Easing the Mobility of Disabled People in Supermarkets Using a Distributed Solution

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Abstract. People's impairments cause a wide range of difficulties in everyday tasks. Particularly, handicapped people face many challenges both at home, but especially outside it, where their reduced mobility is a burden. Buying in a supermarket can be sometimes troublesome for them and so as to facilitate this task, a product locator application is proposed. This application runs on heterogeneous personal mobile devices keeping the user private information safe on them, and it locates the desired products over each supermarket's map.

Keywords: shopping, mobility, disability, mobile devices, triple space.

1 Introduction

Some of the most common impairments that disabled people suffer are somehow related to mobility. Indeed, impairments not directly related to mobility can easily derive in causing disabled people to move slowly in a normal environment. These mobility limitations often become worse in crowded places such as supermarkets, where avoiding people and remembering where to go depending on the desired products becomes challenging. Applications specifically designed to enhance the shopping experience, i.e. guide applications, can easily palliate these difficulties.

The solution proposed in this paper displays products' location over a supermarket map, so disabled customers can decide the better route. Its data is fully distributed on their mobile devices and in the supermarket servers where common information is held. This approach is respectful with the privacy of the users, but yet lets them locate where they must go next inside the supermarket.

J. Bravo, R. Hervás, and V. Villarreal (Eds.): IWAAL 2011, LNCS 6693, pp. 41–48, 2011.

Although this application will be useful for any kind of customer, people with mobility limitations will benefit most as the time they spend moving when they are buying will be considerably reduced. Doing so, the stress that such kind of crowded places generates in them is expected to be palliated, resulting in a better shopping experience.

The remainder of the paper is organized as follows. Section 2 discusses related work. Section 3 presents a use case where the solution will be used. Section 4 details the technical aspects of the proposed solution. Finally, Section 5 concludes and outlines the future work.

2 Related Work

With ageing of Europe [8], the infrastructures used for treating the elderly will gain relevance, and the costs of these infrastructures will increase notably. In order to optimize the costs of these infrastructures, the development of new technical solutions is required. Given that the ageing of the population causes physical disabilities, it is expected that the number of users with physical disabilities will increase in the near future. The elderly of the population is a problem that the European Union is addressing by the promotion of programmes to develop applications and frameworks that enable the reduction of related costs and the increasing of factors that ease the quality of elderly's life. Within this context, Ambient Assisted Living [2] solutions are arising across Europe to tackle these costs.

Efforts are being placed in supporting an automatic system that guides disabled users in a known system, as reported in [7]. However, these systems require that the supermarket provides an indoor location system, which is not the case in the supermarkets we work with. Therefore, no automatic guiding algorithm can be implemented within the supermarket.

The use case presented in this paper is formed by several independent nodes which share their information. In order to share it in a very decoupled but expressive way TS paradigm [3] is used. TS comes from tuplespace-based coordination languages where the interaction between processes is performed sharing information in a common space. Although, several approaches in the field of semantic tuplespaces exist [6,5], to the best of our knowledge this kind of solution has never been specifically designed and implemented to use mobile devices as another peer of these semantic spaces and not only as simple clients apart from in our middleware [4].

3 Use Case Description

The target of the developed platform is to enable elderly and disabled people to optimize the search of products in supermarkets. We expect that for certain types of disabilities, such as physical disabilities that make them move slowly in a supermarket -requiring wheelchairs, or just walking slowly-, will be more willing to go to supermarkets if their shopping experience is considerably better, by finding the desired products immediately.

In order to achieve this, users will first use a mobile application in their mobile device, technically described in section 4.1, on which they will select which products will try to buy in the supermarket. They will be able to do this task wherever they are: at home, work, in the street... The mobile application will connect to the supermarkets global servers through the TS and it will retrieve which products are available, and at what price. In this first application version, we do not include more information, although supermarkets usually have other information such as products preview images that would increase the shopping experience. For instance, ALIMERKA[1] lists the available products, prices, codes and images. Once products are listed in the mobile application, users will select from the list what items are willing to buy.

Then, at some point of the week, users go to the supermarket. They will be able to ask for a device with the *product locator application* (technically described in 4.2) already deployed. These devices will typically be tablets such as Apple iPad or Samsung Galaxy Tab, properly tagged so users can't leave the supermarket with them. In fact, similar technologies are already provided to users in a secure way in restaurants [1] to let users select the products, pay and even play videogames.

Once they have the device, users will launch the *shopping cart application* in their own mobile device. Then, users will write their username in the *shopping cart application*, which automatically will retrieve the selected products from the users' mobile devices. With this information, the *product locator application* will query to a server placed in the supermarket for the location and availability of the selected products and it will show in a seamless way those available products in a map of the supermarket. With this information, users can go through the supermarket with the customized map in their hands.

This solution is built within the ACROSS project[2] (TSI-020301-2009-27), funded by the Spanish Ministerio de Industria, Turismo y Comercio. The project aims to build social robotics services in certain areas, including supermarkets. Therefore, it is expected that in the near future the *product locator application* will run on the TICO robot, developed by Treelogic and Adele Robots[3].

The robot will then guide users if there are not many users waiting for the robot and if there is enough battery left. Otherwise the map of the *product locator application* might be showed or the system would rely on the tablet acquisition by users or the automatic deployment of the *product locator application* in the user's mobile phone. Within the project, this system is expected to be deployed in certain ALIMERKA supermarkets in Spain. Since a network infrastructure and the maintenance costs are assumed by the supermarket, the system can't be deployed in every supermarket.

[1] `www.alimerka.es`
[2] `www.acrosspse.com`
[3] `www.adelerobots.com`

4 System Architecture

The system is divided into three main elements (see Fig. 1), the mobile Shopping Cart application allows users to search for supermarket products; the Products Manager, which main purpose is to manage each supermarket product list (e.g. adding another milk brand); and the Product Locator application, which finds and locates in the different supermarket's corridors and shelves where users' desired products are.

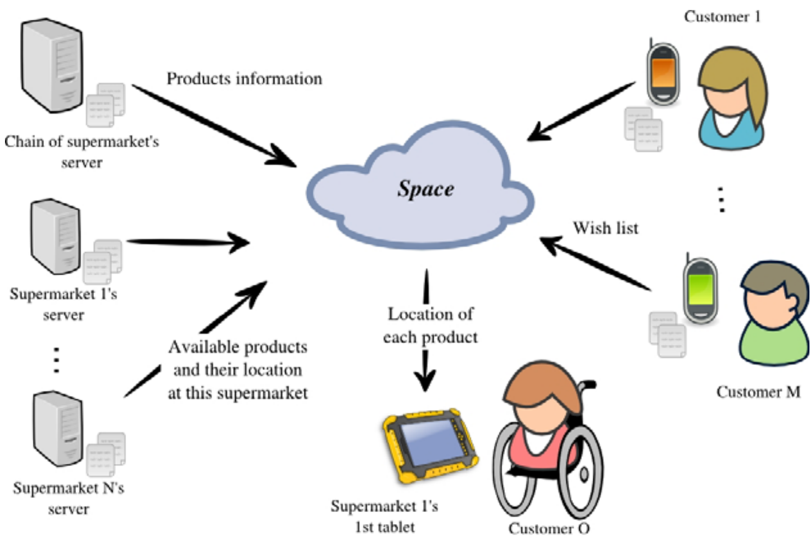


Fig. 1. System architecture diagram

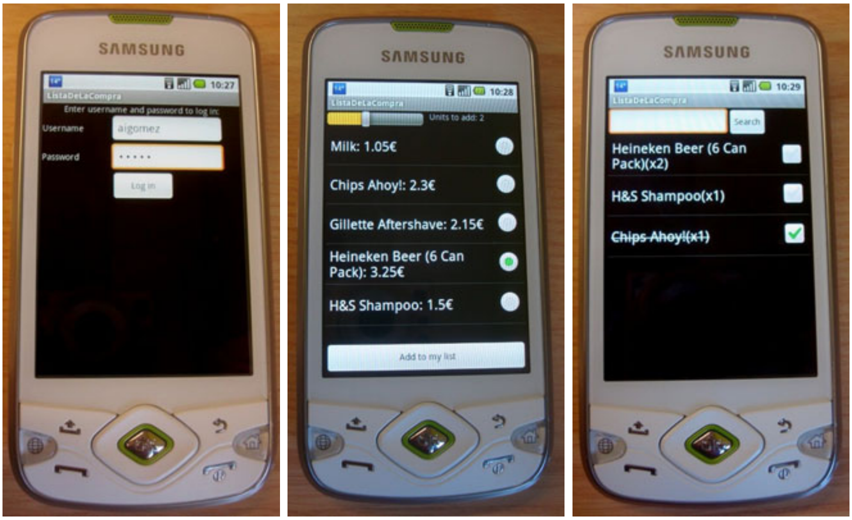
These applications share information between them using a common space where they can write and also make queries as shown in 1.

4.1 Shopping Cart Mobile Application

In order to encourage the users to note down the products they are willing to buy, a "todo list"-like Android[4] application has been designed to be run on the user's personal mobile phone. Doing so, the user can benefit from our solution not only being guided in the supermarket, but also avoiding inconvenient oversights.

The proposed *shopping cart application* connects to different triple spaces. First, the user must identify himself in the application (see Fig. 2a), then to retrieve the list of all available products in a chain of supermarkets the global space is used (see Fig. 2b). Finally he connects to a users' space, where the concrete shopping list of each user (see Fig. 2c) is written. Due to the implementation of the used TS solution, the data written by the user in his mobile phone will stay

[4] www.android.com



(a) (b) (c)

Fig. 2. *shopping cart application* running on a Samsung Galaxy Spyca

at his device considering privacy issues but it will be accessible by the *product locator application* whenever the mobile is connected to the space.

4.2 Product Locator Tablet Application

Trying to find out where our shopping list products are in a supermarket can be tedious and ponderous. Supermarkets tend to change products shelves, bringing new market brands and putting special offers in the end podium every month.

The presented Android application focuses on helping users with this task. By querying Ts, wish list's products will be drawn over the current supermarket map (see Fig. 3). Every product is stored semantically annotated with its position in the supermarket. Therefore, *product locator application* just needs to query those "coordinates" and draw the products in the supermarket map.

4.3 Supermarket Servers

The supermarkets count with two scopes for their servers:

- Internet, with global servers available from anywhere
- A particular supermarket, with servers placed in the supermarket itself

A survey performed with ALIMERKA (a Spanish located chain of supermarkets) for this research revealed that in their particular case they have a middle server located in the supermarket between the check-outs and the global servers located in their headquarters.

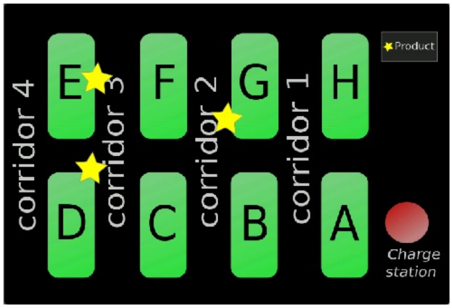


Fig. 3. Desired products marked on a supermarket plan

When users are at home defining what products they wish to buy, the *shopping cart application* will connect to the global servers of the chain of supermarkets. The retrieved information will contain global variables such as the name, price and code of the product. However, it will not contain information related to a particular supermarket.

Then, users in the supermarket will connect to both the global servers and the server located in the particular supermarket, which will contain information such as the current availability of the product in the supermarket (it may not be available in a supermarket as it would in bigger supermarkets; or it may not be in stock in that moment), or the location of products in the supermarket. The information available in each scope of the servers is summed in the table 1.

The communication of the different applications with the servers, and the synchronization among the servers is performed with Triple Spaces as detailed in section 4.4.

Table 1. Summary of the information provided by the different servers

Scope	Information	Description
Global servers	Name	The human readable name of the product
	Code	A unique identifier of the product
	Price	The price used in all the servers
Located servers	Location	Where is it in the supermarket (X,Y)?
	Availability	Is it sold here? Is it in stock?

4.4 Triple Spaces

TS is a paradigm which enables the coordination between processes deployed in heterogeneous devices writing and reading semantically described data in a shared space. The concrete TS solution we use is characterized by a full decentralization of the space through the nodes which joint it. In the described use case the different nodes are user's personal mobile phones, the supermarket's tablets, the chain of supermarket's global information management server and at least a server to manage the information of each specific supermarket (see Fig. 1).

This knowledge distribution is particularly interesting because the user information is written in his mobile device (section 4.1) fulfilling privacy issues. In any case, this information will become accessible by other nodes in the same space (i.e. *product locator application*), just when the user is connected to it.

4.5 Ontology

The ontology, which is dumped in the TS, is depicted in the Fig. 4. The most relevant concepts described by the ontology are:

Supermarket represents a concrete supermarket which belongs to a chain of supermarkets.
Product represents a concrete product sold by the chain of supermarkets.
ProductInSupermarket indicates if a specific product is sold in a given supermarket and its position. This information is required to locate a product in the mobile application map (see Fig. 3).
ShoppingCart represents the products the user wants to buy.

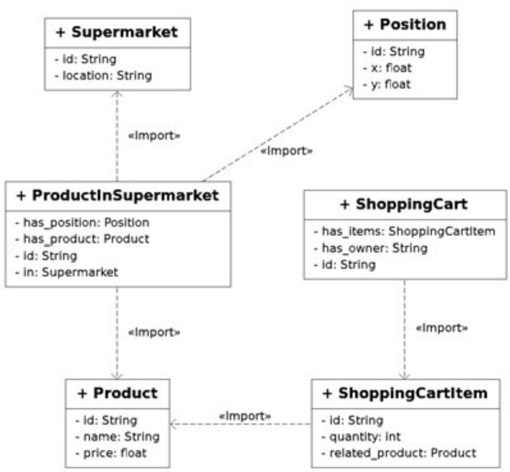


Fig. 4. Supermarket ontology

5 Conclusions and Further Work

This paper explores the use of a product locator application to enhance the shopping experience of people with mobility problems at supermarkets (such as handicapped or the elderly). The infrastructure used is fully decoupled and runs in mobile devices keeping the information of the user inside the boundaries of their personal devices.

In the future a robot will be responsible of guiding users, avoiding some issues such as security concerns related with the use of a supermarket's tablet. Moreover, the map will only be displayed as an alternative to the physical guiding of the robot, in those cases where supermarket is too crowded or the battery level is low.

Finally, an exhaustive evaluation of the final scenario is planned to be carried out. Similarly, the TS solution briefly described in this paper will be tested both in a heavily instrumented deployment scenario and using simulation tools.

Acknowledgments. This work has been supported by project grant TSI-020301-2009-27 (ACROSS), funded by the Spanish Ministerio de Industria, Turismo y Comercio.

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