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Title: **Shopping Assistant: Product Discovery for Senior Citizens within Local Groceries**

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Abstract:

Shopping is a need of mankind and it is also a fact to be a part of society. When it concerns to ageing population, there are difficulties elderly to come up. Such difficulties bring case that yields to negative vast factors to be part of society. At the research, the case is examined with target group of senior citizens (65+) and aimed to integrate a solution to shopping tasks to encourage elderly by analysing the facts of the case and the existing solutions based on Information and Communication Technologies. The proposed solution is designed by the feedback of the target users and its prototype implementation performed by following Agile Development Methodology and tested in the field with the target users. It is found that, integration of a specific solution for the target users will bring an indispensible value to be encouraged at the social life and it is also found that future studies are also necessary.

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Forewords & Acknowledgements

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1. **Introduction**

1.1   Motivation and Background

Shopping in general is a social behaviour where many enjoys it, however for senior citizens there are some constrains such as transportation, *accessibility, manoeuvrability in store, shelf alignment*[1], etc. that brings negative effects for their shopping experience.

Inverse ratio of senior citizen population with young population encompasses the social life participation for senior citizens while the world population is ageing. As the senior citizen population increases, density of young generation to take care decreases; *by 2020 around 25% of the EU population will be over 65; people aged from 65 to 80 will rise by nearly 40% between 2010 and 2030*[2]. Following is a suitable example for the situation*: "Try this experiment. Next time you're in a mega supermarket, make a note of how few people over age 60 are there versus how many people under 45 are. Then, if you're lucky enough to have a smaller, neighbourhood market, do the same thing there. The percentages reversed, with far more people over 60 in the smaller store."*[3] A supporter research[4] shows that, the biggest difficulties upon elders(65+) in the shopping experience is about ability to reach products on shelves and freezers, finding the products from shelves, ask for a help from store staff and finally at the checkout point where they have to pack their goods and do the payment. Another research[5] brings a new theory in the behalf of elderly's (67-88) shopping, *Civic Socializing*. The research argues the contradiction of senior citizens' dependency to their family members while they are shopping. Their social interaction is moving towards the interaction with the local shopkeepers and other senior shoppers in store. This approach introduces a potential social network for senior citizens; network with shopkeepers and other shoppers in store. With Civic Socializing, senior citizens' and shop owner's mutual benefit is obvious; senior citizens have social interaction, a smile with assistance and shopkeepers improve the loyalty by delivering the service needed. However, when we address the decreasing amount of the young people with ageing population, shopkeepers will still not be able to fulfil all the needs of the seniors, for example accessing the products needed.

1.2   Problem Formulation

The digital age bring diverse solutions for the human being. The major part of the digital age is enhanced by the information and communication technologies (ICT) and now the solution enablers are indispensible facts in our lives. Seniors are experiencing the digital age as ICT solutions become verve help for enhancement of human responsibilities by decreasing the workload- even partially replacement to the human labour-for a better quality that a job requires. In this regard, ICT solutions are considerable fact for senior's participation in the daily life in such a case to help for shopping difficulties. Mobile computing is a revolutionary form of ICT solutions referring to the movability of computing devices enabled by cutting edge communication technologies.

Mobile computing also emerges such solutions to process the context information, so it can be a meaningful help by empowering the user in the context; that was the time the Pervasive Computing was born so the Pervasive Retailing[6]. Pervasive Retailing is explained as "i*n always-online environment that allows consumers to be online anytime, anyplace* and *the next step will be the integration of online and offline markets*[7]*"*. Pervasive retail environment become usual as the users carry their connected smartphones while different shops offer various shopping services. Even though introduced earlier than Pervasive Computing, one step ahead is the Ubiquitous Computing[1]. At the moment practically we are not in that phase, by definition of Weisler, Ubiquitous Computing helps us in our everyday life tasks with intelligent everyday life tools; an alarm clock updates itself based on our daily life activities, an electric toothbrush alerts-reports the latest case to the doctor or even a tennis racket that tracks and analyses the player's abilities matches the best couples to play, for example.

iGrocery[8] is one of the proposals for Pervasive Computing where users able to use their smart phones in store to locate desired physical goods also have recommendations base on their nutrition profile. However the philosophy of the iGrocery mostly focus on the replenishment of the products present at home with assumption that presence of the nutrition profile rather than improvement for shopping experience of senior citizens as social need. Another replenishment proposal solution based on Pervasive Computing within Ubiquitous Computing Environment is *MyGrocer*[6]. With MyGrocer, user picks up a trolley in store, which is donated with shopping assistant device and continue shopping or with predefined shopping list ordered by home server (products to be replenished at home) or continue shopping by choosing the product navigation. However, still both solutions do not

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[1] *The ubiquitous computing environment that Mark Weiser proposed means that a huge number of computers will exist around us and work with-out disturbing the user's consciousness as they appear to be*

employ a senior citizen's physical manoeuvrability of reaching a product. An upcoming trend is the Online to Offline or Offline to Online shopping (O2O)[9]. O2O is based on users connectivity states while s/he achieves the shopping task.

O2O users able to handle their shopping partially with online (price comparison, receive shopping list and check the entire store's product inventory for particular product, check the ingredients of a physical good, product reviews, recommendations) services for goods within offline environment - physical goods. O2O shopping addresses the Pervasive Computing. One example is *Ubira*[9], enables users to do check-in to a specific store and compare store prices with online prices, if the online price is lower, Ubira lets shop owner to offer discount coupon as serendipity to end user. However Ubira does not address to senior citizens since employing the complex usage and still responsibility of reaching the products belongs to user. Another example is *Shoppulatto from Docomo*[10] , a O2O platform where the application is enabled whenever one is in the store (check-in) and receives offerings and coupons base on gender, age depend on approximation to store, however as the address of the research project is particular products in the store rather than store promotions, Shoppulatto also considered as incompatible with senior citizens grocery shopping. An argument for mentioned services is that, their focus is for more products to sell instead of assist to the senior citizen's need, a service as a partial replacement of store staff. Partial replacement addresses service which employs store staff's assisting duty. Hence, a grocery store service, for senior citizen to be used as online assistance with smart phone addresses online shopping, where adaption is an important phenomenon. Related shopping assistant adaption reveals the perceived risks for trust [11]. Those risks are related to online shopping however when the offline shopping concerns meet the online shopping, risks can be eliminated by design. Dimensions of the risk for trust on all kinds of online shopping sorted as[11]:

Security: Payment instrument misuse, fraud of personal data

Financial: Choosing a wrong product yields monetary loss

Performance: Low performance of shopping service

Psychological: Disappointment of the purchaser because of wrong product choice

Social: Lower respect to purchaser's peers

Time: Delivery time also in case of repair and replacement duration

Physical: Risk to the health or safety of the purchaser.

On one hand, consumers presence at the retail shops allow hands on product evaluation, on the other hand online services allow them to reach details which may not be available in

store and receive recommendations for the goods without responsibility of carriage to home. Demographics related to customers in store shopping satisfaction and here satisfaction is directly related also described as *quality of the shopping experience*[12]. Concerns of the senior citizens offline shopping sorted as following[13]:

- Courteous and Dignified Service

- Help when shopping, ex: locating items, faster checkouts and package carry-out

- Package related concerns as readable price tags, readable ingredients

It can be seen that poor customer service is a dissatisfaction reason-except of package related concerns- for senior citizens shopping experience. In order to solve relevant issues in store product discovery situation and deliver a proof of concept within the full concept solution, following problems should be examined:

How to integrate smart phone application to retail supply chain for seamless shopping experience?

- **How to present the products to help senior citizens to choose them on mobile device?**

- **Which communication technology would be easy for senior citizens to use in order to choose products?**

- **How to notify store staffs for products that has been chosen?**

2. Research Methodology

Problem area is a case for seniors' participation at the social life by addressing grocery shopping difficulties with underlying facts of shopping satisfaction. Project focuses to the case study approach and enhances the approach by considering aspects of applied research with defined problem. This section describes and gives a generic introduction to followed methodologies consisting of interdependent three sub-categories; Study Research, Design Methodology and Development Methodology.

Firstly, aim of the study research section is to collect data from existing and recent studies with the state of the art solutions as well as worldview knowledge from stakeholders as qualitative data. Qualitative data used in sense of bringing a generic knowledge for the case that helps to create the conceptual design as well as feeds up initial requirements.

Secondly, case addresses to a solution that is a pursuit of helping the senior citizens' difficulties to participate at the social life. Seniors will be the primary users of the solution that should necessarily involve their ideas. In this regard, a design process that takes the users' ideas would be feasible to underline the elements of a solution. In order ensure those, prototyping and evaluation and redesigning would be the fitting approach by taking target users and ideas.

Lastly, the chosen implementation methodology is the Agile Development process, seen appropriate for the case. Besides a sequential development methodology as Waterfall model or linear iterative and incremental development methodology as Unified Process, Agile Development is based on the spiral increments of the software before the delivery by involving the target user's and stakeholders' interaction with development side. As the research addresses to the specific target users case, involvement will be based on target users. Agile Development starts with the core functionalities needed by the target users and those functionalities evolved by taking their feedback to consideration. With Agile Development methodology, software increments based on iterations by employing real context based feedback to have insights from the real world usage.

2.1 Study Research Methodology

Project goal addresses integration of the software as a service that delivers improvement for the case of seniors shopping experience hence their participation in social life. In order to clarify the situation and perceive the state, initial desk research is an essential first step.

Matter of the initial desk research is for inception of fundamental worldwide solutions and nuances with supporter arguments from papers, articles and statistics. With the secondary research, it is convenient to collect data and have an understanding from already existing scientific papers for seniors grocery shopping situation in the stores. Parallel with the desk research, as a stakeholder of the problem area, knowledge and experience of the grocery store's owner is able to be a source for qualitative data for gathering initial requirements. Semi structured interviews and desk research will be used in order to gain knowledge and feed up the conceptual design with the grocery shop owner's perspective as they are the domain experts.

2.2   Design Methodology: Prototyping and Evaluation

Iterative prototyping is the core design method that is the first phase to turn the case to be an applied research project. With the iterative prototyping, system has been able to be formed in consistent and concrete working paper prototypes to bring a solution for the case. Flow 1 visually describes the followed prototyping methodology based on iterative and incremental improvement with the evaluations. There are two types of prototypes got the focus at the research project; *Low Fidelity* and *High Fidelity* prototypes[14]- high fidelity prototypes explained at Section 2.3.

Low Fidelity prototypes, cheap to produce that give the advantage for ease of evaluation from the evaluator point of view for the usability aspects of the solution before the implementation cycle. Low fidelity prototypes can take different forms, research low fidelity prototypes have been paper based and first prototyping started with the Storyboard- explained below. Also, interfaces have been prototyped and easily evaluated because they are just papers and evaluators did not mind to give constructive feedback that would yield to change them.

Storyboard is a framework for mapping the components of the problem area into the visual drawings that gives the understanding for the user tasks. In order to define the storyboard frames the contextual scenario used for creating a basis for the overall design. By using the stakeholder interviews and the secondary desk research, it has been possible to develop a scenario addressing to the context of the problem area and solution with the target user. Storyboard has been the emerging frames from the context scenario that specifically focuses on the user's motivation, behaviour and interaction in order to accomplish the tasks that are explained with the understandable simple visual frames.

At the storyboard, it was also illustrated the technical implementation of the idea by considering the problem formulation and how the system could be used with the tasks by specific target users in the specific context.
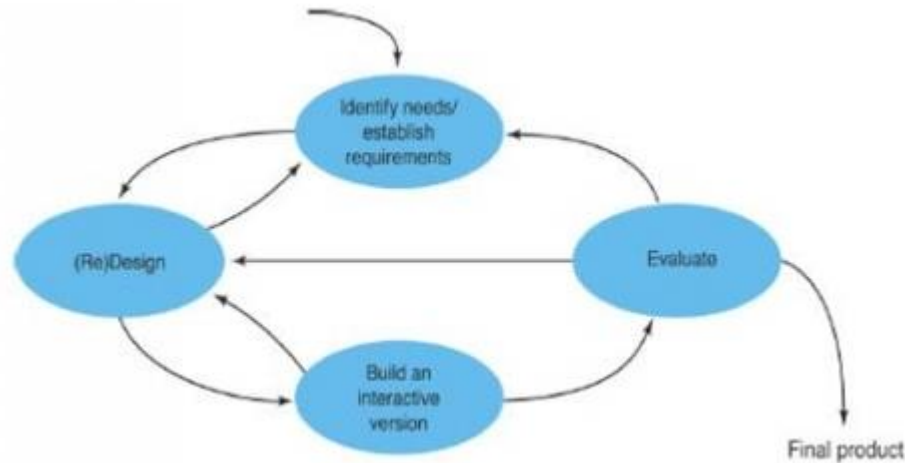
Flow 1 A simple Interaction Design Lifecycle Model used for Prototyping[15]

Interface paper prototypes have been the emerging solutions from the storyboard. They included functionalities to motivate user to accomplish the task that causes the problem area, as described at the context scenario and storyboard.

Paper Prototypes evaluated in two usability testing approaches; analytical evaluation[15] based on evaluator's inspections with Heuristics[16][17] and the observation in the field evaluation by involving users[18][19][20]. Usability evaluation methods contribute substantially to the usability problems of the user interfaces as they are applied both during the low fidelity and high fidelity prototypes development cycles[21]. By considering the usability engineering as a complementary part of the prototyping lifecycle, paper prototypes have been evaluated and redesigned in order to increase the level of usability- high fidelity evaluation is described below.

Even though many usability evaluations are expensive, intimating and time consuming to handle, Nielsen defines the Heuristics as *discount usability engineering* because it is easy, fast and cheap to overcome. However, Heuristics require a level of knowledge of usability principles and attention to apply them from the evaluator's point of view. More evaluators take part in a Heuristics evaluation; more interface usability problems can be highlighted. However, in the research project, Heuristics are used as a supplementary evaluation method for the prototypes before the users' involvement.

At the applied research, as explained at the introduction of the Section 2, users' involvement was necessary as the solution will be addressing the seniors' case who will be the users of the system for their shopping tasks. In this regard, users' involvement was the critical point at the stage with the reliable prototypes for taking their ideas. Involvement delivered the empirical data for requirements engineering of the system before any performance within implementation cycle. Before involving the users, system paper prototypes have been tested with usability principles[17] by the evaluator in order to ensure that the system did not have any misleading functionalities that can also occur misunderstandings for the purpose of the system prototypes. Cooperative Evaluation[18][19] approach has been the interface evaluation technique which takes the user into centre point by introducing tasks that reveal the situation in the context of the case for them to evaluate the interfaces. Cooperative Evaluation first introduced as a research tool from York University[18] then used in the industry in order to improve human-computer interfaces by involving the users with their ideas in the design process. Cooperative Evaluation takes user's ideas as the essence to the design process by observing and getting the feedbacks explicitly on the proposed designs from the users. Dilemma 1 brings a discussion upon when to involve the users.

When to involve users?

At the iterative prototyping process, the phase of the user's involvement is a strategic decision, as the related decision will be revealing the system's interfaces and their usability vulnerabilities. Before conducting with the users, system prototypes had to be tested heuristically in order to ensure proposal prototypes did not have those usability vulnerabilities before introducing them to the users with the task to be accomplished.

Dilemma 1 When to involve users?

Another user test is with the High Fidelity prototypes. As the system's development iterations will be aiming to realize the User Stories- explained at Section 2.3- Think Aloud protocol[20] seen appropriate for the case. Think Aloud protocol was first introduced by Clayton Lewis and he explains the Think Aloud Protocol as following, "*The basic idea of thinking aloud is very simple. You ask your users to perform a test task, but you also ask them to talk to you while they work on it. Ask them to tell you what they are thinking: what they are trying to do, questions that arise as they work, things they read.*" Main steps of the Think Aloud protocol are; Choosing the users to test, Choosing the Tasks to test, Providing the System to Test Users to Use, Deciding what Data to Collect and Perform the Think Aloud[20].

2.3   Development Methodology: Agile Development

Main goal of the project is to deliver a proof of concept while ensuring the answers, results for the research questions emerged from the problem area. The proof of concept is a prototype as well namely High Fidelity Prototype as introduced at chapter 2.2. The goal of the High Fidelity prototypes is to give the intention to the target users how the system would be looking like in real life[14]. In order to give such intention, system requirements had to be implemented with sufficient development languages and frameworks with a sufficient methodology that ensures the computing side of the concept is well defined in the cyberspace so that it can be evaluated as well.

Agile development is an evolutionary software development process where the target user interaction is the essence; evolution is where their feedback taken to account then the software is iterated and requirements incremented. User's face to face interaction with development team, especially, within the process decreases the potential large impacts compared to large-scale software development methodologies[22]. Within the large-scale software developments, *projects very often developed using rigorous development processes since it was believed that only through intensive analysis, design and documentation that the intended software can be delivered*[22]. However more dynamic and flexible methodologies emerge with today's volatile business context respect to development time and non-responsiveness to users' and stakeholders' opinions before the delivery of the product. This is done by, employing the users during development that directly assists win-win; development side wins by delivering what users need, user win by getting what they really need.

Agile development manifesto[23] consist of principles by taking the users satisfaction to central. Flow 2 Agile Development *[25]* illustrates agile development methodology. With agile development it is critical that initial requirements should be gathered-explained at section 2.1- and system should be defined as functionalities with User Stories. User Stories are different than any other scenarios since they describe specific stories which can be implemented by following decomposed tasks to deliver the functionality a user can perform to use the system. At the project, Mike Cohn's suggested[24][2] formal structure is used which is easy to learn and apply by different types of users.

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[2] Mike Cohn suggests the formal format of user stories as: **As a (role) I want (something) so that (benefit).**
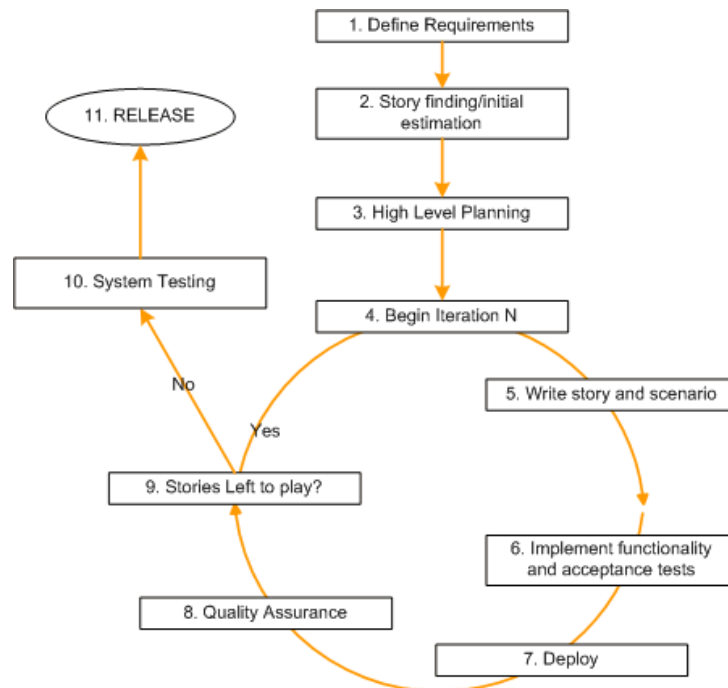
Flow 2 Agile Development [25]

Depending on the strategy and consciousness of the team skills[3], iteration may consist of more than one user stories to gather a meaning for a product's demonstration to a user. After each implementation of functionality and test-explained at Section 2.2, new stories should be implemented as long as users getting what desired. Before moving to the next iteration, the product tested with the target users to ensure the implementation's usability- early and continuous delivery.

With the amount of the resources and demand such as motivation, funds, available materials, size of the team, level of the knowledge that the team has; Agile Development can have different forms. All the forms are based on Agile Development principles but they are modified, by enhancing the process with below resources. Different forms can be sorted namely Extreme Programming, Scrum, and Test Driven Development also the Behaviour Driven Development that is derived from Test Driven Development. In the applied research, followed development process is the Agile Development by adopting principles as much as possible.

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[3] Time estimation and if it is implementable[24]

2.4   Project Delimitations

- This project is an applied research with the documentation for development of a working prototype of an idea that has been produced witappendihin the motivation of helping seniors' shopping difficulties in the grocery stores. Applied research includes formulation of the problem area and state of the art solutions with secondary data- desk research

- To come up with the concrete solution, minor aspects of the Interaction Design has been the tool used for gathering the requirements

- Mobile Software development has been the tool for delivery of the working prototype

- Even though the need of Identity Management rose, project will not include the implementation

- Project does not include any Business Model development but considers the minor aspects of business context from existing technologies

- It is known that the cutting edge technologies are meaningful with the users' adaption. However research does not include focus any social perspective neither the technology adaption

3. **Literature Review**

3.1   Scientific Literature Review

Purpose of this section is to derive the published articles into explicit knowledge by taking the problem formulation as the basis.

Offline Shopping Barriers for Senior Citizens

In order to interact with the society, seniors need to do daily practices themselves, such as shopping, exercising, and talking to other people in person to avoid psychic sickness such as depression of staying inside and alone. To do all this in one, shopping is the easiest solution. The focus of this project research is not about the sociological aspects, but about the barriers that affect the elders shopping experiences, based on already existing researches. Concrete barriers are various, and when the focus goes to senior citizen's daily difficulties; those would be generalized within physical limitations ageing brings.

 Shopping is a habit for senior citizens with the barriers they have to live with. They shop quite frequently, few times a week[4][26]- can be tend to everyday[27]- for the products will

be consumed in short term; research[26] highlights the reason because of the barrier such as decreasing physical power to carry goods to home. However senior citizens also have barriers they have to handle every day, research[28] concentrates in store difficulties such as *staff, carrying equipment* and *reaching to products. Staffs* are the human labour aspect of the shopping experience, and a generic term for all customers of a shop, nevertheless the age of the customer. However, when we look at the Civic Socializing[5], staff-senior person relationship is the fact which makes the difference and reveals the trend. Considering carrying equipment and reaching the products; those barriers are the ones take the physical conditions into the fact of shopping experience. Carrying equipment addresses the trolleys and shopping bags which effects the manoeuvrability[1] relating to the physical abilities of senior citizens with aisles in store- design of the store. Moreover, reaching the products is a matter of physical ability[4][28] since the needed products at the shelves can be in a too high or low position to reach and put into the carrying equipment. Another research[29] brings different perspectives in the matter of helping senior citizens for shopping. As the research shares the arguments below – as difficulties in store, adds another possible solutions such as online shopping and other shopping services based on home delivery or employing volunteers or store's delivery services with extra costs. On one hand, extra costs for small quantity is a limiting fact for such services, on the other hand, car manufacturer Chevrolet Partners with Inter-Faith Food Shuttle to voluntarily deliver grocery bags to senior citizens and low-income families within Philadelphia-USA by engaging community service solutions[30].

Online and Telephone Shopping Services for Senior Citizens

Online shopping is a prejudiced shopping trend for senior citizens with presence of perceived risks of trust[11] such as *Security, Financial, Performance, Psychological, Social, Time, Physical*. Besides shopping, research[29] at UK 2011 highlights %41 of 65-72 aged persons did not use internet but on 2012 Q4[31], this percentage decreased to %30 within same age population. Internet usage is linked to the cost of equipment and other charges such as subscription[29] and in this case also effects online shopping. Demographics[32] also remain concerned about privacy issues and info graphics[33] show that biggest concern for internet shopping is touching the real product. Senior citizens mostly use internet for catalogue-price check and go in store shopping (reference present but could not found).

With the arguments below, since it is the project focus for senior citizens' participation at social environments, online shopping systems lacks such experience[29].Another option for the senior citizens is telephone shopping. With voice communication based option, senior

citizens call the related retailer and order their products. This option gains one level of socialization as they do speak with a person respect to online shopping however, as described at section below, extra costs for small quantity and being not able to physically touch or see the products demotivates[29].

Online versus Offline Shopping

Nevertheless the statistics for online or offline shopping, according to study of the Bazaarvoice, consumers are more satisfied when they do shopping online[34]. Senior citizen consumers (65+) have the biggest gap among demographics for shopping- 4.34 for online satisfaction 4.06 for offline over 5.0 – while research indicates that %70 of all consumers use their smartphone in the store. Advantages for online shopping application are product discovery and price comparison over offline shopping. However, with offline shopping, shoppers are able to handle and examine the goods in person before purchase. In the study, satisfaction criteria are sorted into easiness for information retrieval for products and easiness of the product discovery.

Mobile Computing: Increasing Our Capability to Physically Move Computer Services with us[35]

Mobile computing emerged *with the rapid growth in the wireless mobile communication technology, small devices like PDAs, laptops are able to communicate with the fixed wired network while in motion*[36]. *Mobile computing is a paradigm characterized by the ability of computers to change location while still being able to communicate with one another when they so desire*[37]. Mobile computing relays on three different but interdependent areas:

- Mobile Communication
- Mobile Software
- Mobile Hardware

Mobile computing is the phase arise after the transition of the internet era with distributed computing[38]. Main fact for the growth of the mobile computing is the evolution of the mobile communication technologies with radio technologies. Since the need of the connectivity for the portable devices revealed, wireless communication technologies had to be adapted to the speed of fixed communication networks. Also, motion speed of the mobile devices have been the another adaption criteria for the evolution of the communication technologies- Graph 1 Evolution of Radio Frequency Technologies[39] illustrates the

evolution of the radio frequency based communication technologies respect to mobile device movement speed and time.
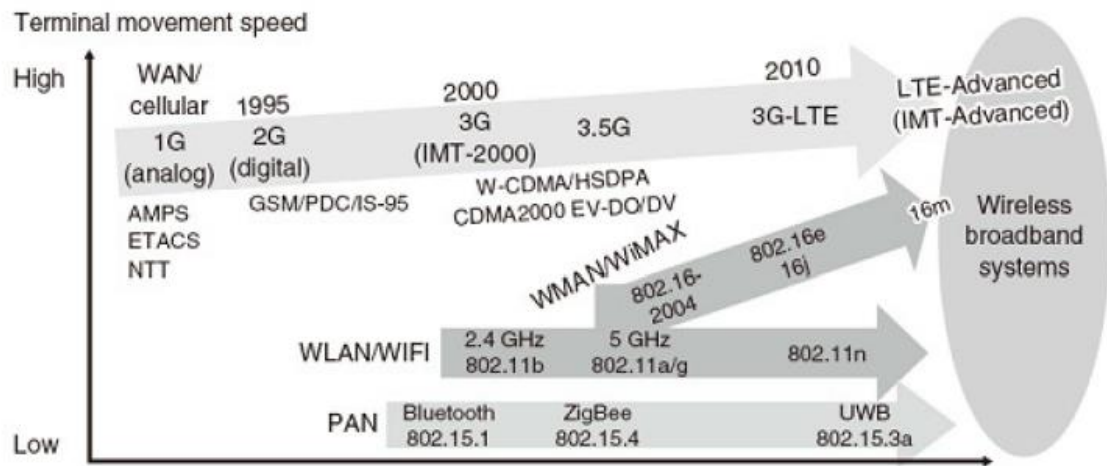
Graph 1 Evolution of Radio Frequency Technologies[39]

This adaption has been parallel with the evolution of the mobile software. As the wireless communication data rate increased, this opened a gate for more complex operating systems enhanced with services.

Pervasive Computing: Obtaining Information from the Environment and Utilizing It to Dynamically Built Models[35]

Pervasive computing emerged from the need of the contextual information that employs mobile computing devices and other devices interactivity. *Pervasive computing represents a major evolutionary step in a line of work dating back to the mid-1970. Two distinct earlier steps in this evolution are distributed systems and mobile computing.*[40]. In this manner, other devices here address the problem of need for contextual computing devices that interacts with the mobile computing devices to perform user's tasks. Thus, Pervasive Computing consists of Mobile Computing that evolved from Distributed Systems that can use contextual data. *Figure 1 Taxonomy of Computer Systems Research Problems for Pervasive Computing[40]*is an overview perspective of the problems of the Distributed Computing and Mobile Computing that move towards to Pervasive Computing.

Pervasive computing has examples depend on the context of the use, Intelligent Transportation Systems; for example Driveless Cars[41] which can drive without driver's interaction to control directions but user enters the destination to go. Pervasive Retail systems; *IBM has introduced pervasive computing in the context of retail* [6] and the pervasive retail concept is further developed with a richer user experience named MyGrocery[6]. Figure 1 shows the evolution of the computer systems with their taxonomy
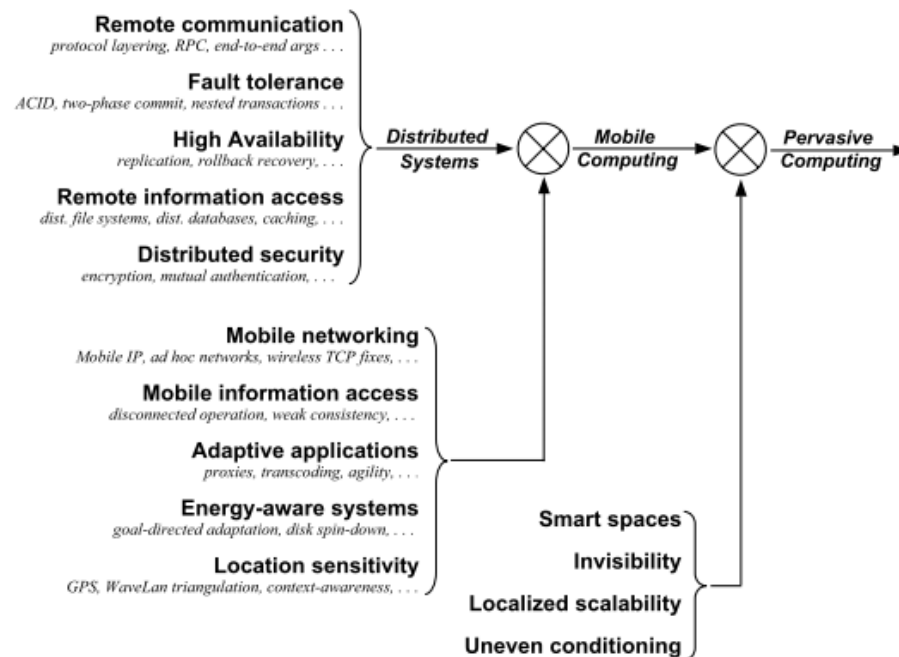
Figure 1 Taxonomy of Computer Systems Research Problems for Pervasive Computing[40]

Ubiquitous Computing Environments: Integrating Large Scale Mobility with Pervasive Computing Functionality[35]

"*The most profound technologies are those that disappear. They leave themselves into the fabric of everyday life until they are indistinguishable from it.*"[42] Mark Weisler proposed the Ubiquitous Computing and we still are not in that phase. Ubiquitous Computing consist of the context aware, "invisible" and cheap technologies within a network that ties them together[4]. Context awareness appeals to be the *incorporation of several attributes (identity, location, time, history and environment) into the business logic of the application*[43]. By invisibility of the technologies, Weisler and his team does not mean non tangibility but *integrating computing to everyday life tools*[38] that connects each other and seamlessly interacts with user that make them Things That Think[5][38]. Interaction is one of the fundamentals of Ubiquitous Computing, Abowd and Mynatt interpreted as "*Computer interfaces that support more natural human forms of communication are beginning to supplement or replace elements of the GUI interaction paradigm. These interfaces are lauded for their learnability and general ease of use*"[44]

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[4] Ubiquitious Computing heavily depends on the existence of Pervasive Computing

[5] MIT Media Lab. "Things That Think." http://ttt.media.mit.edu/

Ubiquitous Computing can be differentiated than the Pervasive Computing as the concepts addressing. Ubiquitous Computing concept addresses the world that consists of intelligent everyday life tools within different contexts and their connectivity between upon; clearly connectivity of Pervasive computing environments. *Ubiquitous computing aims to provide Pervasive computing environments to a human user as s/he moves from one location to another*[45]. As a supporter from same article; *Ubiquitous computing refers to building a global computing environment where seamless and invisible access to computing resources is provided to the user. Pervasive computing deals with acquiring context knowledge from the environment and providing dynamic, proactive and context-aware services to the user.*[45] Within Ubiquitous Computing world, all the tools we are using for our everyday tasks have embedded intelligence and they individually connect each other to help us to perform our daily activities. In this way, they become disappeared because they do not require human interaction based on GUI as the personal computers do because they are the tools of us we naturally use them every day to accomplish everyday tasks.

Filling the Gap between In-Store and Online Shopping Experience: State of the Art Technologies and Solutions

Growth of the technology approaches to Mark Weiser's Ubiquitous Environment[42], however there is still long way to achieve the goal. As previously stated, %70 of offline shoppers carry their smartphones among while shopping which environments provide services to assist to achieve user's shopping tasks. This percentage is only for smartphones and it will rise cumulatively with new technology releases such as wearable smart devices. As stated at research paper, *mobile applications for shopping come at the intersection of ubiquitous computing and electronic commerce, and are gaining research attention from both communities*[46]. Even though, focus on this study excludes payment process, following state of the art technologies will be elaborated nevertheless if the excluded parts of the study included. Reason for this elaboration is to reveal knowledge from the state of art solutions proposed and inspire to deliver higher experience for in store shopping which has been missing on proposed solutions.

Following subsections will be describing the solutions chronologically, which attract the online to offline shopping:

iGrocer, is one of the predicators proposed on 2003 and its frontend implemented with J2ME for Symbian Mobile Operating systems. What makes iGrocer related to study is the objective of the connection of mobile and personal computer experience to offline shopping

experience. As stated, *iGrocer*[8] *will help the user create and maintain comprehensive shopping lists to prepare and plan for the weekly grocery purchase. These shopping lists can be accesses both from the smart phone also from the iGrocer website.* iGrocer focuses on the replenishment of the products at the user's fridge by scanning the barcode, then navigate and find them in the store. Also iGrocer has features that combine the user's Nutrition Profile to shopping assistant, a potential disadvantage that gives a level of complexity for senior citizens. Also, iGrocer assumes that 72%[8] of the shoppers buy the same products when they shop at the grocery stores. This assumption is enhanced with the Personalization of the shopping categories that the user automatically received the shopping list by this feature. Figure 2 shows the iGrocer system architecture.
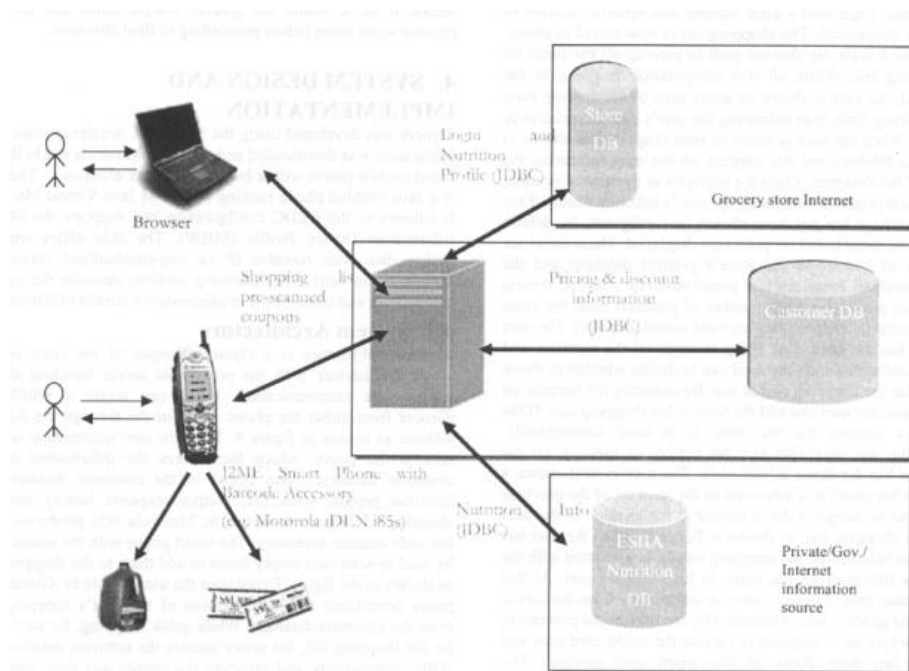
Figure 2 iGrocer System Architecture[8]

iGrocer is a client-proxy-server architecture-*Figure 2 iGrocer System Architecture[8] -* that proxy delivers related action's data to database and each time a request sent from agent-whether PC browser or Mobile browser- proxy again retrieves the information from related database. An example from research is, whenever user created a profile, and then new user information will be sent to customer database through proxy.

MyGrocer, proposed with the objective; *rather than having a supply chain terminating at the supermarket checkout, it is now possible to extend its reach in the consumer household*[43]. MyGrocer is a conceptual framework proposal adds value both for business and

technological aspects of the inefficiencies of the supply chains, Supplier-Manufacturer-Retailer and POS[47]. In this regard, MyGrocer can be sorted as a business and technological framework proposal that empowers supply chain management with technological solutions that addresses inefficiencies of the present framework and takes it beyond of the store for customers. *Figure 3 MyGrocer Functional Concept Architecture* illustrates the business and technological framework of the MyGrocer concept.
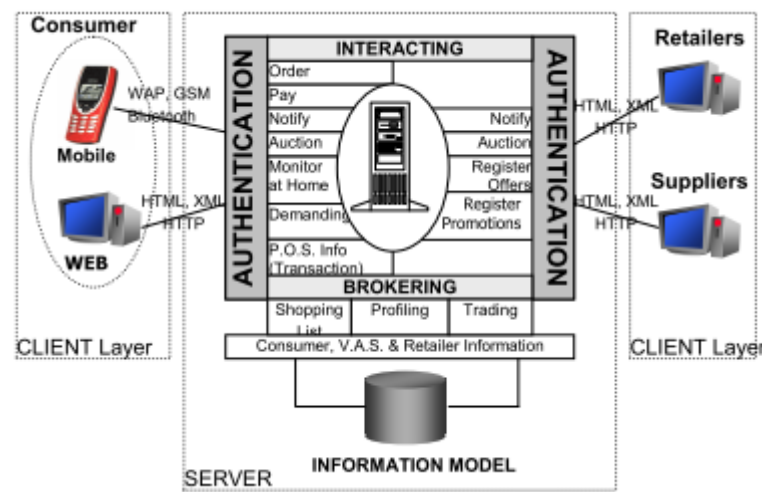
Figure 3 MyGrocer Functional Concept Architecture[47]

Project addresses the Retailer and POS aspects of the whole chain, so analysis will focus into store consumer perspective. MyGrocer started off with the design principles derived from Ubiquitous Computing requirements[43], namely *Natural Interfaces, Context Awareness, Automatic Capture and Access to Information* and they have been put into architecture -*Figure 4 Overall Architecture of MyGrocer enables* Store Consumer[43]- that fulfils the requirements.

As argued[43], the core technological innovation of the proposed solution is the use of Radio-Frequency (RF) technology for the products' identification as a barcode replacement. With the data collected by RFID readers, MyGrocer takes the advantages of Bluetooth and WAN communication technologies to transfer data from mobile device to server. MyGrocer concept has sophisticated advantages with RFID tagged products and their traceability also for users, navigability to products. However, the cost of RFID tag equipped individual products has been ignored. Also, as stated below at the introduction, even though concept helps to have replenishment information about products and their position at the store, MyGrocer ignores senior citizen's manoeuvrability capabilities and does not employ any requirement related to difficulty of reaching-placing the products to carrying equipment within store. Also, MyGrocer concept appeals Supermarket environments where customer-staff relationship is minimized in behalf of active help; reaching to the products that

discovered and carry them until POS. Figure 4 shows the overall architecture of the MyGrocer.
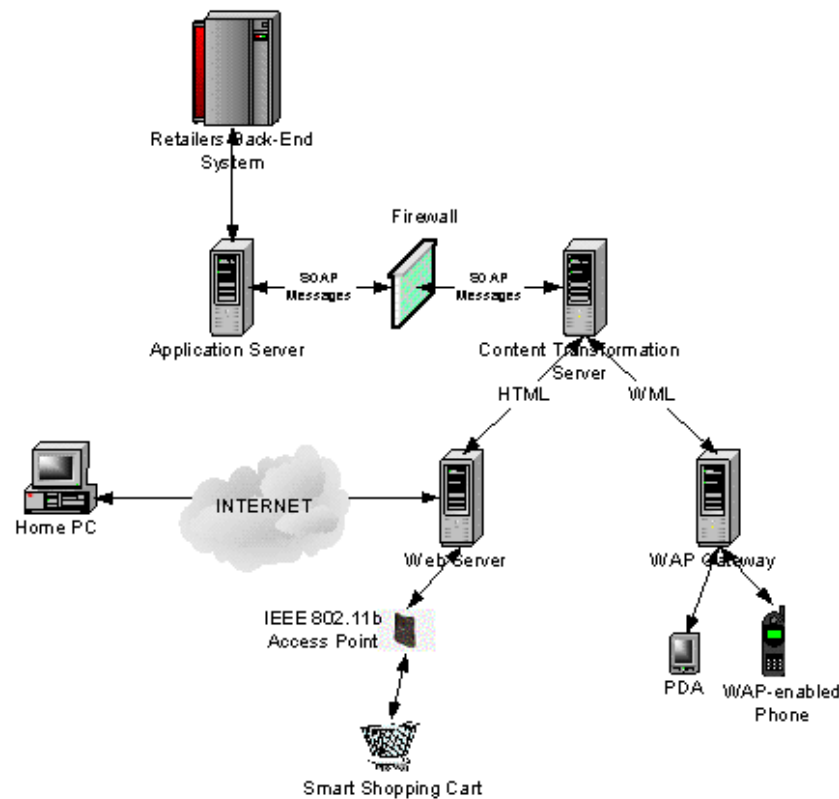
Figure 4 Overall Architecture of MyGrocer enables Store Consumer[43]

Based on the architecture[43], MyGrocer appeals three different usage scenarios:

In Store: Carrying Equipment (shopping trolley) donated with Smart Shopping Cart,

Smart Home: Homes donated with RFID readers that communicate with Home PC- for example fridge- that user need to place products to be replenished within the near distance,

On the Move: Users able to access their products with Internet enabled mobile device which receive the information for the products from Home PC that need to be replenished and create the shopping list.

Ubira[9] is an O2O shopping assistant integrated in the domain where users can participate within the old and new service models of shopping. Old service models, Ubira addresses the offline shopping and the new service models are the online shopping services. Ubira generalizes the shopping in three states; discover the product, evaluate and buy it. Generalized states are applicable both for online and offline shopping environments where the Ubira is a balancing solution both of them. Ubira offers offline shop owners a coupon issuing service which is the main balance factor if a store customer interested with a product

and decided to buy it online-because of low prices- Ubira client can immediately issue a discount coupon to store customer and offer the discount at the state before store customer purchase as serendipity. Still, if the user scans the product within offline store and purchases online, Ubira platform provides affiliation fee to offline store owner. This is a software as a service with a Win-Win business that every segment of users wins; offline store owner able to keep store customers, online stores able to increase their traffic and gain potential customers and the store customer gets the lowest price[9]. *Figure 5* illustrates the states that are also the design principles for the user. *Figure 6* illustrates the functional flow of the states more detailed.
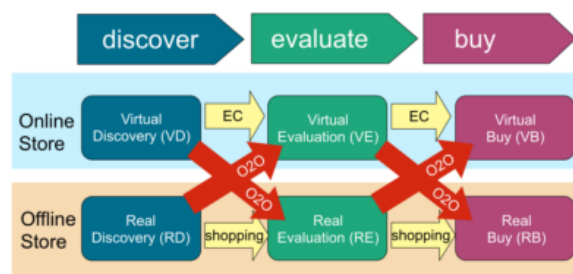
Figure 5 Ubira O2O Shopping states as Design Principles[9]   *Figure 6 Ubira Main Functionality Flow*[48]

Ubira is an inspirational platform for the study that addresses the both online and offline shopping states of a consumer. Ubira is a solution that concentrates on the possibility of different prices then the offline store, "bargain hunting" that implies the users will prefer lower prices than the offline shop. However, bargain hunting can be sorted as a contra to Civic Socializing where the Senior Citizens do visit local grocery stores within the feeling of socializing with shop staff. Also, technically, Ubira is equipped with the barcode scanner which is a potential physical disadvantage to Senior Citizens to focus the mobile phone camera to products on the high level of the shelves.

Point & Find[46] is a solution motivated by the argument *"much of the prior work is to support transactions on mobile phones and information consumption on-the-go, the experiential aspect of shopping remain largely unsupported*[46]*"* which is also partially motivation of this study. Point & Find focuses O2O shopping where the users expected to be in the short distance of physical goods to point the mobile device camera and take a picture to be processed for price search within internet. Point & Find introduces *a vision-based mobile*

interface[46] which takes real world objects to central point in order to query information about-Picture 7 and Picture 8.

Figure 7 User takes picture of the product within offline environment   *Figure 8 Application returns the product and similar ones*
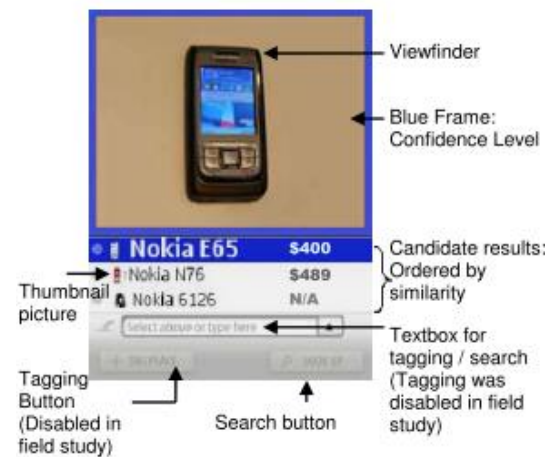
However, when the target users appeals to be Senior Citizens, physical difficulties – for example, as seen on the Picture 7 focusing the camera to a specific product- brings the Point & Find solution disadvantage. Also, when we address the products within distance – products at the top of the shelf- camera usage would be disadvantage again. However, design principles of the Point & Find make the solution interesting. Point & Find employs the proposal of Pascoe's [49]design characteristics. Respectively they are[49]- interpretations are for shopping:

- *Dynamic User Configuration:* Depend on the context- on the move in a store or standing outside of the shop- the user will be able to use the application and have the all provided experience.

- *Limited Attention Capacity:* The user should not pay great attention to application interfaces; application should suit to user's shopping task while the user observes the products.

- *High-Speed Interaction:* The user should be provided smart spurts of activity metaphors that make the time dependent observation tasks to be easy to accomplish by interacting with system for products.

Within their field study, team formulates the four characteristics of field worker into two general HCI principles:

Minimal Attention User Interfaces: Providing interface mechanisms that minimize the amount of user attention, though not necessarily the amount of user interaction, that is required to perform a particular task.

Context Awareness: Imbuing the device with the capability to sense its environment

The captured characteristics of Pascoe are relevant to study since a "worker" is defined as "a person activity involving mental or physical effort done in order to achieve a result[50]" which definition is carrier by a Senior Citizen as one has effort in order to complete his daily shopping task.

Shoppulatto, provided by Docomo[51] is a O2O commerce solution which is still in field test. Shoppulatto is software as a platform focuses on shop and product discovery. Technically, users will be able to automatically check-in to a specific store as they approximate themselves to store boundaries, this is achieved by sending high frequency sound signals to mobile phone's microphone, enabled application. From the website

announced the Shoppulatto; *if a user enters one of the stores, an inaudible high-frequency sound signal transmitted inside the store activates the app's check-in feature. The user then receives coupons or other promotions that have been tailored to their age, gender and so on.*[51]

As the Shoppulatto's technical specifications are not announced, for a better understanding, Figure 9 Sonicnotify Retail platform[52] gives the overall usage area. Sonic Notify is a technological solution addresses the same area
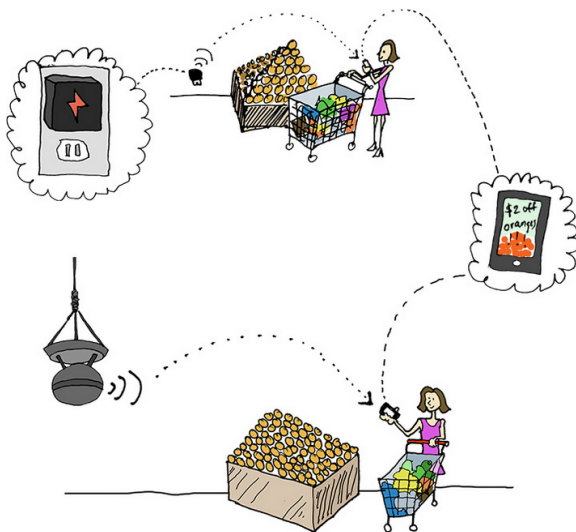
Figure 9 Sonicnotify Retail platform[52]

consists of data carrying sound transceivers namely "beacons" which sends the data via inaudible sound signals.

An analysis for the solutions

Above solutions, iGrocer, MyGrocer, Ubira, Point & Find and Shoppulatto are described within scientific focus. As they partially bring a solution to the problem area, they also ignore the main facts that raise the problem; manoeuvrability because of the physical difficulties of a senior citizen and the easy to use interfaces enhanced by the cutting edge technologies.

It is seen that iGrocer, focus on shopping solution that does not employ in store product handling. Moreover, iGrocer user interface is implemented for Symbian OS with Java to Micro Edition which has lower capabilities for user interaction compared cutting edge technologies for example Java for Android OS. Also iGrocer is a system that is difficult to deploy since it requires individual servers and staff that will be administrating those servers.

MyGrocer, even though the framework is including promising features for described scenarios, likewise to iGrocer, MyGrocer does not take manoeuvrability situation to consideration in order to reach products lying on the different positions of a shelf. Also, MyGrocer is difficult to deploy by requiring the full supply chain management operators interaction in order to make the distributed system work as well as each store should be able to administrate the individual servers which will be also big expense. Another expense is that, MyGrocer assumes RFID tags replace the barcodes that identifies the products. Also, MyGrocer architecture employs heterogeneous devices that require Content Transformation Server in order to adapt visual interfaces of WML and HTML to system that can be seen as an out-dated approach with the presence of the HTML5 and its features. Morover, MyGrocer user interfaces, can be seen at the Picture 1, might be complex for the elderly persons to interact with and carry out their shopping tasks.
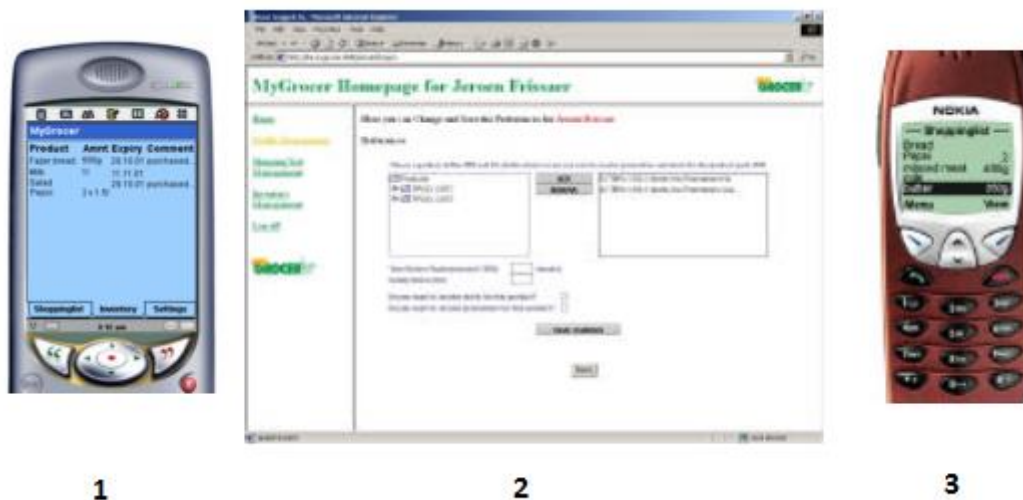
Picture 1MyGrocer User Interfaces[43]*: 1Personal Digital Assistance, 2 Home PC Interface, 3 Cellular Interface*

Ubira can be sorted as focusing on price differences with online and offline stores that the bargain is delivered to the shopper and system makes is available for store staff to bring "price equality" if one would like to keep the customer loyalty. This solution is an inspirational for the solution with the user interaction with the offline products. Ubira

employs the phone camera to capture product barcode and compare the prices of the product details on Internet. This solution is a limitation to project's problem area since it is addresses the users whose age 65 and above who would have difficulties to handle camera to focus on a barcode.

Point & Find is another online to offline shopping and recommender solution by taking the physical product's details with barcode scanning enabled by phone's camera. Besides the Ubira's offers as serendipity, Point & Find more concentrates on the prices of the same physical good at different online shops and other products that has similarities to related physical good-brand, category etc. Just like the Ubira's camera focusing problem, Point & Find can be sorted with the same disadvantage as well as the complex user interface for senior citizens to accomplish a simple shopping task.

Lastly, Shoppulatto is the cutting edge solution for product discovery and recommendation to the users with its unique communication technology-inaudible sound signals- that could be the advantage for seamless user experience for senior citizens. However, Shoppulatto's use cases require user interaction for the product offers and still do not employ a solution for shopping difficulties of senior citizens such as manoeuvrability. Another aspect is the deployment expense of the solution that the audio frequency provider hardware arises.

Even though this growth is unpredictable for ultimate user experience within pervasive environments, there are various high level proposals employ robots such as *Conversational Humanoid as a Shopping Assistant Partner*[53]. Those solutions address human-technology switch over that robots will be replacing the duty of the store staff; customer service. There are examples for such assistant services, for example TOOMAS[54], navigates the user to shelves within store for their desired products. Another research[55] focuses on remote shopping from home to store where a user can interact with a robot- YAMABICO[55]- within grocery shop and choose products with the pictures taken real time. However, what makes different *Conversational Humanoid as a Shopping Assistant Partner* is the focus for senior citizens participation at daily life however still alters their physical difficulties to reach products. Focus on the *Conversational Humanoid as a Shopping Assistant Partner* research is to help senior citizens to carry the goods enhanced with navigation solution while interacting as a human. Another proposed concept solution[56] considers discrete usage of smartphone and robots within grocery store. Solution assumes that, in sociologic study matter senior citizens adapted to smartphone usage as using shopping list and prepares & uploads the shopping list at home to their smartphone. As the person gets into the shop, server authenticates with pin code and assigns a robot to senior citizen's usage and navigates one to shelves and carries the product. From the research, user study shows that, informants would

like to use this technology provided from store however it is not signified if the stores are ready to pay such expense, assigning a robot for each customer, nor at Humanoid[53] neither at another concept solutions[56]. Even though, this study does not address any market-business and robotics research, it is obvious that assigning a robot for each customer and implementing algorithms to handle multiple customer-robot interactions in stores bring huge expenses, at least for middle scaled local stores. Moreover, none of the proposed solutions did concentrate on the physical difficulty of senior citizens of reaching the products on shelves and placing them in carrying equipment, responsibility is still delivered to user. Also, as highlighted at the research, senior citizens mostly complain in the ethical manner that such kind of solutions isolate them from society, because they believe those kinds of human replacing solutions will be forcing them to use robots.

All in all, literature shows the present state of the art solutions that address the problem area. However, proposed solutions raises the need of a solution, a bridge to gap for senior citizens to be present at the grocery shops and assist their physical difficulties with technology. With such solution, senior citizens still should be able to be in the communication with store staff by participating in the social environment but also solution should motivate them by taking major weights, namely reaching to products on the shelves and handling the products to carry within store so they can wander. Pervasive retailing is suitable for the need and an argument from symposium reveals a consequence *"pervasive computing environments can be regarded as robots that we live inside"!*[57]

4. Requirements Analysis

4.1 Stakeholder Interview

In purpose of development of the vision and deeper understanding of the problem area stakeholder interviews conducted[58]. Stakeholder interviews are the understanding point of the technical and business domain surrounding the solution[58]. Stakeholders are identified as grocery shop owners that a grocery shop consists of aisles where various types of goods sorted on shelves. For related primary research phase, parallel with secondary desk research, open-ended questions derived from problem formulation and gathered to be semi structured interview. Questions can be seen on Appendix 2.

4.2   Interview Analysis

Before conducting the interview, semi structured interview guide has been prepared with the focus of the meanings. As suggested at the paper[59], interview questions included the meanings that are the categories derived from problem area addresses different perspectives such as; Socialization of the Senior Citizens, Shop Assisting and Pervasive Environment. Also, putting meaning into the questions bring a level of easiness for the analysis phase to come up with a conceptual model. At the debriefing, concept idea has been explained to stakeholder without any technological specification. Conducted interviews-Appendix 2- revealed the grocery shop owners interest for the problem domain. After the stakeholder interview, it is seen that both stakeholders have a necessary for a system that will improve the shopping experience of the seniors.

4.3   Conceptual Model

Before any implementation or any technological decision, conceptual model is the high level visual definition of the system model that takes current user experience situation into concept within the problem space. Conceptual model created with metaphors and analogies that expresses product discovery situation to support user experience[60].

Main inputs of the conceptual model are the stakeholder interviews and desk research that highlights the current situation of the elderly persons shopping. Drawing 1 shows the conceptual model of the system, the user who is holding the smartphone receives the product information and chooses the desired products and sends them to store staff to be delivered at the check-out point.
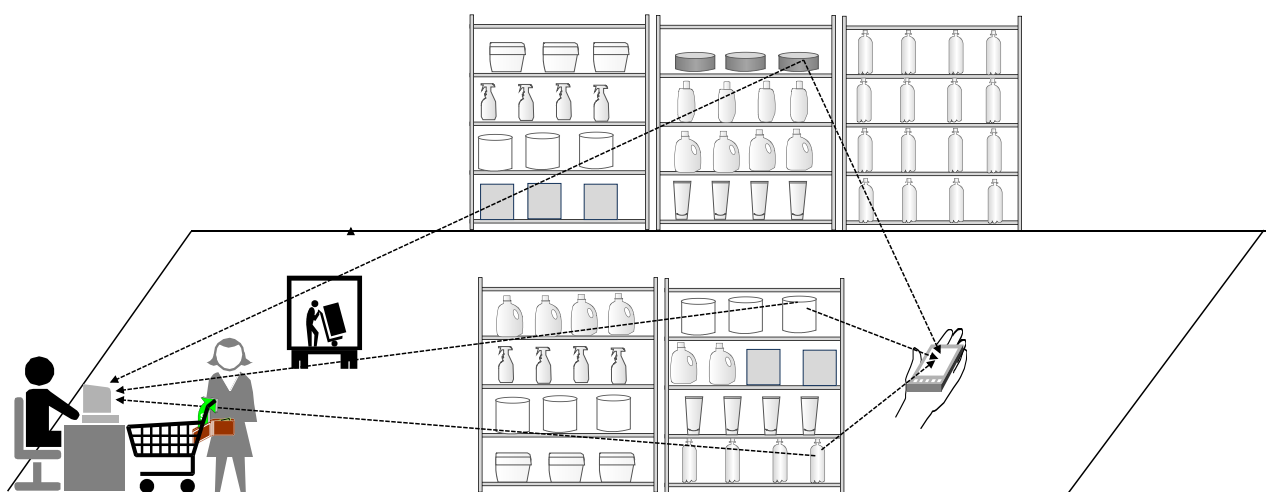
Drawing 1 Conceptual Model of the System

Conceptual model is an important part, a step to concretization of the problem space. While it does not hold any user interface or any system architecture specification, conceptual model describes what the users can do with the system and what they need to understand in order to use this system[61][62].

At the stakeholder interview debriefings, from the each stakeholder's perspective, it has seen that an ICT solution would bring value to both sides- seniors and the store- if such solution could enable the seniors to choose the physical goods from a smartphone application. With this solution, store staff would decrease the manpower needed for a help- compared to nowadays situation- and even sell more products also senior citizens would examine and buy products easily since they would not need to ask for help for every product. Drawing 1 Conceptual Model of the System is a one way of defining the system based on self-knowledge with the data collected from desk research and interviews. It can be seen that user need to know that there is a smartphone application which can be used for choosing products from related shelves that products will be received in the checkout point. User still can carry other products that s/he handled to reach and place to carriage equipment but system also helps to request ones that were not able to reach or handle to place to carriage equipment.

At the stakeholder interviews, it has seen that the need of the help is mostly based on the products on a shelf. In these regards, the concept addresses to a solution for a senior citizen to choose the products via a smartphone application and receive them at the checkout point while performing the payment.

Concept does not bring any limitation to a shopper, besides, still lets a shopper to carry another product along and optionally choose other products with the application that will be delivered by the store staff. This has been underlined at the stakeholder interviews with the circumstances of the help by asking *"Which shopping is the most interaction occurs?"*-Appendix 2.2 and 2.3 Interviews. Concept brings a value by integration of online service to an offline environment without any disruption, as it is also sentenced at the stakeholder interview- Appendix 2.2 and 2.3 Debriefing Sections.

4.4   Context Scenario: Senior Citizens and Grocery Shopping with Assistant

Scenarios are one of the most useful tools for the design process of an engineering project. It reveals the informal knowledge of the target users by the description of their tasks and the

motivations for the usage of the product. Scenario is a futuristic tool as well that underlies how the product is used and how the user's tasks are performed. Using scenarios in design process have many benefits such as[15]:

- A basis for overall design
- A basis for technical implementation
- A cooperative framework with the design and implementation tasks

At the research project, the context scenario has been helpful for the all above. It was able to highlight the overall design, it was able to give a basis for the technical implementation, a cooperative framework for the implementation-for example the state diagrams and high level system architecture and their implementation.

Moreover, contextual scenario has been the main supplier of the storyboard-section 4.5-where the activities of the problem are has been visualised.

Following engineering scenario narratively expresses the usage of the system in consideration within the engagement of the research questions.

4.4.1   Scenario

Malene, 65, wakes up every morning by 06.00, waters her flowers at the window frame and prepares breakfast. Malene lives alone, she takes care about herself, she used to work as dentist and now she is enjoying her retirement at one floor house with garden. She lives 10 kilometres away from downtown but there is a local grocery store within her surroundings, 500 meters away, namely Blue Sea. She does not drive car, prefers public transportation systems to go downtown. Malene has two grandchildren; they live in another city 4 hours away. She has a smartphone that has a front camera so she uses it to have video conference and see her grandchildren.

One of the winter days, Malene needs to buy cleaning materials to home. Cleaning materials are heavy products to handle to carry in the shop, so with application Malene is able to order them inside the store. Malene goes to Blue Sea store. She is welcome by store staff. She says "hi" and as she moves within the aisles, she reaches to cleaning material shelf, takes her smartphone out of her bag. She needs to buy soap and sweeper. She runs the application. Application welcomes her with a button indicating that "please press here and tap a shelf". Malene presses the button. Another screen appears and informs Malene by highlighting that she needs to approximate the phone to the shelf tag point, she approximates phone to shelf tag point and hears a "*beep*" and simultaneously a processing icon appears and informs that

the products are being downloaded. Few seconds later, Malene is able to see the products that are able to swap in order to reach to product that she needs on the shelf. Malene swaps upon the products. She can see the soap that she needs. She presses the picture that is the soap. Simultaneously a processing icon appears indicating that product information is being loaded. Few seconds later Malene can see the soaps price, quantity that she desires to buy and to add the basket, "add to basket" button. Malene decides to buy only one piece of soap and she presses "add to basket" button. Now there is another button available, which is "shopping basket" button. Also information on the screen shows the total basket price. Price of the soap, quantity to be set and total basket price are vertically aligned independent information texts (price of the soap times quantity automatically added the total price of the shopping basket as the user sets the quantity and presses to "add to basket" button).

Malene still needs to buy sweepers that she can see on the top of the shelf. She swaps upon cleaning materials and finds the sweepers, again she presses the picture and adds product to basket. Now she is ready to be done with the shopping. She presses "shopping basket" button and simultaneously she is able to see all the products that she added to basket. Also she can see "edit" buttons next to each product that she added to basket. Moreover, she can see a "purchase" button that she can send her virtual shopping basket to check out point in order to products to be collected. She presses "purchase" button and a new screen informs her whenever she will be on check out point, the products will be delivered to her.

Malene wanders in the shop lastly decides to finish her shopping. She approximate to check out point and when her turn is to pay, cashier can see from the stationary computer screen that identifies Malene and the products with her picture (and other customers pictures who used the application to order the products and press "purchase" button) which is expendable button whenever it is pressed it will show product details and recipe print button which is the function in order to print out products to be collected. Cashier presses Malene's picture and presses to the print out button during cashier talks with Malene about daily life situations. Cashier calls service person and gives the recipe of the product to be collected. Service person collects the products and brings to check out point while Malene is paying the amount. Malene's products are packed as she is done with the payment.

4.5   Storyboard

Storyboard is the high level description of the potential users' task motivation and their interaction with the system. The goal of the storyboard is to bring a visual narrative depiction for the tasks of the user as they are performed via the system within the context of the research questions. With the context scenario-section 4.4.1, research questions have been

able to be preliminary opened up and even bring a conceptual solution by using narrations at the context. However the main user-system interaction for the tasks and the user's behaviours have been missing and that bring the limitation for the development since it did not include any specific visual telling of the system- for example any user interfaces. Scenarios lack the envisioned explanations of problem and solution that brings a big impact for understanding the real problem as well as the reason why is it solved in a way rather than others[63]. However, when the scenarios are explained with a few set of drawings by including following aspects, the delivery of the understanding is higher level with the impression of the visualising the problem and solution[63], as it is also the reason storyboard used.

- *Level of detail*; number of objects and their interaction with actors which brings the understanding of the problem domain and its solution

- *Text*; in order to emphasize the actors' emotions and task motivations with bubbles, a descriptive narration of the context at the top of the frame etc.

- *People and emotions*; in order to bring a level of empathy where the main actors and the secondary actors interacting with the system through interfaces

- *Number of frames*; in order to deliver the understanding of the problem domain its tasks their motivation as simple as possible

Main inputs for the storyboard are the context scenario and stakeholder interviews parallel with desk research. Storyboard is an extraction of the system usage part from the scenario that visualizes the solution for a better understanding. Storyboard enhances the user and their behaviours in the context also lay the foundations of the low fidelity application prototypes. Storyboard is a low fidelity prototype as well, which reveals the behavioural circumstances of the situation to concrete mappings of the users, context and interaction. Initial drawings of the storyboard can be seen at Appendix 5.

Table 1 shows the storyboard frames from the original storyboard-Appendix 5- which give a deeper explanation of the problem and the solution to be evaluated while it is first time visually proposed with initial paper prototypes that are emerging from the storyboard.

4.5.1 Storyboard Frames and Explanations
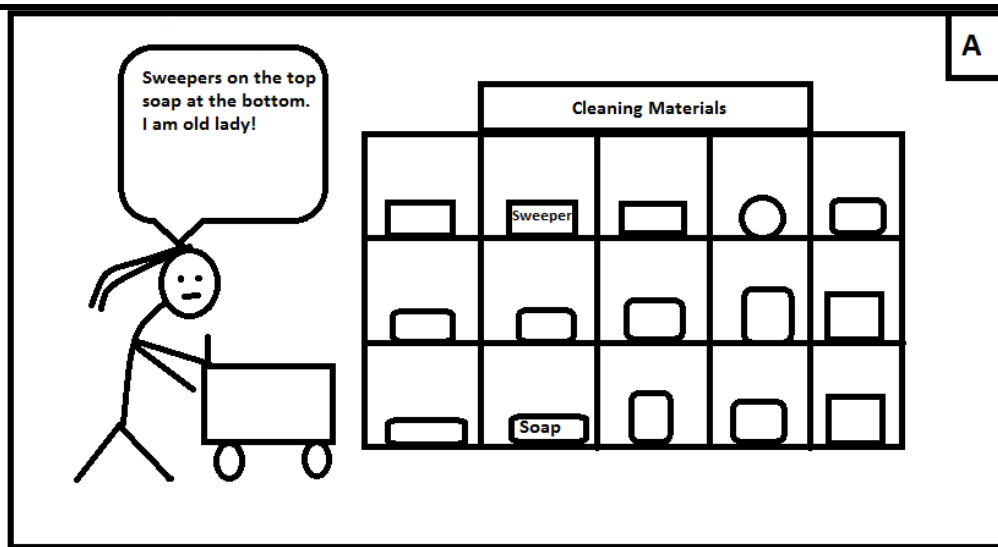
Storyboard frame A illustrates user goes into shop, while she is between aisles, she has difficulties to reach the products she needs.

Storyboard Frame A Illustrates the problem with the objects in the context: products on a shelf of a grocery
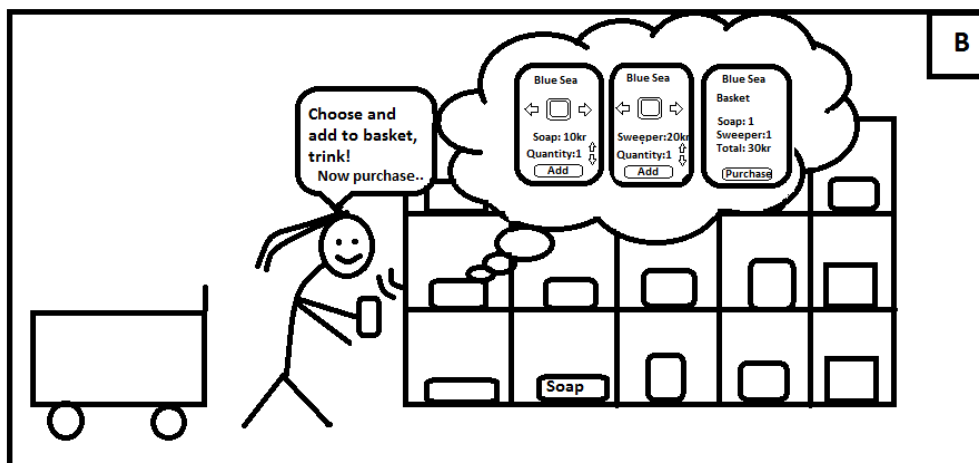
Storyboard frame B describes, user receives the specific shelf's products information by using her mobile application running on smart phone. She chooses products and sends the shopping list information to checkout point.

Storyboard Frame Illustrates the user's first interaction with the system; first step to online to offline shopping

Storyboard Frame C User identified the products that he needs and now she is at the checkout point where the store staff has the interaction both with the user and the system

The interface drawing at the frame C is to illustrate the event flow's end point that the Senior Citizen's shopping profile is enriched with her picture than the cashier is able to easily identify the customer on the queue by the one's picture and the picture is pressed, system expends the picture with the products ordered by the customer and a print button that is the function to print out ordered products

Storyboard frame C describes the user choses products and when she is at the checkout point, cashier is able to print out a receipt for user's products and store staff will be collecting them while cashier has time to have daily talk with customer.

Storyboard Frame D User receives the products
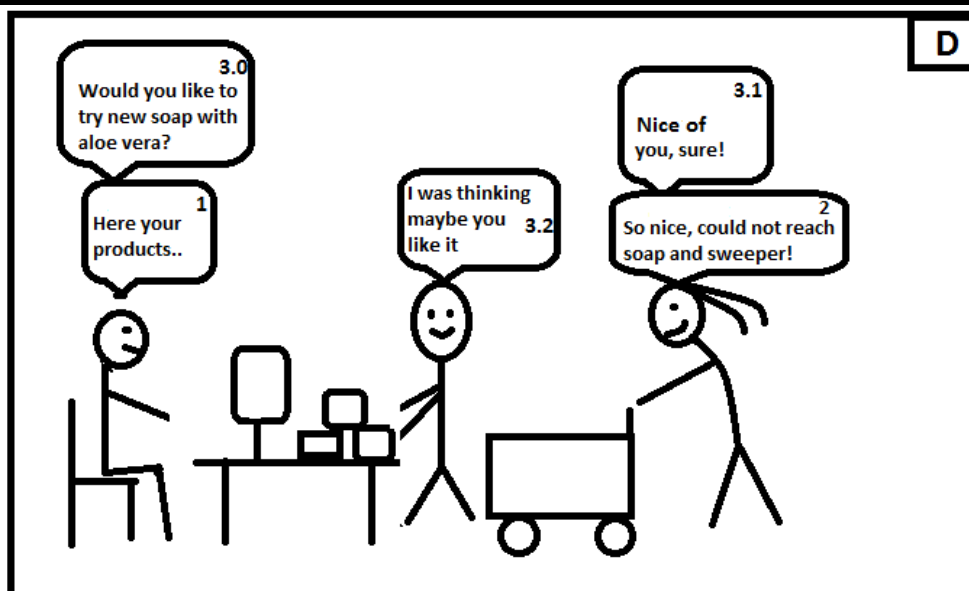
Storyboard frame D describes, store staff collected products and he also has an extra product to recommend based on the product she ordered. Customer nicely welcomes recommendation.

Table 1 Storyboard Frames

4.6   Low Fidelity Prototypes

Paper prototypes are the core of the design for a solution. Paper prototyping is being used in cutting edge mobile solutions[14] within industry. In this research, paper prototypes are emerging solutions from the Context Scenario –Section 4.4.1- and the Storyboard-Section 4.5.1- for the senior customer.

4.6.1   Initial Working Prototypes

Paper prototypes following are named initial, because they have not evaluated nor by designer's neither by user's perspective. They are emerged form of the solution described at the storyboard.
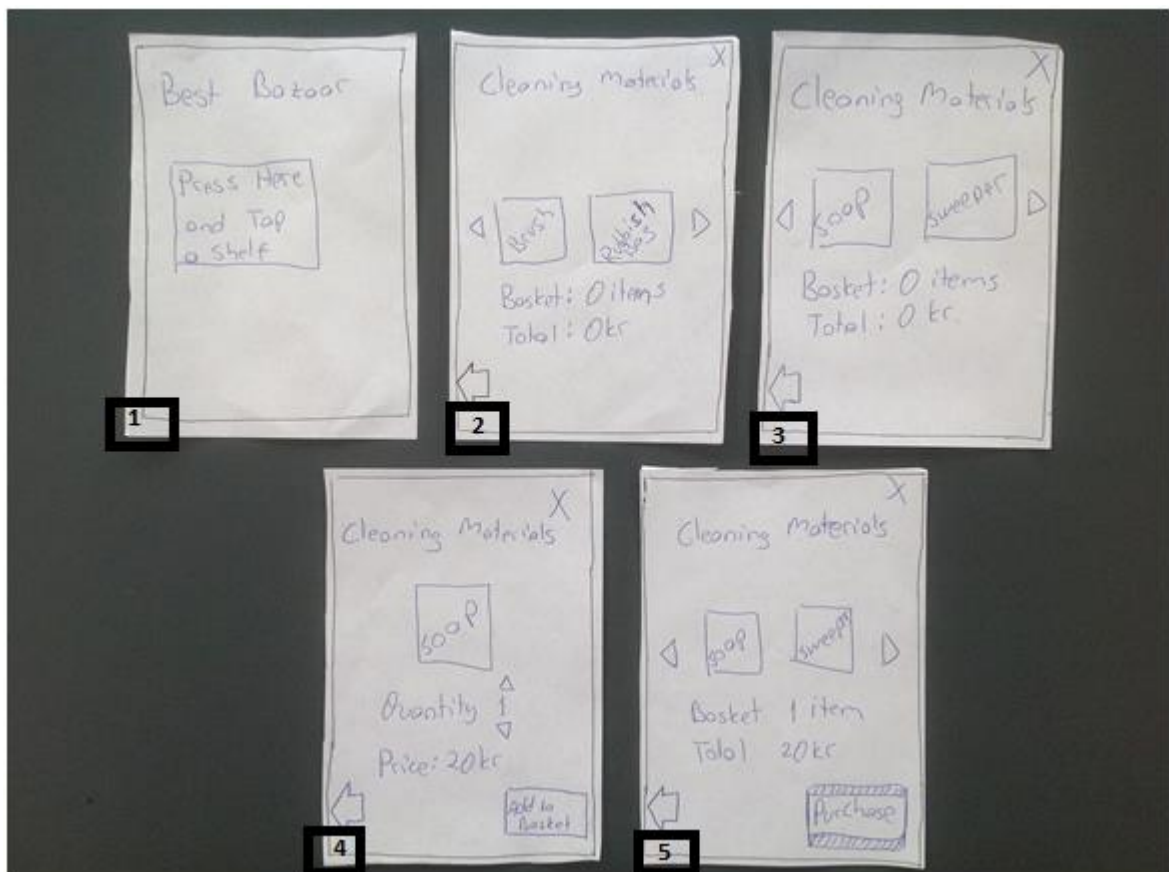
Prototype Set 1 Initial Low Fidelity Prototypes

Initial prototypes have been focusing to screens that dimensions with 15x10cm smart phone. Main elements of the prototypes are the communication technology-triggering button –*Press Here and Tap a Shelf*, products on the shelf as swappable product names, shopping basket information, total amount information, *Add to Basket* button and the *Purchase* button. Those buttons describe the functionalities alike state transitions of an online shopping site where the purpose of the research is to also to integrate aspects of an online shopping to offline context.

4.6.2   Heuristic Evaluation: Iteration 1

Within the scope of the context scenarios and storyboard, prototypes have been able to be tested heuristically. Nielsen's heuristics address the usability aspects of the system; it is able to test the prototype functionalities with the 10 Heuristics before involving users. This approach gained a corrected prototype for the task is being done without any system interruption. Below, Prototype Set 2 shows the modifications.
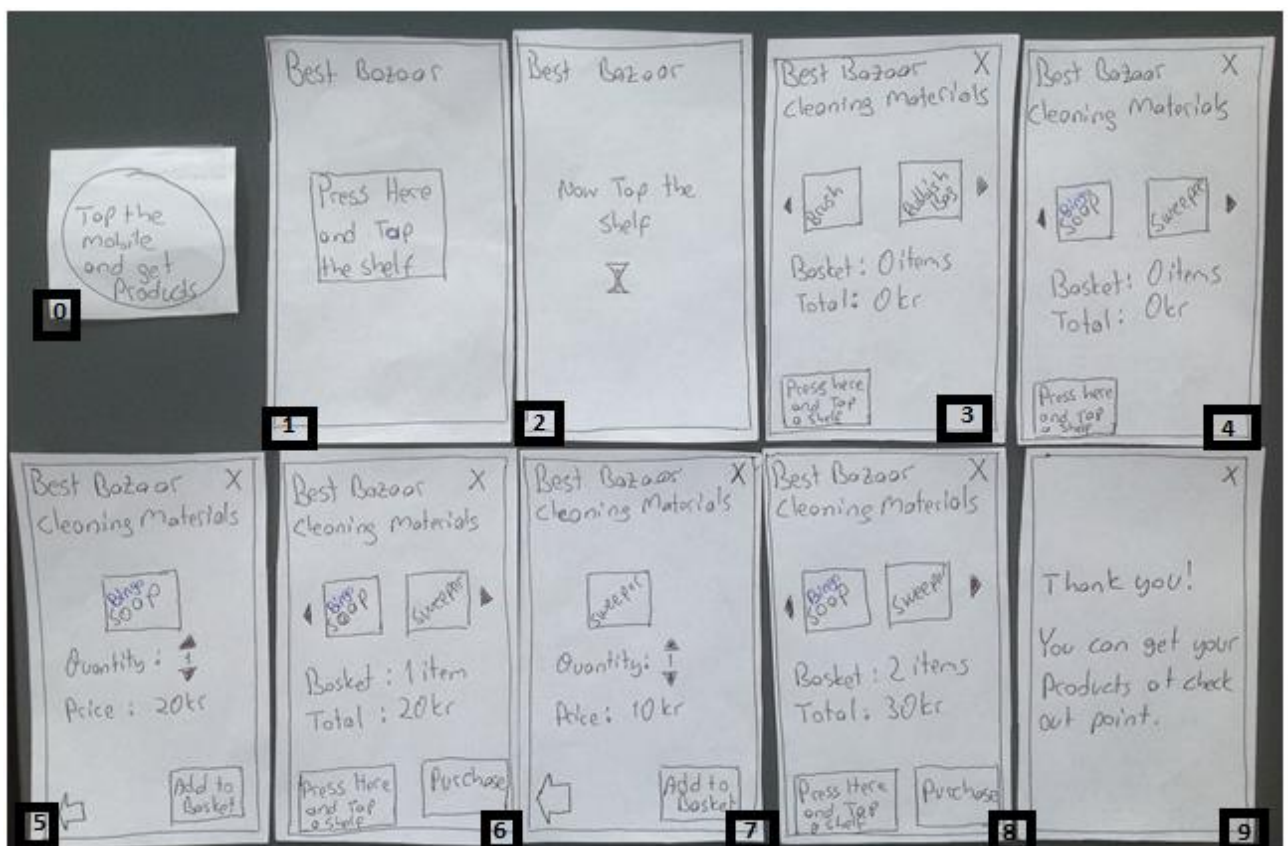
Prototype Set 2 Initial Low Fidelity Paper Prototypes modified after Heuristic Evaluation

Another modification realized after the heuristics for the dimensions of the paper prototypes changed to be 12x8cm for a more realistic concretization of the screen dimensions. This modification does not address any interface usability heuristic however before the test it was important to simulate the prototypes to closest to market[64].

4.7   Low Fidelity Prototype Field Evaluation

Field evaluation has been actualized in a local grocery shop namely Best Bazaar where one of the stakeholder interviews conducted. It was chosen as the shop for field test because of its location brings a density of the customer ages are close to project's target users compared to Elite Bazaar[6]. Best Bazaar's location[7] is seen that it was able to conduct with more target users since there is not another alternative grocery shop expect of ones at the Albertslund Centrum that are 1.4 km walk distance. Also, Best Bazaar has many aisles and those vary to 1.80 meters to 2 meters – some products are at the high position for an elder person compared to Elite Bazaar where the shelves are shorter-that supports the problem scope. Test setup is focused on the shelves that include heavy products on the top of the shelf and the bottom of the same shelf. Tests have been lasted 3 days.

Test addresses Cooperative Evaluation[18] of the partial low fidelity paper prototypes by involving users for a shopping task prepared by evaluator. As the target users are 65 years and older, evaluator found that it is reasonable to be ready for helping the user to complete the task instead of just observation. At the task- more explained below-the user has two items to buy and with this way, evaluation will be considering user's daily life situation that believed to give more insight to user to give inputs for the system. As the interfaces will be the medium between the real users and the system, test welcomed the users to bring out their ideas for the design to make the system better to answer their needs to complete the tasks.

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[6] Elite Bazaar is a grocery shop where the stakeholder interview is conducted with owner. Its location is inside the city hall, with homogenic age density of customers which would bring a level of difficulty to find and contact with target users.

[7] Outcome comes from the mentions during the interview with the chief of the Best Bazaar. He mentioned they have a big density of the 60+ age costumers because of their location since there is no other grocery shop within close surroundings for an elder person to have an easy transportation and carry the goods.

4.7.1 Target User Selection Criteria

Project target users are seniors, to define more precisely, project aims to assist 65 years old and older seniors who have ability to walk within the grocery aisles and see the products; also they should be able to handle their shopping tasks within the daily life.

At the research[4] it was found that, shopping difficulties are experience for all demographics- 65 and above- nevertheless the education level, gender or the income. However, purpose of the study research is to have feedback for an ICT solution from the widest perspectives- all education levels, all genders- to deliver a solution that is usable by all. With this assumption, below criteria is selected which will be used to employ the participants:

- Age: 65+ (as the target users of the research project)
- Education: Minimum one participant from all segments of the education level so that solution's usability can be improved by a wide range of academic intelligence
- Gender: As much as equal number of participants from each gender
- Current Occupation: In order to capture the participants social life situation
- Spoken Language: English or Turkish required since the evaluator is not a native Danish speaker to handle the briefing, secondary questions, debriefing…

There have been more than 15 participants conducted and choices can be seen at Table 4.7.2.3. Reason for the selected participants is that their fully willingness to participate (time or language constrains) and understanding the purpose of the test which is using the paper prototypes.

4.7.1.1 Participant involvement strategy

Before starting to test with participant, we developed a strategy to contact the customers in right manner with store responsible. First conduction with the customer will be realized while they complete their shopping, at the checkout point when store staff and customer are packaging the goods.

Strategy is as following:

1. First of all, staff asked the senior customers if they have time to participate in a scientific research, if they have time,
2. Staff asked the specific person, the age, if the age is equal to or older than 65,

3. Staff asked if one speaks and understands English or Turkish, if yes,

4. Staff routed the participant to interviewer for briefing,

5. Interviewer briefly introduced the purpose of the research-Appendix 5.1 *Field Test Briefing-*; if the participant has the ability to complete the task, the task is introduced.

As the customers know the store their attitudes have been warm for participation. One of the main problems has been for finding English or Turkish speaker participants since the evaluator is not native Danish speaker. At the first day, evaluator has been able to evaluate the prototypes with two participants, next day two participants again and the last day only one participant has been eligible to participate. Also, weather conditions-snow- has been another factor that the senior citizens did not shop as they did; this is the acknowledgment from store staff's experience.

Interview briefing- Appendix 5- has been the first interaction with the evaluator and the test participants.

4.7.2   *Test Task*

Task is established on 4 main functionalities that reflects the idea of the service, respectively they are; ability to see the products on a specific shelf, ability to navigate upon those products, ability to add a product to shopping basket with quantity, ability to request of collecting the products decided to buy. Products at the task were chosen carefully so the user could imagine the situation that the product addresses, a product on the top of the shelf and a product at the lower section of the same shelf.

Task: You want to buy a Bingo Soap (at the lowest position of the shelf) and Sweeper (at the top of the shelf). With the mobile interfaces, you come closer to shelf, tap the phone after pressing the button and choose the products to be received at the payment point.

4.7.2.1   **Test Setup**

Earlier presences at the field-during the stakeholder interview- bring inspiration for test setup that the service addresses. As the test had to refer a real life situation that the customers need to ask for help, cleaning materials aisle was a relative chose. Cleaning material aisle includes both heavy products at the bottom of the shelf and lightweight products on the top of the shelf. Picture 2 and Picture 3 below show the test setup.

Picture 2 Test Setup aisle   Picture 3 Shelf Tag point

Picture 2 shows the cleaning materials aisle, 2 meters shelf that the products are sorted regardless the base on their weight that if the user needs a heavier product, would need to bend down or reach up. Picture 3 shows paper prototype illustrating a tag point that will be the start point of the application to get the products on a shelf and navigate.

4.7.2.2   Participant Demographics

Table 2 shows the participant's variety of the education background that system low fidelity prototypes are evaluated with a wide range of education level that bring a rich data in order to consider in the re-design phase of the prototypes.

Participant	1	2	3	4	5
Age	68	65	65	65	66
Gender	Male	Male	Female	Female	Female
Education Level	High School Degree	Bachelor Degree	-	Technique High School Degree	Primary School Degree
Current Occupation	Pensioner	Pensioner	Pensioner	Pensioner	Pensioner

Table 2 Field Evaluation Participant Demographics

One of the main factors for the participant's employment has been their education level. Evaluator was intended to evaluate the prototypes as many diverse education level of the participants so that the many ideas from different levels of educated participants would bring unique aspects for the usability design of the application.

Another factor has been the participants' gender. Since the shopping is a concept where the both genders may have difficulties and both genders may need help, it has been logical to employ participants from both male and female genders.

4.7.3 Test Observation: Highlights

Table 3 shows the test highlights as the pictures and explanations captured during the Cooperative Evaluation. Pictures are published with the each participant's permission. Explanations are based on the moment the picture taken.

 Test Conduction 1	Test participant 1, had difficulties to understand the reason of approximating the prototype to tag point. He asked the reason, after a high level technical explanation, he easily understood the purpose and then tried to find the Bingo Soap in order to add to basket. Test Conduction 1 shows the participant perceives the NFC technology from paper prototype.
	Test participant 2 did not have problems with completing the task however; he had the problem with the last step that is the Purchase functionality. After he pressed the Purchase button, he still wanted to edit the basket in the manner of cancelling the shop or adding new products to basket. He advised to change the Purchase naming to "Send Products to Checkout" and add a functionality that permits

Test Conduction 2

users to still edit the basket even though they pressed the purchase button. Test Conduction 2 shows the user finished with the task but at the end he gives his intentions about the Purchase functionality.
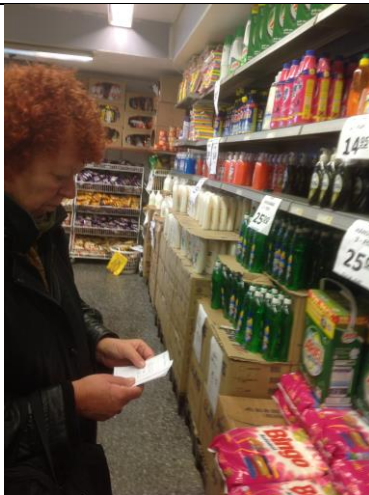
Test Conduction 3 Picture 1

Test participant 4; at the first sight she had difficulties to get used to with paper prototypes, because it was her first trial. But with the help of the evaluator, she started to think loudly and at the moment of picture taken-Test Conduction 3 Picture 1- she was thinking loudly that she is trying to find Bingo Soap, she pressed the navigation arrow button and went to next page then saw the Bingo Soap, but in the written way. ***Situation deeply explained on next picture…***

Test Conduction 4 Picture 2

At the Test Conduction 4 Picture 2, Participant 4 reflects the need of the pictures instead of written information of the products, so she can interact with more real products by seeing pictures that will bring practical manner to system. This situation can be sorted as the relationship between Usability and User experience. As the usability, with Nielsen's usability heuristic; *Match between the system and the real world*, users can see the real product's name, but still users need more clear definition for a specific product which makes it easier to complete one's task, in this context picture of

	the product gives a higher user experience.

Table 3 Low Fidelity Prototype Cooperative Evaluation test highlights

4.7.3.1 Central Findings

Tests revealed many data for the aspects of the proposed service that are useful in the manner of usability of the system with interfaces and from debriefing it was able to capture aspects for the user experience. Table 4 highlights the usability findings- sorted as below- to complete the task.

1- 3 users had difficulties with retrieving the products at a specific shelf.

2- 4 Users had difficulties to understand the products shown. They advised that products should have the pictures.

3- 1 user considered that after choosing a product it should be able to be added to shopping basket at the same page. More precisely, when a product is selected, it should not go to another page, instead it should still be in the same page that the user can just swap and see the details at the same window and add to the shopping basket.

Finding/Participant	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
1	X		X		X
2	X	X	X	X	X
3	X		X	X	X

Table 4 Usability findings/ Participants table

4.7.3.2 Reflections

Tests show that, even though it has been difficult to explain the paper prototype's purpose to the participants, service is valuable for them. Users were able to give their constructive ideas to be used in the redesign.

4.7.4   Modifications: Iteration 2

With the interview analysis, user inputs have been the source data for modifications of the prototypes for the evaluation of system. Evaluation goal was to find the usability weaknesses within the scope of functionalities with the buttons and their explanations that yield for misdirection for the user at the system. Evaluation goal has been directed for improvement of the design by taking user's ideas in consideration.

Prototype Set 3 shows the modified end-user mobile interfaces. First modification is done by drawing the prototypes and their transition actions to the whiteboard-can be seen on Appendix 6.

Paper prototypes 1 and 2 have not been included in modification process since they are the interfaces that are related to users' technology adoption, in this sense the NFC technology. 3th and 4th paper prototypes were able to convince users that the products could be seen but in real implementation product pictures will be shown to user.
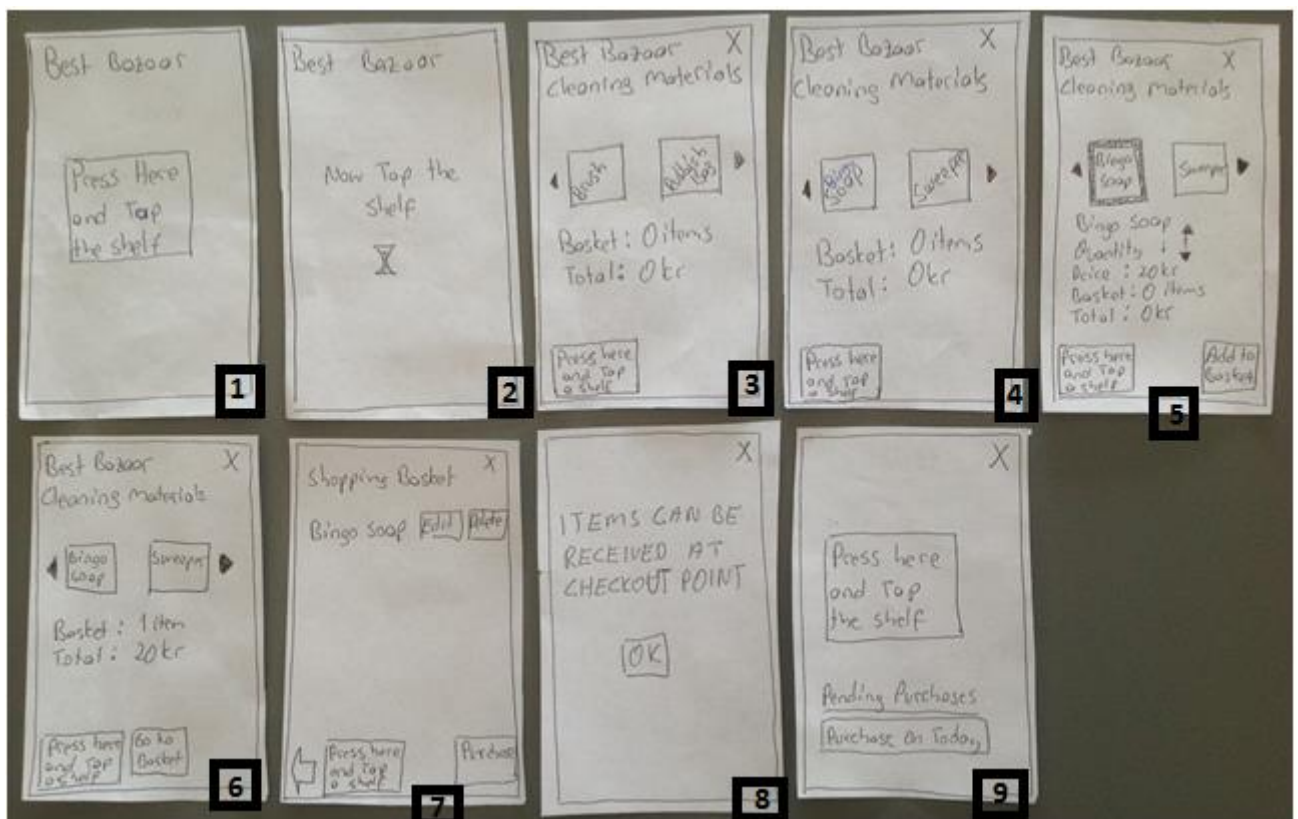
Prototype Set 3 Modified Low Fidelity Paper Prototypes

Prototype Set 3- Drawing 5 is the modification that is a merged form of older Prototype Set 2- Drawings 4-5 and 6 into one. This idea was coming from the 2nd participant of the evaluation and taken to consideration since with this modification system is more useful in a way that decreased user clicks and taking the user's attention to one screen where one can

still navigate the products and add them to basket by specifying the quantity as well informed for the price.

A new feature is added to prototypes, even though it was not included on field test prototypes, users were conjecturing that a shopping basket exists, with this modification shopping basket is more concrete. Reason the shopping basket was not included in the test task, because the focus have taken place on system's overall goal as getting the products from specific shelf and navigation within the products.

Prototype set 3 - Drawings 8 and 9 are also modified screens, from now on users are able to edit the shopping basket even though they sent it to checkout point.

4.7.5 Heuristic Evaluation: Iteration 3

After the modifications, Heuristic evaluation has been applied to prototypes. Still with one product purchase goal, Heuristics revealed usability problems such as Visibility of the System Status, Recognition Rather than Recall. Prototype Set 4 is the modified version- Appendix 6 shows the original whiteboard drawings- from the previous prototypes in consideration to above usability principles.
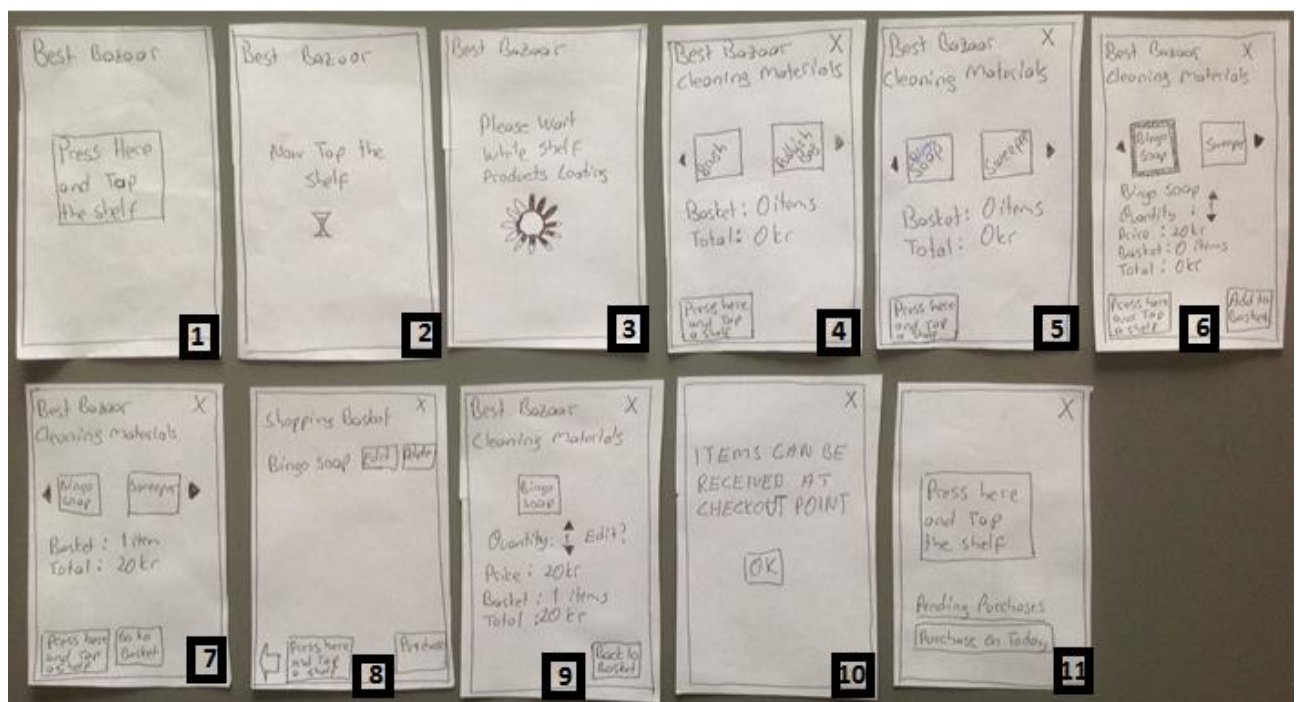
Prototype Set 4 Modified Low Fidelity Paper Prototypes after Heuristics

Prototype Set 4- Drawing 3 is an output from Heuristic of Visibility of the System Status which informs the user when the product information is being fetched from the system. This page informs user and gives another opportunity to developers to set timeout for error handling in such situations if the product information cannot be gathered. With this, system can give an error message to user such as "Please contact to store staff".

Prototype Set 4- Drawing 9 is revealed from another Heuristic that is the Recognition rather than Recall. With this page, in case of editing a product in the shopping basket, the user is not shown other products than the one is editing also user do not need to press extra buttons in order to update the product –in this situation the quantity- besides explicit update information. Then one just need to press "Back to Shopping Basket" button and system automatically updates the quantity set by user as well as turns back to previous screen.

4.8   Use Cases

Use Cases define the static behaviour of the user-system interaction. At the research project, use cases took their form after the prototype evaluations. Use cases illustrate a user point of the system, their reason to use the system. At section 4.8.1, overall system scope can be seen. Within the research project, use cases addresses two types of users-actors to interact with the system.

In general terms, use case diagrams consist of actors and the association to the boundary of the system that encapsulates the behaviours into the modelling language namely Unified Modelling Language [65]. Use cases simply, highlights the reasons to use the system with actor-behaviour associations enhanced with the scenarios namely use case scenarios[65].

One important point is the descriptions being used for use case definitions. Use cases should be defined with as much as clear and simple words- noun and verb- that describe the main capabilities of the system when the actor interacts. Other important point is actors, which can be the main users of the system-primary actors- and others-secondary actors- who help primary actors to accomplish the given use case(s). Secondary actors can be the other users who also partially interact with the system or other external intelligent systems or databases that help primary actor to accomplish the use case(s).

Project aims to provide a solution for the senior citizens-primary actor- while partially interacting with secondary actors-store staff- to accomplish the tasks. Essential goal of the use cases is to define the flow of behaviours-can be seen at Use Case Specifications- and have the main flow of the all possible events that the primary and secondary actors can be. Behaviour consists of six different aspects, respectively they are; the actors, preconditions,

and action that triggering event, flow of events, post conditions and the alternative flows for the each event can take another flow alternatively to accomplish the task. Use Case creation is based on the brainstorming, low fidelity paper prototype evaluations and the stakeholder interview parallel with desk research.

4.8.1 System Definition with Use Cases

Figure 10 shows the Use Cases within the system boundary. The full system works with the two actors, primary and secondary actors. Senior Citizen is the primary actor of the system for who the system will be designed for while Store Staff will be using the system in order to help to realize the primary actor's use cases; such as products declaration and receiving the shopping basket information from the Senior Citizen.
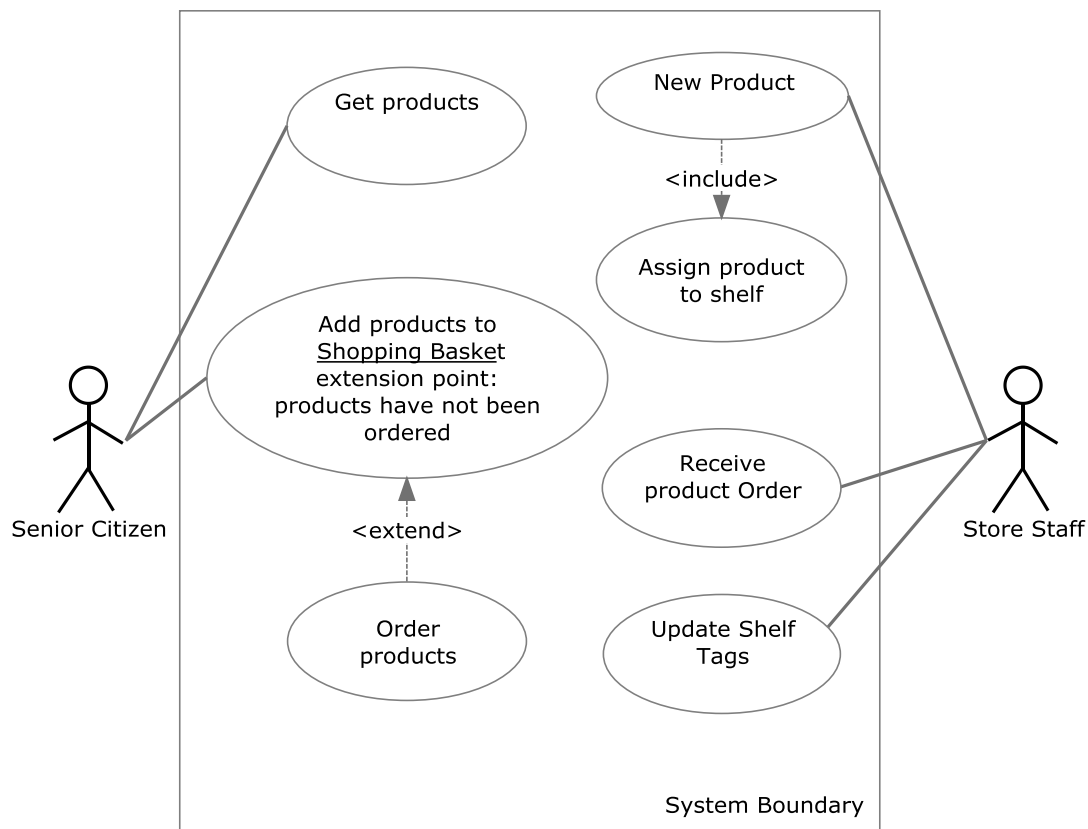
Figure 10 Use Cases

Use Case specifications can be seen at Appendix 3.

4.9   Software Requirements Specifications

At the software development projects, most critical part is the specification of requirements, namely Requirements Engineering[66]. At the sequential development process, requirements engineering occurs at the beginning of the project and implementation starts based on the requirements until the test of the overall system. At the iterative and incremental methodologies, requirements engineering is a lifetime process since each of the iterations will bring out new requirement to be involved. Likewise in the research project, Agile Development employs lifetime requirements engineering, after implementation and test of the each functionalities, there is a high possibility of adding new requirements, so the system increments based on iterations. Another reason of this vitality, requirements specification should encapsulate and reflect the analysed research data to the future implementation phase that will be delivering the software needed.

In the research project, requirements specifications are classified in two subsections of the software development cycle. First form is the functionalities of the software with behavioural statements that realizes the user needs by implementing them using programming languages-Functional Requirements. Second form is the basis criteria of the implementation that will be assuring the elements of the quality for the user's need, namely Non Functional Requirements. While the specification of the functional requirements are the critical for the desired system's delivery, non-functional requirements, as stated, are the quality assurance factor of the desired need.

Non-Functional Requirements (NFR) are the essential elements of the system's quality that increases the success rate to deliver user needs that defined by functional requirements[67]. Also, in the field of software engineering, specification of the NFR is one of the difficult are to deal with[66] since the higher success rate requires more deep thinking on particular aspects that creates the result. System quality can be consisting of many factors. McCall introduced quality parameters in 1977; parameters can be seen on Appendix 7. Parameters consist of the system quality metrics[68][69] some of them are Traceability, Security, Operability, Access Control, Error Tolerance, Hardware Independence, Consistency, Simplicity… Applicability of the metrics subjective to system architect while those metrics are covering different sections and topics of the computer science. Involvement of the metrics and being able to elicit the related functional and non- functional requirements requires amount of specific knowledge based on professional experience. Also, after elicitation, requirements should be clustered so that they can be related to particular quality metrics[70].

Existence of the structures help requirement engineers to cluster the quality assurance aspects-NFR-to more high level definitions[66]. Extend PLUS[71] is one way of non-

functional requirement specifications structure that extends the use case specifications by adding Performance, Security and Usability requirements. Extend PLUS uses the UML (Unified Modelling Language) and it is advantageous in sense of putting the non-functional requirements into design artefacts, however, it does not fully include the software quality parameters.

Another structure is called FURPS which is the abbreviation of the Functionality, Usability, Reliability, Performance and Supportability. FURPS has been used by IBM for many years in order to capture architectural requirements[70]. FURPS is a framework that is covering the quality assurance parameters in a systematic and structured way [66][70]. FURPS has been appropriate choice for the project since it encapsulates the most of the quality parameters into the structure that can be formulated for the proof of concept high fidelity prototype.

Table 5 shows the detailed explanation of the FURPS with the aspect-factor and explanations that are the quality parameters used for the research project:

Aspect	Factor	Explanation with parameters
Functional Requirements	**Functionality**	All functional requirements that delivers the features of the system, the functional requirements emphasizes the degree of the level to assure security, operability with generic definitions in order to assure the quality with the capabilities of the system from users perspective. Mainly the requirements that realizes the use cases.
	Usability	The user aspect of effectiveness gathered from field evaluation. Usability heuristics enhancement with the target users.
	Reliability	Testing the system's reliability with developer created code based on requirement engineer's test cases, which are suitable to real life situation. The test cases and their implementation namely called *mutated code*[66].
	Performance	Performance evaluation criteria that assures the predefined process-response times.
Non-Functional Requirements	**Supportability**	Ability of extending the project and ability of adaptation of the project to the environments that requires the same need. Those

		aspects can be grouped into Maintainability that can be created in architecture, design, and source code implementation stages.

Table 5 Requirements Classification table

4.9.1 Functional Requirements

Functional Requirements form the solution for the problem area as they are elicited from the literature review, stakeholder interviews, prototype evaluations and Use Cases. It has seen that, proposed solutions concentrated on product's individual tagging or with RFID else with Barcodes, however expenses for RFID tags and their position-dependency still require the users to physically reach those tags, these reasons altered RFID technology. Even though it does not bring any expenses, barcode scanning has seen to be the disadvantage for the senior citizens to focus their smartphone to individual products and still they needed to reach them if they are positioned at the top or bottom of a shelf. These limitations also address to the research question" *Which communication technology would be easy for the senior citizens to choose the products?".* When those considerations applied to design process-Section 2.2- NFC has been proved as the appropriate solution for the senior citizens. This approach brings out two favours; easy and seamless information retrieval-each shelf includes an NFC tag that contains products URL provided by backend- and lower expenses to get the products information.

As the term, Product is a definition of a physical good at the stores which are able to be declared in the cyberspace with basic attributes that are able to deliver the basic specifications a person need while shopping. With the brainstorming, inspirations and the user field studies, a product's basic values are identified as its name, its description, its price, its expiration date and the most important that plays the role for a product to be recognised is its picture.

Another term is the Shelf. Shelf has been the other basic virtual and physical component that plays a big amount of role to combine online and offline shopping characteristics. From the research and stakeholder interviews and the field studies it is seen that, a shelf is a very useful everyday life tool for shopping which also can be positioned at the cradle of the problem. A shelf is a reason that the senior citizens mostly ask for help. It is strategically decided that the shelf will be the gate to the cyberspace since it is the latest spot that the senior citizens can have a touch and feel of a product and it is also the spot that senior citizens can have the difficulties for manoeuvrability as well as handle the product carriage. So, in sense of if a shelf would be providing information about the products that are lying on via a seamless connection by using ICT technologies, that would be the right combination of

online and offline shopping aspects, it would be an appropriate help for the senior citizens shopping difficulties as well as store staff to provide information about the products as well as interaction with them without any physical help. This assumption also enhances the idea of the Ubiquitous Computing Environment while embedding a computing device into an everyday life tool to solve a specific problem. At the high level, this approach is not unique- other solutions also provide specific information about the products with different tagging technologies- however, when the solution is enhanced specific tasks for the users; for example showing the store' shelve as a shopping catalogue, this approach gains unique competences. Easiness with the content declaration-products and shelves- as well as easiness with the retrieval of them puts the approach on right track that altered the expenses of other solutions as well as outcomes which does not fully cover the shopping difficulties that yield dissatisfaction.

Since this approach has been altered at the solutions as seen on literature view, the idea has seen worth to be prototyped and tested with the users. When the low fidelity prototypes empirically tested with users - as well as heuristically by the evaluator- the outcome has been satisfactory to continue the project and the data was enough to describe the use cases and scenarios in order to capture the functional requirements.

At the literature review solution section, MyGrocery and iGrocery have been analysed as the inspiring solutions however it is also seen that they have been lacking the picture capabilities of a product that would improve usefulness as it is also underlined by the prototype evaluation participants. Another inspiring and recent approach is that Point & Find which is a solution at the market that returns the picture-price and related information of a product. This can be related to evolution of the Mobile Computing with the evolution of the Radio Frequency Technologies as seen on literature review *Graph 1 Evolution of Radio Frequency Technologies*. When we look all those from up, a picture-name-price and the expiration date have been the necessary attributes of a product to be described to the user. This is the point the Functional Requirement 1-Table 4- has been elicited also as the answer for the research question "*How to present the products to help senior citizens to choose them on mobile device?*"

At the literature review, all the solutions required users to physically pick the products on a shelf while they are in store- iGrocer, MyGrocer in store scenario, Ubira- and this approach has been analysed as a contra to the target users' physical conditions. There needed to be a feature which could enable senior citizens to see the products and add it to shopping basket in a virtual world where the basket information can be send to the store staff in case of purchase decision. The purchase and the notification of the store staff for those products

address the research question *"How to notify the store staff for products that have been chosen by senior citizens?"* This potential feature has been described by the Use Cases 2-3-6 with the interactions. Senior citizens had to be enabled to perform three steps as navigating-highlighting and adding products to the virtual shopping basket and sending these products to the store staff so they can be collected. As it is also described at the literature review-Online to Offline Shopping- these three steps are the basis for the integration of Online to Offline shopping. Functional Requirements 2, 5, 9 have been elicited in order to enable the senior citizens and the store staff to perform activities as also described by Use Cases 2, 3 and 6. Moreover, Functional Requirements 4, 7 and 8 have been elicited that ensures the manageability of these features by performing Create-Read-Update-Delete actions.

Table 6 shows system functional requirements as the statements.

ID	Statement
FR1	Senior Citizens shall be able to get relevant product's information include picture, name, price and expiration date
FR2	Senior Citizens shall be able to create a virtual shopping basket by choosing multiple products from different shelves
FR3	Senior Citizens shall be able to be informed about the number of products and total sum of the price for the products at virtual shopping basket
FR4	Senior Citizens shall be able to manage –update, delete- products at the virtual shopping basket
FR5	Senior Citizens shall be able to send the shopping basket to Store Staff
FR6	Store Staff shall be able to manage NFC tags by writing the shelf URL
FR7	Store Staff shall be able to CRUD shelf information links
FR8	Store Staff shall be able to assign products to a shelf by creating-updating and deleting product information
FR9	Store Staff shall be able to receive product orders simultaneously

Table 6 Functional Requirements

4.9.1.1   Requirements Traceability Matrix

Traceability matrix guarantees the system's use cases are fit by functional requirements. A nuance in this approach is that is the many-to-many relationship between requirements-use

cases where each requirement must be traced by a use case as one requirement can be traced by more than one use cases. Traceability matrix is also helpful for the black box test cases that prove the implemented system is meeting with requirements and the use cases. Table 7 shows the tracing of the Functional Requirements and the Use Cases.

UC/FR	UC1: Get Products	UC2: Add Products to Shopping Basket	UC3: Order Products	UC4: New Product	UC5: Assign Product to Shelf	UC6: Receive Product Order	UC7: Update Shelf Tags
FR1	X						
FR2		X					
FR3		X					
FR4		X					
FR5			X				
FR6							X
FR7					X		
FR8				X			
FR9						X	

Table 7 Requirements Traceability Matrix

4.9.2   *Non Functional Requirements*

Table 8 defines the non-functional requirements that are related to system quality assurance. Table is sorted with the aspects of the Usability, Reliability and Supportability of the system that will be used and managed.

Aspect	ID	Statement
Usability	NFR1	Frontend shall render the product's price-expiration and quantity spinner whenever a product is touched
	NFR2	Frontend shall render the add to basket button whenever the quantity spinner is

		edited
	NFR3	Frontend shall enable users to edit shopping basket by rendering all products in a list view with quantity and delete buttons
	NFR4	Senior citizens shall be able to seamlessly get the product information lying on a shelf with an interface that informs the user for the retrieval process of the pictures
	NFR5	Senior citizens shall be able to interact with the system with standard buttons that performs the same functionalities. Examples: Standard Back Button, Standard Shopping Basket Button etc.
	NFR6	Senior citizens shall be able to edit Shopping Basket even if they pressed the Purchase Button. System should be able to recognise their latest shopping purchase
	NFR7	At the mobile frontend, whenever a product picture is touched, system shall be responding the senior citizens by highlighting the product's picture as well as rendering the price, description and expiration date within neighbourhood of the product picture
	NFR8	All error messages shall be able to be transferred to user interface within understandable message screens
	NFR9	Senior citizens shall be able to quit from the application on each states. If the user quit when one had a shopping basket, system should recognize the shopping basket
Reliability	**NFR10**	Whenever the S3 repository is not authenticable, system shall render an error message Mutated code tip: enter wrong authentication details after creating the product successively
	NFR11	System backend shall be running on RESTful Web Service
	NFR12	At the initial loading of the products and during the usage process if the connection is down, frontend application shall simultaneously render the error message related to the server status code received
Support ability	**NFR13**	Shelf/Product URL shall be transferred to shelf tags by using NFC technology. Implementation of NFC technology shall be able to be replaced by other communication technology that addresses the same purpose without changing the system's architecture. For example UHF tags, Ultrasonic Data Exchange

		technologies, Voice Control technologies.
	NFR14	Mobile frontend shall be able to be installed from Google Play
	NFR15	For each client-server response duration, application shall inform the user with loading icon
	NFR16	Mobile frontend application running device shall have internet connection
	NFR17	Mobile frontend application running device shall have NFC hardware and have related permissions to access the capabilities
	NFR18	Mobile frontend application use cases and functionalities shall be tested with test cases implemented with JUnit
	NFR19	System backend application use cases and functionalities shall be tested with Capybara test framework

Table 8 Non Functional Requirements with FURPS framework

5. The Proof of Concept

In this section, proof of concept implementation's first iteration will be explained. Before thay, first approach will be the definition of the high level system architecture and its enhancement with Object Oriented Analysis[72] tools in order to put a vocabulary for the system's high level classes and their responsibilities. Then, before any implementation, Object Oriented Design[72] will be enhancing the behaviours to vocabularies defined in the analysis in order to accomplish the Use Cases.

Next, still within the Agile Development Methodology philosophy, each of the functionalities will be written as stories that can be implemented. Functionality stories will be another framework for the agile development which is useful tool for establishing a communication with the stakeholders as well as other potential team members in the future of the project. Also, defining the functionalities with the stories ensures the system is being well defined. Functionality stories do not need to be understood by only developer or other potential developers-designers, they are useful to establish an agreement with the project's technic or non-technic background stakeholders (customers, end users) to ensure the system is being developed as it is needed.

Implementation will start from the most critical requirements that make the system's baseline to work as well as ones bring the elementary functionalities to grow by adding new functionalities on the top of them such as a spiral model.

After the functionalities-backend and frontend- implemented and tested, if the system becomes to be able to shown to stakeholder (customers and end users), their feedbacks will be taken to consideration and if considered as necessary, requirements will be modified or new ones will be added so the system will have evolution.

5.1   High Level System Architecture

Following sections will be describing the system from the most generic form to the technical architecture with implementation details.

5.1.1   *The Context diagram: Terminators, Flows and Processes*

The purpose of the context diagram is to bring an overview to the system with the limitations from the most top position[73] that answers the research questions. Context diagram views the system components, other systems that the system should interact and even the stakeholders as an answer to the research questions. Limitations have been analysed through the domain knowledge gained from the literature review, stakeholder interviews and prototype evaluation with users.

At the literature review, it is highlighted that the different solutions address different business contexts that are solving a particular problem; iGrocery is a solution for weaknesses of the Supply Chain Management, Ubira is an integration of Online shopping to Offline shopping with the focus of price comparison and product/price recommendation, Point & Find is an another approach to Online to Offline shopping with product/price recommendation. However, all the solutions address a particular case, as they have been limited within a particular problem area. Context diagram is an emerging solution from the research questions supplemented with literature review and Use Cases as a specific solution that empowers senior citizens to have a better shopping experience so they can socialize.

Context diagram-Diagram 2- represents the highest architecture of the system with its limitations as the external components that make it work through their communication-information retrieval and process, users' interaction. Each limitation, namely terminator and its flows represent the external system that is needed for fully implementation. Terminators-rectangular shapes- delivers inputs and receives outputs through data flows and control flows. A process-circle shape- is mainly a system that delivers the user needs by interacting with the terminators. Diagram 2 represents the overall architecture of the system that consists of two context diagrams nested to form the full system.

At the literature review-Shopping Barriers for Senior Citizens- it has seen that carriage of the goods is one of the main barriers that decreases the shopping satisfaction. Also, it is seen that, the delivery medium is moving towards to be a part of the ecosystem since it is expensive for both customers and individual stores to handle their own deliveries-Literature Review Online and Telephone Shopping Services for Senior Citizens- the Shipping Medium is put as an external system that handles the delivery of the goods. Another coming up is that, the role of the Supplier plays a focal role-Literature Review Solutions MyGrocer- to provide the products and their information to the stores. Lastly it is also seen -Literature Review Solutions Ubira, Shoppulatto and Point & Find- that product recommendation is a major feature for all types of customers. Product Recommender is an external system processes the User Information with sufficient algorithms and returns the Recommendations. With this domain knowledge, the overall system is founded. Overall system interacts with four terminators-Shipping Medium, Supplier, Product Recommender, and Resource Planning- creating the ecosystem of the supply chain where the shopping assistant plays a role to reach to the customers more easily as aimed by the MyGrocer architecture- Literature Review Solutions MyGrocer.
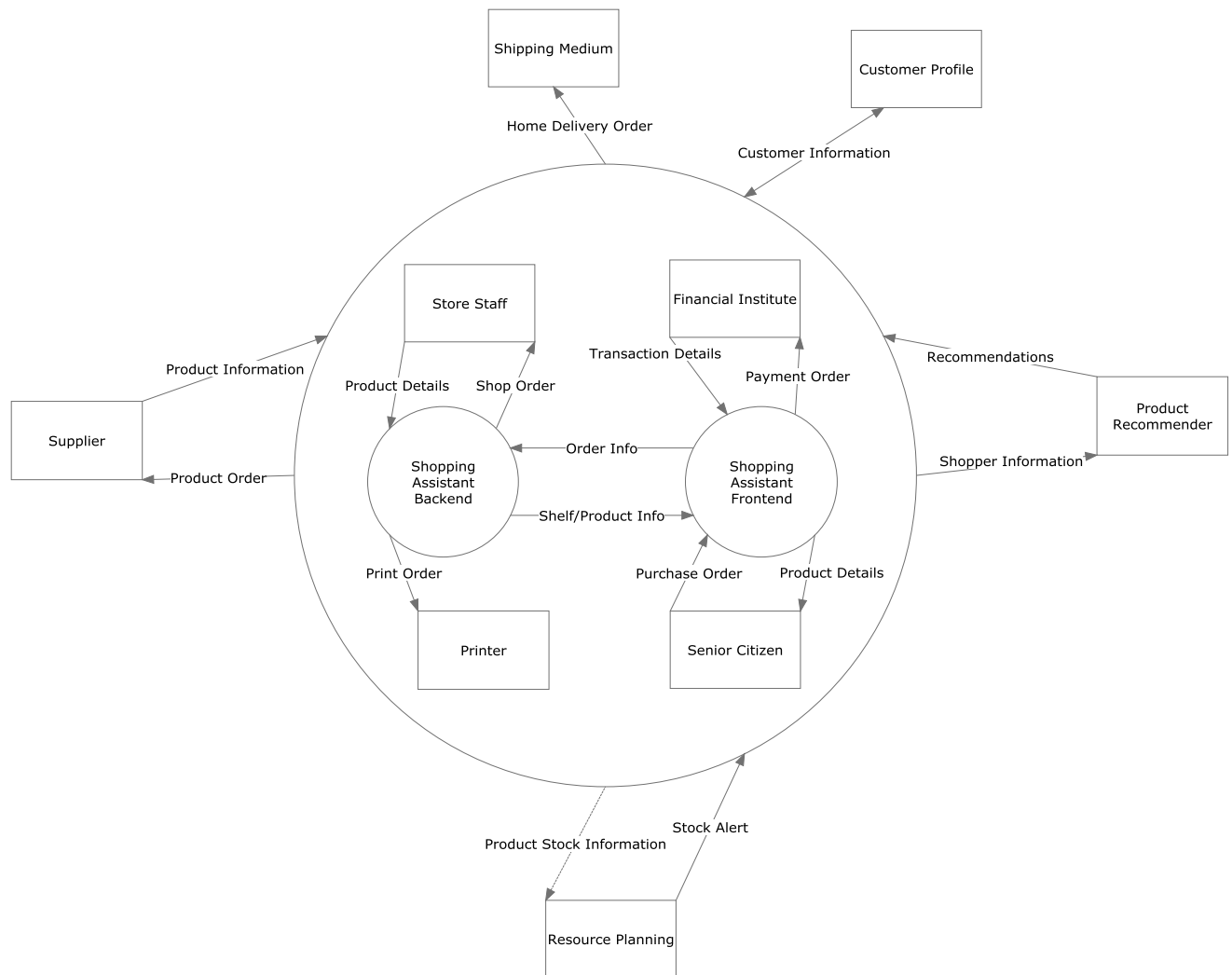
Diagram 1 Context Diagram

At the centre of the system, two nested systems exist, namely Shopping Assistant Backend and Shopping Assistant Frontend. Two nested internal systems form the solution by considering the research questions. Backend is mainly fed by the Store Staff which is a user provides the product details obtained from the Supplier. With this information, Backend is able to provide information about the products on shelf-Shelf/Product Info- as the main data for the Frontend system to process.

Frontend processes the Shelf/Product Info by Senior Citizen's interactions that consist of getting the Product Details and providing the Purchase Order processes. As the Purchase Order information is provided, depend on the Senior Citizen's choice-home delivery, store delivery, electronic payment or cash-Frontend is able to perform the payment transaction with the Financial Institute and forward the Order Info to the Backend where the Store Staff is able to Print the related products by performing Print Order process, while the point of sale payment is being performed.

With the limitations above, analysis and the design will be concentrated only on the Shopping Assistant Backend & Shopping Assistant Frontend to answer the research questions focusing on Senior Citizens and partially the Store Staff[8].

5.1.2   *Technical Architecture: System Backend & System Frontend*

In the favour of a generic, easy to deploy and manageable solution for the stores- regardless the brand of the store and size but the ones that serve the products on aisles- the cloud computing advantages is taken to consideration. The reason for such decision is that the solutions at the literature review have been focusing on particular shop that would need to have to deploy the system on their servers, none of the present grocery shopping solutions based on the cloud computing. Cloud computing has many advantages for deployment and management prices as well as the possibilities to reuse the components moreover other stores can easily setup the system, in sense of scalability. Another technology decision is for the product identification. At the literature review it is seen that, RFID or Barcode Scanning technologies have disadvantages as expenses to implement- tagging each product with RFID tag- or usage difficulties –focusing camera as barcode scanner to each product- and overall those two identification technologies are contra assumption to the problem space since the aim is to letting senior citizens freely move and handle their shopping in the store without disruption by their potential physical problems- bending down or reaching forth.

Finally, system target users-senior citizens- enabled through fully mobile solution with the usage of the open standard HTML5 technology and it is harmonisation with operating system's accepted development language- Android OS is taken to consideration[9]

The overall system architecture of the system consists of "System Backend", "Mobile Backend" and "Mobile Frontend". System is a client-server architecture where the client is the "thick client". Dilemma 2 brings a deeper understanding to use thin client or thick client.

Thin Client vs. Thick Client[74]

In the client-server architecture, difference between the thin and thick client comes up with the responsibility of the workload to be processed by client or server. A thin client is mostly dependent on the server to process the data whereas the thick client does the data processing as much as it can then send the pre-processed data to server for the final process. The reason system

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[8] Due to the research scope, there was not any study for the store staff.

[9] Andorid OS enabled devices has the highest market share have been keeping the ascendance since the release and forecasted to keep the market leadership in near future, within 2015[92] At 2013, 900 Million Android Devices Activated[93]

uses the thick client is the matter of the context. System addresses the application to be used in offline context for online data; more precisely users will be in grocery shops where the frontend should be as much as dynamic for creating and editing the shopping basket. With this assumption, a server dependency for shopping basket is a factor of slower data processing –in case of adding new products and editing them in shopping basket- so lower shopping satisfaction for users. However, on one hand it is clear that thick client is dependent on the device's hardware and operating system specifications on the other hand nowadays smart phone hardware is in such state that has competence with notebooks.

Dilemma 2 Thick client or Thin client

Drawing 2 shows the high-level system architecture.
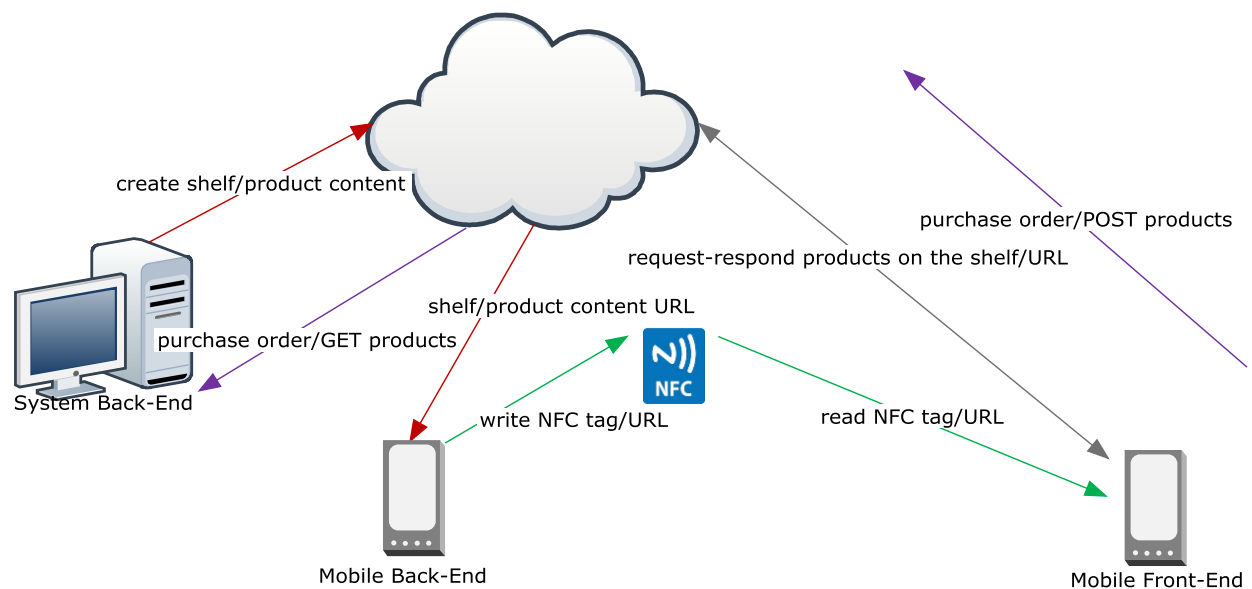
Drawing 2 High Level System Architecture

System Backend is responsible for creating the product content. Product content includes product's name, price and picture as well as the shelf belonging information. Another responsibility of the System Backend is to receive the purchase orders sent by Mobile Frontend.

Mobile Backend is responsible for encoding the shelf tags with created URL by System Backend. Mobile Backend is able to reach to shelf based URLs and encode those to NFC tags so that users can navigate upon the products only exist on a specific shelf.

Mobile Frontend, project's focus area, which is responsible for reading the tags and getting the products belong to a shelf. More precisely, Mobile Frontend only connects to web page whose URL is written to NFC tags and gets the related products just like a shopping cart.

5.1.3   Object Oriented Analysis

5.1.3.1   System Analysis: State Diagram

UML State charts are most often used for low-level design, like modelling the internal behaviour of a complicated class. But they are also useful on a higher level on modelling different states of a whole system; this can be compared to the usage of class diagrams on several levels[75].At the research, state diagram has been the helpful tool for gaining a unified description of the Backend and Frontend states by taking the Context Scenario-Section 4.4.1- as the reference. State diagram consist of the states (Start State-States-End State) and the transitions. States describe the system's behavioural points, which are reached by the processes and conditions, namely transitions. Purpose of the state diagram is to realize the behaviours of the Use Cases-Section 4.8- within the boundaries of the Context Diagram-Section 5.1.1- Shopping Assistant Backend and Shopping Assistant Frontend. A transition may consist of three parts; Event, Guard and the Action (Event [Guard]/Action). Event is the main triggering factor of the transition to be performed and moved to the next state where the Guard is the additional condition if it exists the Event can be performed so the transition. Lastly, the action is the process that will be performed during the transition and its accomplishment brings the related transition to be performed in order to pass to the next state.

Diagram 2 State diagram of, a technic view of overall system

Figure 11 is a state diagram definition of the overall system process that starts with the frontend user's tag read action ends whenever the users received the products physically.

State diagram illustrates technic point view of the system with the self-understanding by taking the URL as the input.

5.1.3.2   System Analysis: Block Diagram

Diagram 3 shows the block diagram focusing to the static view of the system. Block diagram consist of the principle parts that realize the behaviours described by the Context Diagram – Section 5.1.1.2 Diagram 2.

Context Diagram consists of two interdependent Context Diagrams, which are System Backend and Mobile Frontend, has been explained with the behaviours above state diagram, at section 5.1.3.1 that have been realizing the Contextual Scenario-Section 4.4.1. Besides the implementation details, block diagram show the system in a generic view that is analysed with interdependent parts also realizes the technical architecture- Section 5.1.2.

Block diagram addresses to the distributed systems, their communication brings the possibility to complete a shopping task with the interaction of senior citizens as defined by Use Cases, defined at 4.8.1

Block diagram consists of System Backend, Mobile Backend, Mobile Frontend as well as Shelf Tag.
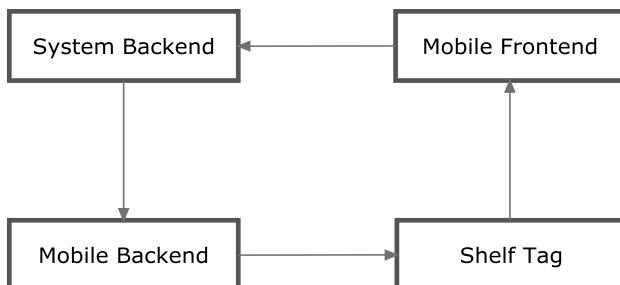
Diagram 3 System Block Diagram

The definitions of the blocks are as following:

"System Backend" is able to create the links which route to the products on a shelf. Links are reachable by the "Mobile   Backend" which is responsible for writing them to the appropriate "Shelf Tags" by store staff.

"Mobile Frontend" is the one that is able to read the link from the "Shelf Tag" and enables the senior citizens to choose the products and send them to the "System Backend".

5.1.4   Implementation Decisions

A various programming languages can be used in order to implement the system backend, such as Python, PHP, Ruby or Java Also, mentioned programming languages supported with the frameworks to minimize the development duration and code maintenance such as

Django[76], Zend Framework[77], Ruby on Rails[78] and PlayFramework[79]. All can provide RESTful[10] web services and able to take the advantages of cloud computing.

Using the Ruby language with Rails framework seen as an appropriate choice since it has seen many advantages for the project's particular development case as the aim is to develop High Fidelity Prototype using Agile methodology. Advantages of the Ruby on Rails applied and explained at the rest of the sections, however, in terms, as the most important reasons for the choice of the Ruby on Rails framework, Ruby ActiveRecord Pattern, Ruby Gems and the Ruby Asset Pipeline highlighted as following.

Ruby on Rails framework[11] is a Model-View-Controller architecture, which works flawless with Sequel databases by using Ruby ActiveRecord. ActiveRecord is a design pattern to store data in relational databases. Ruby ActiveRecord implements the Object Relational Mapping[12] in its libraries. Rails is compatible with many relational database management systems such as MySQL, SQLite and PostgreSQL. PostgreSQL has been the appropriate choice since its compatibility with Heroku cloud application platform.

Ruby Gems can be considered as the reusable building blocks of any Ruby on Rails application that provides the set of functionalities for particular cases to handle the most important issues. The absence of Ruby Gems would generate huge implementation-test costs for any developer. Presence of the Ruby Gems brings decreased amount of time-workload to spend and code reliability favours while they have been used and tested by many various developers in the community.

The asset pipeline is an inner framework to handle serving the external JavaScript and CSS libraries (assets) by having the advantages[80] of *concatenating, minifying* and *compressing* them into the one centre[13] file in application directory. These advantages are returning as reduced number of request-responses for a web page, reduced space for files and ability to code assets with high level languages like CoffeeScript to code JavaScript or Sass to code CSS libraries.

---

[10] REST stands for Representational State Transfer. REST emerged with the Web 2.0 as a design pattern with set of rules simplifies the reaching the Resources such as Web site, HTML page or a physical device with human understandable URLs by using HTTP actions such as GET, PUT, POST and DELETE[94][95]. Main approach of the REST is simplicity. All the services that use simple REST rules called RESTful web service.

[11] Rails Version 3.4 is used and following explanations are related to Version 3.4

[12] ORM is a database design method for mapping the objects into database tables. ORM design method takes the system objects, relationships and their behaviours into consideration[96].

[13] application.js for JavaScript library files and application.css for CSS library fies

Rails framework provides useful commands, as they are executable from a command line[14] to create individual[15] models, views, and controllers also database tables for the models with their attributes and relationships between upon. Ruby on Rails employs Object Oriented programming approach where a Model can be sorted as an object with its attributes and Views-Controllers render related Models with HTML5-Javascript and CSS3. Rails provide command to describe relationships[16] between Models, so that the database tables and their relationships can be established. With the ActiveRecord it is able to add new Models or new attributes to already implemented Models with commands, called Migration[17]. One of the biggest advantages of ActiveRecord is the option to recover the database previous versions[18].

With the arguments below, it is seen that Rails architecture is cut out for the Agile Development; all the objects, views database tables can be spirally incremented (else the contra) in case the new functionalities or modifications needed.

Mobile frontend is chose to be a Hybrid Android application as it is decided to take Android's advantage since it is the highest market share. Hybrid applications are the combined form of the Native applications- ones using the specific vendor platform's compatible languages and SDKs, for example pure Java written Android Application- and Mobile Web Applications-using the features of HTML5- that provide big advantages for specific scenarios. In this research, it is seen that the product information will be already provided by the backend as HTML5 pages and as long as it will be provided in a stable environment it had to be reused, on the other hand, NFC hardware had to be used in order to get those URLs containing the product information. Hybrid application is a fitting concept since the advantages of Native libraries- consistent way to reach NFC hardware with Android Java libraries- and the Web Application to render those pages inside the application via WebKit as a product catalogue for the ones at a shelf.

---

[14] Ubuntu Terminal is used

[15] rails generate model *model_name*, rails generate view v*iew_name,*rails generate controller *controller_name* **also** it is able to create all Model-View-Controller in a scaffolded form by running "rails generate scaffold *model_name"*

[16] A one-to-many association example: rails generate model *model_name1* belongs_to *model_name2*

[17] rake db:migrate

[18] rake db:rollback

5.2   Implementation of the High Level Prototype

System requirements- Section 4.9.1 and 4.9.2- define the raw needs for implementation of wide range of software components while the Use Cases define the particular interactions of the users with the system. With the help of these tools, iteration compiled into User Stories-Sections 5.2.1.1 and 5.2.2.2 - in order to describe the raw needs of the user into the software that will be implemented during the cycle.

As the Agile Development Methodology is an iterative and incremental process, project started with the first iteration that is the implementation of the critical requirements and their tests. Critical requirements choice the ones that can create the baseline and grow and evolve with the users or stakeholders feedbacks in a spiral form.

Following sections will be explaining the implementation of the High Fidelity Prototype by applying the Agile Development Methodology.

5.2.1   Iteration 1

First iteration is started with the system's most critical requirements. The backend chose to be the critical point because it will be producing the URL that routes to the shelf-products information. With the system backend the content, the products on a physical shelf in shopping store will be served on the web. Products should be able to shown under a specific shelf so the users can retrieve all products with a URL defined as shelf and all products related. For the backend first iteration should have the ability to create-read-update-delete a product has name, description, price and a picture that will be belonging to a shelf. The user also needs to have ability to create-read-update and delete a shelf has a name and description. Besides two different models-products and shelves- user should be able to bind each product to a shelf, so the products can be shown under a specific shelf.

Next, parallel with backend, mobile frontend chose to be the critical point because it is the application that the senior citizen will be interacting with the system. For the first iteration, the Android application will be able to show the users products on a shelf provided by backend.

Dilemma 3 explains how the iteration was planned by considering the Requirements, Functionalities, User Stories and the Tasks.

> **Requirements -> Functionalities -> User Stories -> Tasks**
>
> As it is explained at the Sections 2.2 and 2.3, the differences of the Requirements-Functionalities-User Stories and Tasks are critical for the design and development of the system. At the research the requirements have been collected, by taking users feedback and scientific literature into the consideration. However, when it becomes to implementation of these requirements, followed technique let them to be gathered into the functionalities. In order to deliver the functionalities, user stories have been the iteration goals. However, user stories are written in a high level, user point of view language that would not be able to make sense for particular situations. In this point, as also suggested[81], user stories split into specific implementation tasks. Implementation tasks are technic point of view to plan and track the iteration where the user story is being implemented[82] in the boundaries of the Context Diagram, Technical Decisions and the System Analysis Block Diagram. Implementation tasks can be described with words as the milestones to plan the iteration[83] and track the implementation- Appendix 1 Milestone numbers 18 to 23

Dilemma 3 How to perform the iteration planning; using the tasks

5.2.1.1 User Stories

User Stories for Backend

Functional Requirement 7 addresses the system backend where the user should be able to Create, Read, Update and Delete the shelf information links. When it is alone, this requirement will not bring a big outcome to show to a stakeholder. However, when it is combined with the other interdependent requirements of the system backend, it will form a functionality that the stakeholder need. Functional Requirement 8 is the Creating, Reading, Updating and Deleting a product with its attributes defined and a product is depend on existence of a shelf which is defined on FR6. When a shelf can be created, then a product can be also created-so assigned to a shelf. These requirements can form functionalities, which can be defined as stories to make it understandable and simpler way. This is the advantage of putting the requirements into user stories that makes the sense to build the system. Another advantage is at the evaluation-test state where the iteration's user stories can be used as scenarios for low-level unit tests or high-level black box tests as well as building a communication with stakeholders since the user stories are simple natural languages.

Story 1.1.0: As a user I want to create a new shelf with its name and description so that I can assign the products

Story 1.1.1: As a user I want to create product content by its name, price, expiration date and picture and assign it to a shelf so that I can provide a shelf-catalogue look alike of products

User Story for Frontend

Functional Requirement 1 is "*user shall be able to get relevant product's information include picture, name, price and expiration date*". FR1 is a requirement that can be delivered as functionality itself. Following is the user story that ensures the functional requirement.

Story 1.2.0: As a Senior Citizen I want to see the products pictures of a shelf on my smartphone so that I can choose them

5.2.1.2　　　　　　Object Oriented Design: Sequence Diagrams

UML sequence diagrams are used to model the flow of control between objects[75]. Sequence diagram has been the helpful tool to illustrate the interactions in a specific duration. As the State Diagram-Section 5.1.3.1- and Block Diagram -Section 5.1.3.2- provides the information about the system's generic parts to realize the Use Cases and Context Scenarios, Sequence diagrams used in order to identify and illustrate the Use Case behaviours that accomplish the Functional and Non Functional Requirements-Section 4.9.1 and 4.9.2. – as they are described with the User Stories at Section 5.2.1.1

Each sequence cycle-shown by the numbers- describes a single task that a target user needs to perform in order to accomplish the user story.

In order to a product to be shown at the mobile frontend first of all the relevant product information had to be able to successively uploaded and retrieved from Web. Next, the system should aggregate the content (pictures and other information) to the mobile frontend in order to let the user interact with the virtual products and continue the shopping at the store.

Sequence Diagram for User Stories 1.1.0 and 1.1.1

Diagram 4 shows the sequence diagram as the series of processes for uploading and retrieving a new product's information to cloud picture repository (Amazon Web Services S3) with the system backend served from cloud application platform, Heroku. Sequence diagram proves the behaviours described by Use Case 4 and 5 as well as the user stories described under section 5.2.1.1 within Stories 1.1.0 and 1.1.1

First of all, the user (store staff) will need to trigger the sequences with "new product" request at the interface provided for Products. New product request automatically orders all available shelves and sort them by names as created by the store staff.

Next, the user will need to insert the "product name", "product price", "product description", "product picture" as well as the "product expiration" and set the "shelf name" that the product belongs to.
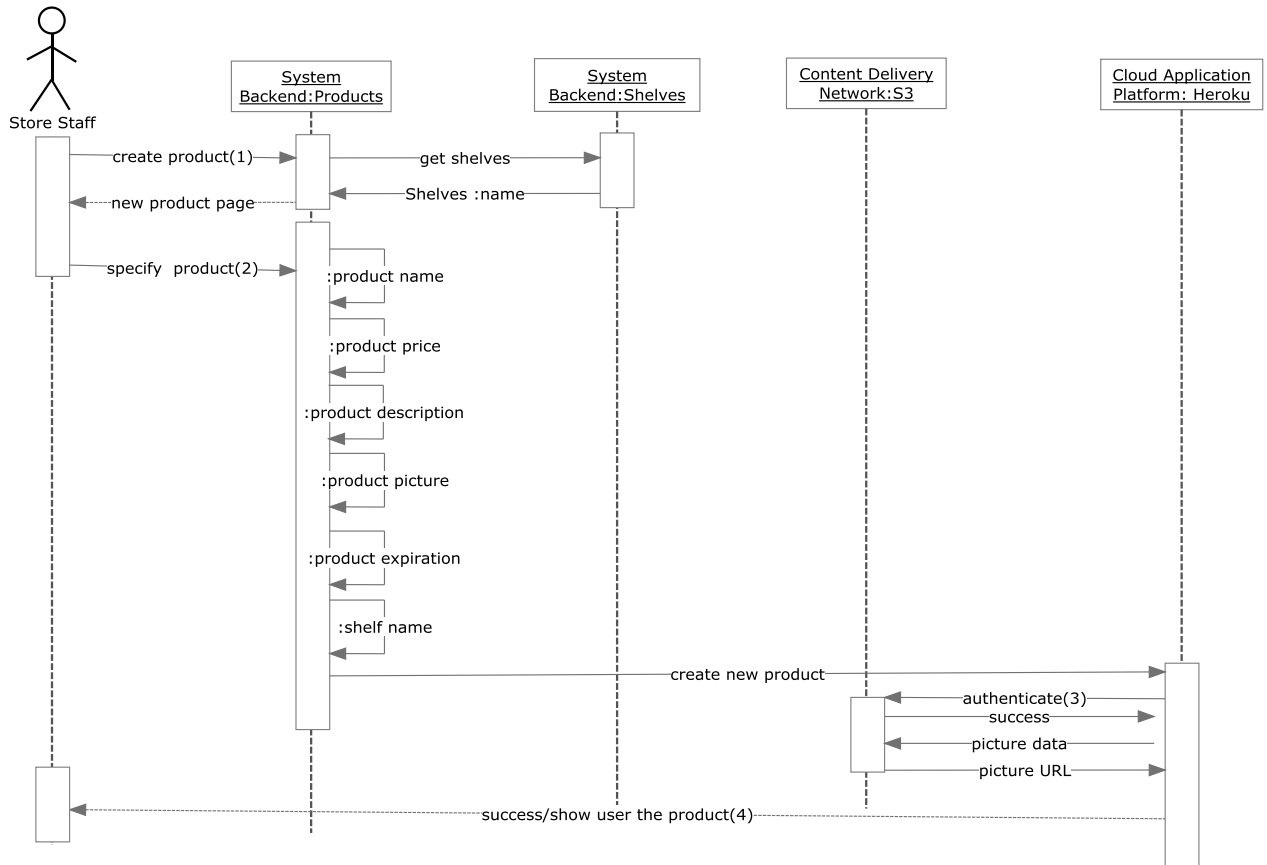
Diagram 4 Sequence Diagram for System Backend creating a new product and uploading pictures to cloud repository- More Readable Version is on Appendix

Whenever the user set all the required fields for a product, then product information is ready to be uploaded to the Web. Latest step to upload information to the web is to press the "create" button. As the user presses the "create" button, next sequences are handled by the system automatically.

The system- served from Heroku- sends the product picture data to the cloud storage-S3- after authenticating and cloud storage sends back the picture URL, which will be encapsulated inside the specific product information to be shown to the user.

Sequence Diagram for User Story 1.2.0

Diagram 5 shows the sequence diagram for the mobile frontend, for the usage of the senior citizens. As it is also described by the Use Case 1 and User Story 1.20, sequences will be triggered whenever senior citizens' will be touching "Tap to Shelf" button, then application will be activating NFC chip in order to read the shelf URL. As the shelf URL will be connecting to cloud-defined at section 5.1.2- to get the products details, these details will be able to be rendered at the smart phone, as the User Story 1.2.0 explains-Section 5.2.1.1
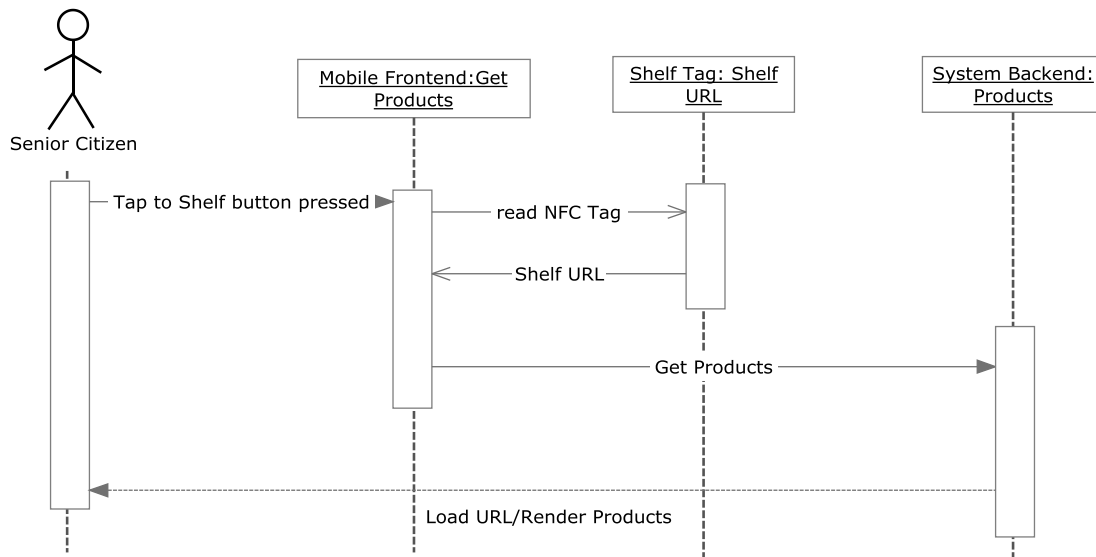
Diagram 5 Sequence diagram for Mobile Frontend to render the products

Mobile frontend sequences realized by a hybrid HTML5 & Android application; it is hybrid because the application connects the smartphone's NFC chip with Android-Java libraries to obtain the URL stored on the NFC tag and by using the URL application is able to connect to the web site where the product information (price, name, description, pictures) shown as an app look alike using HTML5 features. HTML5 features gives app look alike by using Javascript libraries to navigate between products, CSS3 libraries to give better look than older CSS libraries.

Moreover, Android OS is able to run WebKit browser engine that is implemented by Java libraries-namely WebViewClient- then HTML5 pages will be rendered via WebKit browser engine. With this way, the products will be able to be seen inside the application within the browser frame independent from the application buttons (quantity, add to basket etc. would be described as the 2nd iteration) that let interaction with those products.

5.2.1.3   Object Oriented Design: Class Diagrams

Following sections will be showing two distinct but interdependent class diagrams for system backend and mobile frontend.

Class Diagram for User Stories 1.1.0 and 1.1.1

Implementation of the system backend is form of the MVC architecture that has two models in one-to-many relation, Products and Shelves with their views-controllers. Diagram 6 shows the class diagram for the first iteration's backend and Screen Shot 1 below shows the "New Shelf" view deployed to cloud application platform Heroku.

Rails framework enables to use specific purpose Ruby libraries, called Gems. Ruby Gems are easy to use bundled set of functionalities for specific purposes that an application needs. There are various Ruby Gems for various purposes.
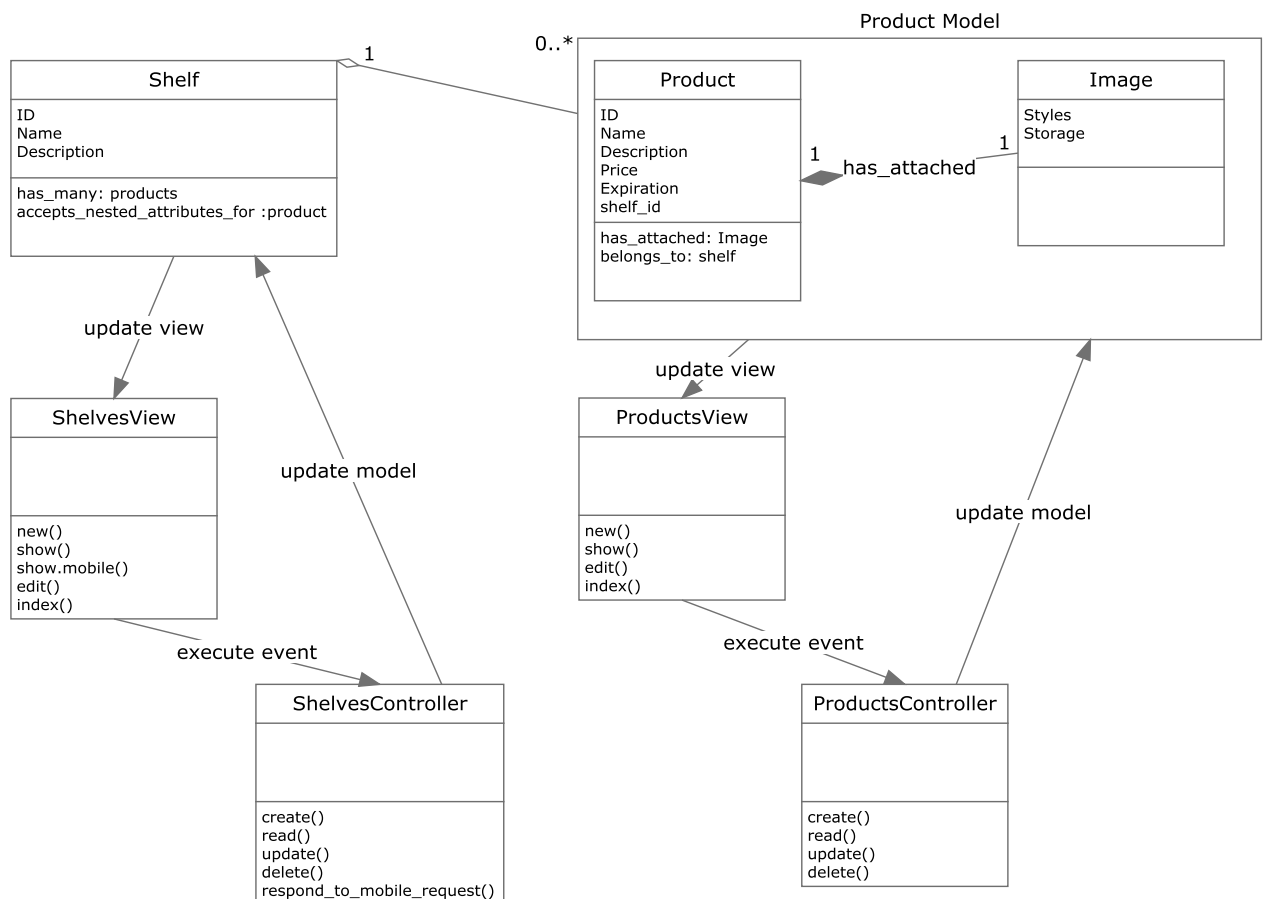
Diagram 6 System Backend: Detailed Class Diagram, Iteration 1

Within the development phase of the research project, there have been many Ruby Gems used that helped the developer to accomplish the tasks. Main examples are "Paperclip", "AWS-SDK", "Twitter-Bootstrap-Rails", "JQuery_Mobile_Rails" and "Mobylette"

Paperclip[84] is a set of functions for picture handling; picture manipulation, picture-model association at the ActiveRecord with built in "has_attached" relationship (1-to-1) as well as picture repository options that includes content delivery networks such as Amazon S3, Google Cloud Storage and even the cloud storage Dropbox.

AWS-SDK is the holder of Amazon S3's authentication credentials that the Paperclip works flawless.

Twitter-Bootstrap-Rails *is the toolkit from Twitter designed to kickstart development of webapps and sites. It includes base CSS and HTML for typography, forms, buttons, tables, grids, navigation, and more*[85]. Bootstrap functionalities have been used for the look and feel of the backend. There are many functionalities of the Gem, which are compact and easy to use for developers.

JQuery-Mobile-Rails[86] is the Gem that provides the JQuery Mobile libraries from the asset pipeline. Related Gem can be used for frontend application's capabilities such as JQuery libraries that are provided by the shelf URL in order to bring JQuery Mobile functionalities to the user. Since JQuery Mobile can

Screen Shot 1 Backend: New Shelf Screen, system deployed to Heroku Cloud Platform

reach to smartphone's local storage that can be also in favour of writing the shopping basket information. Another purpose is to deliver the mobile application look alike (list views, buttons) by using JQuery Mobile functionalities.

Mobylette[87] is a specific purpose Gem that is able to identify the request owner device than render the mobile interface provided by backend. It is seen useful since the hybrid frontend application will need to render a mobile friendly interface. With the Mobylette Gem it is able to specify mobile friendly layouts and views (instead of application.html.erb layout file, whenever the request owner is mobile device it renders application.mobile.erb) by defining controller specific statements and functions that only takes specific action to consideration. For example, at the research project, it is very useful since there is only one page that will be

rendered at the mobile frontend, which makes the application hybrid, and the rest will be the store staff's usage purpose. The mobile frontend page is the shelf's page that holds all the products belongs to, then with the Mobylette it is able to specify shelves/id/show page as mobile and whenever a request comes from a mobile device for the shelves/id/show page, now the backend only responded with the mobile version of the page which is show.mobile.erb instead of show.html.erb.

Class Diagram for User Story 1.2.0

Mobile frontend's most critical requirement was chosen to be FR1 application must be able to connect the site provided by system backend and render the product pictures as well as the assigned information with the WebKit. Functional Requirement 1 also proves the basic concept of viewing the products of a shelf as a shopping catalogue (next step of the proof is to add them to "shopping basket"). As long as the products can be viewed, within future iterations functionalities can be added with modifications. Diagram 7 shows the two classes should be implemented at the first iteration

WelcomeActivity	ShoppingActivity
+StringURL	+String URL +WebViewClient webView
+readURLonTag()	+loadURL()
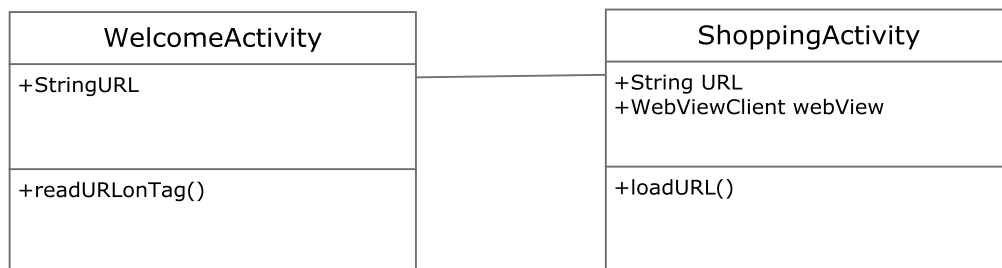
Diagram 7 Mobile Frontend: Detailed Class Diagram for Iteration 1

WelcomeActivity is mainly responsible as the application's launcher activity, which consists of a button that triggers the NFC hardware to read the URL embedded inside. Whenever a URL is read, then ShoppingActivity is able to load the URL with loadURL method provided by WebKit. Whenever the URL is loaded, mobile interface of the backend will be rendered as a picture list of the products with their information.

5.2.1.4 Tests

Agile Development methodology employs the stakeholder-customer-end user interaction within the development cycle also it requires the implementation iterations to be the highest quality as their communication is iteration based. Software testing is the main spot for validation of the quality statements of the needs, which are sentenced within Requirements Specification as well as the User Stories. As the generic definitions for the 1st iteration tests,

before the explanations of the applied tests, following information found important to emphasize.

Depending on the Functional-Non Functional Requirements and the strategy of the team, tests can have various forms depending to the results needed, tests by involving the users and the software tests by the development team. User involvement is the most critical point at the iteration since development team ensures the user story of the High Fidelity Prototype has been implemented, as it will make sense for the users. User Involvement can take various forms such as Think Aloud Tests and Cognitive Walkthrough, which are taking the focus on the usability of the system with the features and their interfaces performing the test with the predetermined tasks. In order to perform the user-involved tests, the best strategy would be to ensure the system works as it was described by the chosen requirements and user stories. In this point, firstly, developer team's tests are essential to perform- the user tests will be explained below. There are various tests and their procedures a developer team can perform such as Unit Testing, Volume Testing, Smoke Testing, Integration Testing, and Black Box Testing etc. Use Case Specifications, Requirements Specifications and the User Stories can be used as the data needed for the tests since applicability of all these tests are heavily depend on the requirements specification and the team's strategy. As the research development methodology gives the permission, system could be tested in all the forms as stated at examples below, however, within the research, first iteration has been tested in two forms, Integration Testing and Black Box Testing;

- **Smoke Tests**[88] are applicable after any changes at the code with the purpose of to identify if any changes at the code broke other parts, if so there is no reason to run any further tests. Smoke Test could be applied and documented to the picture retrieval-since it is one of the main part -after any edition at the code.

- Main purpose of the **Unit Test**[89] is to assert an output of a particular class, method that can accomplish a smallest part of system. Unit Tests could be applied to the frontend, as Android JUnit Tests would ensure the reliability of the reading URLs from NFC Tags nevertheless the brand of NFC Tag[19].

- **Volume Tests**[90] are used to identify if the system can handle the big amount of data as well as still work without losing them. Volume Test could be applied for the picture repositories if they can handle a big number of pictures to be uploaded-downloaded at the same time

The reason for chosen test cases and tools have been covering the most aspects of the other testing approaches as explained above and since it is the prototype, there was no need to

apply luxurious tests such as Volume Testing. Integration Testing is an approach to ensure the different layers of the system works flawless with different components of the system. Applied Integration Testing mostly performed to the backend with the RSpec and Capybara testing frameworks.

RSpec is a Ruby test tool with many functionalities and RSpec is provided as a Ruby Gem. Within RSpec's nature, it is able to write human readable test cases-Domain Specific Language- since RSpec was born under Behaviour Driven Development, so that RSpec gives the huge possibility to have an agreement with the stakeholder for the delivery of the system[20]. Another favour of the RSpec integration test is that, RSpec provides such functionalities that the Ruby:Test:Unit does. With the RSpec, it is convenient to include the unit test approaches within different scenarios.

Capybara is the supplementary to RSpec and it is also a Ruby Gem. With the Capybara it is able to test the user interfaces and their transitions since Capybara provides high-level functionalities to simulate the interface interactions such as clicking on a specific element on an application. When the Capybara's favours are combined with RSpec there reveals a flawless set of functionalities to test all levels of the system.

Black Box tests mainly focus on system's specified functionalities. Black Box tests do not require making any tests by writing any code-unlike the integration tests explained above-however the documentation is the focal point for efficient modifications. Purpose of the Black Box testing is to find the system's any potential functionality errors and documenting them before any user test. A reusable tool, Use Cases and their specifications provided the test scenarios to ensure the system is being implemented as it was described.

Backend Automated Integration Test with RSpec Testing Framework

As explained above, combination of RSpec and Capybara testing tools creates a framework that is big help for writing automated test cases by using its DSL. This is very useful in manner of integration testing. Integration testing consist of the tests for the system's objects overall compatibility within the scenarios. Before the acceptance (or Black Box explained below) tests, integration tests are one level after the unit tests where the every individual object or module of the system combined and their reliability is verified, tested. DSL is advantageous, first of all it is easy to learn and explain, it is easy to describe specific purposes and behaviours for a system and its simplicity brings advantageous aspects in

---

[19] It is experienced that different brands of NFC Tags may have extra bytes when the string is written

[20] Besides the BDD, this agreement can be the communication framework with the stakeholders and users to deliver the real need.

order create a framework within team as well as with customers or stakeholders[21], that is the what Agile Development needs.

Depending on the strategy, tests may have different forms such as Top-Down or Bottom-Up. At the research, Top-Down is seen as the approach for integration testing where the high level of the system is tested until reaching to the post-conditions every low-level module or objects of the system are tested, sequentially. Bottom-Up is the contra approach to Top-Down that takes the consideration of testing every low level components of the system within each cases and moving a level up until the level of the user interface. At the first iteration, tester identified the need of the Bottom-Up approach with the following reasons:

1- System's most strategic points are product pictures since they will be the main elements of the system's usability- as from user evaluations

2- Both requirements, FR7 and FR8 are taking the product attributes as well as the pictures to the centric point and product pictures reliability and should be verified from individual cases to their combination with other modules- a product can be assigned to a shelf

Those two strategic reasons bring out the need of the test cases that focuses on pictures reliability and validation and that product's reliability when it is assigned to shelf.

In order to test these important issues, following test case is created with RSpec DSL-Code Snippet 1:

```
describe "new product" do

  before do


    visit '/shelves/new'

    fill_in 'Name',:with=> 'Cleaning Materials'

    fill_in 'Description',:with=> 'Wide Range of Cleaning Materials'

    click_button 'Create'

  end

  it "displays the success message picture was added and product successfully assigned to a shelf " do


    visit "/"

    click_link "New Product"

    fill_in "Name", :with => "Soap"
```

---

[21] This is the actual point that the RSpec is emerged from BDD, to make it easy to communicate with customers and stakeholders

```
fill_in "Description", :with => "Organic Soap"

select "Cleaning Materials", :from => "Shelf"


attach_file 'Product Picture', 'spec/pictures/soap.jpg'

click_button "Create"


page.should have_text "Product was successfully created"

end
```

Code Snippet 1 RSpec-Capybara Integration testing

Code snippet 1 gives an example for a passing test that the system is able to work. However, when we consider different types of files that can be attached as a picture or if no file is attached, this test case does not make sense. In order to test the pictures reliability as well as its combination with other objects, tester had to create more test cases which consider wrong file formats and unattached file situations.

Code snippet 2 shows the test cases of wrong file format of a picture and unattached picture and they fail since there have been no validation implemented yet…

```
 it "displays the error message after wrong type of file was attached as a picture and product did not created" do

   #shelf = FactoryGirl.create(:shelf, :name => "Cleaning Materials", :description => "Cleaning materials for test")


   visit "/"

   click_link "New Product"

   fill_in "Name", :with => "Soap"

   fill_in "Description", :with => "Organic Soap"

   select "Cleaning Materials", :from => "Shelf"


   #select 'Shelf'=>'Cleaning Materials'

   attach_file 'Product Picture', 'spec/pictures/soap_text'

   click_button "Create"


   page.should have_text "Image content type is invalid"

   end
```

```
  it "displays the error message after pictures was not attached" do


    visit "/"
    click_link "New Product"
    fill_in "Name", :with => "Soap"
    fill_in "Description", :with => "Organic Soap"
    select "Cleaning Materials", :from => "Shelf"
    click_button "Create"


    page.should have_text "Image can't be blank"
  end
```

Code Snippet 2 RSpec-Capybara integration testing

After the test cases failed, they raise the need of the picture validation so the implementation is done in the matter of assurance. Control validations include the file format and pictures presence. After the implementation, test cases pass. Now, by testing a problem at the bottom level, system also tested on high level within different test cases.

System Backend and Frontend Black Box Test

In this section, the Use Cases 1, 4 and 5 are tested and the Use Case specifications are used as the Black Box test scenarios.

One of the main finding of the Black Box testing from UC4 event 3 where the user supposed to be able to choose and remove a product from the page showing the products of a shelf (shelves/id/show). Within the Black Box test procedure, it is found that, such functionality did not exist on the related page. Table 9 shows the modifications and their explanations.
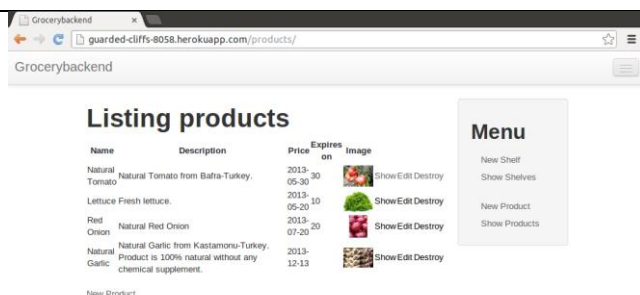
Screen Shot 2 shelves/id/show	Screen Shot 1 showing that each product could be seen however there was no possibility to remove a product from the specific shelf where the user was supposed to sort all products (regardless the shelf) and delete the desired product.
Screen Shot 3 Sorting All products	Screen Shot 2 showing that, the situation of Screen Shot 1 was also related to system backend's usability since the consistency was missing with the products junction regardless to their shelves.
Screen Shot 4 Modified shelves/id/show page	After the modification-Screen Shot 3-now system is able to show every product of a shelf as well as each product picture is defined as a URL where the user can specifically choose and delete it-Screen Shot 4.
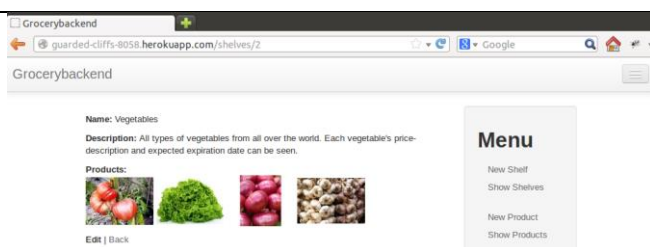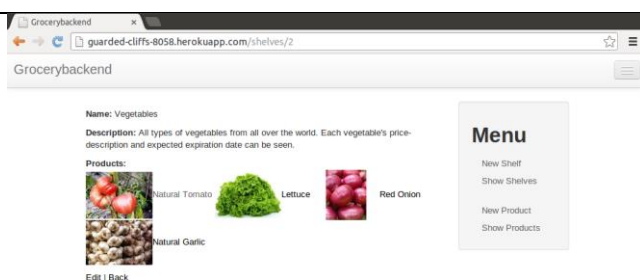
By assigning the picture as a URL to related products show page (product/id/show), it was able to render the specific product's view. Another modification was implementing the destroy action with the confirmation message inside the show page so that user would be able to perform the action after the confirmation.
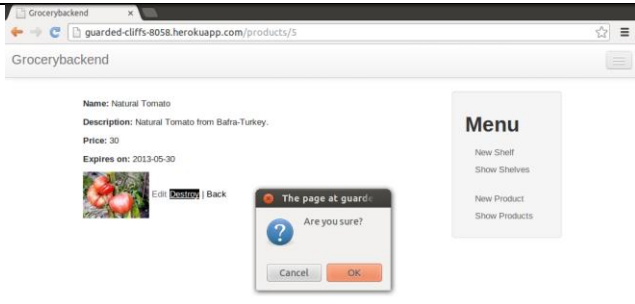
Screen Shot 5 Specific Product to be deleted

Table 9 Black Box Test modifications

One examination of the Black Box testing revealed the reused views of the backend for the frontend. At the Use Case 1, it was planned to view the products of a shelf at the hybrid mobile application by reusing the views provided by backend. However, it was not the perfect solution for the users since it was not mobile friendly view. By using JQuery Mobile features with the JQuery-Mobile-Rails Gem and Mobylette Gem, it is seen that only one view-shelves/id/show- is configured to have two types of views; HTML view and Mobile view. Table 9 Screen Shot 3, above, shows the HTML view for the backend user, and with related Gems it was able to reuse the same view to render a mobile friendly version-Screen Shot 7- of the application after approximation with the shelf tag that is requiring to use NFC chip- by touching to the button on Screen Shot 6.
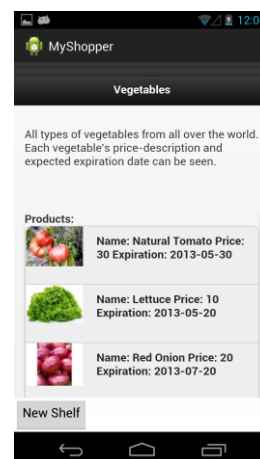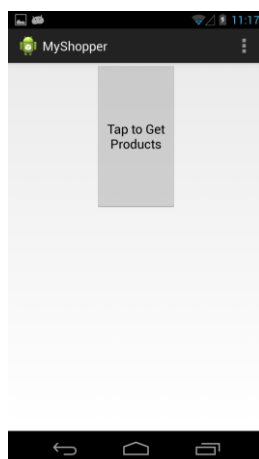
Screen Shot 6 Activation of NFC Hardware

Screen Shot 7 Mobile View of Products on a Shelf

High Fidelity Prototype Field Tests

As it is also explained at Sections 2.2 and 2.3, t**he purpose** of the High Fidelity prototype user test is to gain users' feedback by performing tasks with the working prototype. The structure of the test addresses to Think Aloud test protocol. Main advantage of the Think Aloud test, it is easy way to get users intentions concerning to usability problems since participants will need to think loudly while performing the tasks with the prototype[16]. First iteration is mainly addressing to two research questions; *"How to present the products to help senior citizens to choose them on mobile device?"* and *"Which communication technology would be easy for senior citizens to use in order to choose products?"*

Target user selection criteria and Involvement Strategy

As it is applied at the low fidelity prototype evaluation- Section 4.7.1- it is also seen fundamental to establish the criteria before the user tests. Following are the criteria for the selection of test participants:

- Age: 65+ (as the target users of the research project)
- Education level: Obtainment of the diverse education level in order to have data as much as generic backgrounds target users.
- Gender: Equal diversity of genders
- Current Occupation: In order to capture the participants social life situation
- Spoken Language: English or Turkish required since the evaluator is not a native Danish speaker to handle the briefing, secondary questions and debriefing

   At the participant involvement phase, the Cooperative Evaluation user involvement strategy- Section 4.7.1.1- reused.

Test System Setup

As the low fidelity prototype tests, test field has been chosen again the Best Bazaar. Drawing 3 is the test system setup at the Best Bazaar.
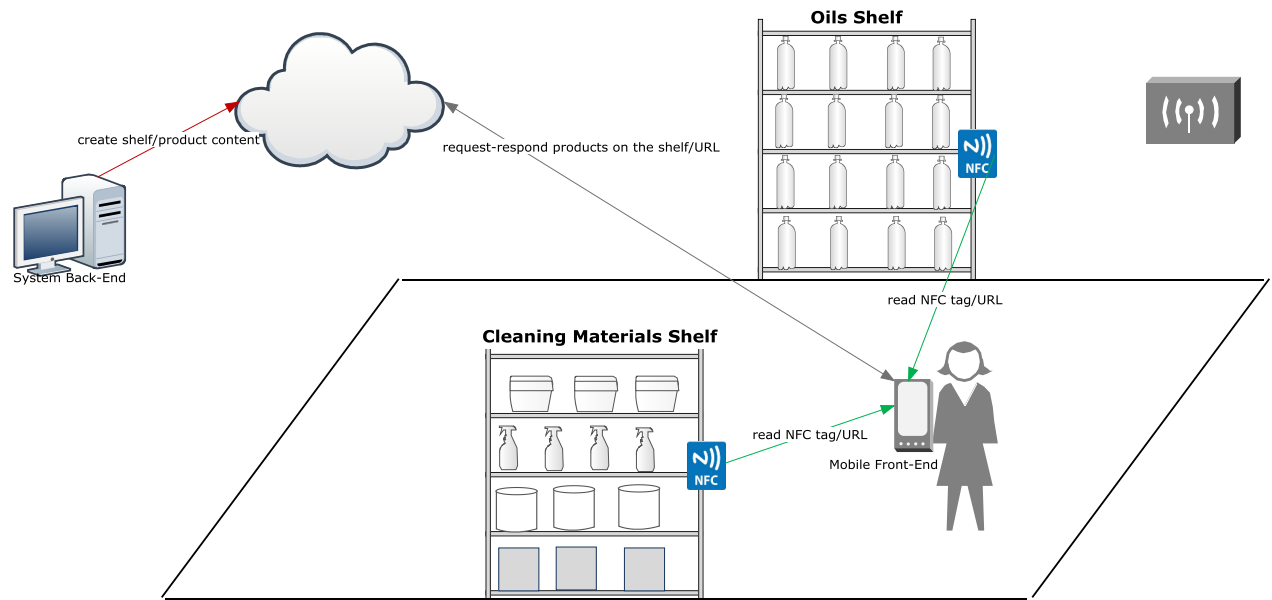
Drawing 3 The Test Setup in the field

Test setup has been a realistic approach with the permissions of the grocery owner. Before the test day, evaluator prepared the tasks-below section- and the necessary materials and information. Evaluator took the products pictures and noted their information-name, price, expiration date- to enter the system, so the participant would adapt to the context and experience the solution partially. Table 10 shows the test setup pictures and their explanations.

Test Setup Picture 1 The Shelf Tag and embedded NFC	Test Setup Picture 1 shows The poster. The poster is designed to take the attention as possible; "Tap Here" followed by an Arrow indicating the "Tap Area" to approximate the smart phone. Right at the behind at the Tap Area, NFC tag is taped.

Test Setup Picture 2 Shelves

Test Setup Picture 2 shows the shelves where posters are hanged. Two shelves have been used in order to have the feedbacks from the user possibility to each shelf where the tasks will be performed.

Table 10 Test Setup pictures and explanations

Test Tasks

The test aims to get the data how the target users perform the tasks and what they think during the accomplishment to the tasks, so the data will be used in order to identify potential usability vulnerabilities. As the first iteration is mostly focusing on the shelf-products presentation at the smart phone, it has seen necessary to give an understanding of the concept to the participant at the briefing and related explanation aimed to motivate the participant for the particular test, which is the basic part of the concept. At the test briefing-Appendix 8- it can be seen that evaluator explains the concept by giving a general overview of the system that underlines the problem area by explaining with the real life situation. Test tasks have been decomposed from the User Story 1.2.0 and prepared to take data for all functionalities and presentation of the products by using all possible situated benefits of the store and the application.

The test consists of four main tasks that can be performed by the user:

1. **Tap to cleaning materials shelf poster to see the products**
2. **Find the 6.4 Kg. OMO Detergent at the smartphone**
3. **Tap to second shelf-Oils- poster to see the products**
4. *Find the 5 Kg. Agrotiko Olive Oil at the smartphone*

The desired data is mainly related to research questions. The first desired data from test is to get usability feedback of the NFC feature; or from the first screen-Tap to Get Products- or from the button that the user can retrieve other shelf's products-New Shelf. And the second desired data from test is to get usability feedback how the products being presented to the user.

Conducting with Participants and Test Highlights

Participants have been chosen to have feedback from wide range of backgrounds and genders. Table 11shows the participant demographics.

Participant	1	2	3	4
Age	67	65	65	65
Gender	Male	Female	Male	Female
Education Level	PhD Degree	Gymnasium Degree	Primary School Degree	High School Degree
Current Occupation	Pensioner	Pensioner	Pensioner	Pensioner

Table 11 Participant Demographics

Table 12 shows the test highlights with the pictures.

Test Conduction 5 Picture 1 and Picture 2	At the first task, participant 1 was unable to use the NFC technology, asked evaluator to explain. However, at the third task participant pressed the "New Tag" button and approximated to shelf himself while thinking loudly. After waiting for the process, participant 1 was able to perform the fourth task as he has seen the products. However, while participant is looking for the products, he emphasized a need for bigger pictures to distinguish the products, so he would not need to use the glasses- Picture 2.
Test Conduction 6 Picture 1 and Picture 2	Test Conduction 6 shows a situation participant 2 experienced. After pressing to the "New Shelf" button, she sees the blank screen however; participant was not sure if she is doing the approximation enough. So, she needed to re-approximate the smartphone several times until she heard the sound- Picture 1. Then she was sure
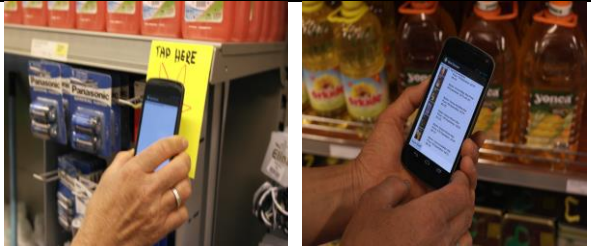
	it worked- Picture 2.
 Test Conduction 7 Picture 1 and Picture 2	Test Conduction 7 Picture 1 shows the first task participant 3 had the same problems with the NFC. He was not sure if he had to still the phone at the same approximation until he heard the "blip" multiple times. At the fourth task, participant 3 did not have any problems, as he was thinking loudly; he was able to find the product- Picture 2.
 Test Conduction 8 Picture 1 and Picture 2	Test Conduction 8 Picture 1 shows the participant was able to find the first product then at the Picture 2 she found the second product as well but without pressing to New Shelf button. While she was performing third task, she did not press to New Shelf button and directly approximated the phone.

Table 12 Test Conduction Highlights and Explanations

Results & Reflections

One of the main results is that, all participants emphasized the size of the pictures. Reasonable fact is that, a modification in relation with the bigger picture size is essential.

Second important result from the test setup, both application interface and the shelf posters should be more explanatory for integration of the smart phone application to render the specific shelf products. Based on the questions asked, it should at least include information about the minimum distance and meaning of the notification sound, so that target users will not hold the smartphone for duration of time.

Third important result, even though only 4th participant was able to find out, the application still renders the products from another shelf if the New Shelf button is not pressed. This could be sorted as a decision for the next iterations, since New Shelf button will be included at the various interfaces to perform other tasks.

With the Think Aloud test, it has been able to reveal the useful problems by observing and recording how the users perform the tasks. Since the participants were thinking loudly, evaluator was able to capture all the data by taking notes and pictures. It is seen that, application is able to be used by all demographics participated at the test.

6. Future Perspectives

Stakeholder interviews, the literature review and the user tests showed that the problem scope addresses a niche market. It is encouraged with many aspects in the field to finish the project; all test participants of Cooperative Evaluation and Think Aloud tests underlined that they need such an assistant and with that solution they would feel more encouraged to perform their shopping tasks. Even though the research did not have enough time to implement and test all the functional requirements, system implementation created the baseline, the framework, with stable components that are reusable for the next requirements. By considering the store shelves as everyday life tools, project opened a gate to move towards on Pervasive computing. Also, as it is stated at the Non-Functional Requirement 13, the system architecture and its implementation are designed to be able to be replaced to other specific futuristic technologies without requiring a big amount of implementation cost; for example replacement of the NFC tags with Ultrasonic Data Exchange tags. As the favour of the Agile Development discipline, now the system is ready to be incremented by implementing the second iteration and testing with target users.

With these encouragements, it is believed that the system can be at the market within one year. However, before the implementation of the next iterations, it is seen that a study for a convenient business model with an adaption study and a rollout strategy are sufficient to deliver the value to the target user group and stakeholders.

7. Conclusion

Applied research was able to reveal an amount of knowledge and solution for the particular case; the difficulties of elderly people while they are shopping. The research problems examined and it was able to come out with a High Fidelity Prototype which is implemented based on the requirements captured both from Cooperative Evaluation of the Low Fidelity Prototypes and Literature Review. Also, Cooperative Evaluation was able to bring an amount of data to concretize the solution for the main problem to address the target users; **How to integrate smart phone application to retail supply chain for seamless shopping experience?** Supporter questions *"How to present the products to help senior citizens to choose them on mobile device?"* and *"Which communication technology would be easy for senior citizens to use in order to choose products?"* have been critical points to solve the main problem by involving users. The first iteration of the High Fidelity Prototype included a usability test to answer supporter research questions-above- by using Think Aloud protocol with target users. At overall, one challenging issue has been the involving users.

Since the case addresses to 65+ years old users, various difficulties experienced both at the Cooperative Evaluation and Think Aloud processes. It is seen that, when the terms "technology" and "test" spelled together, elder people lost their willingness. There have been tens of participants who were willing to participate, but when the briefing was given, users underlined their focus problems for a field which they do not greatly intimate. On one hand it is observed that there is a fear for the technology, not a fear to use it but to understand and adapt to it. On the other hand, the participants who performed the test, at the debriefing, they underlined a great willingness to use the product in their daily lives even though they had the same fear at the beginning as well. With all these observations, it has been a valuable experience to work in the field with target users and understanding them without losing the enthusiasm to deliver a solution for elder people.

It has been necessary to enhance the different aspects of scientific methodologies in order to bring a solution to the problem area; the research methodology was able to reveal a knowledge for the domain, design methodology delivered a great amount of knowledge to gather the requirements of the system and the Agile Development methodology has been a great useful tool to concretize the problem solution and test with the target users.

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Appendix 1 Milestone Planning

Number	Task	Resource	Start	End	Duration
1	Secondary Data		1/2/2013	10/5/2013	51
2	Stakeholder Interviews with Grocery Store Owners	Problem Formulation	6/2/2013	8/2/2013	3
3	Stakeholder Interview Analysis	Interview Notes	8/2/2013	9/2/2013	
4	Initial Requirements with Contextual Scenarios		11/2/2013	12/2/2013	2
5	Conceptual Model		12/2/2013	14/2/2013	3
6	Storyboard	Contextual Scenarios	14/2/2013	15/2/2013	1
7	Low Fidelity Paper Prototypes	Storyboard & Contextual Scenarios	17/2/2013	19/2/2013	2
8	Low Fidelity Paper Prototypes Heuristic Evaluation	Expert User	19/2/2013	20/2/2013	2
9	Low Fidelity Paper Prototypes Field Test		19/2/2013	22/2/2013	4
10	Use Case Diagrams and Specifications		19/2/2013	22/2/2013	4
11	Software Requirements Specification	Contextual Scenarios, Feedback from Heuristics	20/2/2013	20/2/2013	8
12	Context Diagram		1/4/2013	5/4/2013	5
13	State Diagram		5/4/2013	8/4/2013	2
14	High Level Class Diagram		8/4/2013	9/4/2013	2
15	Iteration 1: User Stories		9/4/2013	10/4/2013	2
16	Iteration 1: Sequence Diagrams		10/4/2013	12/4/2013	2
17	Iteration 1: Class Diagrams		12/4/2013	14/4/2013	3
18	Iteration 1: Implementation Task 1: Install Ruby on Rails Framework and Twitter Bootstrap		14/4/2013	14/4/2013	1
19	Iteration 1: Implementation Task 2: Create Shelves and Products Models with one to main relationship		16/4/2013	16/4/2013	
20	Iteration 1: Implementation Task 3: Create Account/ NFC Reader class and read from the NFC Tag		18/4/2013	18/4/2013	
21	Iteration 1: Implementation Task 4: Create Frontend User Interface XML files		22/4/2013	24/4/2013	3
22	Iteration 1: Implementation Task 5: Create Web/NFC Client and render the Products		24/4/2013	24/4/2013	2
23	Iteration 1: Implementation Task 6: Create Model friendly user interface from backend for Shelves by using the jQuery Mobile		23/4/2013	8/5/2013	10
24	Iteration 1: Integration Tests		8/5/2013	10/5/2013	3
25	Iteration 1: Black Box Tests with Use Case Scenarios		10/5/2013	14/5/2013	3
26	High Fidelity Prototype Field Test		3/6/2013	5/6/2013	3

Appendix 2 Interviews

Appendix 2.1 Interview Guide

- **How do you define the relationship between senior customers and store staff?**
- **How do store staffs help senior customers?**
- **Which shopping state is the most interaction occurs?**
- **How can technology play a role to help senior customers?**
- **How can technology help senior customers to reach products on the shelf?**

Appendix 2.2: Interview with Best Bazaar

Interview Briefing:

A new trend is that Civic Socialization that addresses interaction between the senior citizens and local grocery shop staff. With Civic Socialization senior customers mostly choose local grocery shops, because they want to communicate with shop staff and other peers. However, another research reveals the ageing population and soon density of young generation will not be enough to assist senior citizens as it is now.

Interview:

- **How do you define the relationship between senior customers and store staff?**

Civic Socialization is what we also see and that applies to us which makes our shop different than the supermarkets. When Senior Citizens go supermarkets or malls, they got lost within the crowd and can't find the products needed neither the service we provide. Especially seniors who are alone-male or female, they immediately look for a help. This is current for all nationalities. This help is for product information and alternatives for that product. On one hand it seems they are not good at decision on the other hand, they just want to talk, and this is what I experienced. They want to confirm if it is good for their purpose and our approval is enough for them. For senior citizens, we mostly accompany during their shopping, we accompany to transfer their goods to car park or to home if they live within surrounding. For home delivery, they do their shop and we transfer their products to home maximum within

half an hour. Soon we will start a new service, telephony order, this demand we see now. I think, soon all local groceries will start such service. Transfer is a problem as I observe. Of course they also face with difficulties during the shopping; they have difficulties to use trolleys. They come with their own wheeled folding shopping cart trolley. They don't buy that much because they can't carry or handle in the shop. Even if they want to buy, they don't buy because they don't consume that much.

We have such relationship base on smiley. This is not only for senior citizens, if you are a good person; all customers think your product is also good. My previous grocery was in Sweden. There was a senior that used to come in the opening hour and stay there for hours, sometimes 2, 3 hours. He used to say hi to everybody and sometimes talk with us. We love senior citizens, I think talking with them gives value to both sides; for us, sometimes we have such speeches that we don't forget for all day that makes us smile, for them, they are being social. A senior's joke is really nice to me. We, store staff joke each other but their jokes are really making our day. This is what we enjoy.

- **How do store staffs help senior customers?**

Collecting, transferring in the store and packing as well as stated before transfer to home. No doubt, the products can be found but they want to communicate and when they ask, we accompany them we do not just show where the product is we go with them and grab the product. We also grab an alternative that they might be interested, this attitude makes them happy, and when you bring the alternatives; for example bulgur, there is thin bulgur, thick bulgur, dark bulgur. When I present those three, mostly they do not ignore others, they buy all- of course not in an overstated way, just the related ones in the context. Another example based on brands. For example a senior wants a brand X milk and when I represent other brand that is not different but the other brand, s/he satisfies with that and buys. When s/he trust you personally, s/he trusts your recommendation hundred per cent. In this case, we never recommend something that we are not sure. If so, return is a broken trust which is nearly impossible to re-establish. For asking the help, with this relationship they feel free to ask. Mostly they do not hesitate for asking.

- **Which shopping state is the most interaction occurs?**

Product discovery and reaching to that product is the state that occurs they need help, this is what I experienced. With this attention, they choose us, even another chain market store with cheaper prices within surroundings, they choose us.

- **How can technology play a role to help senior customers?**

For me, technology could be used for distance ordering, say telephony or internet. But when we talk about socialization, it is different. Such solution would be demanded from various shops. Sometimes I can see volunteers help seniors to shop and this is a big expense without the volunteers, if technology could be involved in a shopping state that would decrease such expenses a certain amount. With a worthwhile technological solution, even government would support us.

- **How can technology help senior customers to reach products on the shelf?**

Well I am not involved with technology that much. However the question is, if they look for a technology solution or a person's need? Even with technology, such solution would be so expensive. They have at the Pharmacies, pressing button and pills are there but when you put that system to a shopping market, it would be so expensive even chain stores would not employ such solution.

Interview Debriefing:

- On my thesis, I want to develop a solution for senior citizens which can help them to reach the products on the shelf. On one hand, I want to keep the interaction that you have now, both of you-Senior Citizens and Shop Staff- have social communication and this encourages senior citizens to participate in the social life. On the other hand, by reaching to products on shelf, this brings a feeling them that they ask for help so many times and it will bring a level of shyness for asking also amount of extra job is obvious for store staff to help for each products for discrete time. Now the solution more precisely, let's say a product on the top of the shelf and the other bottom, with a smart phone application they can choose the products at the shelf as they reach checkout point, a staff collects all products and packs

while payment is processing. So while the payment is being done, products can be packed and you still have the time to talk with senior.

- That makes big sense now, all the questions and your solution. If such solution would exist that would be great. As I said I am not involved to technology but this kind of solution would be quite practical. Because when you say socialization and shopping for senior citizens, this solution would definitely makes life easier for both store staff and senior citizens, even encourages them to be outside of the home. They could collect the products needed by application and while they are talking at the checkout point with the staff, their products will be collected which save big amount of time and working power. When you said this solution, it is really good because all our products already with a unique serial number so easy to identify each of them. So when s/he is wandering within shop, the products s/he could not reach or carry, with a smartphone application s/he can request them and when s/he is in the checkout point we collect them all. This solution does not break our traditional interaction because while s/he is waiting we will have interaction, and collecting staff can also bring other related products. Now when you said, technology makes sense for those situations we talked. At the moment, we do not have difficulties to help but when you also say the decreasing amount of young people respect to senior citizens, this is a bigger sense.

Appendix 2.3: Interview with Elite Bazaar

Interview Briefing:

At the researches, senior citizens aged 65 and above prefer local shops. Reason is that the social interaction between seniors and the shop staff. However, with the researches again, increasing population of the elder persons have an inverse ratio to young persons, this will yield insufficient amount of young persons to help within shops. In my thesis, I am trying to find a solution based on technology, which will not break the relationship between senior citizens and local shop staff as it is becoming a tradition now.

Interview:

- **How do you define the relationship between senior customers and store staff?**

Our relationship is, when we are not on busy hours, we ask how they are doing. Especially, as they see us warm, they chat with us their situations. This is so important for us, because

this makes us to feel good as well as reason choose us. If they go to a supermarket, they will not be in such communication, they just buy and go.

- **Does interaction play a role for senior customer to choose Elite Bazaar frequently?**

Generally it does, here for example since we are not in the center, especially senior citizens, %70-80 shops here every day. This makes them a weather change and socializes their life.

- **How do store staffs help senior customers?**

When they buy a lot, we provide home delivery. They like it so much. Since most of them do not have a driving license, this is a big help for them. If we are not so busy, I immediately send the products along with them otherwise deliver the products within 1 hour.

- **Which shopping state is the most interaction occurs?**

When they can't find the products, we accompany them we do not only show. When a product is in a position that they cannot reach, we grab and carry until check out point. Even though we are not that economic as other chain stores, senior customer chooses us because we help them, assist them. If a desired product is out of the stock, we immediately order that product and it comes the day after. The interaction mostly occurs at the mornings when the mostly senior customers shop as well. We open by 07.30 and most seniors shop by morning. We interact with them when we do our jobs as well. We chat with them everywhere in the shop.

- **How can technology play a role to help senior customers?**

I am planning to put LCD screens to various parts of the shop to display offerings and commercials.

- **How can technology help senior customers to reach products on the shelf?**

We do our best not to put products high positions at the shelf. When they need a help, our staff is mostly nearby and help them.

Interview Debriefing

- On my thesis, I want to develop a solution for senior citizens which can help them to reach the products on the shelf. By reaching, let's say a product on the top of the shelf and the other bottom, with a smart phone application they could choose the products and instead of asking for help for each of the products, application send all products they could not reach to checkout person.

- This is a great system as you describe however still for senior citizens it is difficult to adopt unless a specific commercial to promote them. Idea is great but for senior citizens it may take some time adopt. But again with a promotion they would be adopted. This solution would be really useful for our business as well. Instead of a staff help a senior customer for different products while shopping, with such solution staff can collect the products and save time and power. Also, senior customers, we can say they ask for help however not always, they ask few times and become thinking that s/he asked already so many times and skip the other products because they don't want to ask for a help anymore. But your idea is great that, if this kind of system would exist, then they would some kind of "mark" the products needed and when they are at the checkpoint, a staff could collect the products and pack them.

Appendix 3 Use Case Specifications

Use Case ID	UC 1 : Get Products
Primary Actors	Senior Citizen
Brief Description	With the smartphone application, user is able to see all products lying at the shelf
Preconditions	-Application is running on NFC enabled smart phone - User has internet connection -Shelf URL includes Products
Triggering	User taps to shelf tag point
Event Flow	1. User taps smart mobile phone to tag point 2. User receives all products 3. User navigates within product by swapping
Post Conditions	- User able to see all products at the shelf

Alternative Flows	- User routes to all shelves web page

Use Case ID	UC 2 : Add Products to Shopping Basket
Primary Actors	Senior Citizen
Brief Description	User adds/removes the products at the virtual shopping basket
Preconditions	- Application is running on NFC enabled smart phone - User has internet connection - Shelf URL includes Products
Triggering	User presses a product

Event Flow	1. Shopping basket is created when the user touches a product picture, system renders the product's price, expiration date, quantity spinner for the products amount and add to basket button then the user defines the quantity and presses to add to basket
	
	1.1 User is informed simultaneously that the product is added to basket as well as total sum and total number of pieces shown
	
	2. If the user wants to add more products from the same shelf
	
	   2.1 User sets the other products and adds to basket
	
	   2.2 Total sum and number of items updated and shown to user
	
	3. Else if the user wants to add products from another shelf
	
	   3.1 User presses the shelf tap button
	
	   3.2 User taps the smartphone to shelf tag
	
	   3.3 User receives all products
	
	   3.4 User chooses the product to be added to basket and sets the quantity
	
	   3.5 User presses the add to the basket button
	
	4. Else if the user wants to change the amount of a product

	added to basket
	4.1 User presses the shopping basket button and sets the quantity via the spinner rendered nearby the each product's picture
	4.2 User presses the back button and system updates the total amount and total number of items information
	5. Else if the user wants to remove products from the basket
	5.1 User presses the shopping basket button and chooses the products to be removed and the system renders a confirmation message
	5.1.1 If the user presses OK
	4.1.1.2 System deletes the product from the list
	5.1.2 Else if the user presses Cancel
	4.1.2.1 System closes the message and returns to the list without any delete
	6. Else if the user wants to purchase the products at the basket
	6.1 <<extension use case>> Order Products
Post Conditions	- User is able to add, update and delete the products at the shopping basket
Alternative Flows	None

Use Case ID	Extension Use Case 3: Order Products
Primary Actors	Senior Citizen
Extension Use Case Brief Description	User sends the chosen products to checkout point to be collected
Extension Use Case Preconditions	- User created the shopping basket

Extension Use Case Event Flow	1. User presses the Purchase button
	
	2. User is informed that Purchase order is sent for products to be collected as one reaches to checkout
	
	3. If the User would like to add more products before checkout point
	
	    3.1 User runs the application
	
	    3.2 Application renders the button that opens the latest shopping basket
	
	    3.3 User presses the new shelf button
	
	    3.4 User repeats the shopping process and goes to shopping basket
	
	    3.5 User presses the purchase button
	
	    3.6 System informs the user that one's purchase is sent to checkout point for products to be collected

Post Conditions	- Purchase order is sent - Purchase order edited

Use Case ID	UC 4: Add Product
Primary Actors	Store Staff
Brief Description	User adds/removes the products to the virtual shelves
Preconditions	User has product-shelf information
Triggering	User would like to add or remove a product at the shelf

Event Flow	1. If the user wants to add a new product
	
	    1.1 User Presses the new product button
	
	    1.2 User sets the product information-name, price, expiration date and the picture
	
	    1.3 User chooses the shelf
	
	    1.4 If the desired shelf is not created
	
	    1.5 User presses the <<include use case>> New Shelf

	2. Else if the user wants to update the existing product
	
	   2.1 User presses the show shelves button at the welcome page
	
	   2.2 User chooses a shelf
	
	   2.3 User sorts the products
	
	   2.4 User chooses the product to be updated
	
	   2.5 User edits the product details
	
	   2.6 User presses the update button
	
	   2.7 System informs the user
	
	3. Else if the user wants to remove product(s) from a shelf
	
	   3.1 User presses the show shelves button at welcome page
	
	   3.2 User chooses the shelf one the product(s) will be removed from
	
	   3.3 User marks the products will be removed
	
	   3.4 User presses the remove button
	
	   3.5 System informs the user

Post Conditions	- User able to manage products at the shelf
Alternative Flows	None

Use Case ID	Include Use Case 5: New Shelf
Primary Actors	Senior Citizen
Brief Description	User CRUDs the shelf information
Preconditions	User has a product to add to shelf
Triggering	User Presses to New Shelf button

Event Flow	1. User presses to show the shelves button
	
	   1.1 System shows all shelves
	
	   1.2 If the users wants to delete a shelf
	
	      1.2.1 User chooses the shelf and press the delete
	
	      1.2.2 Shelf is deleted

	1.3 Else if the user wants to update a shelf
	1.3.1 User clicks on a shelf to be updated
	1.3.2 User edits the shelf and press the update
	1.4 Else if the user wants to add a new shelf
	1.4.1 User clicks on new shelf button
	1.4.2 User enters the new shelf name and press create button
Post Conditions	- User manage the shelf information
Alternative Flows	User presses the Manage Shelves button on welcome page

|	
Use Case ID	UC 6: Get the Purchase Order
Primary Actors	Store Staff
Secondary Actors	Store Staff
Brief Description	User adds/removes the products at the virtual shopping basket
Preconditions	- Senior Citizen pressed the purchase button - Store staff is connected to system
Triggering	Senior citizen presses the purchase button Senior citizen approximates to checkout point
Event Flow	1. Store staff can see the expandable list button named purchase on the welcome screen with the senior citizen's picture 2. If the purchase queue is senior citizens turn 3. Store staff expends the list and prints it 4. Store staff gets the list and gives to other staff who is responsible for product collection 5. As the products delivered to senior citizen, payment can be received and the payment list can be used as receipt
Post Conditions	- Store staff is able to receive the Senior Citizen's products on backend via the application running on

	smartphone
Alternative Flows	None

Use Case ID	UC 7: Update the Shelf Tags
Primary Actors	Store Staff
Brief Description	User updates the shelf tags which includes URL for the related products
Preconditions	- Application is running on NFC enabled smart phone - User has internet connection - Shelf URL is created
Triggering	User presses the update a shelf
Event Flow	1. User presses the update a shelf button 2. User chooses a shelf on the screen 3. User presses the update button 4. User taps the smartphone to shelf tag
Post Conditions	- User updated shelf tag
Alternative Flows	None

Alternative Flow Use Case ID	UC 5.1: User presses the Manage Shelves button on welcome page
Primary Actors	Store Staff
Brief Description	User CRUDs the shelf information in the welcome screen
Preconditions	- User is connected to system
Triggering	User presses the show the shelves button a shelf

Event Flow	1. User see all shelves
	2. If the user wants to create a new shelf
	   2.1 User presses the new shelf button
	   2.2 User enters the shelf information and press the create button

	3. Else if the user wants to update a shelf
	3.1 User chooses a shelf and edits
	3.2 User presses the update button
	4. Else if the user wants to delete a shelf
	4.1 User chooses the shelf to be deleted and presses the delete button
Post Conditions	- User CRUD the shelf from welcome page

Appendix 4 Storyboard
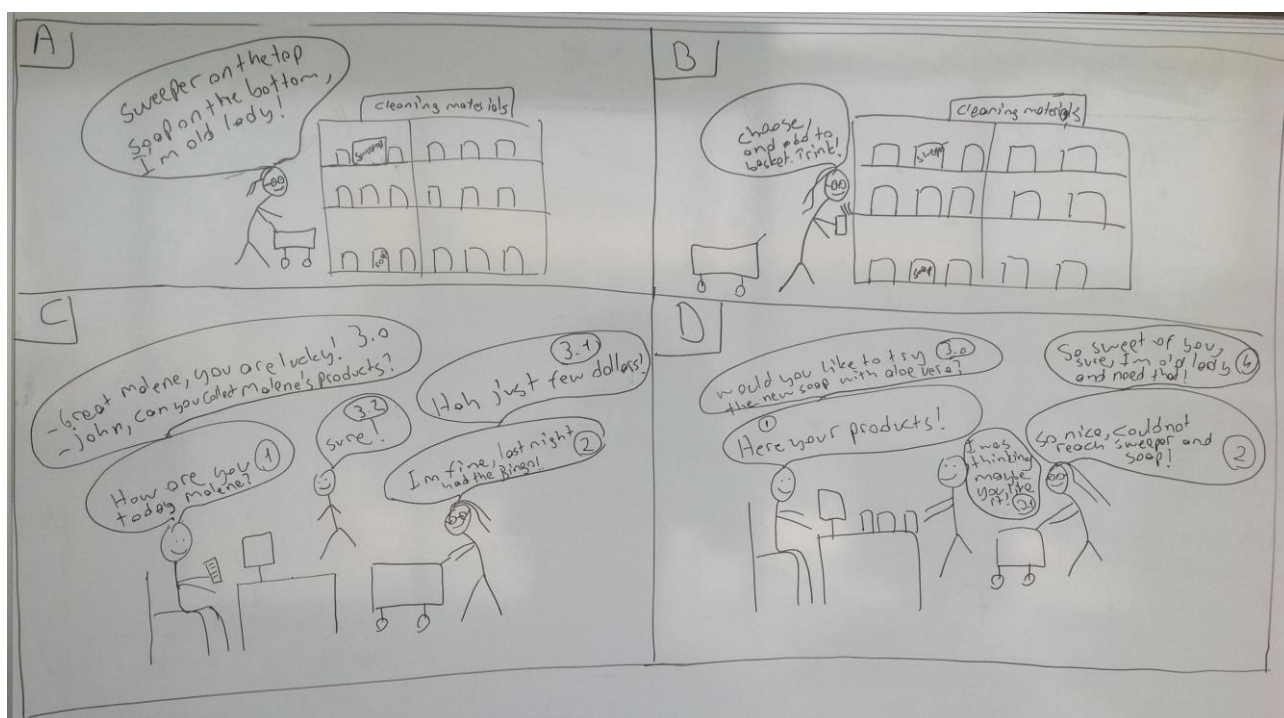
Picture 4 Storyboard

Appendix 5 Low Fidelity Paper Prototype Field Test

Field Test Briefing

Thank you for your participation. This is an evaluation for shopping assistant, which I am preparing for my thesis. Purpose of this evaluation is to test user interfaces- you can imagine

it as a mobile phone -which I will present to you. There is no purpose to test yours competences. All I want to test the user interfaces that I have designed, so I will make sure that they are imaginary working before I spend any time for programming. I need you to think loudly whatever you think about the screens and navigations between them and if there is anything confuses you during the tasks.

Purpose of the assistant is to provide help while you are shopping at the groceries. With the assistant, as you might do in your daily shopping activities, instead of asking for a help from shop staff, you will be able to choose the products on the shelves and request them to be collected and packed for you when you are at the payment point. On your daily shopping, you may need some helps and ask the shop staff, reason of the assistant is to minimize your help need from the staff and solve them. With the assistant, you are able to choose products on the shelves by coming closer to shelf and tapping the described points at the shelves, then all products will appear on the screen.

Before I explain the tasks, I would like to tell you that your ideas are so important for the project and only way we can get them is that while you are doing the tasks think loudly, say whatever you are thinking about the buttons, drawings, words and the relationship of them with your shopping activity.

Test 1:

Participant: 68 years old man. Married has 2 children. He does not use any smart phone but has knowledge about Internet. During the evaluation, he was shopping alone.

Questions asked while performing tasks:

Should I touch the point –showing tag prototype on the shelf- to get products?

So, are those the all products on this shelf? How should I see the Bingo Soap now? Are there any pictures of the products?

How should I buy this soap?

May I receive those products at home?

Debriefing:

Evaluator: Application concentrates on senior citizens physical difficulties during the shopping. We want seniors to participate at the social life by minimizing the difficulties, which discourages them.

Participant: This is very good idea. Also, with this idea it is obvious that I feel better because I don't need to ask for help. It would be also better if home delivery could be involved with this service.

Notes based on Observation: What did the participant like about the service and what are the reflections for improvement?

At first sight, user had difficulties to adopt paper prototypes. It was his first time but after questions and instructions he was able to adopt and understand the idea buy applying with paper prototypes. After getting used to, user did not find out any misleading button-explanation with the product. User told it was easy to use it after understanding the real purpose. User like the service that is able to give him freedom for deciding the products without need for handle the carriage of the products in the shop. Also makes his shopping faster and gives him encouragement.

Test 2:

Participant: 65 years old man. He lives alone. He uses smart phone and has IT background with bachelor degree.

Questions asked while performing tasks:

What if I would like to buy other products on other shelves? How can I change the shelf?

Until now all is good. But in this screen, instead of routing to another screen for specific product, is not it easy to show product details at the previous screen and I still could be able to swap other products and add to basket more dynamically?

What if I still want to add more items if I already pressed the purchase button? How should I return to shopping basket and add more if I want to continue my shopping? Also, what if I change my mind to shop another shopping centre and the staff will be still collecting the products?

Debriefing:

Evaluator: Application concentrates on senior citizens physical difficulties during the shopping. We want seniors to participate at the social life by minimizing the difficulties, which discourages them.

Participant: This is the reason I am here at the moment, socializing and physical exercise. With this way, I feel to go outside instead of sitting at home. Also, even though I come here often, sometimes I might need help. Although I am tall enough to reach products, help

would be for the products on the lower section. If I may not feel to ask then I will pass the product...

Notes based on Observation: At the briefing user easily understood the idea as he has specialization at the software development field. He did not experience any paper prototyping test but he directly got the idea. He liked the idea and emphasized that the interface prototypes was useful to understand the system. He advised to use mostly pictures to make users understand the products shown. He strongly advised to rethinking about the last step, if the user changes the mind-cancel the shopping- it would be extra work for the shop staff to collect and undo collection of the products.

Test 3:

Participant: 65 years old woman. She lives alone. She does not use any smartphone but Internet at home PC.

Questions asked while performing tasks:

I don't understand why I should touch here to get products?

Are those all products, why they are not the ones difficult to reach?

How should I buy this soap?

May I receive those products at home?

Debriefing:

Evaluator: Application concentrates on senior citizens physical difficulties during the shopping. We want seniors to participate at the social life by minimizing the difficulties, which discourages them.

Participant: This is very good idea also it would be better enriched with different usages such as, selecting products at home from the interface that is identical to Best Bazaar's shelf alignment-because I know here-and receive packages here or at home again. When I am sick, I don't want to go outside for shopping and I do online shopping. So I use a website of the supermarket, namely Superbest but their products on the website are not the same I suppose, it gives me limited information for the products, not dynamic as I would be there daily.

Notes based on observations: At first sight, user had difficulties to adopt paper prototypes. It was her first time but after questions and instructions she was able to adopt and understand the idea with helps of the Evaluator for the paper prototypes. She was curious about the overall idea because if she wants to go shop, she directly drives to grocery store and buys the products without any need for help. As observed, ability to drive is an encouraging factor to handle shopping, because she does not consider any power difficulty to carry the products in the shop and carry them to the car.

User told it is easy to use the application after understanding the real functionalities. She mentioned, when she is sick, she shops from online web site of a chain supermarket- namely Superbest. Only time she does the online shopping is when she is sick at home then the Superbest carries the goods for her. But she also mentioned the poor product availability of the Superbest that she cannot have the same experience as she is in the market.

Test 4:

Participant: 65 years old woman. She lives alone. She has been working as Induction Heating Systems specialist, has a bachelor's degree. She does not use smartphone but Internet at home PC.

Questions asked while performing tasks:

Should I touch the point with prototype –showing tag prototype on the shelf and paper prototype on hand- to get products?

Are those the all products in the store? So if I swap, will I be able to see other products?

Debriefing:

Evaluator: Application concentrates on senior citizens physical difficulties during the shopping. We want seniors to participate at the social life by minimizing the difficulties, which discourages them.

Participants: This is very good idea I feel social when I do shopping, that is correct. Also, with this idea it is obvious that I feel better because I don't need to ask for help. Also, home delivery would be great as I may be sick sometimes and with this application, I can search the products at the shop where I often be.

Notes based on observations: User had motivation to participate as she was interested with technology and she needed assist while she has been shopping. Besides the first two screens, user was able to identify products with the words. She also mentioned that showing only two products per swap would not be enough, more products should be visible. She understood the usage easily and she was happy to see an application will be able help her. She did not have any physical difficulties but she said it is a very good idea to donate users with such service that they would have more freedom in the shop to decide products. User also emphasized the idea of shopping in the store to see products and request them by using technology so it bridges the gap between the online shopping and in store shopping. User also mentioned to provide a version of the shops through Internet so when she is sick at home, she can buy the products from application, which shows the known store's shelves, and choose the products from shelves on the application.

Test 5:

Participant: 66 years old woman. Married, has two children. She has a high school degree. She lives with her husband. She does not use smartphone but Internet at home PC.

Questions asked while performing tasks:

Why should I touch the point to get the products?

Are those all products at the market? And how should I reach the Bingo soap?

Debriefing:

Evaluator: Application concentrates on senior citizens physical difficulties during the shopping. We want seniors to participate at the social life by minimizing the difficulties, which discourages them.

Participant: This is very good idea I feel social when I do shopping, that is correct. Also, with this idea it is obvious that I feel better because I don't need to ask for help. Also, home delivery would be great as I may be sick sometimes and with this application, I can search the products at the shop where I am often visiting.

Notes based on observations: Participant was able to understand the concept and has been familiarized easily. Participant was shy that is the reason interviewer has been helping. Even though the low fidelity paper prototype evaluation was first time for her, after instructions of the purpose and abilities of the prototype, she was able to imagine the task with the interviewer's help. She adapted to task easily and when the interviewer showed the each

interface, she was giving positive feedback that the application is easy to use and navigations at the page constructed intelligently. Participant did not find any usability problem to complete the task.

Appendix 6 Modified Prototypes: Sketching at the Whiteboard
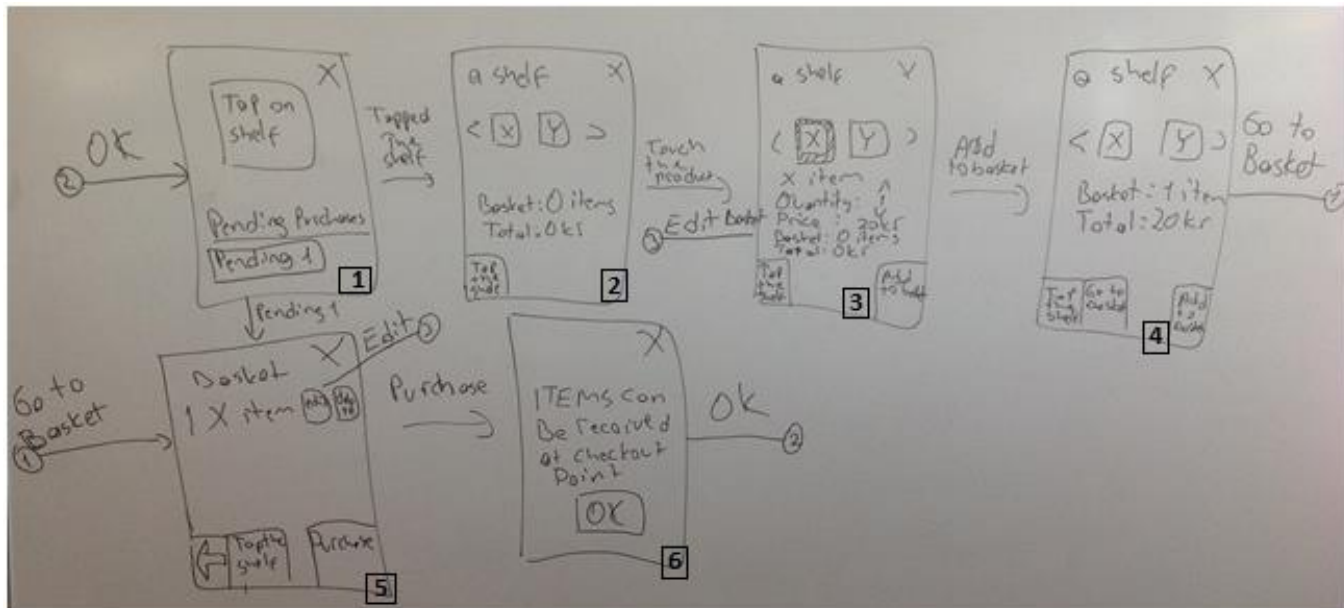
Picture 5Modified Low Fidelity Paper Prototypes

Whiteboard drawing takes focus on 2nd iteration's prototypes that have been prepared on white board before taking the form of paper prototypes.
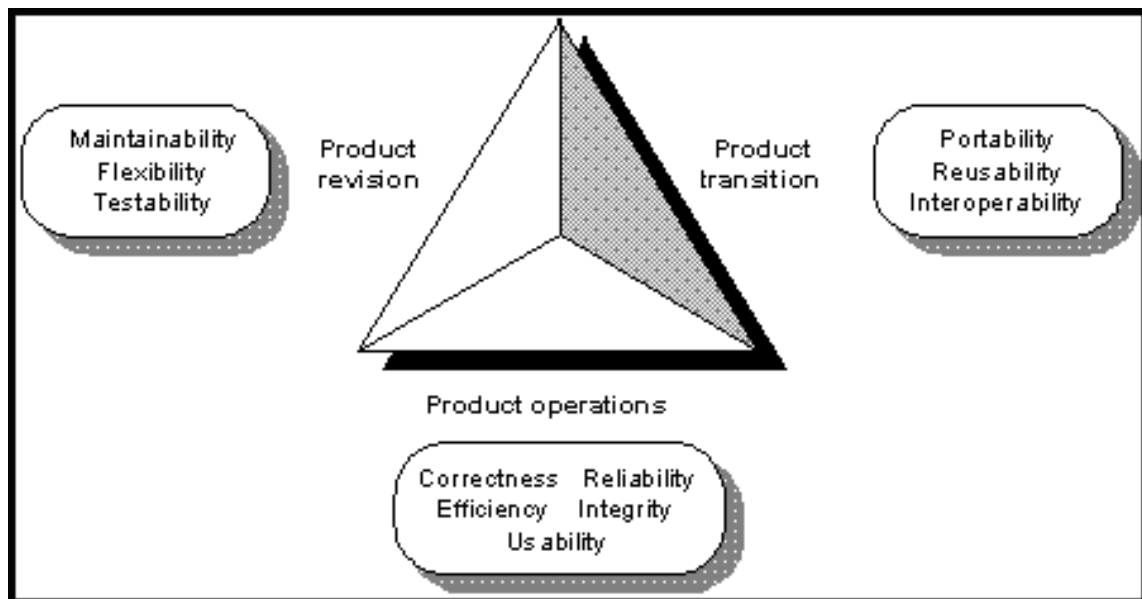
Appendix 7 McCall Quality Parameters

Figure 11 Quality parameters of introduced by McCall[69]

Appendix 8 High Fidelity Prototype Field Test

Field Test Briefing and Tasks

Thank you for your participation. This is an evaluation for shopping assistant, which I am implementing as my thesis subject. The purpose of this system is to help senior citizens with their shopping, for example, the heavy products or the products at the top or lowest level of a shelf, instead of asking to store staff, they can use the application inside the store to choose and send them to store staff to carry. As the concept, system will be able to let the users choose the necessary products they need and store staff will be collecting the products while the user performing the payment. At the moment system only shows the products that are on a shelf and the user also need to approximate the mobile phone to shelf tags, so they can see the products. At the test, I will need you to find the 5kg Omo –physically at the top level of the cleaning materials shelf- and 5 kg Agrotiki Olive Oil –physically at the lowest level of the oils shelf. The most important point is that, I will need you to think loudly while you are performing the actions. There is no purpose to test yours competences. All I want to test how I present the products, if it makes sense for you. Say whatever you are thinking about the buttons, drawings, words and the relationship of them with your potential shopping activity.

Test 1:

Participant: 67 years old man, lives alone. He does not use any smart phone but has knowledge about Internet and technologies. During the evaluation, he was shopping alone.

Participant Thinking Loudly and Asking Questions to Evaluator

- **Participant**: Well, what should I do now-showing the first screen?

- Evaluator: You just need to press the button

- **Participant**: OK, now should I touch to the poster with the phone or should I have to approximate while I was pressing?

- Evaluator: No, now you need to approximate

- **Participant**: I do, how long should I wait for the products?

- Evaluator: A few seconds

- **Participant**: Now I can see, but need to wear glasses. This is the picture, price, this is the name, this is the expiration, 3 years left. Now I am trying to find the Omo, oh it can be swapped, so I swap… Yes now I found the Omo. May I press this button -showing the New Shelf button- to see the oil?

- Evaluator: Yes

- **Participant**: I press the new shelf button and wait for the products. Ok, now they are here, swapping, swapping, how many products on this shelf or which product I do see now? Ok, here is the Agrotiki 5kg. Yes, good.

Questions asked for task:

Should I touch the button and approximate at the same time?

How long should I wait for the products?

Are those all products only of this shelf?

Is the expiration 3 years from now?

How many products in this shelf?

Debriefing:

- Evaluator: This system is on the initial process but at the future we want to setup this system to all shops, so senior citizens can be more encouraged to shop.

- Participant: This is a really futuristic and useful system. A user really needs to follow up the technology, especially in an age like me. But it is a really good help, if this solution, would be

working now, I would use it, even buy a new phone. Also, I can see some more time needed to make the system fully work on all shops. Sometime I need the products on the top of the shelf and in some shops there are even stairs to reach, but it is not the really help, I can fall down.

- Evaluator: Yes

- Participant: With this idea, I can choose the products, maybe in the future with a small amount of money I can also order from the shop and send them to my phone. This is very good idea.

Notes based on Observation: What did the participant like about the service and what are the reflections for improvement?

At first sight, user had difficulties to adopt NFC technology. At the first shelf, it is seen that user needed help to adapt to feature using NFC technology. After the first shelf, the user adapted quickly and performed by own. User did not mention about any misleading explanation at the interfaces however it is observed that the size of the pictures were small. Pictures need to be present within bigger sizes. The user liked the system and mentioned he would like to be a part of such system by using it.

Test 2:

Participant: 65 years old woman, lives with husband, both retired. She uses smart phone and has basic knowledge about the technologies. During the evaluation, she was shopping alone.

Participant Thinking Loudly and Asking Questions to Evaluator

- **Participant**: Should I press the button -showing the first screen "Tap to Shelf"?

- Evaluator: Yes

- **Participant**: OK, now should I touch to the poster with the phone, how long should I press to "New Shelf" button again? *She approximates the phone to poster and takes back, approximates again and hears "blip"* Now it works.

- **Participant**: *She is waiting to application to render the products*-Will the products appear here? *Showing the blank screen, after the products rendered*- Now I see the products, looking for Omo-*showing the real product at the top of the shelf*- yes it is here. I can see all necessary information, picture, name, price.. I don't have problem to see close but a person who has would not have problem to see since they would use glasses.

- **Participant**: Now going to oils, looking for this oil-*showing Agrotiki-* I press the new shelf button, approximate and wait for the products. Ok, now they are here, swapping, here is the Agrotiki 5kg. Yes, good, I can see all necessary information again.

Questions asked for task:

How the distance should be close to poster?

How long should I wait for the products?

Debriefing:

- **Evaluator:** This system is at the initial process but at the future we want to setup this system to all shops, so senior citizens can be more encouraged to shop, be more at the society.

- **Participant**: This is a really smart idea, I hope to see soon. Sometimes I feel tired and since I will need to carry heavy products, I don't want to go out for shopping. There is technology and at the future you can also grow the system such as the user goes in to a store, chooses the products with the sense and receive them at home…

- **Evaluator:** Yes

- Participant: With this idea, I can choose the products, maybe in the future with a small amount of money I can also order from the shop and send them to my phone. This is very good idea.

Notes based on Observation: What did the participant like about the service and what are the reflections for improvement?

At first sight, user had difficulties to adopt NFC technology. At the first shelf, it is seen that user needed help to adapt to feature using NFC technology. After the first shelf, the user adapted quickly and performed by own. User did not mention about any misleading explanation at the interfaces however it is observed that the size of the pictures were small. Pictures need to be present within bigger sizes.

Test 3:

Participant: 65 years old man, lives with wife, both retired. He uses smart phone and has basic knowledge about the technologies. During the evaluation, he was shopping with the wife.

Participant Thinking Loudly and Asking Questions to Evaluator

- **Participant**: Now I press to "Tap to Shelf" button. What the distance should be? *Holding the smartphone in a ~30 cm distance*

- **Evaluator:** Closer to poster

- **Participant**: *He approximates the phone, hears the "blip"* Now it worked. *He keeps the smartphone at the same distance and hears the blip again*

- **Evaluator:** What do you expect now?

- **Participant**: I am waiting the products, but it is giving sound again *while he thinks loudly he takes the phone back and the products rendered* Oh now there are the products, yes I can see them. Pictures are small but I can see and read the information since I have my glasses. *He swaps the products.* It is going down really fast; hope did not miss the Omo. Yes Omo is here, price, expiration date, nice. I found the Omo. Now the Olive Oil, is this button for a new shelf? *He presses.* Yes, now I have to tap it again *he approximates the mobile and hears the "blip".* Yes, the products, now I will easily find it, swapping and it is here.

Questions asked for task:

How the distance should be close to poster?

Should I wait at the same distance while waiting for the products?

Debriefing:

- **Evaluator:** This system is at the initial process but at the future we want to setup this system to all shops, so senior citizens can be more encouraged to shop, be more at the society.

- **Participant**: This is a really good idea, I would use it. In cases, I don't want to ask for help and not buying the product, so I would use the application if it would exist also my wife, she would learn it easier than me.

- **Participant**: With this idea, I can see all necessary information about the products, expiration date is very good idea because in daily life I have to reach to product, first check

the expiration date and I decide. So with your solution, you handle all my necessary energy with the application.

Notes based on Observation: What did the participant like about the service and what are the reflections for improvement?

At first sight, user had difficulties to adopt NFC technology, because both the NFC poster and the application did not provide enough instruction. Participant asked for help to using NFC technology, however, at the second. Also the poster did not after the first shelf, the user adapted quickly and performed by own. User did not mention about any misleading explanation at the interfaces however it is observed that the size of the pictures were small. Pictures need to be present within bigger sizes.

Test 4:

Participant: 65 years old woman lives alone. She does not use smart phone but she has basic knowledge about the technologies. During the evaluation, she was shopping alone.

Participant Thinking Loudly and Asking Questions to Evaluator

- **Participant**: Now I press to "Tap to Shelf" button then I am coming closer- *holding the smart phone and hearing the "blip" several times*

- **Participant**: Should I wait here?

- Evaluator: No, you don't need to

- **Participant**: Yes, now the products here! I see the products, price, expiration, nice, but I need to find Omo, so I swap, yes it is here. I find the Omo, now the Agrotiko Olive Oil. I am going to the shelf-*she does not press the New Shelf button*- and I approximate again, now the oils, I see them all, I go down and here the Agrotiko. Picture, price, name, expiration, I found it.

Questions asked for task:

How the distance should be close to poster?

Should I wait at the same distance while waiting for the products?

Debriefing:

- Evaluator: This system is at the initial process but at the future we want to setup this system to all shops, so senior citizens can be more encouraged to shop, be more at the society.

- **Participant**: This is a really good idea, I used to work at the grocery shop and I know that many customers do not want to ask for help, so they don't buy. But with this system, it is very easy to use and buy the products.

Notes based on Observation: What did the participant like about the service and what are the reflections for improvement?

At first sight, participant had difficulties to adopt NFC technology, because both the NFC poster and the application did not provide enough instruction. Participant asked for help to using NFC technology. At the third task, participant did not press to "New Shelf" button, while the previous products exist; participant just tapped to poster and received the products from second shelf.

Appendix 9: Sequence Diagram

Store Staff

System Backend:Products

System Backend:Shelves

Content Delivery Network:S3

Cloud Application Platform: Heroku

create product(1)

new product page

specify product(2)

:product name

:product price

:product description

:product picture

:product expiration

:shelf name

get shelves

Shelves :name

create new product

authenticate(3)

success

picture data

picture URL

success/show user the product(4)