# Enhancing the Shopping Experience through RFID in an Actual Retail Store

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*UbiComp'13 Adjunct*, September 8–12, 2013, Zurich, Switzerland.


http://dx.doi.org/10.1145/2494091.2496016

## Abstract
Radio Frequency Identification (RFID) offers an extraordinary opportunity to enhance the shopping experience of customers in a retail store. There are two types of possible enhancements: increasing the efficiency of traditional processes, or offering new use cases at the store. RFID offers a great opportunity in both cases. RFID can be used to improve the availability of products, reducing stock outs, to streamline the check-out process, reducing the lines, or to substitute the typical Electronic Article Surveillance (EAS) "horse gates" by hidden antennas, freeing the entrance to the store from intimidating barriers. Besides these operational improvements, RFID can also be used to offer shoppers new and enticing functionalities, such as a "magic mirror" to virtually try garments on, or an interactive screen in the fitting room that displays information and offers functionalities related to the particular garments brought in by the customer. This paper describes an actual installation in an apparel retail store in Barcelona, and presents some of the initial conclusions after several months of operation with real customers.

## Author Keywords
Pervasive Technologies in Retail, RFID, Shopping Experience, Implementation

## ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

## Introduction

By and large, a retail store of the $21^{st}$ century does not differ greatly from a retail store of the $19^{th}$ century. Lighting, climate control, and the introduction of the barcode in the 1970's are the biggest differences in a sector that has not seen the rapid progress experienced in transport, communications, industry, healthcare, and most other areas of human activity.

This did not seem to pose a serious problem to the retail sector until e-commerce started to experience widespread success, and the new digital native generations started to expect the rich level of interaction and operational perfection of the on-line world everywhere else. These new generations are less understanding to not finding a particular product in the store due to a stock-out, or waiting in line for more than a few minutes. Besides, they expect a depth of information, comparison, interaction and participation that traditional stores cannot offer them. Until now.

In [4] Krüger et. al. review the potential of computing to improve all aspects of retail. Some laboratories such as the Innovative Retail Laboratory (IRL) [8] have conducted extensive research on the use of Radio Frequency Identification (RFID) and other technologies applied to enhancing the consumer experience at the store, using the living lab methodology. In [9] the very relevant aspect of privacy is discussed.

The use of item-level RFID tagging in retail opens the door to solutions to all of the above situations [2]. RFID can be used to streamline operations, giving retailers much more accurate and frequent data about stock availability, cutting the time it takes to check out a customer to less than half, and reducing the visual and operational impact of Electronic Article Surveillance (EAS) to almost none. Once the store has reached operational excellence, RFID can also be used to propose enhancements to the shopping experience, such as magic mirrors or interactive fitting rooms. Furthermore, these enhancements allow novel ways to model customer activity, with opportunity to improve recommender systems, and thus, increase sales rates.

A number of RFID-based enhancements, both operational and experiential have been deployed in an apparel retail store in Barcelona. This retail store is in the premium retail district of the city, and carries garments of high price, just on level below the traditional luxury brands. The store offers garments for both adult men and women, has a surface of about $250m^2$ all at street level, a single entrance, a single checkout desk, and 3 fitting rooms at the back. The store also has a warehouse of about $150m^2$ in the basement level.

## Operational improvements using RFID

Before any new use case is implemented in the store, a perfect control on the available stock is necessary, and the basic operational processes must be performed almost flawlessly. For this, the following systems were installed in the store:

- **RFID labelling station**: An RFID-enabled label printer together with the appropriate label printing and tag commissioning software, is linked to the retailer's RFID Enterprise Resource Planning (ERP). It is used by the store staff to relabel every garment received at the store with a new label including an

RFID tag. The *defacto* standard for RFID in retail is the Electronic Product Code Class 1 Generation 2 [3] (EPC Gen2 for short). The identification of each electronic tag is known as EPC code, being defined by GS1 Standards [1] from the Stock-keeping Unit (SKU) and a serial number. In the future, garments will be RFID-labelled at the manufacturer [7], but for now this system is necessary. It took some training to get to the point where the store staff were completely autonomous, but after several weeks, RFID tagging became a routine job at the store.

- **Hand-held RFID reader for inventorying the store**: Once all the items in the store are tagged with RFID labels, a handheld reader may be used to inventory the store. Control tags are placed in pre-defined places to control that no areas are left out. An RFID inventory software application was parametrized and customized to integrate the data into the retailer's ERP. The inventory process, which used to last between one and two days, and involved 3 or 4 persons, can now be done by a single staff member in under 30 minutes. Inventories were never done more than once every several months, and are now possible every day. In practice they are done once a week, which is more than enough in this case to avoid significant divergences. The accuracy of the manual inventory is above 99%. This has been a star functionality for the store staff, who hated traditional inventories based on barcodes. A full inventory can now be done in a slow time of the day, and does not require to work on Sundays as it used to. The store staff would not want to go back to barcode inventories, which acts as a strong incentive for the RFID tagging process.

- **Overhead antennas for real-time inventory of the warehouse**: Since the warehouse is out-of-sight for customers (c.f. Figure 1), a more innovative approach was used there to try to obtain real-time inventory. Overhead antennas were installed, providing a full inventory every few minutes. This functionality is still under evaluation, and inventories in the backroom are also done with a handheld reader.

**Figure 1:** Overhead antennas for real-time inventory at the store warehouse.

- **RFID Point of Sale (POS)**: An RFID reader was installed under the counter, with a software that emulates a keyboard, so that the integration with the store's POS software system did not require any modification of the store's system. The POS

receives the data from the RFID reader as if it were read from a barcode reader, or typed on the keyboard. Since the RFID POS can read several garments at the same time, and deactivates the RFID EAS alarm, the time to process a customer's purchase is cut to less than half. However, the staff still uses barcode readers frequently at the check-out. The advantage of RFID is not perceived as differential in this case.

- **RFID-enabled floor mat EAS**: The typical EAS "horse gates" at the entrance were substituted by a floor mat with RFID antennas inside (c.f. Figure 2). The entrance to the store is now much more appealing and inviting, and the EAS alarm can now be deactivated at the same time that the garments are identified for payment. The store design architect was the main supporter of this particular use case.

**Figure 2:** Antennas hidden inside the entrance floor mat for EAS.

## Extending the customer experience through RFID

Once the operational systems were running smoothly, the following new use cases were installed, with the goal to extend the customer experience:

- **Interactive fitting rooms**: RFID antennas and readers were placed above the ceiling in each fitting room, so the garments that are brought in are detected (c.f. Figure 3). That is, the interactive fitting rooms are context-aware, and can be categorized as smart environments [6]. A photograph of the garments is automatically shown on a touch screen on the fitting room wall, allowing the customer to request recommendations for accessories, and to request a new size (request which is automatically sent to a store attendant using a handheld device). This functionality has been very well accepted by customers, and the store staff credit it with an increase of sales. Actual quantitative data about this particular effect is currently being obtained. The functionalities in the interactive fitting room are used much more often by younger customers than by middle age or older customers. Although quantitative data is currently being processed, the store staff confirms that this particular use case increases sales at the store.

**Figure 3:** Interactive fitting rooms showing the touchscreens. The RFID antennas are hidden in the ceiling.

- **Virtual fitting room using a "magic mirror"**: A "magic mirror" consisting of a large screen, an RFID system, and a dual RGB and 3D camera, is used as an interactive fitting room (c.f Figure 4). When a customer brings a garment and leaves it on the shelf or rack next to the screen, an image of the garment appears on the screen, having in effect "crossed the mirror" as in "Alice in Wonderland". The physical garment is now both on the shelf or rack, and in the screen. At this point, the customer can, using gestures detected by the 3D camera, try the garment on, and request other garments that fit, and also try them on simultaneously. This is done using a specially designed augmented reality application that fits the garments to the body shape, follows the movements of the arms and legs, and knows how to layer the different garments (e.g. it knows that a shirt goes under a jacket). The staff requested a mode through which they, using a tablet, can actually change the garment on the customer, rather than the customer him or herself through gestures. This way, they can suggest garments based on their experience. This more "assisted" mode was better accepted in this particular store and has also been reported to increase sales.

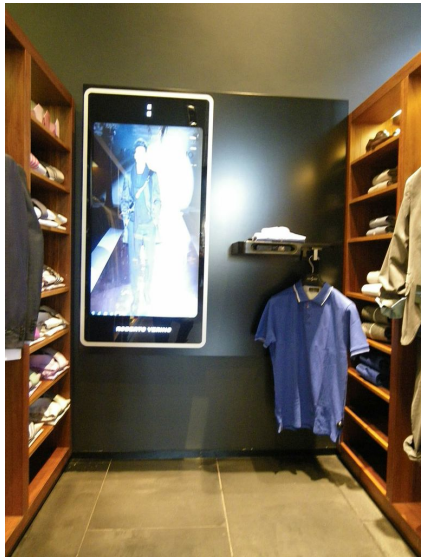

**Figure 4:** RFID-equipped "magic mirror" used as a "virtual" fitting room.

- **Interactive rack with contextual media**: In a corner store that this same retailer has in a large department store in Madrid, an interactive shelf, equipped with RFID and a large vertical screen was installed, which is able to detect which garment is being examined by a customer, and shows photographs and videos of the garment being worn by a model. Store staff suggested this use case since customers at this particular location prefer to shop unassisted.

The aforementioned enhancements not only extend the shopping experience, but also allow improving the customer understanding and modeling. The interactive and virtual fitting rooms permanently track the RFID labels attached to the garments. By means of RFID, the store can obtain valuable information like the time spent in the fitting rooms, or the garment combinations brought by customers. Improving the user modeling allows, in turn, better recommendations to the users [10, 11]. The RFID data being captured by the interactive and virtual fitting rooms is expected to be used in the future to build a recommender system, based on user modeling in the store.

## Future work and discussion

The above systems have now been in continuous operation for over one year. Very little maintenance is needed. The tremendous improvement in inventory time motivates the store staff to keep labelling every garment at reception.

The positive reaction of customers to the interactive and virtual fitting rooms has also been observed. At present, data is being collected to calculate the effect on customer loyalty, average ticket value, and other key indicators, with the objective of producing a Return of Investment-based business case for the installation. Observed data will also be used to model the customer's behaviour, and classify customers into several categories, with the objective of designing new shopping experience enhancements [5].

## Acknowledgements

The authors would like to thank the anonymous reviewers for their valuable comments and suggestions to improve the quality of the paper. This work was partly funded by the Spanish Government through project TIN2012-34965 PIGALL, and Obra Social "la Caixa"-ACUP through project 2011ACUP00261.

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