ORIGINAL ARTICLE

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Consumer perceptions of privacy, security and trust in ubiquitous commerce

Abstract Commerce is a rapidly emerging application area of ubiquitous computing. In this paper, we discuss the market forces that make the deployment of ubiquitous commerce infrastructures a priority for grocery retailing. We then proceed to report on a study on consumer perceptions of MyGrocer, a recently developed ubiquitous commerce system. The emphasis of the discussion is on aspects of security, privacy protection and the development of trust; we report on the findings of this study. We adopt the enacted view of technology adoption to interpret some of our findings based on three principles for the development of trust. We expect that this interpretation can help to guide the development of appropriate strategies for the successful deployment of ubiquitous commerce systems.

1 Introduction

Over the past decade, the rapid proliferation of electronic commerce technologies has fundamentally transformed the way we conduct business. This trend is expected to accelerate in the coming years due to a number of different factors, including the introduction of new mobile and ubiquitous computing technologies, the wider recognition by business of the strategic advantages offered by the implementation of ubiquitous computing and communications infrastructures, the emergence of novel business models which become

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possible only through this technology and, last but not least, the development of new economics that can be used to understand and value ubiquitous commerce activity. There are, thus, several areas of contestation that must interact to produce the conditions for the successful implementation of ubiquitous commerce. Indeed, recent experience has shown that the concerns of these (traditionally distinct) areas are intimately interrelated and, thus, have to be co-developed in parallel. Moreover, researchers and practitioners from all fields need to be informed of the concerns and the priorities of each other, so that they can include each other's requirements in their models.

In this paper, we report on a recent study on the consumer perceptions of retail services carried out as part of the MyGrocer research project [7, 13]. MyGrocer is a second-generation ubiquitous retail system that offers new ways for home inventory replenishment. The system underwent several stages of evaluation and the research reported here was part of the early stages.

The paper is organised as follows First, we discuss the background for the development of ubiquitous retail systems and highlight their importance from a business perspective. Then, we discuss the design and the findings of the study carried out in the context of the project. Finally, we discuss our findings and relate them to three principles for the development of effective strategies in designing ubiquitous commerce systems.

2 Creating consumer value with ubiquitous commerce

Among all the retail sectors, grocery is the most competitive as it operates at minimal profit margins. It is, thus, important that grocery retailers exploit any possible efficiency improvement opportunities offered by technology and, indeed, over the past 50 years, they have pursued this objective with considerable success. In particular, the supply chain of grocery products—or else, fast moving consumer goods (FMCG)—has attained considerable operational gains through the

implementation of a number of technologies, including bar codes, resource-planning software and optimised logistics. This need has also produced Efficient Consumer Response (ECR), a voluntary and industry-wide initiative to raise performance levels across the entire retail sector [8]. ECR aims to carry out a continuous and in-depth self-examination of processes and procedures for the industry as a whole, recommend improvements and oversee the implementation of recommendations. ECR was initiated in the United States, but its distinct advantages from a business perspective have rapidly extended its scope to the rest of the world, with national and regional initiatives in action.

ECR have identified three priorities: (1) to increase consumer value, (2) to remove costs that do not add consumer value and (3) to maximise value while at the same time minimising inefficiency throughout the supply chain. In practice, these priorities are used to identify and fulfil specific goals; for example, providing consumers with the products and services they want, reducing inventory, eliminating paper transactions and streamlining product flow. To meet these goals, distributors and suppliers are making fundamental changes to their business processes that can only be enabled through the implementation of novel information and communication systems.

In this context, the new information sources made available by ubiquitous retail can offer significant benefits for business. For example, decades after the introduction of information systems in production and logistics control there are still significant inefficiencies in modern supply chains, which adversely affect the cost of retail operations. Upstream supply chain inefficiencies affect the relationships of all trading partners and result in high out-of-stock conditions at the point of sale, a high returns rate and long lead times. Inefficiencies in the downstream direction negatively affect demand forecast accuracy, which results in low on-shelf availability and, thus, loss of revenue, despite the fact that products are available on site. Moreover, information-sharing ineffectiveness between trading partners reduces the accuracy of demand forecast and the scheduling of the replenishment process. A direct consequence of low demand forecast accuracy is that trading partners have to maintain increased inventory levels to address unpredictable increases, which, in turn, result in increased logistics costs. Common practice today is forecasting consumer demand by processing historical point of sale data using decision support systems that utilise data warehousing and data mining techniques. However, using point of sale data to make forecasts results in lower accuracy because demand patterns are changing rapidly and such fluctuations cannot be captured at the point of sale, but have to be identified earlier in the consumption process. Moreover, historical forecasts cannot effectively take into account the influence of promotions and other marketing instruments since the success rate of such mechanisms is generally hard to quantify beforehand. A quantitative description of this situation according to a recent study by Andersen Consulting (currently Accenture), a management consulting and technology services firm, estimates that 53% of out of stock conditions are due to store replenishment inefficiencies. Even worse, a further 8% of on the floor out of stock conditions occur despite the fact that the necessary supplies are in storage on site. Ubiquitous computing technologies applied to this problem space can provide the necessary consumption data early on in the replenishment process so as to allow for greater prediction accuracy, which leads to reduced inventories and optimised supply chains both upstream and downstream.

One contribution towards the ECR goals is the so-called vendor managed inventory (VMI) approach where the vendor, rather than the customer, specifies delivery quantities sent through the distribution channel. This reversal in the procurement process has become possible only through the deployment of electronic data interchange (EDI) systems, a computer-to-computer exchange protocol for business data. VMI had succeeded in reducing stock-outs and inventory buffers in the supply chain. Common features of VMI include reduction in supply chain length, centralised forecasting and frequent communication of inventory levels. From a fleet management perspective, delivery vehicles are loaded in a prioritised manner: items that are expected to stock out have top priority, then items that are furthest below the targeted stock levels, then advance shipments of promotional and, finally, items that are least above targeted stock levels. In addition to EDI, a second technology critical for VMI is the universal product code (UPC), a standard for constructing bar codes to automatically identify products. This technology plays a core role in the automated creation and entry phases of the order cycle and can take days out of the total cycle time. The two technologies together can help develop collaborative relationships in which any combination of retailer, wholesaler, broker and manufacturer work together to seek out inefficiencies and reduce costs by looking at the net benefits for all participants in the relationship.

Overall, VMI has been successful in significantly reducing inventory levels and the number of stock-outs. The latter issue is particularly important not only because of lost sales, but also because shelf availability is central to supermarket strategy. Indeed, a significant proportion of supermarket profit margins are due to interest-free periods for products already available on the selves. Thus, one of the main concerns of retailers implementing VMI has been the perception that reduced inventory will result in less product being available on the shelves at any one time and, therefore, loss of market share. A partial solution to the problem is to fill shelf space with other stock-keeping units (SKUs) from the same vendor, but this approach does not fully address the problem.

3 Ubiquitous retail and consumer VMI

In the previous section, we identified the relatively late collection of sales data at the point of sale as one of the main factors for the low accuracy in forecasting demand and as a barrier in developing effective replenishment strategies. For this reason, the next natural step for ECR is to extend the use of technology to the collection of data directly from the selves and, even more, to consider extending the supply chain to the consumer home. Indeed, the replenishment process starts when the consumer runs out of a particular product. Gaining such early information and using it in supply chain optimisation can potentially increase considerably the accuracy of predictive replenishment strategies to a degree that is well beyond what is possible today. Ubiquitous computing technologies can fulfil exactly this requirement. Several projects have attempted to explore this space; here, we will discuss MyGrocer, one of the earlier attempts (for a review of work in this area, see [7]).

MyGrocer was primarily aimed at creating an early prototype and identifying some of the core issues in this context, while several more recent projects examine specific aspects of ubiquitous commerce systems. More recent work has focussed on other aspects of the system; for example, the Auto ID Centre at MIT developed some of the standards required for the facilitation of business data exchanges in the new retail environment, now taken over by EPCGlobal. EPCGlobal has defined three new standards as extensions of its existing UPC bar code and EDI initiatives with a view of facilitating optimisations to the supply chain. For example, the so-called electronic product code (EPC) uses radio frequency identification (RFID) tags to store information about specific product items (rather than SKUs) and relate them to product descriptions written in product mark-up language (PML) retrieved through the object naming service (ONS) [15]. The Super Market of the future developed by the Metro Group in Germany aims to quantify the operational gains from this new infrastructure and identify the exact cost of its deployment in a controlled environment. An ongoing research project at Intel Labs, Portland, is exploring cultural aspects affecting the deployment of ubiquitous retail systems.

Nevertheless, extending the supply chain in this way has significant repercussions for the consumer, who is now involved in the data processing pipeline. Ubiquitous commerce services use personal data associated with individual consumers in intimate ways and that can be used to reconstruct their private activities at an unprecedented level of detail. Moreover, as evidence from our recent studies [7] corroborates, the implementation of these technologies may cause fundamental transformations to the consumption experience due to the continuous replenishment process at home and, on the other hand, it creates a novel retailtainment experience on the supermarket floor. This change can be seen as a shift from particular retail ecology to another [14]

and, thus, it should come as no surprise that consumers show considerable scepticism to ubiquitous commerce value propositions.

The argument developed in this section points to the significance of adopting ubiquitous computing technologies in FMCG retail. The success of such technological offerings depends heavily on their adoption by consumers and, thus, the development of trust between the service provider, the consumer and the systems is of paramount importance. Indeed, the role of trust in developing particular markets has been clearly identified in [5] and has been one of the core issues affecting the slow adoption of both electronic and mobile commerce in recent years [11].

4 The enacted view of ubiquitous commerce

There are different ways of conceptualising ubiquitous commerce, and, hence, different ways of understanding what is needed for its successful implementation. One perspective is the objective view in which technologies are seen as distinct entities with specific qualities and mostly predictable consequences. An established alternative to this view is to consider strategic choice as the defining factor. Thus, success is seen as dependent on decisions made by management in selecting and deploying technologies. In the previous sections, we discussed in some detail the strategic view and its arguments for the development and deployment of ubiquitous commerce. This viewpoint sees consumers adopting technology on the basis of value gains, but completely disregards the implications of the deployment of such systems for everyday life or their interactions with well-established practice.

To be sure, as argued by Orlikowski and Iacono [9], it is also crucial to recognise the enacted view of technologies whereby they are seen as part of an open-ended socio-technical process, that is, "a mass of particular actions taken as individuals and groups make their own uses of technologies" [9]. The enacted view sees technologies in the context of their use and their acceptance depending on a dynamic, unpredictable and strongly mediated process by the idiosyncrasies, needs and preferences of individuals and groups.

More importantly, the enacted view argues that, if we remove individual human agency and free choice in the actual and day-to-day use of technologies, then we reach an artificial and unhelpful understanding of their success or failure [9]. Hence, we need to attend to technologies-in-use, that is, the actual results of introducing technologies into particular situations, contexts, tasks and communities. The introduction of a continuous replenishment process based on data collection at home may potentially cause a fundamental transformation to the experience of consumption.

In addition to appropriate security and privacy protection mechanisms, we believe that, in developing trust in ubiquitous commerce systems, it is also necessary to

develop suitable interaction paradigms. To help conceptualise and discuss them, we have introduced three principles that may be used to guide the design of appropriate systems and help interpret behaviour when this technology is seen in its use context [12]. The three principles are:

– *Reciprocity and understanding*. The principle of reciprocity and understanding concerns the negotiation and knowledge of the identity of a peer in a trust relationship as well as the need for mutual comprehension [17].
– *Context and locality*. This principle implies that relationships of trust are situated in particular contexts, relationships, roles and communities, and that the decision to trust or not to trust may change depending on the perceptions of different contexts [6].
– *Communication and interaction*. This principle recognises the importance of non-cognitive aspects in building trust [2].

5 The consumer viewpoint

Despite the fact that ubiquitous commerce was perceived as potentially having a major impact on improving retail efficiency, the different technologies available made possible the implementation of very different systems. Due to the diverging views of project partners, the first step in creating consensus was to develop and agree on three usage scenarios. To this end, a workshop was held where the different interests and options were discussed and consensus was reached on the development of three usage scenarios. These seemed to satisfy the requirements of all the participating organisations. The scenarios were subsequently used to collect functional requirements for the system.

The three scenarios agreed upon related to the usage of the system "on-the-floor" during a supermarket visit, while on the move using a mobile device and finally at home, to monitor consumption:

5.1 Supermarket scenario

The consumer enters the supermarket and selects a "smart" shopping cart equipped with RFID readers and a tablet PC. She identifies herself to the system with her username and password. The system logs her in, responds with a welcome message and then proceeds to present a "suggested" shopping list, based on monitored home inventory and actual consumption data. The consumer walks down the supermarket aisles and picks up products from the shelves. For example, she may decide to buy a shampoo, which she picks up and places inside her shopping cart. The cart identifies that the shampoo bottle has been placed in it and triggers the following event sequence: the product ID is sent to the back end system, which retrieves related information that is used to update the shopping list and the total cost of the shopping cart contents. Next, the consumer decides to buy a brand of hair conditioner that the retailer is promoting for customers with her profile. When the consumer places the product in the cart, the system displays the relevant offer on the screen together with instructions on the shortest path to the aisle and shelf where the associated products are held. Later, the consumer decides to remove one can of orange juice from her cart and replace it on the supermarket shelves. The system updates the shopping list with the new total amount and the new contents of the cart. When the items on the shopping list are exhausted, the consumer proceeds to the checkout. When she approaches the till, the system rescans all the items in her shopping cart, calculates the total value of the products, displays that information on the till display and prints out a receipt. The consumer pays at the till or charges everything to her account.

5.2 Home scenario

The consumer returns home and places her shopping in her RFID-enabled storage (including her fridge, cupboards and so on). New product information is recorded by her home server and consolidated in the home inventory data. The home maintains data on inventory levels as well as consumption. Periodically, the consumer gives permission to her home server to upload her new shopping list to the system.

5.3 On-the-move scenario

While on her way to work, the consumer uses her mobile phone to check which products she needs to replenish before the weekend. After logging in, the system displays her current home inventory and/or her shopping list. The consumer decides to add new items to her shopping list for the dinner party she is giving on Saturday night. The consumer is happy with her new shopping list. The system displays the total cost of her shopping list at her usual supermarket. The consumer is unhappy with the price and she decides to look for a better price, thus, initiating a reverse auction. The system forwards her list to participating retailers and prompts the consumer to define the duration of the auction, which she does. The system sends a confirmation message that the process has been initiated. A short while later, the consumer receives offers by different retailers and selects the best. The consumer selects "home delivery" and confirms the order. Later in the day, the system notifies the consumer, via SMS to her mobile, that baby diapers are going to run out in the following few hours and request confirmation of instant replenishment order. The consumer confirms and the order is placed.

As reported elsewhere [7], this ubiquitous commerce solution attracted significant interest from consumers as a shopping option, in addition to the ones available

today. In particular, the in-store scenario received the most favourable response with the main benefits perceived to be the improvement of the shopping experience, which was understood to be faster, easier and offering better value for money. In summary, features that proved to be the most attractive were:

– The constant awareness of the total cost of the shopping cart content that offers the opportunity to accurately control spending during a shopping trip
– Access to complete and accurate descriptions of products, including price, size, ingredients, suitability for particular uses and so forth
– The ability to compare the value of similar products
– The provision of personalised, targeted promotions that reflect the individual consumer profile in addition to the usual generic promotions, as well as the fact that consumers could access all offers available in the specific supermarket at a single interaction point
– The proposed in-store navigation system, especially in the case of hypermarkets, where orientation is particularly difficult
– The smart checkout and the ability to bypass queues and reduce waiting time

6 Research methodology

Because of its novelty, it was deemed necessary to conduct an exploratory research study on consumer views of MyGrocer. The aim of the study was to understand consumer perceptions of the MyGrocer value proposition and to collect user requirements that would lead to appropriate system design. To this end, we employed a methodology often used by Procter and Gamble (P&G)—one of the project partners—for product development. This approach is based on conducting focus groups with consumers and aims to identify the features of a product according to the ECR principles (discussed earlier in Sect. 2). Market Analysis, a market research firm, was commissioned to conduct the field study in Athens, Greece, over two consecutive days in June 2000. Market Analysis was selected because it carries out all product development, research and evaluation for P&G and has developed expertise in this area.

Participants to the study were introduced to the three ubiquitous retail scenarios. Following the ECR principles, the study investigated perceptions of added consumer value and barriers to use, interest in the system as a whole and in its different subsystems specifically, and consumer motivations for using the system, for example, perceived impact of system use in consumption patterns.

6.1 Research participants and procedures

Four focus groups were conducted in total at the premises of the company; two in each day and each group consisted of 12 people. Participants in the first group were women between the ages of 25 and 34, responsible for grocery shopping within their household and who demonstrated some familiarity with information and communication technologies, either as regular users of personal computers and mobile telephony at home or at work. The second group consisted of women with the same background as those of the first group but from the 35 to 50 age range. Married couples were invited to join the third group, with both partners between the ages of 25 and 34, both responsible for shopping and with similar background to groups 1 and 2. Finally, group 4 consisted of couples as in the previous group, but from the 35 to 50 age range.

Focus group participants were received by the moderator and directed to the focus groups room of the company. Participants were positioned around a table so that, at least partially, they were facing a video camera which recorded the sessions. A one-way mirror that allowed members of the development team to follow the proceedings unnoticed covered one of the walls. In addition to recording the proceedings on video, the camera transmitted the discussions to a second room (via closed circuit television (CCTV)) where others members of the team were able to follow the discussions, but also to discuss between themselves and keep notes.

At the start of each session, participants introduced themselves and were encouraged to talk briefly about their background, including their education, current employment, family status, shopping habits and use of technology. The moderator then introduced the subject of the discussion and related it to current retail trends. Participants were then introduced to pervasive retail concepts through a presentation based on concept drawings with explanatory text, which the moderator uses to develop the usage scenarios (Fig. 1). The sessions were split in two phases; first, the supermarket scenario was developed and discussed (for approximately 20 min) and then the on-the-move and at-home scenarios were introduced and discussed (for approximately 20 min). Following the introduction, participants were encouraged to discuss their thoughts, feelings and reactions to this new approach to retail as well as to express their anticipated reactions, attitudes and potential purchase behaviour in this environment. The discussions of all groups were recorded in audio and video with the permission of the participants. During the discussions, the moderator tried to identify exactly the aspects of the product that were perceived as valuable by the consumers and to identify possible barriers for the consumer to choose and use the product. Then, transcripts were analysed following a set group of categories and a strategic planning report was delivered. At the end of the discussions, participants were offered a gift voucher for shopping at the supermarket participating in the project.

6.2 Data analysis

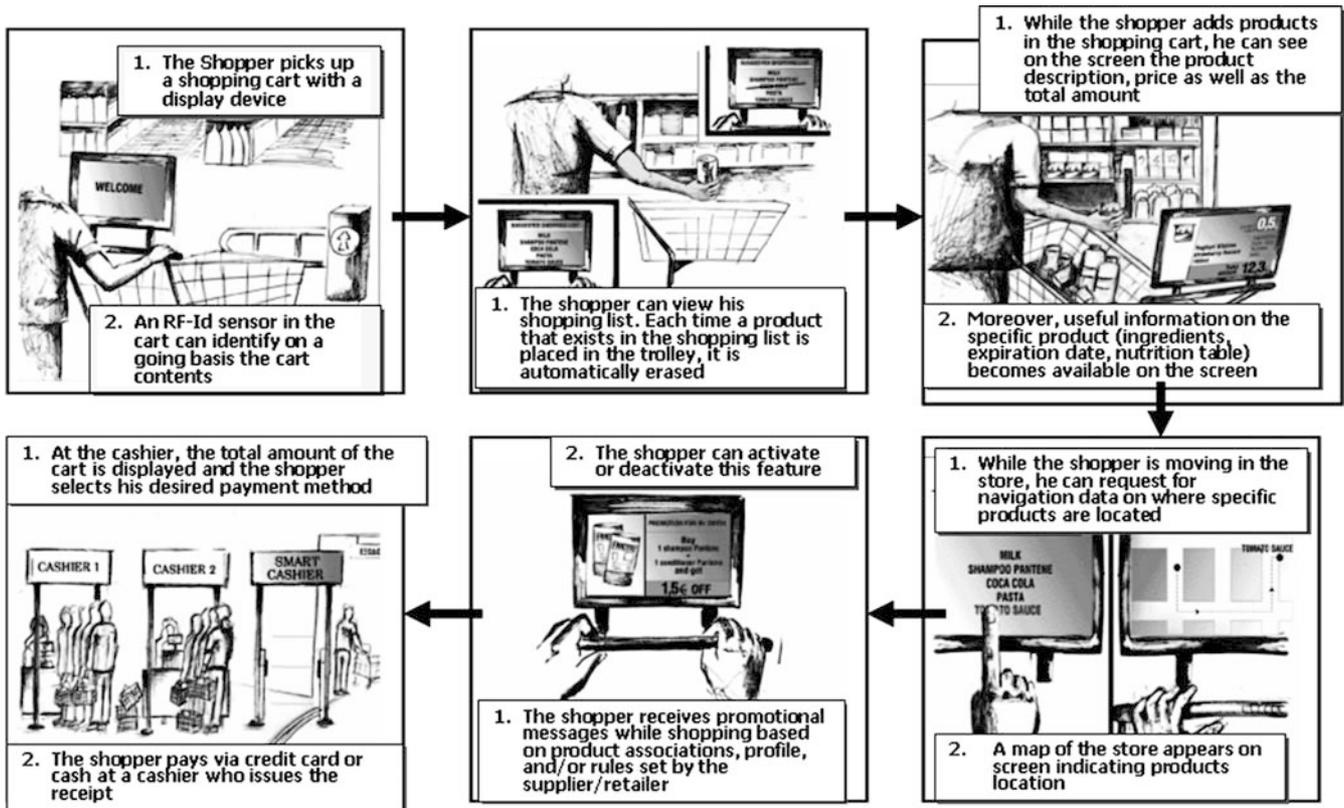The report delivered by Market Analysis followed the conventions of the P&G methodology, and focussed

Fig. 1 Sketches used to support the presentation of usage scenarios

solely on the value vs. barriers to use aspects of the system. Nevertheless, since several members of the development team had observed the groups via CCTV or behind the mirrored wall, there was a strong impression that the analysis was too structured for the particular system (it is designed for products that were almost ready for market introduction) and that many significant aspects have not been raised. For this reason, it was decided that the data are revisited and analysed more freely with categories developed through the data rather than using predefined classes. In particular, it was evident that primarily aspects of trust and personal identity have not been adequately addressed and that further investigation was warranted.

Recently, transcripts of the discussions were produced from the video recordings and analysed using the QSR NVivo software. In re-analysing the data, we abandoned the pre-determined categories used for product development and opted for a qualitative approach to data analysis where categories were constructed to reflect the themes that emerged from the data. In doing so, the transcripts where scanned for discussion that related to issues of privacy, security or trust and coded accordingly. Categories that emerged ranged from the collection and processing of private data and personal security to the impact of the system on social roles, etiquette and the law.

In the following section, we discuss the findings of this re-analysis of the focus group transcripts. When we use quotations, we indicate the person speaking and the group it belongs to following the convention: M is used for males and W for females, followed by a number that identifies them in their group. The group they belong to is indicated with the letter G and then the number of the group. Translations from Greek have attempted to follow the speaker's style and were carried out by the author.

7 Research findings

In Sect. 5, we briefly discussed the findings of the initial work by Market Analysis, which indicated that several aspects of ubiquitous commerce appeared attractive to consumers (for a complete discussion, refer to [7]). The re-analysis showed that, although this is indeed true, there are several system elements that seem to directly affect consumer perceptions of privacy and security protection and their trust in the system. In fact, consumers expressed substantial reservations about specific aspects of system functionality and often objected strongly to their implementation and use. In the following paragraphs, we discuss the findings of this study, examining in turn privacy protection, security and trust.

Before proceeding with this discussion, it is useful to identify a common pattern that became apparent across the four groups in their use of metaphors for the appropriation of system functionality, frequently discussed in terms of social practice or human characteristics. That is, system functionalities were often likened

to the behaviour of a person attempting to perform the same tasks and judged on the basis of whether such behaviour by a human being would be socially acceptable or not. For example, the following are typical responses produced while discussing monitoring home inventories via wireless sensor networks.

> (W5, G2): The idea is extremely repellent. I consider it rude that someone would open my fridge and look inside.
>
> (W9, G2): If someone comes and asks me, "Do you want a girl to clean your house?" Yes! "Do you want a servant to check what is in your house?" No, I don't want that!

7.1 Privacy protection

Clearly, the most controversial aspect of the system was its invasiveness, in that it collected and processed intimate personal information and used it to provide a commercial service. With the exception of only three individuals, all participants identified invasion of their privacy as their main concern, especially when considering the home scenario. Intrusion of their private space and time was seen as having three aspects: continuous monitoring of consumption, frequent commercial communications and data mining for personalisation.

7.1.1 Home scenario response

The deployment of a sensor network for consumption monitoring at home sparked the most negative reactions by all but one participant. At the end of the first phase of the discussion, all groups had reached a good understanding of the in-store scenario, with some participants favouring and others opposing the service. All participants considered the system plausible and accepted the fact that they may need to make a decision about its use after a few years. Without doubt, they were all willing to discuss the issues and contemplate the new situation. The introduction of the at-home scenario changed this immediately. Even before being able to articulate the particular aspects that they found objectable, they were concerned and expressed their sentiments in brief and decisive statements.

> (W8, G1): I am stressed from only reading this.
> (W11, G2): But to me, this is stressful.
> (W3): Yes, indeed.
> (W11): I prefer to run out of products.
> (M1: G3): I am already stressed.
> (M2, G4): I will be dreaming about this.
> (W6, G1): No, no, no. This is pure oppression.

7.1.2 RFID and consumption monitoring

After their initial strongly emotional reaction, the study participants were asked to identify the specific charac-

teristics of the system that caused their reaction. Consumers perceived monitoring of home inventory levels using a network of sensors as a direct violation of their privacy, since it recorded information which they considered strictly personal and private.

> (W5, G2): I don't like this. The previous system, if it would work with my PC at my home, I would like. It would be a system by choice, not by spying. With this system, I would feel that there is a person who observes me—what I eat—and who spies on me.
>
> (M4, G3): This thing, in my home! I consider my home to be my personal space, it is my personal life.
>
> (W2, G3): How personal will this be?
> (M2): Very much.
> (W4, G1): There should be no sensors.

7.1.3 Commercial communications

Moreover, receiving notifications that the system generates proactively (presented as part of the on-the-move scenario) to alert about the need to replenish inventories was also seen as a violation of personal time.

> (M3, G4): It will send all the promotions.
> (W3): Yes, and it will drive us crazy.
> (W1, G1): I am sorry, but where do you see saving time when the mobile rings all the time with messages and you may be busy at the time?

Indeed, the home is perceived as a space where individuals can make and enforce choices about which commercial communications they may receive. With the exception of one person who would consider the installation of the system at his apartment, participants resisted the idea of yet another channel through which they would become available for contact. An aspect of the system that was seen as particularly negative is its ability to deliver such communications in multiple devices and situations. When the moderator suggested that the type and mode of notifications could be controlled by the user, the majority of the participants considered the overhead of managing all these different channels as unacceptably high; much more complex than the currently available channels of television and telephone. This violation was seen as being very significant since the home is perceived to be the most private environment.

7.1.4 Data mining for personalisation

A feature of the system that runs across the three scenarios is the use of personal data for the provision of personalised services. To be sure, the fact that the system monitors intimate details of daily life, for example, food quantity and types consumed, is perceived as constructing too detailed a picture of one's life, and indeed

one that is hardly ever shared outside one's immediate family.

> (W7, G2): If I used to buy 10 yoghurts per week and now I am out of a job and buy none, these people would see what I used to buy and now I don't, and I don't like this. Not even my son knows that I do not have money—why should the company know?

Indeed, one individual indicated that data collection would allow for a variety of facts about one's personal life to be inferred. There are clearly aspects of life that one would not be willing to share with a grocer.

> (M2, G3): So, there are in fact products that will put a stigma on you.
> (W1, G4): In general, I do not like this philosophy that someone's bothered to get my own list with what I buy every time in the supermarket.
> (M3, G4): So, if I eat pasta it will be kept on my record!

7.1.5 Use of personal profiles

In particular, the in-store scenario received criticism with regards to personalisation by more than half of the participants. Personalisation in the sense of prediction of personal likes and dislikes and shopping habits was seen as intrusive rather than helpful. On the other hand, several participants identified significant implications of the use of personalised systems in relation to social practice and etiquette.

For example, several participants feared that, by following the recommendations of the system, it would effectively reduce their control on the shopping decisions and transform the shopping experience to a primarily mechanistic activity where they follow instructions rather than make their own decisions. It was also anticipated that inaccuracies in predicting preferences would prevent the consumer from receiving the full benefit of offers and a significant proportion of the participants would not trust such decisions to be made by the system. A considerably stronger view was expressed by one of the participants who directly disputed the possibility that a software system may predict his preferences.

> (M4, G4): I don't believe they can do that, they cannot predict how I am going to feel like. I don't believe it, I would always be able to fool them.

He saw this claim as directly challenging his perception of himself as a unique person and an individual, free to make his own choices. In fact, he considered the suggestion that it might be possible to anticipate his choices before he even makes them as directly insulting to his human nature.

> (M2, G3): But, the computer to tell you what to do?
> (M1, G3): Think that two friends are in the supermarket and they are looking at the screen and they don't speak because they miss each other.

> (M2): Like robots...
> (M1): I would not like something like that.

7.1.6 Personalisation vs. functionality

After some discussion with the moderator and among themselves, it was clear to the participants that effective adaptation of the system to individual needs required the collection of personal data. Hence, the implications of different tradeoffs between more advanced functionality and privacy protection was seen as a core issue for system design.

> (W4, G4): I don't know; I don't want it to recognise me.
> (M4): Yes, but that way, it will not be able to give you the list of your previous purchases.
> (M3, G4): Guys, it cannot be done like that because then it will not be able to give you statistics about your previous purchases.
> (M2): Yes, but we do not want that; that's what we are saying.

7.1.7 Consumer value tradeoffs

The majority of the study participants offset the loss of privacy against the perceived value of system use. However, in this case, they did not perceived the value of the service to justify their own costs in terms of loss of privacy, and in other cases, they would be happy to use a partial service but one that would offer much more control and protection of their privacy.

> (W1, G1): It sounds good as an idea, as long as there is the basic thing that interests us; that is the prices. The lady [moderator] said it at the beginning that the supermarket has to offer competitive prices to be successful.

In most cases, they could see how MyGrocer would benefit the business through cost reduction and more accurate prediction of the success of particular offers and promotions, but they did not perceive the service as equally or at least as comparably valuable to the consumer.

> (W4, G3): This is not for us; it is for those who sell the products. We do not care that it knows if I am a brunette; It is for those, for the company that sells the dye.
> (W4, G4): Why should you take the extra load if you do not need it?
> Moderator: What do you mean by extra load?
> (W4): This service, someone must be getting paid for it.
> (M3): When you buy online, do you pay anything extra?
> (W4): They must be getting something out of it!

(W2): I'll tell you what, if we really thought this was truly useful, would we be taking about the price?

7.2 Trusting the service

Second to the protection of their privacy, consumers were concerned about how much trust they could actually put on the MyGrocer service. In addition to their emotional reactions to the usage scenarios discussed earlier, and which indicated a strong sense of risk, study participants also articulated specific concerns about using the service by relating it to particular system functionality. In the following paragraphs, we discuss each of these elements.

7.2.1 Fair use of personal data

The uncontrolled use of personal data attracted significant criticism since consumers understood that, once collected, the data could be used proactively by the business in ways that may not directly related to the provision of the service. The vast majority of the participants would resist providing their data unless they could be confident that they would be used fairly and only in the context of this particular service.

(W7, G1): Personal data harm because of bad use. To be bothered every day by some salesperson that calls in the middle of the siesta and says "we sell this, we have this offer." We haven't given them this telephone number, others have given it without our authorisation and it has end up with them [the salesperson] improperly.

This practice appears to violate the trust relationship between buyer and seller and the (silent or explicit) expectation of the consumer that both parties involved would do whatever possible to protect the relationship from outsiders. At the time of the study, unsolicited commercial communications had attracted considerable public interest due to the massive increases in sales calls using automated systems and SMS messaging. Some participants related this with the development of a ubiquitous commerce environment, which clearly offered unprecedented opportunities for this situation to deteriorate. The resulting communications overload was too extensive and created concerns that managing (or indeed deflecting) these communications would demand a significant percentage of their daily time.

7.2.2 System control

More than half of the participants demanded that provisions be taken in all cases to offer them more control over the system. This relates to both the shopping processes overall and the operation of the different devices involved in the provision of services.

(W5, G1): I want to have control myself, not the company.
(W10): That's right. That's what I also want.
(M1, G3): To turn it on and off whenever you want.
(M1, G4): We like this technology, as long as we keep control ourselves.

Five participants observed that it is not appropriate to make this system the only available shopping mode; they demanded that they are offered a choice between using the system and not using it.

(W4, G1): If I want to shake it [the service] off, I switch off the monitor or I do not use my PIN or I take a different cart [without sensors]. So, it is not mandatory, a supermarket that offers this possibility in addition to normal cashiers.

In the case that they would use the system, they required that control of its operation remains with them and not with the service provider. For example, in the home scenario, they required that an on–off button be available at all times, although some questioned their ability to confirm that the system has indeed been shut down even when they received this indication.

(M2, G4): And let's say we are bona fide and that there is no scheme. I sign an agreement and I say to the inventory control service: I cross three things I want you to check for me; A, B and C, I don't want anything else to be monitored, just those three. How do I know that this is what happens?

7.2.3 Anonymity

Allowing for anonymous use could provide another approach to system control. For example, for the in-store scenario, an intermediate option where the smart shopping cart was used but offered only navigational assistance and extra product information, rather than a personalised shopping list, together with offers and promotions. Most of the automated features of the system were seen in the same light; that is, as control mechanisms become available to the consumer.

(W3, G1): I might not want that all I buy to be recorded.
(W3, G2): It is convenient to know the cost of my cart, but I don't like the supermarket to know at any time that I am Mrs X and I prefer that. I like anonymity. I do not want them to know my name and that at this time I am shopping.

7.2.4 Branding

Branding also appeared to be a rather significant element in developing trust. It appears that trusting or not trusting particular systems depends on preconceptions about the qualities of a particular technology or or-

ganisations providing the solution, rather than concrete evidence or as a result of a conscious risk management decision.

> (W6, G1): Like the new one that opened at Mesogion Avenue, you know, the Carrefour. Some prices are shown on the shelves and others are typed at the cashier. The differences are huge.
> (W3, G4): But how do I know that my data are protected?
> (M2): It says here [points to the printed scenarios] NOKIA. They have good technology and can protect your data.

7.3 Infrastructure security

The third major issue raised by the participants is the security of the proposed architecture for their personal use. This aspect of MyGrocer was mostly viewed through their previous experiences with digital and Internet technologies.

7.3.1 Systems and communications infrastructure

Most participants viewed MyGrocer as an extension to the Internet and existing cellular mobile telecommunications networks, which were seen as potentially presenting some risk to the user. In particular, approximately one third of the participants indicated that they do not trust Internet commerce and that they would not make payments on-line.

> (M1, G4): I do not trust giving my credit card number over the Internet, I do not do it.
> (M3, G4): I am afraid of the Internet and the hackers, I don't like that.

They claimed that, based on their experience with electronic systems, they would be very cautious in accepting the MyGrocer proposition. When looking back at their experiences with computing and telecommunications, they were not convinced that an innovative system would be sufficiently mature to effectively protect their personal data and their transactions. They referred to both their own experiences with systems terminating abnormally and to widely publicised security breaches of commercial systems. Their own experiences related primarily to word processing or spreadsheet software, which is seen as unreliable and often crashes with a resulting data loss. On the other hand, hacking of well-known Web sites and online service providers as presented by the mass media also placed considerable doubts on the ability of service providers to protect their data against persons with criminal intent. Last but not least, they referred to the increasing ease with which viruses and related mechanisms propagate through the Internet and the potential compromise of their own data.

7.3.2 Electronic payment

Another subsystem that received significant criticism is credit card processing, which was perceived as inadequate in providing sufficient protection with frequent cases of errors in processing reported in the mass media, although none of the participants reported that such an incident occurred in their immediate environment.

> (W1, G4): Yes, but how are you going to prove if there is a mistake, that you have not made the purchase?
> (W2): You keep one receipt and the cashier keeps another.
> (W1): So, how would you prove it if you buy online?
> (W2): When they bring what you shopped online, don't they bring a receipt?
> (W3): Yes, they do, so on the receipt you can see the date etc. We are all wary, even myself when the credit card first became available, I said, "like hell if I ever get a credit card." In the end, they become familiar and it is a mistake being negative with new ideas.

It appears that, rather than having a good understanding of credit card payment systems operation, this was a value judgement of either trust or distrust based on an ad hoc understanding developed through use. It appeared that several of the participants were unaware of the type of data transferred and recorded during a credit card transaction. Moreover, comments by one of the participants—a regular user of credit cards according to his own statement—seemed to indicate that the authorisation process of a credit card payment was fairly opaque, but he was willing to use it on the basis that it was recommended by his bank. In fact, at least some of the participants showed various misunderstandings of the principles of credit card payment, despite the fact that they would use the system on a regular basis.

> (W9, G2): And when you pay by credit card they always know your PIN code.
> (M3, G4): When you pay at the cashier with your credit card they cannot steal your number.

7.4 Other issues

Particular individuals raised a variety of other issues. For example, one person noted that the system has the ability to trace and prove that specific transactions have taken place.

> (M4, G4): So what do you mean, there is a murder and at the crime scene they find a can of Coke. So the murderer is the person who bought the Coke? Understand? This is where this is going I believe.

Another person who was interested in knowing the ingredients of particular products because of his intolerance to certain substances valued the possibility of having feedback from the system and confirming that his choices were safe.

(M2, G3): There are often times that we have questions about specific products, should I buy it or not, is this the right thing?

Viewing the system as a "carer" or "valet" was considered to unbalance the social roles and relationships with particular implications for the family unit. In fact, speculation of the role of the system sparked discussions with different participants identifying the system as a replacement to the spouse, the mother, to the housekeeper, the supermarket assistant or the nosy neighbour who would judge your social status by your purchases.

(W9, G1): It will be my next husband then? It will be my housekeeper? Will I have a contract with it? This scares me.
(W2, G4): No, there are some things that are taboo to buy and you do not want the other to see them, and when you buy them, you buy them secretly, even condoms for example.

In groups 2 and 4, where participants were mostly middle aged, the effect of the system on the status of the persons within the family unit responsible for the replenishment of home supplies was highlighted. Both men and women undertaking this task place significant importance on it and were worried that the loss of this responsibility would result in their status with family members to decrease.

8 Discussion and conclusions

Despite concerns about privacy protection and the security implications of ubiquitous commerce, the value proposition of MyGrocer did indeed attract substantial interest by consumers. At the same time, it was also evident that, if implemented as described in the user scenarios, several aspects of the system would create considerable friction and would pose barriers for the wider adoption of the system. In the short term, and so that we could further develop and evaluate ubiquitous commerce with MyGrocer, we opted to restrict the use of the system to the supermarket floor and carry out testing with members of the loyalty card program of the participating supermarket. In particular, the home scenario, which received the strongest resistance, was subsequently implemented only in a much restricted scale than originally planned, and was seen only as proof of concept and without a view to test further or deploy.

Asking loyalty club members to test the system offered two distinct advantages: it capitalised on the established trust relationship between consumer and the supermarket and allowed for the regulation of the relationship via a contractual agreement. Indeed, participation in a loyalty program often implies a relationship built over a longer period of time, which fosters mutual trust and helps develop a set of reasonable expectations. Furthermore, having agreed on a contract, the two parties clearly understand their rights and responsibilities to each other and have an explicit set of rules for interacting. It is, thus, easier to explore the extension of the relationship to include the new ubiquitous commerce services. In practice, this approach proved very successful and allowed for the evaluation of the deployed system in conditions where security and privacy were not the dominant factor. The results of this work were reported in [7].

Arguably, some of the research findings of the previous section should be seen within the context of the study, especially with respect to the evolution of retail practice in Greece. To this end, we will briefly discuss the timelines of the emergence of supermarkets as the dominant retailing option and of the adoption of credit cards in this country. Until the early 1980s, most grocery shopping was done in small, neighbourhood shops, with very few large supermarkets, primarily located in the two main metropolitan areas in the south and the north. Over the decade, this situation changed in accelerated pace with most of the local shops disappearing and, by the end of the decade, almost completely being replaced by supermarkets and hypermarkets. Today, even in rural areas, most grocery shopping is done in supermarkets that belong to one of the five national chains. The end of the 1980s also witnessed the rapid adoption of credit cards for electronic payment. Deregulation of consumer loans at the beginning of the decade played a key role in making credit cards common place and accessible to most within a few years. Since the mid-1990s, supermarket shopping and payment by credit card is as common as in any other Western European or US country, although middle-aged Greeks still prefer to use cash and would opt to shop from a smaller grocer if possible. At the same time, the traditional family roles have also changed significantly. With the urbanisation of the population in the 1950s, more women entered higher education and joined the professions. Today, especially in urban areas and with younger couples, the norm is that both partners work outside the home and share the responsibility of running the household. In particular, it is likely that either the husband or the wife would be responsible for the replenishment of home supplies, although women take up this role more often than men, certainly in middle-aged couples.

This work highlighted several aspects of researching ubiquitous computing systems which may have wider implications. Unlike more traditional information systems where interaction is mediated by a computing device, for example, a desktop or mobile computer, in

ubiquitous computing, things seem to happen transparently in space that cannot be approximated through a real or even a representational one. Thus, users are confused by their lack of appropriate language to describe it and will need other abstractions to be offered to replace the device. In our case, consumers attempted to express their opinions by anthropomorphising system behaviour so as they could relate it to their existing experiences.

One aspect that appears to be highly relevant, but which we were unable to investigate in depth, is the question of how pre-existing attitudes towards privacy affect consumer views of ubiquitous commerce. Previous studies [1] have indicated that there are considerable variations in how people deal with such issues and there is a reasonable expectation that some of these attitudes would directly affect their perceptions of ubiquitous commerce.

The novelty of ubiquitous computing means that, for more significant observations to be made, one has to allow for an extended period of interaction with the system. Unlike system functionality, habits and practices take much longer to develop and, often, what seems novel and threatening at first glance quickly becomes part of the routine. Longer-term implications of use cannot be discovered without ethnographic studies. Of course, the problem with this approach is the very high cost for deploying and maintaining the required infrastructure at the required scale and time frame.

This last observation points to another aspect of trust that is often overseen. Indeed, trust in information systems is often seen in the tradition of cognitive psychology, which was also the basis for machine learning and artificial intelligence in the early 1960s. While this approach has made considerable contributions to computer science and systems engineering, we expect that it may not facilitate further development of our understanding of trust. Indeed, in the technical literature (for example, [3] and references therein), trust is considered as a purely cognitive process. It is often treated as a utility function that system users try to maximise for their own benefit. We believe that this approach is better suited as a measure of trustworthiness, which is quite different from trust [16] and, moreover, that trust is a non-cognitive function that cannot always be approximated well by mathematical constructs [2]. Hence, in the intimate computing context of ubiquitous commerce, the development of concepts of trust on this basis is of restricted use.

Approaching trust within its social context may provide a more productive alternative. To this end, in the following paragraphs, we will use the principles introduced earlier to interpret some of our findings and provide insight in the reasons behind some of the observed attitudes. It appears that this is particularly relevant in cases where there is little information on which to make a judgement of the trustworthiness of the other party and, thus, the decision to trust or not depends mainly on non-cognitive elements. Clearly, this aspect of trust played some role in the case of our studies where the information to make an unambiguous and provable trust judgment were not available. In fact, the system frequently created significant levels of stress for the participants, which they could not justify in concrete and objective terms.

In this context, we believe that the enacted view of technology adoption has a critical role to play. In this view, the reciprocity and understanding principle bears on issues of privacy protection, personalisation and consumption monitoring. It implies that collecting personal data by tracking the activities of individuals will be unacceptable if it is not reciprocal. That is, not knowing who is the organisation collecting the data, how the data will be used, how to correct errors in the data and whether to expect a return, describes the relationship as non-reciprocal and introduces asymmetry, making it unacceptable for the consumer. The fact that our profile is formed under circumstances that are well beyond our control, which we cannot influence and that are invisible to us introduce considerable stress to the relationship, irrespective of whether the profile is accurate or not. Moreover, this principle implies that consumers need to understand the service provider as well. Thus, although ubiquitous computing technology may allow busines1ess to offer new ubiquitous commerce services, consumers may choose to engage in business activities with parties for whom they have access to a comprehensible company identity and, thus, a clear set of expectations of trust.

Another aspect that creates considerable tension is the fact that people using the system are seen as having a single dimension—that of the consumer. This view is not restricted only to the space where the actual shopping activities are carried out, but extends into their own home. But following the principle of context and locality, consumers in ubiquitous commerce cannot be expected to be comfortable with a single identity profile in relation to ubiquitous and pervasive services. Rather, we can expect a strong preference to maintain different identities attached to different functions, roles, communities and spaces, and to exercise control over these. This would explain the overall negative reaction of the participants of the focus groups to ubiquitous retail since users of the system were characterised and treated singularly as consumers.

The communication and interaction principle implies that, rather than focussing singularly on the trustworthiness of a system, design should also address the affective aspects of interaction between ubiquitous commerce services and the consumer, and address the emotional impact of system usage. It accepts that, since emotions are akin to strategies, even while they remain inarticulate and non-deliberate, they can be brought into the realm of rationality and have to be taken into account for the development of a trust relationship.

Last but not least, our findings have specific implications for the current discussion on the value of ubiquitous retail systems. With several major retailers currently making significant investments in RFID infrastructures, the issue of user acceptance is widely discussed. The common approach to this is that consumers will find the value proposition of ubiquitous commerce so attractive, that they will disregard any privacy concerns. Such comments anticipate that adopting the strategic approach will indeed provide the required mechanisms to commercialise this technology. We find that two issues indicated by this study are in conflict with this view. First, ubiquitous retail systems are clearly viewed as being for the benefit of the business rather than the consumer. Looking at the benefits and costs for all involved parties, it is easy to see that consumers have marginal benefits that would probably not be justified by the huge investment required to develop and use the infrastructures. Moreover, most benefits to the consumer are indirect and, thus, are not visible and easily discounted. More importantly, it is unlikely that, without allowing some degree of control over the system, consumers will be persuaded to use it. Indeed, controlling the flow of personal data was seen as a core element in developing a trusting relationship between consumer and retailer.

In the long term, developing a trusting relationship between ubiquitous commerce and consumers is critical for its wider acceptance. To be sure, there are several examples of technologies that were eventually rejected by the market [10], due to the attempt to capitalise on public apathy and withhold information about their true operation. Attempting to develop ubiquitous commerce by following this approach [4] may well have the same result.

Rather surprisingly, we did not find any major differences between the perceptions of the system across the four groups. Differences were mainly in the elected ways for expressing their concerns, but the concerns themselves were on very similar issues. There were only two areas where significant differences were found; the implications for family roles for older women and overall trust to information technology.

Ubiquitous computing has been described as "invisible, everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere, and makes a computer so imbedded, so fitting, so natural, that we use it without even thinking about it." Its potential for transforming everyday activities is indeed considerable, especially in the context of retail.

Ubiquitous commerce is emerging and its wider acceptance by consumers depends centrally on forces that may manifest themselves in new shapes and forms, and, while a re-examination of these factors and their relationships may be required, the issues themselves have not gone away. In this paper, we advocate that, in designing ubiquitous commerce systems that inevitably incorporate trust management as a core component, the enacted view is the appropriate basis for analysis. Indeed, the level of involvement of human factors in discussing trust is crucial. We expect that widening the discussion on trust in ubiquitous commerce will be essential for the development of appropriate service provision models.

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