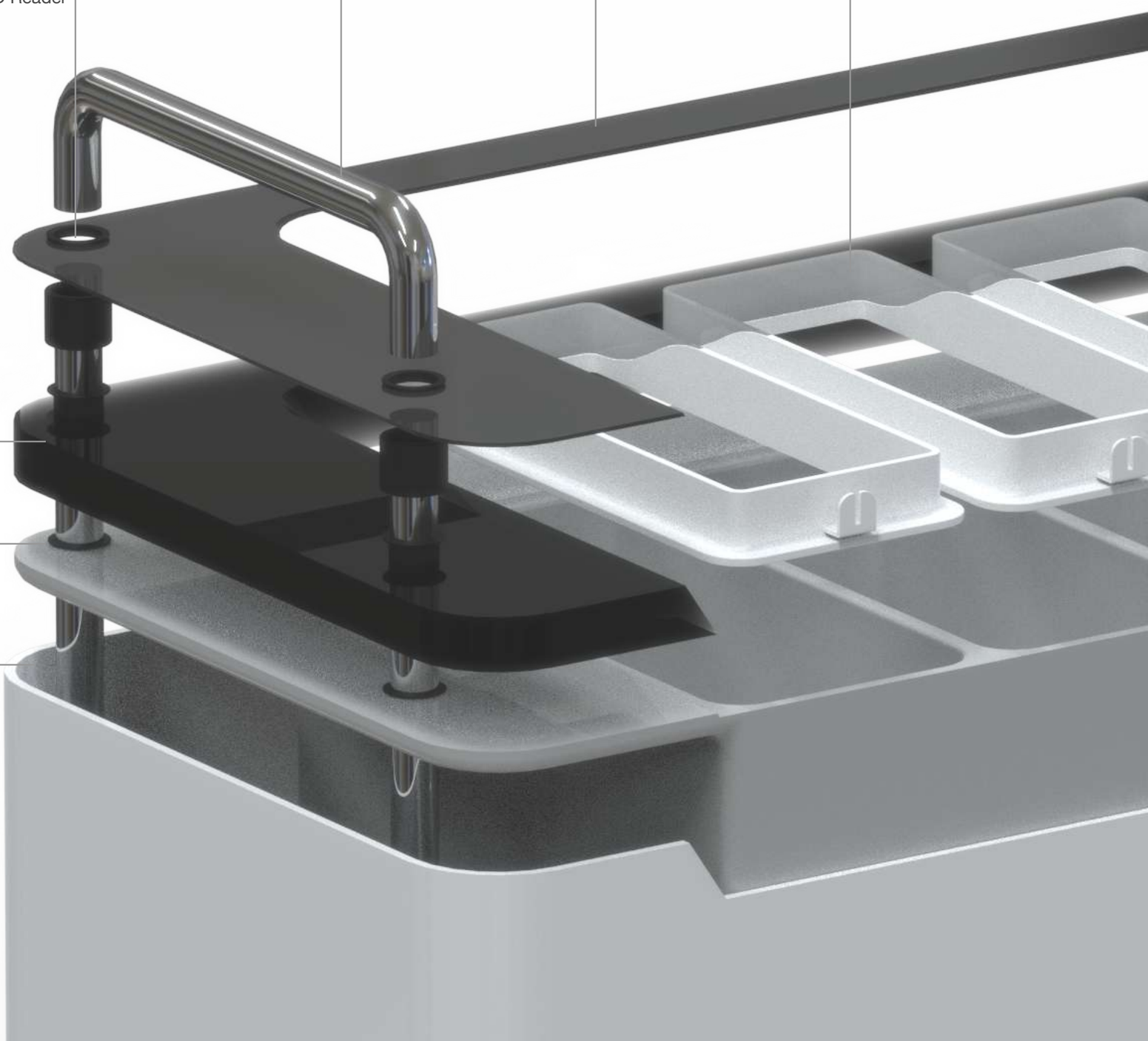
- Material: Polished steel
- Manufacturing method: injection molding

Glass Interface

- Material: Translucent Glass
- Function: display infromation

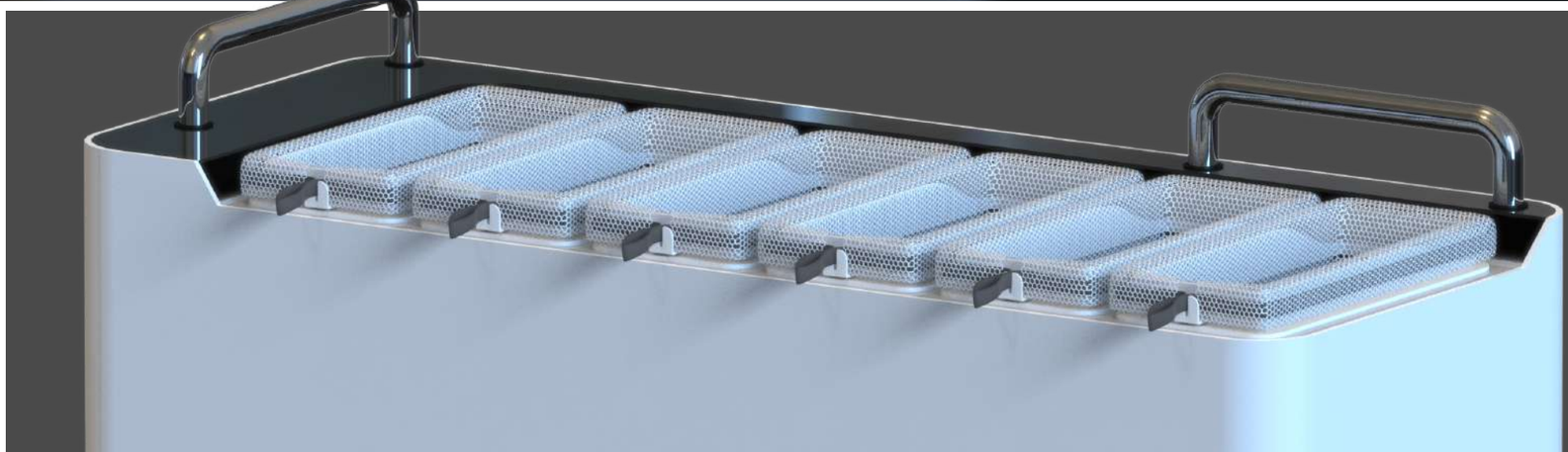
Basket Lid

- Material: ABS Plastic & TPU
- Manufacturing method: injection molding
- Manufacturing detail: Parting line is in the middle of the wide-brim, and a draft angle of 1° is applied to both sides.



Design for Assembly

This product is designed to be assembled from above. Orienting features are clear as very few parts are symmetries. Parts like Basket Lids are standardized to reduce variety. Rubber Bushings are used as fasteners.



Reflection

At first I was in favor of the concept of mechanical claw, because it has addressed a vital problem of the waiting gap between washing and drying in the launderette. Since building a robotic gripper system in every public launderette can be insanely expensive and difficult, so I changed direction to develop a laundry storage system. However, most previous research and investigation was aimed to find opportunities in launderette, thus there's a gap between the Discover and Define phase. More research about the new concept of laundry storage should be done.

Future Work

There are several issues need to be look at in the future. First is power supply. Since one of the main purpose of the product is to protect the environment, dry batteries should not be used. As a result, a charging plot should be considered. However, charging could be dangerous as the product may be put in the bathroom by user, which requires water proof feature for the charging system.

Secondly, a detailed architecture need to be developed in the Integrated Circuit Level, including how those components should be attached and fixed in it, how they are connected and how they are powered.

Finally, a complete final model should be made to test how it goes with surroundings. What need to be recorded for further development include its interaction with RFID tagged clothes and phones and people's feeling about using this product.

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