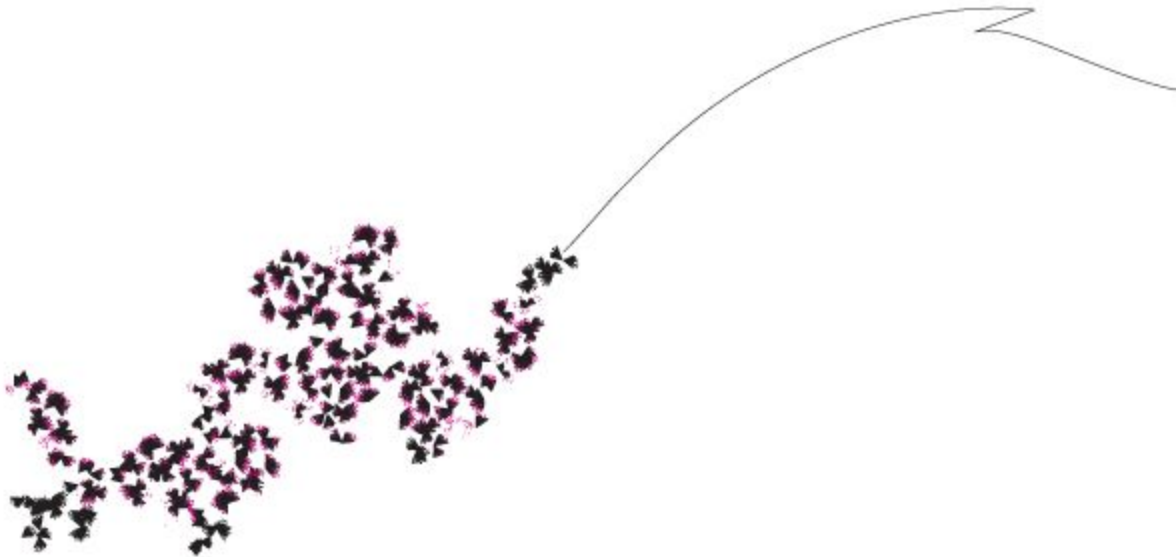


SMART ENVIRONMENTS PROJECT

Team Lincoln (se20) - Smart Fridge Addon



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CHAPTER 0

Introduction

Smart environments can be defined as ubiquitous and interactive smart systems that are embedded in the physical environment. Smart environments advance an otherwise passive environment to become an active partner of its users (D. Wolter, A. Kirsch, 2018). This report contains the documentation of the Smart Environment Project of Team Lincoln in which the goal is to create a disaster solving smart environment.

Food waste has become a major challenge in today's society. In the EU, around 88 million tonnes of food waste are generated annually with associated costs estimated at 143 billion euros (FUSIONS, 2016). Wasting food is not only an ethical and economic issue, reducing food waste also helps achieving the Sustainable Development Goals and the fight against climate change (European Commission, n.d.). All actors in the food chain have a role to play in preventing and reducing food waste, from those who produce and process foods to those who make foods available for consumption and ultimately consumers themselves. Different studies show that between 1/3 and 1/2 of the world food production is not consumed (Gustavsson et al, 2011; Bio Intelligence study, 2010), leading to negative impacts throughout the food supply chain including households. There is a pressing need to prevent and reduce food waste to make the transition to a resource-efficient world (FUSIONS, 2016). It is time for a solution!

When looking at the food waste in different sectors, the most food is wasted in the households, around 92 kg per person per year (FUSIONS, 2016). Therefore, we focus on a solution within the household sector since the most profit can be gained. The proposed solution is a smart fridge addon. This addon keeps track of the products in the fridge and the expiry date in particular. Accessible via a mobile app and/or screen, the consumer knows what is in the fridge and up to how long. This helps inventory management with reminders when products come close to the expiry date and is useful when grocery shopping. The addon is very user-friendly, the addon can be attached to any existing fridge and the consumer scans the barcodes of the products and fills in the expiry date. This addon can also be used in the kitchen of businesses/restaurants or in the catering industry. Furthermore, this addon can also be used to expand with more smart features in the future.

Team Lincoln is led by Mikus Vancans. The tasks are divided according to everybody's skills and experience. Menke and Mikus are responsible for the technical things like the server and Arduino. The design, documentation, presentation, and all other things are taken care of by Alex, Quinty, Stefan, Thirsa, and Wout.

CHAPTER 1

Publications of disasters

Publication 1:

The Internet has become a basic necessity for almost all things in our society. But what if the ability to pay via card or online would fail? This happened in India, net banking, as well as debit card transactions, couldn't be done. The failure was most likely started due to an overload of people trying to buy stuff.

Source:

<https://gadgets.ndtv.com/internet/news/icici-bank-down-server-outage-downtime-2311142>

Idea:

We could find a solution to the problem when online banking fails.

Publication 2:

Even after 34 years, there is still a lot of radiation to be found because of this disaster. Bees are highly affected by this radiation and therefore have a 30 to 45 percent chance to not reproduce themselves.

Source:

<https://www.sciencetimes.com/articles/27816/20201021/present-levels-radiation-chernobyl-still-harmful-even-bees.htm>

Publication 3:

Sitting is the new disease! Sitting is detrimental to your health, alignment, and movement. People of all ages are struck by this disorder and are facing real problems in the future. As of now, most people are obligated to stay at home due to covid-19.

It's not only in working hours, think of

- The corporate lifestyle sitting at a desk
- Driving in a car
- The couch watching television for hours
- Flying on a plane, etc.

"A person sits an average of 6 to 10 hours a day at a desk or on a couch: and possibly more considering these past months. The excessive amounts of sitting slow down your metabolism and puts your health at risk for:

- Obesity and excess body fat
- An increase in cholesterol, blood pressure, and cardiovascular disease
- Hyperglycemia and Type 2 Diabetes"

Sitting too much is now considered a risk factor for diseases. A study done by Loughborough University and Leicester University with 800,000 people who sat for long periods throughout the day increased the risk of:

- Cardiovascular (CV) event 147%
- Diabetes 112%
- Death from a CV Event 90%
- Death 4%

Source:

<https://www.stack.com/a/sitting-the-new-disorder>

Idea:

Make a smart chair, this way you can maybe sport or get your daily dose of movement while working from home or behind your desk all day.

--> for gaming interactive gaming, vr but with more movement. Have a look at

https://www.kat-vr.com/pages/KAT_Walk_C?gclid=Cj0KCQiA-rj9BRCAARIsANB_4ADTSXNOImtqRPI45Xk6ZZuYdwUVP81GCxxDLeThOTXRrGBd5rNIG5IaArZSEALw_wcB

Publication 4:

Groundwater will normally look clear and clean because the ground naturally filters out particulate matter. But natural and human-induced chemicals can be found in groundwater. As groundwater flows through the ground, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water. Industrial discharges, urban activities, agriculture, groundwater pumpage, and disposal of waste all can affect groundwater quality. Contaminants can be human-induced, as from leaking fuel tanks or toxic chemical spills. Pesticides and fertilizers applied to lawns and crops can accumulate and migrate to the water table. Leakage from septic tanks and/or waste-disposal sites also can introduce bacteria to the water, and pesticides and fertilizers that seep into farmed soil can eventually end up in water drawn from a well. Or, a well might have been placed in land that was once used for something like a garbage or chemical dumpsite.

Source:

https://www.usgs.gov/special-topic/water-science-school/science/contamination-groundwater?qt-science_center_objects=0#qt-science_center_objects

Idea:

Something to detect water pollution or the amount of chemicals in water (i.e. related to nitrogen crisis). Or stagnant water (related to i.e. legionella bacteria) Or something related to farming fertilizers in groundwater.

Publication 5:

Levee breach flood disaster is one of the common natural hazards all over the world. In Bangladesh, flooding, levee breach, and sedimentation over the floodplain have become alarming problems that have severe and adverse effects on the national economy of

Bangladesh. This problem is also growing because of the rise in sea level and the soil subsidence in populous regions.

Source:

<https://www.sciencedirect.com/science/article/pii/S187770581200834X>

Publication 6:

Bridge failures are one of the most severe infrastructure problems facing the world today and usually cause significant economic losses and casualties. This has elicited a considerable amount of attention from designers, engineers, researchers, and policymakers. Bridge failures pose an imminent threat to life and property during their service life, which reinforces the need to implement updated sustainability assessments and optimal risk mitigation procedures.

Source:

https://www.researchgate.net/publication/339116896_Lessons_Learnt_from_Bridge_Collapse_A_View_of_Sustainable_Management

Publication 7:

The population of the common wasps is related to the weather in spring. Warmer and drier springs mean a higher chance to have more wasps in the summer. Professor Phil Lester, lead author from Victoria's School of Biological Science, commented that climate change is also a considerable reason for the increasing number of wasps. He says: "The average global temperature is rising each year. We are therefore likely to see more wasp abundance in the future as our weather gets warmer." Among other places, the common wasp is a major pest in New Zealand. Estimated costs for their economy are around 130 million dollars each year.

Source:

British Ecological Society. (2017, 18 January). What will the wasp plague be like this year? From <https://phys.org/news/2017-01-wasp-plague-year.html>

Publication 8:

Tornadoes that occur during nighttime are more than twice as likely to be fatal than tornadoes that happen during daytime, which means more casualties as a result.

A few potential explanations as of why are:

1. Tornadoes that occur after the sun went down are harder to spot for the public and storm spotters.
2. People are often asleep and won't receive a tornado warning.
3. Homes, where most people are located during nighttime, are often more vulnerable than office buildings, where most people are located during daytime.

Solutions that are mentioned in the article are:

1. Warnings on Television and social media (not useful when people are already asleep and/or lost power during the storm).
2. Sirens to wake people up (but sirens are supposed to be used to alert people who are outside, to go indoors, and some people get confused about whether the sirens are defect or not).
3. Wireless emergency alerts to warn people (although, not everybody might receive these messages. People with poor cell coverage in rural areas for example).

Source:

Ellis, K, and Hass, A. (2020, 5 March). Tornadoes that strike at night are more deadly and require more effective warning systems from

<https://theconversation.com/tornadoes-that-strike-at-night-are-more-deadly-and-require-more-effective-warning-systems-132955>

Idea:

Beds that shake people awake and just yeet you out of bed.

Publication 9:

Driving while being under the influence of drugs is dangerous. Depending on what drug you took, it has a certain effect on your brain, which, in combination with driving, can lead to vehicle crashes.

According to the Governors Highway Safety Association, 43,6% of fatally injured drivers tested positive for drugs, and over half of those drivers were positive for two or more drugs, in 2016. Teens and older adults are most often affected by driving under the influence of drugs. Teens are more likely to underestimate the effects of drugs and have often the least driving experience. Older adults can use a prescription drug in an incorrect way.

It is not known how many people drive under the influence of drugs, because of multiple reasons:

1. It's not possible to test the drug levels in the system on the side of the road (A blood or urine test has to be used).
2. It's difficult to determine whether somebody used drugs recently or already some time ago, since some kinds of drugs can stay in your system for weeks after use.
3. When drivers have already been tested positive on an alcohol test, then they won't check the drugs levels anymore.
4. When a driver has both alcohol and drugs in their system, it's difficult to determine which substance had the greater effect.

Source:

NIDA. (2019, December 31). Drugged Driving DrugFacts.

<https://www.drugabuse.gov/publications/drugfacts/drugged-driving>

Publication 10:

The article is about food waste and its environmental impact and expects that this waste continues growing due to rising populations. A household wastes an estimate of 150Kg of food

a year due to various reasons, not proper planning, or mislabeling on foods for example. An estimate of 10% of all the wasted foods in the EU are still perfectly edible but was discarded because of the labeled date. Unused food is also not good for the environment because it takes water and land to be able to grow, fuel for transport, energy for cooling the product. And if it ends up in a landfill and starts rotting it gives off methane which is 25 times more harmful to the ozone layer than carbon dioxide.

Source:

<https://en.reset.org/knowledge/global-food-waste-and-its-environmental-impact-09122018>

Idea:

Build a small device that can “analyze” the food to check if it doesn’t show any signs of being degraded that far that it shouldn’t be eaten anymore by for example methane emissions or other smells.

Publication 11:

For us roads are essential, we need them to drive over them and move from A to B quickly. But those roads are splitting the habitats of animals and they are not aware of the dangers. In rural areas, when it is dark outside, many cars usually spot an animal too late. Hitting an animal is also pricey for the car owner with an average cost of 1600€. In 2019 roughly 10000 animals were killed near the roads in the Netherlands.

Source:

<https://www.nporadio1.nl/consument/27212-aanrijding-wild-dier-het-gebeurde-in-een-fractie-van-een-seconde>

Idea:

An infrared camera near the side of the road that detects whether it sees an animal on the road and if so it starts blinking brightly to warn vehicles. Or a camera that can be built into a car and then gives off a warning signal inside if it detects humans/animals in front of you.

Publication 12:

80% of all the Grutto’s breed in the Netherlands, but more intensive farming blocks the growing of the Grutto’s population. As for now, there are estimated to be 30000 left in the Netherlands, once it was 150000 birds.

Source:

<https://nos.nl/op3/artikel/2235846-de-nederlandse-panda-verdwijnt-mogelijk-binnen-30-jaar.html>

Idea:

Designating special places dedicated to the birds; drone scanning for nests so farmers can keep an eye on where they are breeding.

Publication 13:

There are anthropocentric, biocentric, and ecocentric reasons why wasting water is bad. Anthropocentric: We need water to survive, but we have only access to a very small amount of fresh water. There are already a lot of countries that do not have a lot of water, while other countries have a lot of water wastage. If the “richer” countries keep wasting water other countries will not have enough water.

Biocentric: If we as humans overuse water, other systems (agriculture but also nature) will get limited access to water.

Ecocentric: We waste clean drinking water in households which forces us to use groundwater or water from aquifers but this is bad in the long term.

It also takes a lot of energy and time to clean water and we are just wasting it.

Source:

<https://www.forbes.com/sites/quora/2016/07/19/why-wasting-water-is-a-much-bigger-problem-than-you-think/>

Publication 14:

There are a lot of people drowning every year. Children and adults. And also for every child that drowns there are five others who need emergency care.

Several factors increase the risk of drowning, such as lack of swimming ability, lack of proper barriers around water, alcohol, no life jackets, etc.

They also mention some things that could help prevent drowning, such as being able to swim, have supervision around water, wear a lifejacket, learn CPR, etc.

Source:

<https://www.cdc.gov/homeandrecreationalafety/water-safety/waterinjuries-factsheet.html>

Idea:

Make something that alerts the supervisor if a child or somebody is in the water when it is not supposed to be and sends updates every now and then about the kid.

Publication 15:

Just a low percentage of people with dementia get lost but for those who do get lost the risks are high. The risks of getting injured or even worse depend on the state of the person but also the place where they get lost and the time of year.

Source:

<https://www.tandfonline.com/doi/abs/10.1080/13607863.2014.924091?src=recsys&journalCode=camh20>

Idea:

Make something that either tracks when they are outside of the home, or something that lets people around them know that they need to be brought back home.

Publication 16:

Between 2005 and 2009 83,000 crashes were caused by drowsy driving. 1 in 25 adults in America reported they had fallen asleep at the wheel. Being sleepy affects decision making and reaction time. Drivers may underestimate how sleepy they are.

Source:

https://www.cdc.gov/sleep/about_sleep/drowsy_driving.html

Idea:

Using a camera to monitor user eye movements and sleepiness. When drowsiness is detected implement stimulating cues.

Publication 17:

The number of cycling-related accidents and fatalities in the Netherlands is increasing compared to previous years (228 in 2018, 206 in 2017). Motor vehicles also contribute to this. Elderly people are a risk group. The Netherlands seems to be planning to slow down motor traffic in urban areas from 50km/h to 30km/h to prevent accidents.

Source:

<https://bicycledutch.wordpress.com/2019/04/18/considerable-increase-in-road-fatalities-in-the-netherlands/>

Idea:

Modify a bike to give it a speed limit (speed is one of the pressing issues), give a bike some sort of light to indicate if there is something behind you / trying to overtake you (for cyclists using headphones that might not hear)

Publication 18:

In 2018, a series of deadly mudslides buried towns in mud and debris. A warming planet contributed to the calamity. Vegetation that would have stabilized the soil had been burned by fires. Extreme rainfall then drenched the destabilized soil, and the hillside couldn't soak up the water.

Publication 19:

When periods of heavy rainfall are followed by relative drought prevent the locust eggs from drying out. This results in the formation of large locust swarms that fed on the vegetation nearby.

Publication 20:

The combined impacts of high tides, storm surges, and human caused sea-level rise could expose an extra 23 million people to coastal flooding within the next 30 years even if ambitious cuts to greenhouse gasses are done. This could mean that 1-in-100 years floods could happen as regularly as 1-in-10 years. As much as 4% of the world population could be affected by it.

CHAPTER 2

General problems and challenges

Groundwater pollution

Problem: Groundwater contamination occurs when man-made products such as gasoline, oil, road salts, and chemicals get into the groundwater and cause it to become unsafe and unfit for human use. Materials from the land's surface can move through the soil and end up in the groundwater.

For example, pesticides and fertilizers can find their way into groundwater supplies over time. Road salt, toxic substances from mining sites, and used motor oil also may seep into groundwater. In addition, it is possible for untreated waste from septic tanks and toxic chemicals from underground storage tanks and leaky landfills to contaminate groundwater.

<https://www.groundwater.org/get-informed/groundwater/contamination.html>

Food waste

Problem: In the EU, around 88 million tonnes of food waste are generated annually with associated costs estimated at 143 billion euros. Wasting food is not only an ethical and economic issue but it also depletes the environment of limited natural resources. People buy too much food and don't always keep an eye on the expiration date. And there is a difference between: "best before" and "use by".

https://ec.europa.eu/food/safety/food_waste_en

Sitting

Problem: people don't sport enough and mostly sit at home (work at home), which increases due to corona (more people work at home and stay indoors). --> health.

Drugged driving

Problem: too many people drive with drugs in their system. Some people underestimate the effects of drugs and the consequences, and it's difficult to determine whether the drivers took drugs or not (police can't check this with tiny machines like an alcohol test, but only with blood and urine).

Water waste

Problem: too much water is wasted in homes and in agriculture. Therefore, less water is available for the animals. Also, rich countries use the most water and less water is available for the poorer countries.

Wasp plague

Problem: global warming causes (among other things) the increasing number of (common) wasps, which gives us wasp plagues. In some countries, the wasp plagues cost the economy lots of money. --> this can also be applied to other insects.

Tornadoes at night

Problem: Tornadoes at night are more difficult to spot and people won't always receive an emergency alert. Therefore, fewer people see the tornadoes coming, with more casualties as a result. Plus, most people are not very concerned about the effects of a tornado happening at night.

Bicycle accidents

Problem: Bicycle accidents and fatalities are rising both speeds of motor vehicles as well as bicycles are often too high. This combined with bicyclists often not paying sufficient attention to the road causes crashes.

CHAPTER 3

Identify

We identified several problems and already thought of some things that might help.

Sitting:

Sitting is a big problem nowadays since a lot of people stay home and sit all day. This is not good for the health of people.

Some ideas:

- A desk that moves up automatically when you sit for too long (it decreases your work speed tho).
- An app tells you “yo, you are sitting for 4 hours now. You just lost 30 minutes of your life” (based on fear).
- Only simple notifications are simple to ignore (like other phone notifications).

Food waste:

Tonnes of food are wasted all over the world every day. This is very bad for the environment and also a huge waste of edible/reusable food.

Some ideas:

- Make users buy more precisely (the commitment from the users needs to be there).
- A smart fridge that keeps track of how much and what you have left in your fridge (the fridge can't see that you already ate half of your egg salad) (and again; commitment from the users).

Solution for the commitment that it needed:

- You can tell with your voice what you took from the fridge. Or a camera in the fridge that keeps track of the food that's left.
- If people already have the commitment, they can do it themselves, without the help.

Water waste:

A lot of water is wasted every day. Many people do not realize how big this problem is or knowingly ignore this important problem. Water is needed for all life on earth and we are spilling way too much.

Some ideas:

- Put devices in the waterline. When you have used too much water while showering, the water will be cut off. (a timer is also possible).
- Notification about how much water you have already used while showering (how much it cost you).
- Keeping track of others in your household (to see how much others used).

- A dynamo in the water pipe or in between the showerhead and the water pipe (keep in mind that this device should be save in combination with water)

Wasp plague:

Global warming increases the number of wasps everywhere and it can cost a lot of money.

Some ideas:

- Do frequencies or smells work to keep wasps away?
- Difficult to do at this time of the year (no wasps to be found).

Wild animals on the road:

Animals do not really understand the dangers of crossing a busy road and that can be very dangerous. They will just cross the street with every consequence that comes with that.

Some ideas:

- Cars with built-in things to see wild animals crossing the road coming in time already exist, BUT only newer cars have this.
What if there is a device that does this and that can be placed on any other car.
- Cameras that pick up moving animals in front of your car (but can also give false information when there is a leaf in front of your car on something).

Bike accidents:

Every year there are a lot of bike accidents. Cyclists are vulnerable in traffic.

Some ideas:

- Limit the speed of electric bikes.
- Programmed brakes (on a bike) make you stop when you go too fast.

CHAPTER 4

One selected and motivated

We selected the problem of food waste.

Food waste is a huge problem everywhere in the world. It is not just a problem in restaurants and hotels, it is also a problem in the agricultural sector and the households. Tonnes of food is unnecessarily wasted and this is tragic. A lot of people do not have enough to eat while others throw away food when it still could have been eaten.

Plus, some people do not really know what they have at home and buy way too much food and leave it there to rot. This is also not efficient.

The problem itself is quite interesting since it is a huge problem but there are not really a lot of solutions. We know that it happens and yet we do not really do anything about it.

It would be amazing if we could help raise awareness about this and reduce the amount of food that is wasted.

CHAPTER 5

Picking solutions for food waste

1. Smart shop

We all know that throwing away food because you bought too much is a problem that everyone encounters. In order to fix problems like this, we could make something like a smart buyer. With a smart buyer, you could implement maybe something like a camera in your fridge. This camera is accessible for everyone in the family or household. With this camera, you can check what is in the fridge and what is not. This way you won't buy items that you already have enough, or even the other way around, skipping items that you need because you thought you had them. With a family or household sharing ability you know not only what products you bought yourself but you could also check up on others to make sure they don't buy the same product because they didn't know that you already bought it.

2. Sharing app

An app you could use to let other people know that you have food left that you are not going to eat. Since almost everyone has a phone, homeless or poor and hungry people could then react to your message and come and take the food you don't want. It is a win-win for everyone and it has zero effort for the people with the leftover food. The feeling of giving and helping other people is also amazing.

3. A lot of food is wasted before it hits the shelves. In countries throughout Africa and Asia poor harvesting and logistics cause the food to deteriorate rapidly during transportation or production. A solution to this would be to create a material that is added to the container that the food comes in to help slow down the food from going bad.

4. The date on food is usually the best before date but it's commonly seen as a hard-line as consumed by (a manufacturer guaranteed date that the food will be in perfect shape). And therefore edible food is still thrown away. A small device that looks for signs of food degradation which tells the user if they should avoid it or that it's still safe to eat.

5. Food waste can be reduced by making customers more aware of what they have inside their fridge. Allowing them to see inside the store whether they have something in the fridge or they ran out of it. The other thing the smart fridge can do is send a notification that a product is about to expire and should be consumed within a few days.

The idea is that this is a small attachment to a fridge (magnetic), which scans the barcode of the product.

CHAPTER 6

Smart fridge

We selected the solutions of the smart fridge over the other candidate solutions.

We didn't choose the first candidate solution because it's already close to the fifth idea of the smart fridge, however, the smart fridge solution has more functions and can also be put into use in the catering industry.

We didn't choose the second candidate solution because not much sensing is involved. Also, a camera and its program are probably not accurate enough, since it has to recognize each product and see the expiration date (which is something on the bottom and can't be read by a camera).

Although, we did like the idea of the barcode/IQ scanner (which was commented by Andreas).

We didn't choose the third candidate solution because it starts from outside the Netherlands. We decided it's better to choose an idea that's closer to home. Plus, it might be too risky.

We didn't choose the fourth candidate solution because for this solution the user needs multiple cameras to keep track of the degradation of the food. This might not always be accurate enough, since some food starts to mold at the bottom or at another blind spot of the camera, or the food might be packed in a box.

So, we chose the fifth candidate solution: the smart fridge. It has multiple functions and can be combined with parts of other candidate solutions (like the barcode/IQ scanner from the first solution and making people aware that the manufacturer guaranteed date doesn't have to be the exact date that the food becomes inedible from the fourth solution). Furthermore, the smart fridge device can be used in multiple fields. Think about households, but also catering. Most food waste happens in catering and companies, which needs to be reduced. On the other hand, consumers can also help reduce the amount of food waste. Therefore, we selected the attachable smart fridge device.

CHAPTER 7

Things we need

The physical things we need to make our project work are the following:

1. A barcode scanner
2. Touch module
3. potentiometer
4. An iPad or a tablet (or a display shield with touch screen)
5. A box/case
6. Something to add everything to the fridge

We also need to be able to connect an Arduino to a database that is connected to a website so that we can see the product that belongs to the barcode and have all the items listed.

For our project, we don't really need to collect a lot of data. We need to be able to scan barcodes and link that to the items. We can do this by implementing API's from multiple supermarkets (Albert Heijn, Jumbo, coop, Plus, etc.). This means that we also do not need to do data analysis.

Furthermore, it needs to be possible to select the expiration date, since reading the barcode won't tell us this information. We can do this by connecting a potentiometer to the Arduino board + a touch module to select dates.

This was the realistic scenario.

The more ambitious scenario would be connecting a camera that recognizes food (without the need of a barcode), and programming an app that makes notifications when food almost expires and with a build-in guide through the supermarket.

We divided the tasks in our group according to everybody's skills and experience.

So for the more technical things we have Menke and Mikus. They will be busy with the server and Arduino.

And the design, documentation, presentation, and all other things will be taken care of by Alex, Quinty, Stefan, Thirsa, and Wout.

- *Barcode scanner and all the other things -> ORDER THIS (keep in mind that some won't work for what we want --> barcode scanner-module voor 1D/2D codes)*
- *Someway for a robot to read time on a product (Mikus)*
- *Connection from arduino -> database -> website (Menke)*
- *Ipad/tablet or something we can borrow for the project (Quinty's tablet?)*
- *(flat) box/case (the add-on itself) --> design (Alex)(Stefan)(Quinty)*
- *Something to add the case onto the fridge (magnets? DUCT TAPE?)-->(Alex)(Thirsa)(Quinty)*
- *Documentation -->(Quinty)(Stefan)(Thirsa)(Wout)*
- *Organisation -->(Wout)*
- *testing/validation -->(Quinty)(Wout)*

CHAPTER 8

Results and Conclusions

In the end, we went for our basic plan.

As we have yet to complete all pieces together we have made a list of all parts and their current state

Website/database:

The main part which handles everything about the products and that keeps track of it is a website. The url will be <https://project.menkeveerman.com> (may be subject to change and this is not a final nor recent version). The website is made with the Laravel framework, the backend scripts are all in php. Nothing is hard coded and gets constructed from so called blades, so no site is hard coded and single element might be used on every page without typing it every time.

Barcodes

The first difficulty was: we have a barcode, which product is it? On the websites of supermarkets you can type in a barcode and it responds with a product, so does it for the app so there should be a way to retrieve that information, through the API. By googling we found how to access the API of the Albert Heijn, the Jumbo and a large international database. However, we weren't satisfied yet, we wanted to have at least the Plus and the Coop too.

After hours of digging through the Jumbo's website we found our way in. (We're not modifying anything of the supermarkets, just asking their servers; what is the product data of this barcode?) But the Plus tended to be a little harder, they had their own sku's (stock keeping units) so searching on a barcode wouldn't work. Still dug through their site but found nothing useful. But their mobile phone app did exactly what we needed; retrieve the data by the barcode. But how do you see which url it makes a request to on a cellphone? We ended up performing a mitm attack on one cell phone (a man-in-the-middle attack is literally a device between the server and the end device, it decrypts the phone's requests, logs it and then re-encrypts the traffic again and forwards that to the server. The response of the server happens in the other way around) which showed us that the Plus first looks up what is the matching sku with the barcode given, and then makes another request for the data of that product.

Database construction

When a data-request is made it will first look through its own database in the Products table which stores basic product information (manufacturer, size, title). If it can't find it there it will look through the 5 different api's and when it has found a product it returns that and also stores it in our own database to improve responsiveness and reduce network traffic.

The Fridges table makes the relation between an owner so an owner can have multiple fridges.

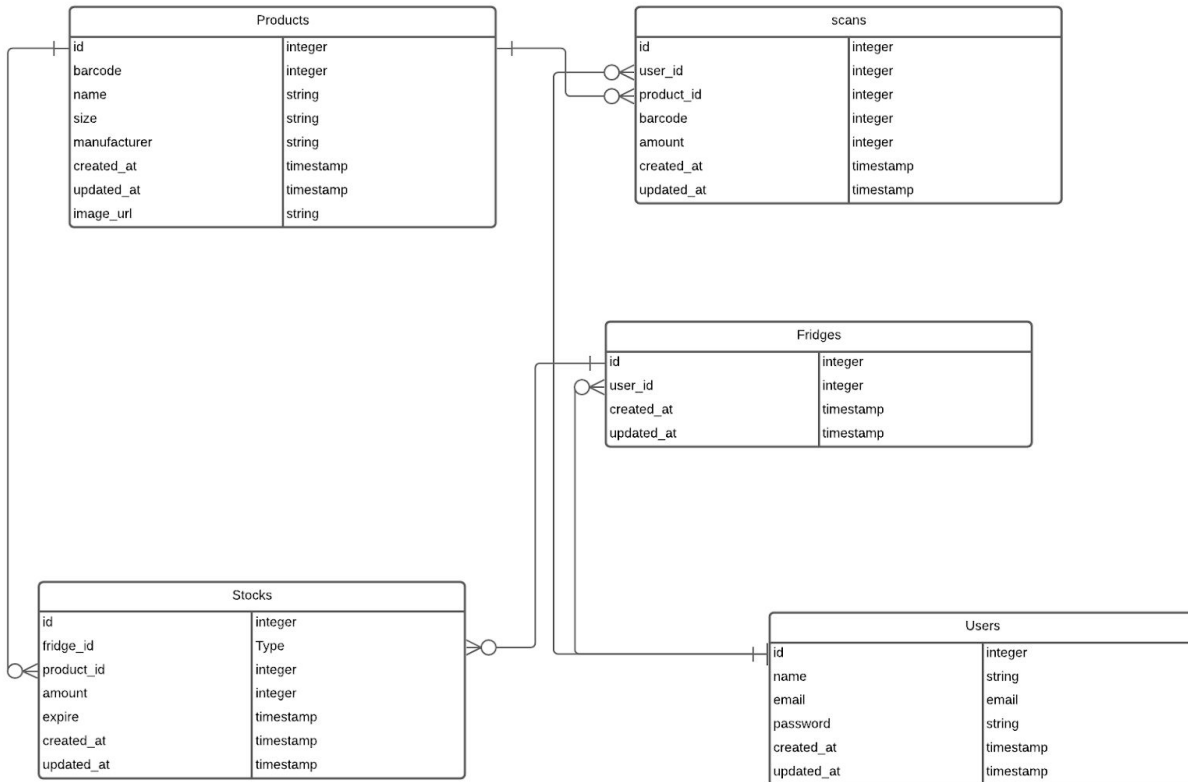
The Stocks table makes a relation between the fridge and the product data, so the items table refers to the products table (which stores basic product information), but it distincts

itself by storing only per-user/per-product data such as the expiry date. The items table and products table was split up to prevent duplicate data storage as well as the “self-learning” capability.

The Scans table is there as a backup to keep track of what actions were made to the database, sort of a logger.

The Users table stores user specific data.

Overview of the database relations:



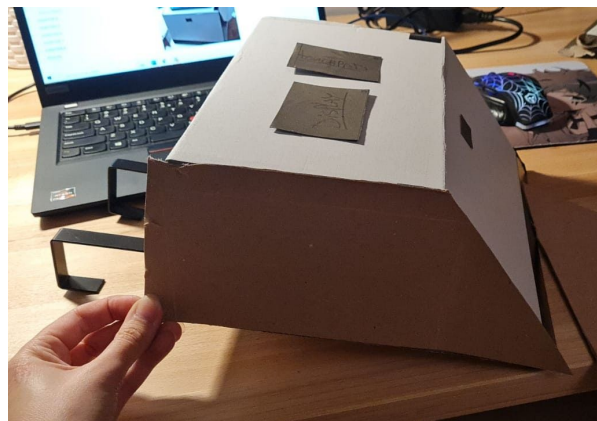
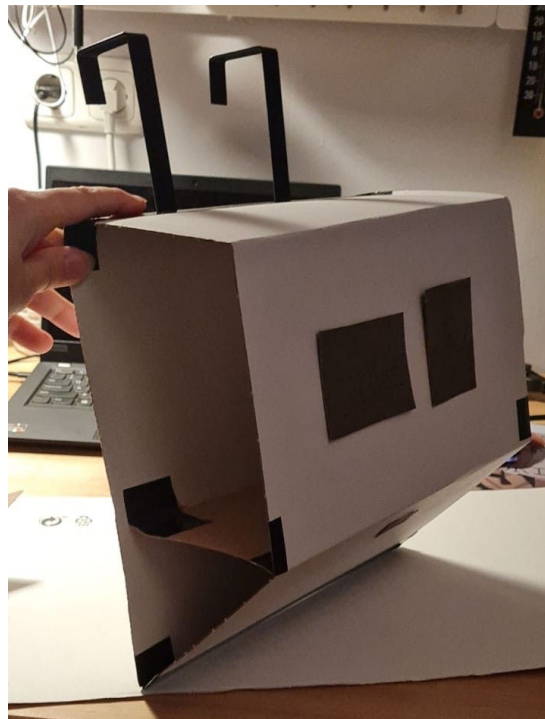
Casing:

We had to make a decent whole of all the other cool things. Not only a connector of other products but also a thing on its own!

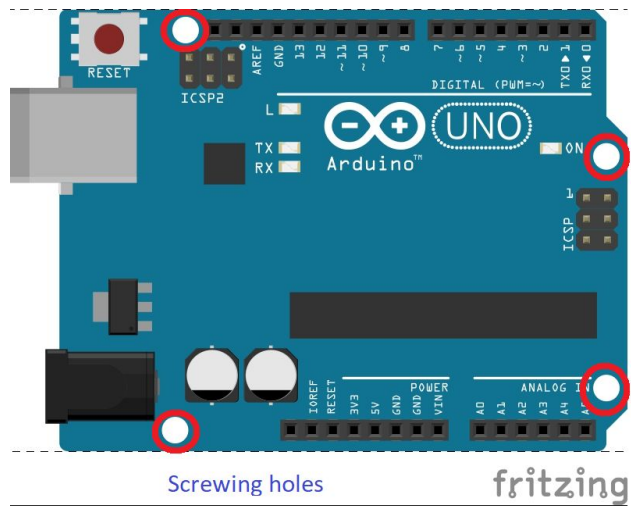
The casing has a few requirements:

- Needs to withstand temperatures from 0°C to 35°C.
- Needs to connect Arduino to barcode scanner to tablet or display, no connection problems.
- The casing needs to be easy to dismantle or adjust.
- The casing needs to be strong and can withstand collisions.
- The casing has to be mountable on different (fridge) surfaces.
- The casing has to look decent.

We have a prototype for the casing. It is yet to be made out of strong material but for visual purposes, we made one from cardboard.



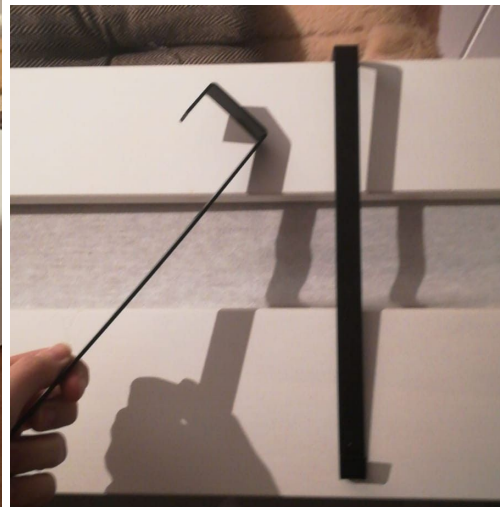
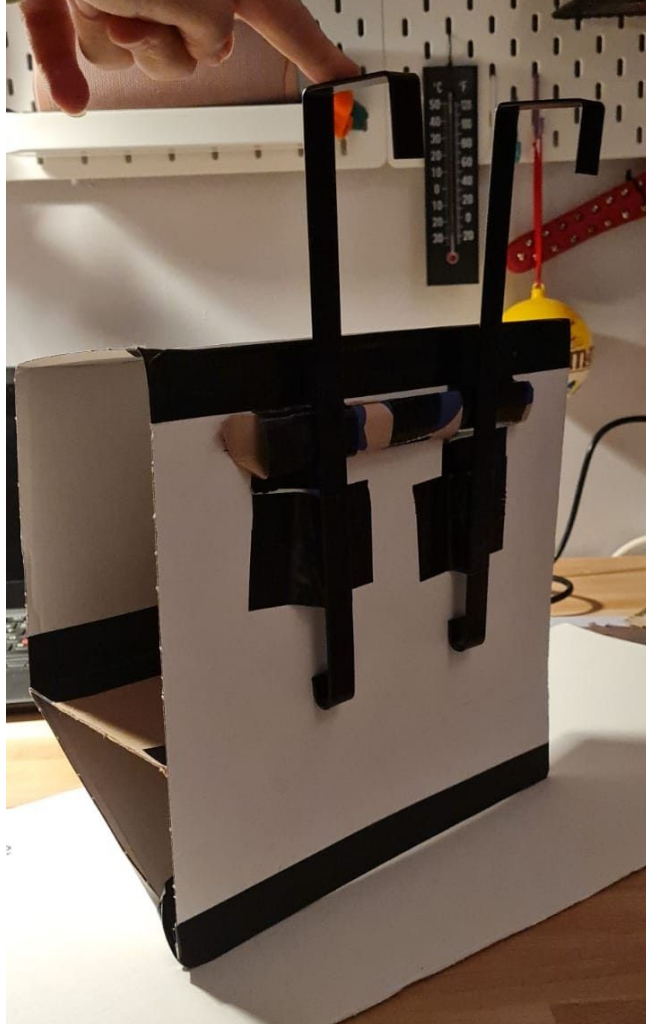
Withstanding temperatures from 0°C to 35°C is not the biggest challenge. However it could be that the air is rather humid, casing should therefore be made out of material that is not affected by humidity. Something like plastic, iron, or wood would work just fine. All of these materials can withstand temperatures between 0 and 35 degrees celsius. Besides the temperature, the case has a function to connect every part together. The Arduino needs to stay in place, this place as well as the barcode scanner tablet or display should be dry. The casing on the back end (not visible part) should be mounted to the backside, this is done via screws as there is an option for that on the Arduino.



On the back end of the casing is enough space for all the wires to move to the desired place. The lowest part is meant for the QR code scanner; keeping it at a right angle with the sloping plate. The upper part is meant for all the other components. Through the front will be the display and keypad or the tablet. This can vary depending on what works best for the smart fridge. Both sides will get a plate, covering all products that need to be invisible.

The back is the visible layer mounting of products that need to be invisible. Either this is done via double-sided tape or suction cups. Wiring is invisible as well, from Arduino to QR code scanner.

Wiring from Arduino to display is a little different to fully hide. The solution to this is that there is little space for the wiring. The wires are the same color as the background of the visible layer. In order to check if everything is working as it should or you want to clean your fridge without the smart fridge on it, you should be able to dismantle or adjust the smart fridge add-on. This goes hand in hand with the strength of the fridge add-on connection. The connection between the fridge and the add-on has to be solid. A solid material that is or could be easily removed or adjusted is, of course, a magnet, suction cups, or with iron bars like these:



As we gained information talking to a professional in this subject (Arte vita, <https://artevita.nl/page/>) The owner told us that most of the newer fridges are built-in fridges. A fridge without a magnetic door but rather a fridge with a wooden or plastic door. Connecting something to a wooden or plastic door is often done via suction cups or double-sided tape. Both of these options are easily available, user-friendly, and easily adjustable. Preferably use a magnet if available. Both the iron bars, magnet, suction cup, and double-sided tape are very solid and strong, bumping into the smart fridge is not a problem at all, as these mounting solutions are very solid.

Last but definitely not least, the looks of the casing. As this is a start / try-out model it is made out of cardboard giving it a rather cheap and ugly look. As mentioned before the real case would be made out of wood, plastic, or even iron. All of the materials give their own look to your fridge. Differences in color and materials make sure that everyone has a good and viable option for their fridge!

Hardware:

In terms of hardware, we chose to use a combination of components. At the heart of this we ultimately decided on an Arduino Mega 2560. We chose the Mega over the Uno for its increase in pins as well as its memory. Another option we kept in mind was to use a Raspberry Pi Zero W for this task. Connected to the Arduino are a 2.4 inch thin-film-transistor (TFT) touchscreen display and a barcode scanner.

Barcode scanner

The barcode scanner automatically looks for any readable barcodes in its view. Once it scans one it sends a code consisting of 13 integers to the Arduino's serial port. The scanner is connected over the S-TX pin to the RX-1 pin of the Arduino for serial input and otherwise uses a micro-USB to USB-A connection for power.

TFT Display

The display offers insight over products. It displays the item last scanned as well as a list of all of the items. The display simply attaches to the Arduino in the form of a shield.

Arduino

The Arduino itself takes care of what is shown on the display. For this we had to use the MCUFriend library which proved to be a challenge at first due to its unconventional syntax. Additionally, the Arduino handles the serial input coming from the barcode scanner. The scanner first sends each individual integer as its ASCII value to the port. In the Arduino code they are translated to their actual value and then combined together as characters in a String. This String is then sent as a request to the website. In return, the corresponding product details are sent back from the database to the Arduino in order for it to display on the touchscreen.

Conclusion

-What is working and how it works

The user scans a supermarket product with the barcode scanner. The website will recognize the product and show it on the display. After which the user has to type in the expiration date manually with the keyboard touchpad. This product and expiration date get saved on the list of products you have in your fridge. When you take a product out of the fridge you can delete it from the fridge inventory list via the website. However, when a product is almost reaching its expiration date, the website will give a notification about this, so the user knows they have to use the product before it reaches its expiration date. This prevents the product from spoiling. This list is a website and will be available everywhere you are. So you can see what you already have in your fridge when you're grocery shopping. This prevents the user from buying products they already have. Our add-on can be fitted to any fridge anywhere and can be used by consumers and producers.

-How does it benefit you?

We are part of the future generation, who have to live in this world for many more years, and later pass it on to the next generations. Food waste won't solve by itself and will only have a greater disastrous effect on the environment as humanity gets older and larger. We benefit in a way that maybe our future will have less wasted food, so we can pass on a better world than what we received to the next generation.

-How does it benefit the environment and prevent disasters?

Food waste is a worldwide problem. Tonnes of food are wasted all over the world every day. This is very bad for the environment and also a huge waste of edible/reusable food. The smart fridge add-on keeps track of expiration dates of food in your fridge and notes the user when and what products almost reach their expiration date. The smart fridge add-on can be used in homes, but also in the catering and restaurants, who have the most food waste. This way, less food will disappear into the trashcan and more of the produced food will be used effectively.

-What is not working perfectly?

The website is not working perfectly yet. The base of the website is there, but there is still some work with the rest of the website.

We are still working on this and we do believe that it can be finished in time.

-If we had more time what would the result be?

If we had more time, we would also make the ambitious scenario (which is described in chapter 7). Furthermore, we would also make the casing look more professional and from better material than cardboard (plastic, iron, or wood for example), and make the different add-on components (iron bars, magnet, suction cup, and double-sided tape) for different kinds of fridge doors, to further demonstrate that our smart fridge add-on is not only limited to one standard fridge.

-What impact could it have in societies?

Saving food can have a big impact in societies.

It can mean that less food needs to be made (growing less crops, catching less fish and slaughtering less animals), food can be made of better quality and animals with a better life, and people with a lower daily budget can also provide from it.

Less food waste can even help solving other world disasters. For example: giving farm animals a better life by giving them more space, means less animals on the same amount of ground, which means that less animal food is needed, which means that the CO2 emissions might reduce.

-How convenient and expensive will it be?

The larger the demand for a product, the cheaper it can be made and sold on the market.

The website and digital inventory have already been made and will only need maintenance.

The case is made out of either wood, plastic or metal (depending on the customers choice), but can be for a reasonable price.

The most expensive part of the smart fridge addon will be the technology inside the case (QR code scanner, display etc.) Right now, the technology inside exists of (amongst others) a simple Arduino. However, if this will be brought to the market, the technology needs to be more professional and less easy to break apart / malfunction.

In other words, it might be on the expensive side for the average consumer. However, the smart fridge addon is a long-run investment (just like a fridge itself, a vacuum cleaner and a microwave are also long-run investments). You buy the product once and benefit from it for a long time. Plus, you might eventually earn back the money you spend on the product, because saving food is also saving money.

-How feasible is this solution?

The average consumer's amount of food waste is only the tip of the iceberg of the enormous food waste problem in the world. This product can also be available for this group of people, because every food waste prevention can help.

However, this product will have the best result when it's used in restaurants, catering, and industry. These fields have much more wasted food. How feasible this product will be in those fields mostly depends on the staff of those restaurants, catering, and industry, and how willing they are to help prevent food waste by using the product.

The willingness of staff mostly also depends on how easy/quick the product can be used. In this case the user needs to scan the product and fill in the expiration date by hand. If this could go manually (by only scanning a product for example), the willingness would already increase amongst the staff.

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<https://artevita.nl/>