Ubiquitous Computing Design Principles: Supporting Human-Human and Human-Computer Transactions

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ABSTRACT
In this paper, we discuss the results from ethnographic and informance work related to transactions in retail settings as related to the design of interactive ubiquitous computing systems. We find that - for practical considerations of design and implementation - transactions can be represented as *balanced exchanges* in the context of a *trust relationship*. We've proposed that such exchanges become trusted – and that trust must be accommodated – through at least three characteristics of social systems as applied to transactions: accountability, real-time inspectability and the capacity to exercise recourse. In this paper, we extend further recent work on designing for accountability (Eriksén, 2002). We suggest that ubiquitous computing technologies applied to transactions in general and, retail transactions more specifically, need to explicitly consider these characteristics in their design to support trusted, balanced exchanges.

Author Keywords
Transactions, balanced exchange, ubiquitous computing, accountability, ubicomp, trust.

ACM Classification Keywords
Ethnography, Ubiquitous Computing, User Experience Design.

INTRODUCTION
It's hard to imagine a more prevalent set of daily interactions involving both humans and computers than retail transactions. In fact, transactions generally are one of the most prevalent forms of interaction among people in all cultures, both now and historically. The way in which we conduct transactions is a well developed and learned activity that varies according to contextual factors such as gender, culture, the purpose of the transaction, the type of establishment and the people involved.

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Technological innovations, from glass panes, steel beams, and elevators to information technologies such as point-of-sale (POS) systems and the internet, have enabled a great majority of retail innovations in the last 150 years that have mostly added to – rather than replaced - the panoply of human interactions necessary to conduct retail transactions. In particular, most information technology innovations, per se, support the streamlining or, rationalizing, of retail operations (cf., Williams & Larsen, 1999, Meffert, 2000). The recent emergence of ubiquitous computing is no exception, with the preponderance of popular and technical writing focuses *pre-transaction* on "inventory management" (cf., Kärkkäinen, 2002) and *post transaction* on "privacy protection" (cf., Albrecht, et al., 2003), although there is recent work regarding information services in pervasive retail computing environments which support the user's information needs explicitly (Kourouthanassis & Roussos, 2003)

Nearly lost in these discussions are the interaction implications for the transaction itself, arguably the heart of the retail industry. Ubiquitous computing, unlike electronic cash registers, steel or elevators qualitatively changes the nature of human interactions surrounding retail transactions. Ubiquitous computing innovations tout "invisibility" and "proactivity" among its main benefits (Tennenhouse, 2000). In retail settings, this ideal has been translated into a transaction model in which customers can enter a store, select their desired products and leave the store without dealing with the usual point of sale – the "automated checkout". The ideal transaction shifts the nature of the interaction from a serial process to that of an apparently parallel process where all components of the transaction, for all intents and purposes, happen simultaneously. However, our research shows that consumers desire transactions that permit accountability and specifically, inspectability and recourse - among other characteristics - especially to account for developing trust in the transaction. Only recently has accountability been expressly considered in HCI systems design (Eriksén, 2002). However, none of these characteristics are accounted for in the "ideal interaction" as described above, nor are they discussed in the design requirements for ubicomp systems in general.

The nature of retail transactions, per se, serves as a proxy for transactions of all sorts, which account for a wide swath of daily interactions, all of which one can imagine seeing as fertile ground for ubicomp solutions. Baggage handling, public transportation, package handling, room service, coat checks, rental cars, etc., is just a short list of day to day transactions that could potentially benefit from ubicomp technologies and applications. However, in all cases, we argue that a **relationship of trust** is required for the transaction to proceed and that this trust relationship is based on qualities of the transaction (visibility) antithetical to the current design imperatives of ubicomp technologies (invisibility). This paper examines recent results from ethnographic and experimental work regarding retail transactions and offers a set of characteristics ubicomp must embrace to support successful human-computer interactions.

METHODS & APPARATUS

While we include evidence from long-term, multi-nation ethnographic work in a variety of retail establishments and settings, we focus on this paper the results of an informance (Johnson, 2003) (previously known in the CHI community as a "focus troupe" (Salvador & Howells, 1998) conducted in the context of this broader work.

The purpose of the informance was to provide a participatory, contextual setting for the ideal checkout scenario in contrast to a currently "normal" checkout situation and to engage participants in a reflective discussion comparing and contrasting their experiences in a somewhat less abstract setting. The participants were a recently former store manager of a large chain discount department store in the United States and, separately, four women who described themselves as the main shopper in their families. We constructed a "mock" mini-grocery store in which products were tagged with radio frequency identification tags (RFID) as well as standard UPC symbols. The point of sale (checkout) system accommodated both UPC and RFID check out. The "store" was constructed in a conference room. Products were arranged around the main table in "aisle groupings". Participants were provided each with a list of five to seven items to "purchase", a purse with case, checks and a "smart" RFID tagged credit card. The basic instructions required participants to select items from their list and proceed to checkout. After each of the four checkout scenarios, the group discussed the experience in an unstructured group interview format.

There were four checkout scenarios. The first two comprised the *serial* control conditions designed to echo shopping situations we found as common from our prior ethnographic work a) a replication of a standard "UPC scan" checkout and, b) a condition in which each participant was provided with a deviation from standard, using a coupon, correcting a pricing error, creating separate lots of items for payment, and paying with a check. The second set of conditions were designed to simulate the "ideal", parallel/simultaneous, ubicomp (RFID tag) supported checkout: c) the standard ideal checkout in which all products in the basket are immediately registered, the price tabulated and payment made automatically (and experientially, simultaneously) by reading the "smart" credit card in the shopper's handbag and, d) the same set of common deviations presented in condition b (coupon, check payment, separate lots and correcting a pricing error), but relying on the ubicomp (RFID tag) as the basis of the checkout process. All the women participated in each condition at roughly the same time and in order: a, b, c and then d. But they were only made aware of their roles at the start of each condition.

Technically, the checkout apparatus consisted of Pentium III "Cappuccino PC" with 256 M Ram and 40 Gig HD, running Windows XP. The cashier's display is a 15' VGA flat panel touch screen using an RS 232 serial connection. The customer screen is a 6' USB (1.0) flat panel touch screen from Mass Works. This product has a multi-mode XP driver for the display and touch screen. XP handles this display as a secondary monitor and routes the touch coordinates to the mouse driver. The location of this screen was positioned in the system "display space" to the immediate upper right hand corner of the primary screen. Two of the three serial devices used USB-to-Serial (UC 232A) converters from ATEN. A wireless 802.11 USB network adapter from LinkSyS was used for web access during development. The scanner was a QueCat bar code reader interfaced in-line with the keyboard through the keyboard port. A Star Micronics SP212FD receipt printer interfaced via a serial port (via the USB-to-Serial converter) with a custom cable. The generic cash drawer connected to receipt printer using a RJ11 phone jack. An Epson M58DB pole display was used and also interfaced via a serial port (via a second USB-to-Serial converter). The Alien Technology RFID reader, "NanoScanner 915MHz ePC Reader", model 9RE-001, is a long range (~3m) and multi-tag reader. It was interfaced via a hardwired LAN connection through a LinkSys Router. For tags, we used the Alien Technology 1800002 Rev A tags (6"x 5/8").

RESULTS

In short, the first two conditions, a & b, resulted in general statements that the experience was just about normal. The checkout process was as expected. There was nothing out of the ordinary. There was, however, one exception: the participants noted that there was no sound attached to the scanning of a product. In the US, when a product is successfully scanned, there is a "beep"; these women suggested that they attend to the beep to assure that products are appropriately scanned – successfully and the correct number of times. That the beep was missing and the omission was detected was telling for us in that it indicated we'd created a sufficiently reasonable facsimile of the checkout experience.

The most interesting results centered on the second set of conditions. On the one hand, the women were rather satisfied with condition c, i.e., the ideal ubicomp checkout. They could immediately make the leap to not having to wait in lines, no need for a cashier, instant payment, etc. They also brought up issues regarding the system reading the smart cards in their purses: “Suppose I wanted to pay with a different card?” and, “What if I don’t want the store to have access to my account information?” There were numerous issues of this sort that presaged the final condition, in which the normal exceptions, using a coupon, splitting the order, etc., were introduced.

On the one hand, this informance experiment could be used to begin the requirements assessment for a ubicomp-supported checkout process, but which was not the focus of this event. Of particular interest arising from both this experiment and our ethnographic work is the emergence of certain general design principles for ubicomp systems as directly related to the general category of transactions. One set of principles we report here focuses on the central concept of trust and especially relationships of trust, which to date, ubicomp technologies have failed to accommodate.

If we examine the women’s comments throughout the four discussions, and especially in the second set of conditions, we note an underlying theme related to the concept of trust, which we discuss further on, especially as evinced in the context of the transaction itself. They noted many issues, a sampling of which are presented here: price checking against what they expect is far more difficult when the basket is “read” all at the same time, making sure they got what they paid for, making sure they didn’t pay for something from someone else’s basket (because the reader might pick it up – and in fact, accidentally did in the informance due to the reader’s range which is a known technical problem), questioning automatic payment through their smart card because they might well have wanted to pay with cash that day, making sure the tally of items and prices was correct, making sure they had recourse, making sure, ensuring they had a receipt in hand in case there were stray charges, and other similar comments. In short, many of their comments taken *in toto* suggest a certain adversarial - though civil – relationship between the customer and the store/clerk.

Further, the former store manager noted that cashiers are trained to look at the basket and cart to ensure that there’s nothing “forgotten” by the customer, i.e., nothing under the cart, under the child-seat or in a coat. In addition, the clerk is required to perform a series of checks – establishing the signature matches that on the credit card, or matching it to (in the US) a driver’s license. Again, what emerges is a civil, but mildly adversarial, relationship.

In summary, and in general, they were unanimous in their satisfaction of the potential for the “ideal ubicomp checkout” experience. Yet, when exposed to the last condition with “normal exceptions” (e.g., coupons, price mismatch), they enumerated a series of small, but cumulatively worrying concerns. Taken together, these concerns – of both the women and the store manager – reflect issues central to the establishment of a trusted relationship in the conduct of the transaction..

DISCUSSION

At issue are two elements clearly deriving from this work that can contribute to the identification of general principles for ubiquitous computing systems in the context of transactions. The first is to qualify a workable definition of transactions in a context useful to support interaction design. The second is to identify a definition of trust similarly useful.

Social network theory (Sahlins, 1972) specifies three types of *reciprocity* – generalized, balanced and negative – in the context of exchanging goods and services. Most retail transactions can be considered as “balanced” exchanges, whereas more intimate relationships like parent child would belong to generalized exchanges, and more antagonistic transactions would belong to the negative category. A balanced exchange is the one of primary interest to us, because it defines an exchange with an expectation of immediate parity on both sides of the transaction – what is given is roughly the equivalent of what is received.

That said, balanced exchanges occur in the overall context of a particular form of trusted relationship. Baier’s (1986) definition of trust is adequate for our purposes: the accepted vulnerability to another’s possible but unexpected ill will. While this definition generalizes beyond transactions, we find it especially useful for ubiquitous computing in the context of balanced exchanges. That is, the exchange is mostly civil – there’s an expectation of equal reciprocity in the exchange – and yet, the relationship is based at least partly on the potential for inequity. Transactions are balanced not only in the sense of expectations reciprocity, but also appropriately balanced against the possibility of perceived harm.

Of particular relevance for design is to consider the elements of the interaction that foster a trusted, balanced relationship. In this paper, we suggest three qualities that support trusted relationships of balanced exchange and which apply more generally to ubiquitous computing systems: accountability, inspectability and recourse.

Accountability

Garfinkel’s (1967) concept of accountability can be used to provide concrete recommendations and principles for the design of ubicomp systems. If a goal of ubicomp systems is to hide the computing - indeed, to hide the actions that comprise the transaction - then we don’t have access to those system behaviors to understand the transaction. That is, there is no entity accounting for those behaviors. Accountability, as a concept in ethno-methodology, provides for both the person’s local construction of what’s real through an understanding of actions and reported actions as well as the ability to generate those same behaviors (Eriksén, 2002). However, accountability is a rather broad concept, and there may be various aspects one might consider in systems design. Two that are of particular, proximal relevance to generating and supporting trust relationships in balanced exchanges are inspectability and recourse.

Real-Time Inspectability

Of particular importance to generating trust relationships is the ability, simply, to "see what's going on. Our observations of checking out as well as the informance data demonstrate quite clearly that both clerks and customers continuously and physically monitor each other throughout the duration of the transaction. A close analysis of the checkout process reveals a series of mini-exchanges – presenting product, pricing product, producing cash, making change, etc. – which are managed and monitored at each step. The ability to literally see what's happening is vital to constructing a relationship of trust in the context of a balanced exchange as we've discussed.

Exercise of Recourse

A third element of ubicomp systems to support transactions suggests very strongly that both parties must have access to recourse. In retail settings, recourse happens largely in situ through the monitoring process. However, it's very clear from both the ethnographic work as well as the informance, that customers make use of the time immediately post purchase to review their receipt and ensure that everything is satisfactory before leaving the store, when, as we've discussed, the specific elements of the transaction are still visible and present. Trust accrues in the relationship in this case because there are physical, inspectable constraints on what might have happened; thus, the balance of the exchange is maintained. Ubicomp systems applied to transactions need to accommodate recourse for all parties.

SUMMARY

In this paper, we've discussed design principles for ubiquitous computing technologies in the context of the broad category of transactions. We've presented results from ongoing ethnographic work as well as a specific informance event in retail settings. We've interpreted transactions as balanced exchanges in the context of a trust relationships and proposed that such exchanges become trusted through the presence of at least three characteristics of social systems: accountability, real-time inspectability and the capability to exercise recourse. We suggest that designers and technologists must incorporate these characteristics in their designs of ubiquitous computing systems. We further suggest more research examining how ubiquitous computing can fit into or change extant social systems.

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