kelvin

food
for u

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Executive summary

Our challenge is centred into delivering food supplies (perishable and non-perishable) in good conditions ensuring its safety. After analysing the current scenario doing interviews and benchmarking other company's activities we have redefined the problem considering both the role of retailers and the users. Home delivery is not profitable for retailers for many reasons: delivery business's margins are very low, logistics systems have a highly centralized structure which makes the whole system very rigid and always adds more steps to deliver the package at home, legislation puts a lot of restrictions on delivery and the service is perceived by the users as a costly advantage.

From the user's perspective, the service has several problems. First, many companies give a two-hour window to deliver and consumers have to wait at their place to receive the goods without to knowing the exact time. Second, many consumers are concerned about the quality of the food received. They feel the retailers give them low quality food. In this way, we present a solution that makes the delivery process profitable for retailers without changing their supply chain, whereas we have relieved shoppers from the frustration of waiting at home for the shipment of their grocery.

This result has been achieved by employing different insulating technologies. Indeed, we have developed a unique process which allows to combine silica aerogel (an insulating material) with paraffin-based phase-change materials (a heat absorber). This specific combination of materials is able to maintain constant the temperature of refrigerated/chilled foods, therefore preserving the safety and freshness of perishable items.

Besides insulating materials, our boxes are also equipped with sensors and RFID (radio-frequency identification) devices for providing information in real time for both retailers and shoppers. Retailers will receive information related to the delivery

route and safety condition of the various food items, whereas shoppers will be continuously updated about the delivery time.

Introduction

Home delivery is a hot topic in both retail and logistic business. This is an extremely complex matter which involved various types of companies: from traditional carriers and retailers (such as DHL, FedEX, Tesco, Carrefour, etc.), to novel and innovative logistic providers (such as Google, Amazon, Instacart, etc.).

Home delivery is expected to gain considerable weight in the shopping experience since it has been associated with the new trends that are shaping the retail industry:

- Omni-channel revolution (various channels for selling and providing information);
- Online transactions, in particular mobile ones.

Although there are no clear numbers to define the value of the home delivery in the grocery market, we can use the to the grocery online shopping as reference market. The latter is a growing market and is expected to reach 80 billion euro by 2018. Therefore, we can suppose that the home delivery is growing very fast as well and it could worth more that the value estimated for the grocery online channel[1].

Our project was based on a user-centred design process, our focus was on the role of retailer: our challenge was based on to improve the current system of home delivery making it sustainable for the retailer from all point of view, economic, environmental and logistics.

From our research emerged that the current system of home delivery considering the retailer side is not sustainable because there are products with a low margin,

[1] http://www.foodtechconnect.com/2015/08/18/global-online-grocery-grows-80-billion-by-2018-syndy/

the logistic system is deeply centralized which adds more steps for each delivery, there are many law restrictions, there are problems regarding perishable foods and the service in not perceived in a good way by the final user.

At the same time the users don't trust of this service, because they have scared to receive the food not in the best conditions (e.g. rotten food, not fresh food, etc.), and because for them the deliver time is not sustainable because of they are forced to stay at home to wait the delivery that will arrive at unknown time. We make the delivery process profitable for retailers without changing their supply chain, whereas we relieve shoppers from the frustration of waiting at home for the shipment of their grocery.

We have developed a modular smart box which is able guarantee the safety of perishable foods with no need of refrigeration up to a long period of time. This result has been achieved by employing different insulating technologies. Our specific combination of materials is able to maintain constant the temperature of refrigerated/chilled foods, therefore preserving the safety and freshness of perishable items. The ability of preserving the temperature in a passive way (with no need of energy) for a such long period provides a dual benefit:

- It allows retailers to improve their delivery performances (by saving money, reducing delivery time), thus making the grocery shipment a sustainable and profitable process, without changing their current delivery system.
- It frees shoppers from being forced at home for receiving their grocery delivery, since it is able to assure the food safety for a long period.

Besides insulating materials, our boxes are also equipped with sensors and RFID (radio-frequency identification) devices for providing information in real time for both retailers and shoppers. Retailers will receive information related to the delivery route and safety condition of the various food items, whereas shoppers will be continuously updated about the delivery time.

Our solution targets the "last mile" delivery challenge, which corresponds to the final leg of the supply chain. Currently we have identified the following types of customers, belonging to both retailers and logistic industry, which are performing the "last mile" delivery:

- City/parcel deliverer (e.g. FedEx);
- Retailers with their own logistic structure (e.g. Amazon, Esselunga);
- Crowdsourced carriers (e.g., Instacert, Uber, etc.).

Our initial target will be represented by traditional retailers (with and without initial logistic structures) and carriers performing the home delivery service. For these customers we intend to provide an integrated set of solutions able to satisfy different needs in the home delivery scenario.

This report is organized in four parts. In the first part we are going to describe the process of benchmarking research. The second part describes the concept idea. The third part describes the technical report. Finally, the fourth part describes the economic viability of the project.

Benchmarking

As we discussed in the introduction food home delivery presents many challanges for the retailers. In this section, we are going to explore the different challanges that arise in delivery and describe the state-of-the-art of this market.

We realised that the home delivery of food is one of the most attractive topic in the retail and food industry. This is an extremely complex matter which attracts various types of players: from traditional carriers (e.g., DHL, FedEx) and retailers (e.g. Carreour, Walmart), to novel and innovative logistic providers (such as Google, Amazon, Instacart, Uber, etc.). In the next future, home delivery of food is expected to gain considerable weight in the shopping experience since it is associated with the trends that are shaping the retail industry, namely the omni-channel revolution (for selling, for providing information, etc.) and online transactions.

Delivery options

In short, retailers have developed two main strategies for delivering grocery:

	PROS	CONS	TYPICAL ADOPTER
In Store pick-up point	Small initial investment; No duplicate stock-keeping; Low floor space requirements; Flexible staff planning	Double workload for replenishment; Challenging data synchronisation; Faster out of stock; In store congestion	Brick-and-mortar retailers
Stand alone pick-up point	Flexible (longer work hours and more locations); Convenient for shoppers; Increases numbers of touch points with choppers	High initial investments; Time intensive; Involvement of more stakeholders; Lower willingness by consumers to use the service	Brick-and-mortar retailers
Home delivery	Preferred by many shoppers	Very high initial investments; High maintenance costs; Requires scale of operations	Brick-and-mortar retailers; On-line retailers
Home delivery (done by a 3rd party)	Small initial investments; Flexible - demand driven; No floor space requirement	Complex stock monitoring; In store congestion; Dependance on third party; Limited process optimisation	Brick-and-mortar retailers

Figure 1: *Food delivery models*

“home delivery service” and “pick-up points”.

We have identified two main models of shipment (summarised in figure 2):

- **fast-delivery**, namely the food is delivered in less than one hour from the order;

- **slow-delivery**, which is characterised by a lead time greater than 24 hours

	FAST DELIVERY	SLOW DELIVERY
Lead-time	<2h	>24h
Duration of delivery	<1h	>2h
Delivery fee	>3,5 euro	>5 euro
Need of refrigeration	no	yes
Minimum order	no	>40 euro
Customer's role	chooses date & time for delivery	no ability to choose the most suitable time
Profitability	yes, if it is done in partnership	no

***Figure 2**: Shipment strategies*

and a delivery process that lasts at least two hours.

Actually the profitability of this service is negatively affected by different types of factors, such as:

- Food items, which have low profit margins (usually between 2 - 5%);
- Supply chain; that has not being designed for the home delivery;
- Food items not designed for being delivered at home (e.g., size, packaging type, etc.);
- Legal requirements;
- Safety requirements for perishable food items, which imply the use of the cold chain at different temperatures.

Food safety is the main constrain in the food delivery process when the shipment period exceeds two hours. The only feasible technology used by the food industry to overcome this issue is the cold chain. Indeed carriers employ refrigerated trucks for maintaining the food at appropriate temperatures; usually they have trucks in which is possible to create zones with specific temperatures for fresh, refrigerated and frozen items. Unfortunately this technology has the disadvantage of being too costly for retailers, and this makes the delivery process not profitable at all.

Survey research

The findings of the MetaPack 'Delivering Consumer Choice: 2015 State of eCommerce Delivery'[2] survey, highlight the increasingly crucial role delivery plays in influencing which retailer a consumer chooses to shop with.

Two-thirds of the 3,000 adults surveyed (66%) confirm they've bought goods from one retailer in preference to another because the delivery options on offer were more appealing – with 49% saying they'd been happy to pay more for a better or more convenient delivery option.

Today's consumers will not hesitate to abandon shopping baskets if they encounter unsatisfactory delivery options. Over half (51%) of shoppers confirm they'd failed to complete an online order due to poor delivery options, citing, among other reasons, that delivery could not be guaranteed by a certain date (30%) or would take too long to fulfil (44%).

In terms of what consumers expect from online retailers, 83% say they want delivery options displayed clearly on the product page itself. And when it comes to convenience, 86% of shoppers want fast delivery and 83% say they now expect a guaranteed delivery date. A further 80% go on to say they also expected a dedicated time slot to be given.

Collect in store topped the list of alternatives to home delivery, and is most popular with UK (47%) and US shoppers (33%). Delivery to a local shop or pick-up point was

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[2] http://www.metapack.com/report/delivering-consumer-choice-report/

the second most popular choice - especially for 48% of French shoppers - yet just 17% of US consumers chose to use this option.

A negative delivery experience can turn shoppers off using a retailer again. Over half of Spanish consumers (51%) would never shop with a retailer again following a poor experience and are the most likely to broadcast their displeasure via social media; 52% of Spanish respondents confirm they've used social media to share a less than positive experience.

Low cost delivery is a priority for 49% of UK consumers and 47% of US consumers. While Dutch shoppers are least worried about low cost delivery, fast delivery proved most important; compared to 16% of UK shoppers, 30% of Dutch consumers rated this as most important.

Another important report form AlixPartners, "The AlixPartners Home Delivery Survey"[3], gives us more insights about the market. It begins showing us what are the reasons for ordering and what are the one for not ordering. The report shows us that the top three reasons to ask for delivery are the ease and comfort of shopping form home (52%), the cost of products (51%) and the selection of products (38%). Whereas, the top three reasons for not ordering are the need to see and touch the item (37%), cost of the delivery is too high (36%), Concerns about the quality (26%).

Furthermore, the report shows us how the free shipping impacts the decisions of the users by stating that the 64% of the consumers are may be deciding to purchase and item if the delivery is free. What's more, the also show us that a consumer would be willing to wait up to a week (50%) in order to receive a free shipping item. In fact, the consumers would like to have a flat fee and control of the delivery time in order to feel that they are receiving some value form the delivery.

[3] http://www.alixpartners.com/en/LinkClick.aspx?fileticket=9D5r3AqCC9U%3d&tabid=635

Key areas of opportunity

- **Low-Cost, Deferred Delivery Services:** Consumers have made it clear that they expect free/discounted shipping. We may have an opportunity trying to save costs or changing the logistics structure so that it is easier to deliver.
- **Outsourcing delivery:** Many companies are exploring different ways to delivery making use of other companies that personally deliver to concrete users. That is the case of restaurant that would like to home deliver they food. We may have an opportunity to build a P2P delivery service so that people could do the deliveries.
- **Premium Delivery**: To compete even more effectively with brick and mortar competitors, Amazon.com is leading the push to same-day delivery. We expect cost-effective, same-day delivery services in key markets to be an important area of growth going forward.
- **Tracking:** Customers wish to know exactly where are their items and when are they going to arrive to plan ahead.

Idea convergence

In the following section we present the different ideas that we have had during the course and how we have developed each idea. We present in detail each idea that we initially had and how we have converged to a single idea: the AIRbox. We are going to show how the features of other ideas have been included in the final ideas and how we have defined all the characteristics of the final product

Initial ideas

1) **Delivery box:** We intend to create a box that could be suitable for home delivery and that improves the current boxes used for shipping food. After our visit to Carrefour we detected that the boxes they were using were very old and made out form plastic. That is, we expect to improve that boxes so that the packaging of the delivered food is better in thermal terms. Our idea goes in the direction of developing a more efficient packaging that could help retailers to reduce costs.

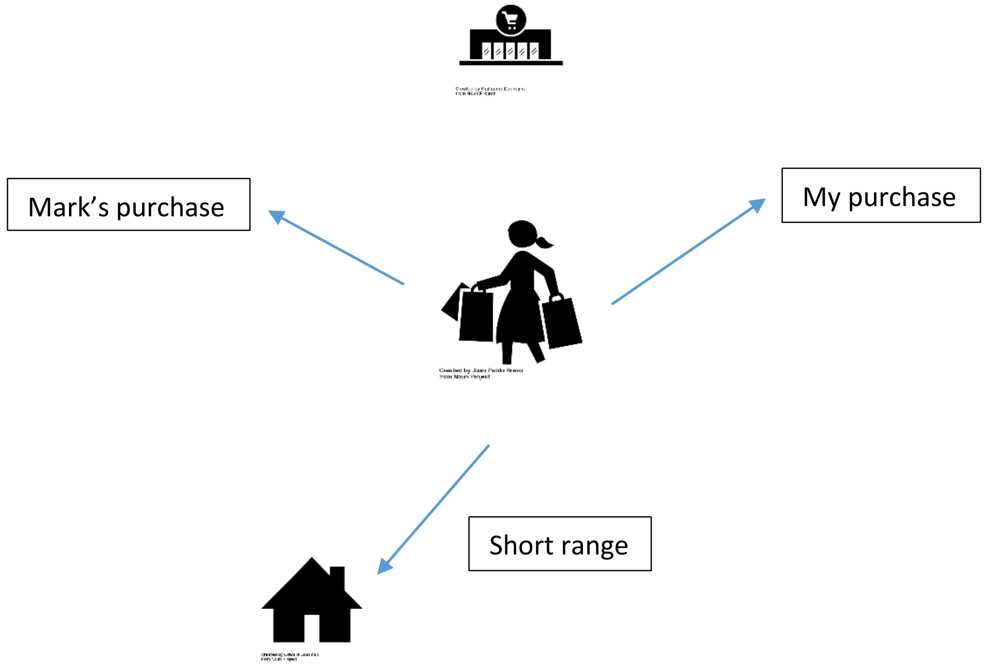
Figure 3: *Delivery box idea*

2) **Measurement system:** We thought about creating a system that could be used to control each food item in a fine grain scale. That is, we thought about creating a system that could be embed in the boxes that carry the

food to deliver and that could be updating a database with the information. In this way, we could be able to control the quantity, condition and ingredients of each item in an easy way. In other words, we explored the solutions of creating a measurement system for delivery boxes that could tell us the state of the food easily so that we could know if the food conditions have not been preserved. That would help retailers to control the food quality and consumer to know that they are receiving good quality items.

3) **Pick up station:** In this idea we tried to create a refrigerated pick up point. From the benchmarking research we have discovered that trends point out that pick up points options are increasing more and more. Therefore, we have thought about creating a pick up point where people could be receiving the items they have purchased from home. This pick-up point would be a locker where the retailers would put the food items and consumers would be retrieving it

4) **P2P short range delivery:** The survey research pointed out that the fees the users were paying for the delivery were considered high and that they would like to have a free shipping. That is exactly why we explored the idea of creating a P2P delivery system. We expected that the consumers that are in a store would be delivering themselves the food to other consumers geographically close in return for a small economic rewards. In this way, we would be able to minimize the costs of delivery and bring new players to it.



5) **Augmented reality:** During the benchmarking part we discovered that one of the top reasons for not going online was the need of the user to touch and feel what they were buying. That is why we decided to go into augmented reality. Apart from the fact that it is an emerging trend we expect to reduce the touch and feel need by giving the user access to a virtual reality market where he or she could be able to experiment with the products that may buy. We planned to build a mobile app that could fit into the whole delivery system and that could let users decide which products to buy.

External experts

During the project we had the possibility to get in touch with some of CERN's researchers and others Experts that gave us useful hints and opinions.

- **Tim Tsarfati – Insulating Materials**

He gave us an overview about the actual commercial insulating materials such as the Polyurethane foam, speaking also about new and disruptive materials like the graphene oxide. Unfortunately, this kind of material is too much unexplored to justify its use in an application so large like the food delivery. In addition, he suggested the possibility to obtain an "half" active cooling system with the use of compressed air.

- **Paola Tropea – Active Cooling System**

We talk with she about active cooling system. She said that actually a CO2 active system for the food preservation has more issue than benefits. Indeed, when you design an cooling system you have to keep into account a lot of factors: how much gas release during the operating workday, the direct contact between the frozen product and the gas, the cost of the sensor to keep monitoring the entire system. In addition, there is the issue about the energy supplier, a box with a own battery is too expensive for our limits. Finally, she suggested a very interesting material: **Criogel.**

- **A.m.a Composites – Aerogel Supplier**

Inspired by Criogel we decided to contact a Company called A.m.a based in Italy near the Unimore University. A.m.a composites is a Retailer that supply different material combined with Aerogel, an Insulating material with really good properties and an affordable cost. They gave us a few quantity of aerogel in order to make tests and prototypes.

- **Zoe Lawson**

Zoe is the one that inspired us about the tracking technology. She told us about her Thermally insulted vessel project, speaking also about a device which is able to measure the T° without a direct contact with the inner environment is new and not used before this patent (year of priority: 2002). Essentially, thanks to a sensor and a wireless communication with the User Interface, we are able to keep monitoring our product without open and damage the inner environment of the box.

- **Nick Ziogas, Matthias Braeger**

We have talked with Nick Ziogas and Matthias about data mining, operations management and traceability. They have suggested us to see a software developed in Cern: C2MON. This software is an extensible Java SCADA framework that can adapt to changes in its environment and meet requests for new functionalities. C2MON manages to combine maintainability and high-availability within a portable architecture. It has an Ability to handle high throughput and millions of different sensors. At this point Nick has suggested us to consider to use heterogeneous sensors to put inside the boxes, for example one sensor to check the humidity, temperature etc. Then he has advised us to put an alarm inside the box to be more sure on it. We didn't make us of C2MON but we get inspired in order to make the retrieving data system using Arduino components, a database and a web user interface written in Java code.

- **Kitty Liao, Timothy Daniel – Inflatable Fridge, Bodybags**

Speaking with Kitty and Daniel, we understood that an active- cooled box was not optimal solution. The technology used for the inflatable Fridge was not feasible for our project because the size of our box was too big than the size of the fridge. The use of the same technology would require a large amount of batteries and of energy suppliers, something not financially feasible for us. A useful suggestion that they gave us was about a kind of soft vacuum used in the bodybag project.

Selecting an idea

We build different draft prototypes for each of the ideas that we have presented and we have experimented with each one and received feedback for each one. In what follows we present the feedback we have received for each prototype. Thus, with all the feedback that we have received we, in short, present the idea of the AIRbox. This idea aims to capture the value of the previous ideas presented and converge in one product the solution for improving food home delivery.

The air box in short

The idea of the AIRbox is to create an insulating box that could be used for packaging the food that has to be delivered. As this box has a high insulating power we will be able to increase the temperature inside the truck that are used to deliver food so that it will be possible to use less energy per user which means that we will be able to decrease the costs. What is more, we will put different sensors inside the box with RFID tags to measure the temperature and conditions of the food and connect the box with the cloud where users may be consulting the conditions of the food and the expected time arrival and retailers may be able to prove that food safety has been preserved. In what follows we present a technical description of the different technologies inside the box.

Technical Report

Kelvin's Final prototype: a simple box, principally composed by a high performance insulating material and IT system (sensor + tracking device) that let you deliver perishable goods without an energy supply. In other word, a passive system which with little changes in the current logistic chain would reduce the consumption (and the cost) of the power and the fuel used for the delivery.

Insulating system

Regarding the passive system, the aim is to build a box with a combination of glass fiber and/ or thermoforming ABS plastic and then combine the material with aerogel powder and reflective layers.

Few Numbers about the Main material used: Aerogel

- Composition: 99,2% Air- 0.8 silicon oxide
- Physical structure: Nanometer porosity
- Main property: The ability to absorb infrared radiation. Low thermal conductivity $\lambda \approx 0{,}015$ W/mK (references: polyurethane $\lambda \approx 0{,}03$ W/mK; Vacuum $\lambda \approx 0{,}006$ W/mK)
- Other properties: Hydrophobic (micro-pore diameter < Ø water); Not inflammable; Thermal insulation (air nanometer); amorphous solid; Low density; Low thermal conductivity; Theoretical life almost infinite compared to other materials that in 10 to 12 years lose about 60% of the performance.
- Cost: 50 €/mq (thickness 1 cm)

The First test and the Evolution: Aerogel + soft Vacuum

Our first tests were made keeping monitored three different boxes thanks to wired thermal sensors. Each box was composed by a different combinations of material: (1) only plastic; (2) plastic + polyurethane foam; (3) plastic + 1 cm layer of Aerogel. Inside each box it has been put the same quantity of cool gel (in order to simulate the coolness of the goods), and all the boxes have been closed in the best way in order to simulate a hermetic closure.

Every two minutes the sensors inside the boxes sent the specific temperature measured to a computer and then to a synthetic chart. In that way we were able

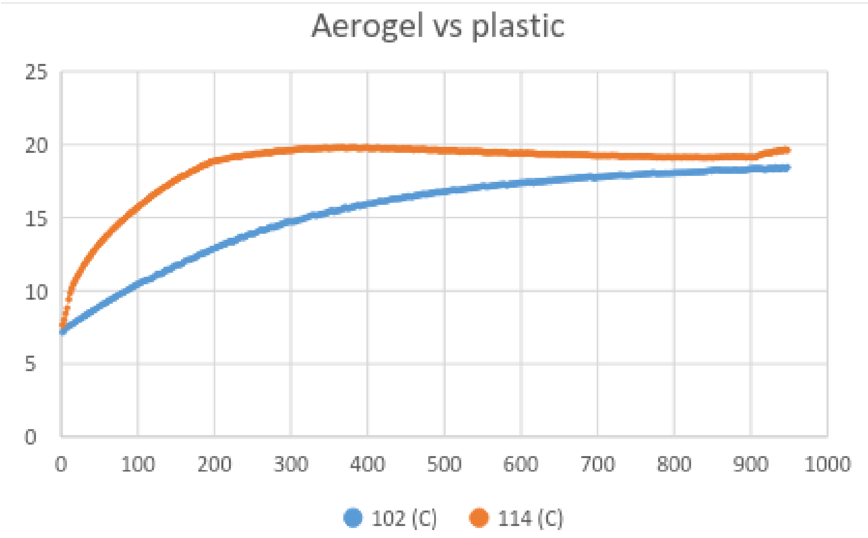


Figure 4: *Aerogel vs plastic test*

to obtain a graphic evidence of the temperature transfer inside each box. The test required a window of 8- 10 hours and in Figure 3 you can see the chart obtained in the first test.

As you can see the test was successful, the box with the new material has the best performance. Although the aerogel showed amazing results regarding our purpose, we wanted to reach the best possible performance with technologies already present on the market. And that's why we started another series of test combining Aerogel and a kind of soft Vacuum.

We did the same test made previously, but with a different basic- box. Indeed this time we decided to use three Tupperware with a vacuum valve incorporated in order to simulate the simplest device able to obtained a partially vacuum. Enough to check if a daily tool (as the tupperware) could make the difference in our purpose. The results shows that with this combination we can keep the temperature in a range of 1°C up to 10 hours. Just to give a comparison, a box insulated with polyurethane lose about 2°C per hour, so our system was twenty times better.

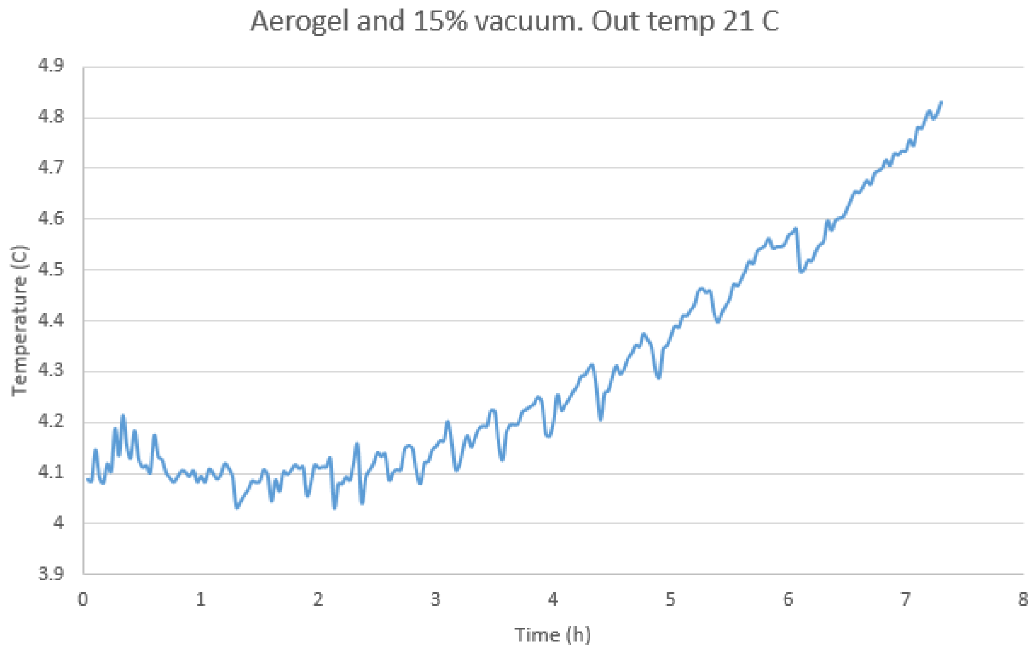


***Figure 5**: Aerogel test*

<u>What does it mean?</u>

It means that we can reduce the amount of energy necessary for the refrigeration of the truck and this can be obviously traduced in a huge fuel saving. With our theoretical model (take a look on financial final report) we estimate at least a 50% of the fuel used for the refrigeration.

Which kind of competitive advantage these empirical results bring?

> The connection between the test results and the user is very simple. Thanks to the High performance of the prototype, the Retailer is now able to guarantee a safe "Last Mile" delivery, in a time windows of 10 hours, with a cheaper fee for the customer.

Tracking system

The tracking system provides both the user and the retailer with real-time information about the condition of the food in every single box. The architecture has been designed in order to fulfill the requirements of being as centralized as possible, which will reduce the cost of the whole system. In our system, we propose an architecture with three main players: the box, the truck and the data management center, located in the cloud. The relationship between the players is the following: many boxes communicate with one truck, and many trucks communicate with one data center.

Box

The condition of the food is measured in real time inside the box. A single device, consisting of several sensors and a feeding device measures the condition of all the groceries. The figures of merit that are relevant for the food condition are the temperature and the humidity, mainly.

Inside each box, we propose the feeding device to be an RFID tag, which has the particularity of not having any battery, in order to save costs in each box and therefore in the whole system. The main particularity of this RFID label would be that there is the compulsory that it covers a range of several meters, approximately 2-3 m. These tags are called long-range RFID.

RFID holds for "Radio Frequency IDentification". Its working principle is simple: they are totally passive devices, which means that they have not any active feeder, such as for example a battery. When you approach the tag to an activator, due to the inductance principle, that generates some electricity, which in our system would feed the sensors and would transmit back the information to that activator.

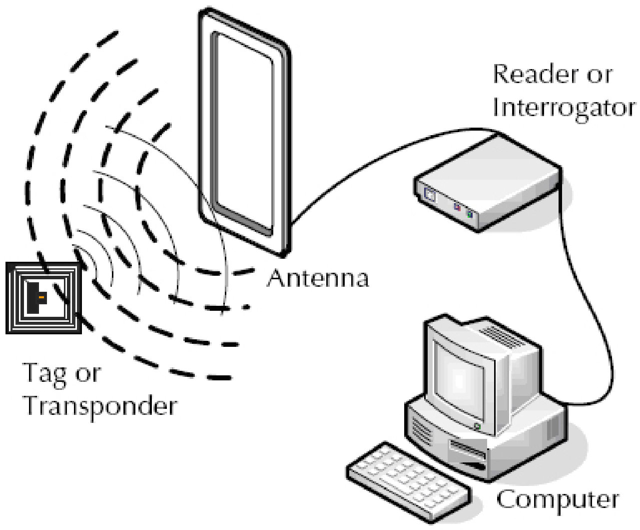


Figure 6: *RFID simple architecture*

Thus, we propose an architecture in which all the boxes communicate with a single device in the second player, the truck.

Truck

In a truck, there are many boxes, that communicate with a central device, that we call the activator. In the figure above the *Reader or Interrogator* would be the Activator in our case. We could place several activators in a single truck.

The activator, as we have stated, would send an ON signal to the RFID tag, that would generate some electricity used for measuring the conditions and then sending back the information to that activator. Then, this activator would have connectivity to the world, working for example with a 3G module (modem) that would send the information of every single box in order to fill a database, placed in the cloud. Another particularity of this device is that it would incorporate a GPS in order to track the position of the truck in real-time.

Then, as we have stated, with the activator we would ask the box the condition of that box, and then we would send that information to the cloud, adding the position of the truck. Someone can think this device to work as a hub, gathering the information of several inputs and sending them to the cloud.

Data management center

The management center would be a place in which all the database filled with the different trucks are inspected. In our case, ideally this place would be Carrefour, which could have the info of all the boxes that are being delivered in real time.

The benefits of that for the retailer could be, for example, that if they detect that in one particular box the conditions are not fulfilled, not delivering that box and then sending to the user a message saying that that box would be delivered the subsequent day due to technical problems. That could satisfy the requirements of high quality and high safety that the retailers are looking for.

The management center could also provide some useful information to the final user, such as the position of the truck (in order to know when the food is arriving to my place) or the condition of the food in real time, or even the evolution.

The decision of this architecture comes from a study of the market, pros and cons of the different alternatives, and after our research, we claim that this is the best tradeoff between performance and cost.

<u>MEASUREMENT SYSTEM in EVERY BOX. Decision tree.</u>

- Does it need to be connected to the world?
    - YES → 3G connection is very expensive in every box.
    - **NO → We need to connect every box with a transmitter.**

- Does it need to have memory?
    - YES → The info is only accessible locally, we want to connect to the world.
    - **NO → We need the transmitter to be connected to the cloud.**
- Does it need to have battery?
    - YES → Battery is expensive, and needs maintenance (change of battery).
    - **NO → We need every box to have a passive system that feeds electricity when is activated (RFID).**

Therefore, the architecture we propose is the following, depicted in figure 6:

Inside the box, several sensors are fed by a RFID tag, which sends the information to the activator, which afterwards adds the position and fills a database placed in the cloud.

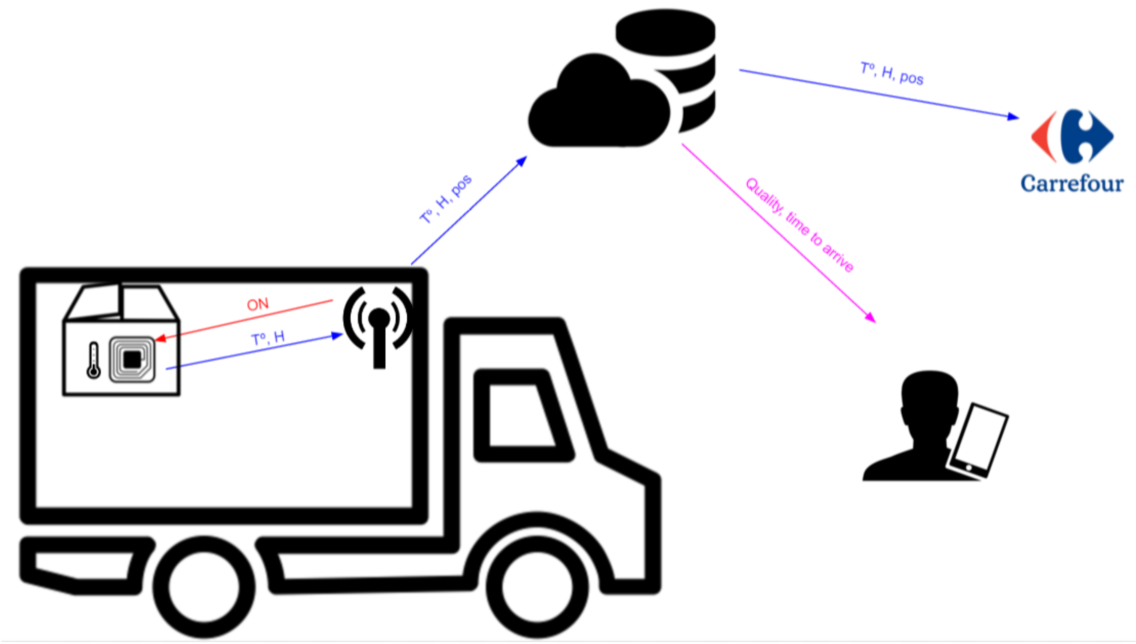


Figure 7: *Tracking system final architecture*

The architecture that we propose is something very novel, not already deployed by anyone. It is true that we still need to further develop some technological aspects, such as the long-range RFID systems, which are not widely implanted yet. However, there are already some products in the market: PHASEIVenger[4] proposes us a system that is able to measure the temperature at ranges up to 5 feet (6 m approx.), and showing the info on a display. On the other hand, POWERID[5] proposes a system working by interruptions, and with a data logger that sets an alarm when the temperature is not within a range.

There is a strong research in this area, with some products already in the market, so for this reason we hope that in a near future with a strong investment in R+D, we could have tags ready to be printed in a short period of time, and with a very small cost per tag.

PROTOTYPE. Difference with the final architecture. Tracking system.

For this part, we have made a proof of concept of the aforementioned architecture. The three main players have been prototyped with different devices that in the final device, but with the same capabilities.

Box

Inside the box, the measure system has turned to be an Arduino UNO connected to a LM35, to an analog input pin. The Arduino has been programmed to retrieve the information of the temperature every second, and then send this information through a xBee module, attached to the Arduino with a Wireless Proto Shield. The Arduino is fed through a USB power bank and placed inside the box.

[4] http://www.phaseivengr.com/wp-content/uploads/2014/02/61-100042_-Data-Sheet-UHF-RFID-Surface-Temp-Kit.pdf

[5] http://www.power-id.com/Products/PowerTMP.aspx

Truck

Outside the box, we have placed a receiver xBee module, which is connected to another Arduino UNO. In order to reach the desired connectivity to the world, we need this Arduino to be connected to the Internet. The way in which we have done this connection is to connect the Arduino to the computer through an Ethernet Shield.

When a data stream is received in the xBee module, we generate an UDP packet, which is sent to the computer via Ethernet. In the computer we have prepared a small Java program which is able to receive this UDP packets and then send them to the database.

Data management center

The Java program connects to an Amazon Web Server, which is managed via a PHP script, that basically retrieves the information sent by the Java program and uploads the Database, working with MySQL commands.

At the same time, for visualization purposes, the Web Server also hosts a website, which has 3 main capabilities working in real time (retrieving the information of the database in the same server):

- Get the current temperature of the box (last element of the database)
- Get the evolution of the temperature (last elements of the database)
- When the food is arriving to my place? (get the position of the box and, through *Google Maps V3 API*, show the route and the estimated arrival time).

Economical report

Unit economics

The first thing we did is to analyze if the product was profitable. So we focused in calculating the cost of a box, a stream of cash flows that a box generates and the expected life of a box.

To estimate the cost of a box we had to fix some variables. The significant ones were: to stick to the size of the prototype (0.3 x 0.3 x 0.35 metres); the used prices for the materials were 3,500.00 EUR/m^3 for the ABS plastic and 5,000.00 EUR/m^3; one hour of labour at 12 EUR/h. With other less relevant estimated costs and an arbitrary mark up of 20% the cost was close to 80 EUR so we round it up to 80 have a nicer number to work.

To estimate the stream of cash flows we worked with the scenario of reducing the temperature of the refrigerated trucks from -20ºC to 0ºC due to the better insulating properties of our box. The box still starts at -20ºC but now it is supposed to require less external energy to keep this temperature. With the use of a mathematical model applied to Thermoking refrigerated trucks (the market leader) we could estimate the savings of thermodynamic efficiency by working at 0ºC instead of -20ºC. For a TK500 model we were saving 1700 Litres of diesel per year (reduction of 50%) and for a TK1200 model 4300 (reduction of 75%). Since the economic unit of the cash flow is not the box but the truck, we applied the trick of dividing the truck by 20 since 20 is the average amount of refrigerated bags of Carrefour per truck.

To estimate the expected life of the box we requested the advise of an expert from ASCAMM. Based just on the materials used and the hard job to suffer it was expected between 1 and 2 years.

Due to the fact that current Carrefour bags cost 90 EUR and that they need to work at -20ºC we considered that the product was profitable and there was room for business.

Regarding the tracking system, the sensor per box was not an issue due to its reduced cost. The activator was expensive indeed with an estimated cost of 250 EUR each in a mass production. But we were advised by the UPC teachers that it was not really expensive put in context.

Business model

Now that we knew that the product made sense and created value we thought about how capturing it.

To design the business model, we worked with the scenario that our boxes' IP was not protected and easily reproducible and that Carrefour was our customer.

Since the boxes were reusable and did not require from maintenance we considered that the best solution was to sell the boxes with a mark-up. Renting them would imply a huge amount of working capital and we preferred to be conservative. We also expected that future competition would bring margins down so we aimed to become a market standard to gain volume. Extending the expected life of the box (with a future improved design) reducing replacement sales was a strategic decision to have competitive advantage.

With the activators we doubted what was the best approach due to their high price. But with the advice that they were relatively cheap put in context we decided to follow the simplest approach and sell them.

Were we expected to have big margins was with the tracking service due to its insignificant marginal cost. We would introduce a pay per use scheme making it very attractive to the customers. And it would give a whole experience more difficult to copy by the competitors. So our business would be the whole solution of boxes plus tracking.

Regarding the production, we decided to externalize both the box production and the electronics production. We would assemble the box and the sensor and reuse electronic parts when profitable. But we would not repair the electronics because it would not be profitable. The sensors were introduced in the cover of the boxes, instead of in the body, to facilitate its maintenance if required.

Funding plan

Since we prepared our presentation as a funding raising one to finish our product, we did not focus on product commercialization but on moving from the prototype to the final product. We had a 9 months' plan with a capital need of 162,000.00 EUR. 40% needed since the very beginning and the remaining 60% in six months.

We were asking for 200,000.00 EUR but for which amount of the shares was not clear. If we gave the 20% of the company this would imply a pre money value of the company of 800,000.00 EUR. Which seems a lot for a company that has not even tested in real conditions nor with the prototype (we have just done concept tests). If we gave the 50% of the company this would imply a pre money value of the company of 200,000.00 EUR. Now the value of the company looks reasonable or maybe even cheap but giving up the 50% of the company in the first capital seeding is not reasonable at all.

Due to the asymmetry of information in favour of us, we should start demanding (maybe giving a 15/20%) and set a walk away threshold between 25/30% (30% implies a pre money value of 466,666.66 EUR). We have to expect that sophisticated investors will try to reduce the asymmetry of information as much as possible but an official commitment from Carrefour as a costumer would give as the chance to mix seeding capital with debt.