Scanning Objects in the Wild: Assessing an Object Triggered Information System

A.J. Bernheim Brush, Tammara Combs Turner, Marc A. Smith, Neeti Gupta

Microsoft Research,
One Microsoft Way,
Redmond, WA, 98052
{ajbrush, tcombs, masmith, neetig}@microsoft.com

Abstract. We describe the results of a field deployment of the AURA system which links online content to physical objects through machine readable tags. AURA runs on commercially available pocket computers using integrated barcode scanners, wireless networks, and web services. We conducted a real world deployment with twenty participants over five weeks. The results from our field study illustrate the importance of moving beyond demonstrations and testing system design assumptions in the real world, as our field study highlighted several places that our seemingly reasonable design assumption did not match with real usage. Our experience deploying AURA highlighted several key features for mobile object triggered information systems including handling groups of items and a robust offline experience.

1 Introduction

For almost every manufactured or packaged object on Earth there are volumes of information available online, from personal reviews to manufacturing details. The challenge has been bridging the gap between physical objects and the collection of relevant online information about them. The rapid development of mobile computing devices, wireless networks, and sensors means that all the elements are present for the creation of mobile *object triggered information systems* that allow people to use a cell phone or PDA with a sensor to scan an object and access related information and services. These systems can be thought of as a new type of mouse for the physical world that enables users to "click" on the objects around them.

Our Advanced User Resource Annotation (AURA) system [14] integrates a wireless Pocket PC with a barcode reader so that users can scan books, CDs, DVDs, packaged grocery products and other barcoded objects and then view, store and share related metadata and annotations. The AURA system can support many different sensor technologies and scenarios of use including accessing reviews for products, doing just-in-time price comparisons, creating an inventory of collections of objects such as CDs or books, and sharing information about objects with others. We developed and deployed a set of core application features (scan, identify, retrieve, store object metadata, annotate, publish, etc.) and then evaluated the platform in a field study to test our design assumptions. As Sellen stressed at a workshop on application-led research in ubiquitous computing [5], we believe these types of field studies are critical to evaluate ubiquitous computing applications because it is impossible to anticipate exactly how design assumptions will play out without real usage experience.

We deployed AURA to twenty people internal to our organization for five weeks and collected data about their experience using surveys, ethnographic observation, and usage logs. We studied how participants used AURA in their homes, offices and on regular shopping trips. The ways in which participants used AURA and the problems they experienced, sometimes quite mundane, shattered a number of our design assumptions and highlighted several important features for object trigged information systems including handling groups of items and having a robust offline experience.

2 Related Systems and Research

The AURA project[1] shares the goal of bridging the gap between the physical and the online worlds with many other research and commercial systems. Perhaps the earliest object triggered information system to bridge this gap was the electronic tags research of Want et al. [17] where electronic tags on items such as books and posters linked to online information and actions. Several more recent systems were primarily designed for use at the desktop including the failed Cue Cat [6] commercial venture and the WebStickers project [11]. In formative evaluations of WebStickers the length of the barcode reader cord was frequently criticized highlighting the importance of mobility.

With advances in mobile computing devices and wireless networks a variety of mobile object triggered information systems have been developed. Products like Socket OrganizeIT [16] and Delicious Library [7] target consumers that wish to inventory their collections of books, music and other barcoded items. Mobile services such as Amazon Japan's Scan Search described at Gizmodo [9] let users take pictures of barcodes with camera phones. Camera phones in Japan also include software for reading QR Codes, two dimensional barcodes that often appear on Japanese advertisements [13]. Of the mobile systems, our focus on authoring and sharing information makes Konomi's QueryLens [10] one of the most closely related projects to AURA. QueryLens used PDAs with barcode readers to allow users to scan items and author queries, view and share information about particular objects.

Another set of object triggered information systems focus on usage in retail environments. Many different aspects of the shopping experience have been studied including preparing shopping lists [12], trying to decrease shopping time [3], and offering comparative pricing based on a user's current product selection [8]. Two systems similar to AURA are the Pocket Bargain Finder [4] system that allows users to shop in a physical retail store, find an item of interest, scan in its barcode and search for a potentially lower price among a set of online retailers and the discontinued Beeline Shopper [2] system that provided a barcode scanner and software for creating grocery lists and recommendations on healthier alternatives.

---

[1] Although they share the same name, our project is not related to Project AURA at Carnegie Mellon University: http://www-2.cs.cmu.edu/~aura/.

Although our system has a goal of building online communities around collections of scanned objects that differentiates it from several of the systems, many of the core features (e.g. scanning and viewing related online information) have been explored in these closely related systems. Thus the primary contribution of this paper is our field study. While Konomi deployed QueryLens on a small scale at a university festival, we are unaware of a similar field study of a mobile object triggered information system with a large group of users over several weeks.

3 The AURA System

The following illustrates a typical usage scenario AURA was designed to enable:

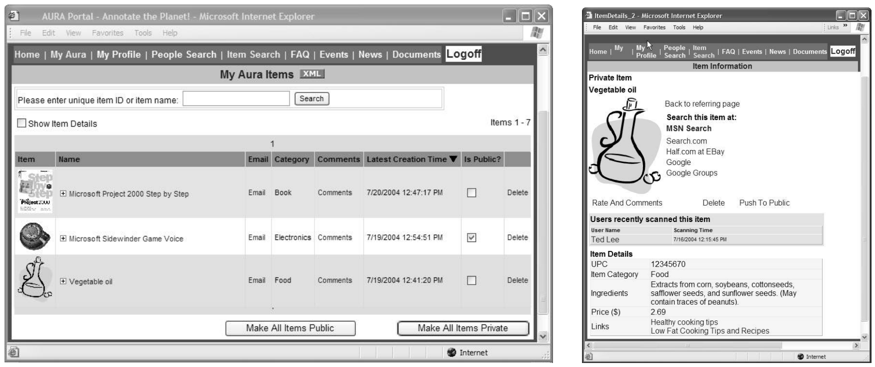
> *While shopping at his local bookstore, James scans a new book he is considering purchasing using the barcode scanner attached to his Pocket PC. His AURA client application queries the appropriate resolution service to identify the book James scanned and presents information about the book including links to reviews and pricing at several online sites. James decides he wants to remember the book and clicks the "Add to My AURA" button. This adds the book to his list of AURA items. James then makes a private comment on the book to remind him of the price at the bookstore.*

Other scenarios of use for AURA include accessing reviews of products, creating an inventory of collections of barcoded objects, and sharing information about objects with others. In the remainder of this section we present the design of the AURA client application and web portal.

3.1 The AURA Client Application

Our current implementation of the AURA client application runs on Windows Mobile 2003 ("Pocket PC") devices with an additional hardware barcode scanner (the "Socket In-Hand Barcode" scanner) inserted in either the Compact Flash (CF) or Secure Digital Input Output (SDIO) expansion slots of the device. Network connectivity in the form of WiFi (LAN) or Cellular (WLAN) connection is essential for many key features, although minimal functionality is available in an offline mode.

Users scan barcoded objects by positioning the external barcode scanner approximately 6-12 inches from the object and initiating a scan. Scanning is most convenient when users map a Pocket PC button to invoke the scanner, but a scan button is also available in the user interface. Users have visual feedback from the laser or LED targeting beam on the barcode reader that helps them position their scanner. If the scanner acquires the barcode's data, the user hears an audio tone signifying a successful scan. Although we currently focus on barcodes, the architecture is extensible, allowing other sensors technologies such as RFID, GPS, WiFi, IR or Bluetooth beacons, accelerometers, images, audio, etc. to be used to generate information to identify objects. After a successful scan, in online mode the client immediately tries to resolve the barcode and provide information about the object. In offline mode, the client adds the



(a) **(b)**

Fig. 1. In (a), an example AURA Web Portal page showing the user's list of scanned items. In (b), an Item Information page with item details

barcode to the scan history. Later, when the user reestablishes a connection he or she can view the history of scans and select barcodes to send for resolution.

To resolve a barcode, the AURA client attempts to match the sensor data pattern against a collection of regular expressions stored in "resolution service definition files" which associate varying sensor patterns with "payloads" - applications and web services that offer metadata in exchange for an identifier. We have implemented some initial resolution service definition files that map the fourteen digit ISBN codes that appear on most books; the twelve digit UPC codes printed on many North American packaged goods; and our own seven letters and number scheme for identifying art-work in our organization's collection to related information and search queries. We make use of a combination of private and publicly available Internet-based services such as Amazon's ISBN web service and various search engines to connect objects to online information about them. New resolution service definition files can easily be added with AURA's extensible architecture. For example, new patterns might be defined to match against a library's ten digit barcode standard and map to the web interface for searching the library's catalog. We consider this open backend architecture a critical feature of AURA and an important differentiator from commercial systems that carefully control what information can be accessed about objects.

After AURA resolves an object, the client displays a limited version of the web portal's item information page for the object. This page shows information about the object that could include description, price, and links to search engines. In the interests of privacy, we designed the system so that all information about an object scanned by the user is initially kept local to the mobile device (and the selected resolution service) and not shared with the web portal. Users can choose to upload the details of scanned objects to the web portal with a single additional tap.

3.2 The AURA Web Portal

The AURA Web Portal provides a range of services to manage private and public collections of objects scanned and explicitly uploaded by users. The home page includes features targeted at encouraging sharing and community building. It displays lists of the most recently scanned and annotated items, the most popular items and the most recently scanned public items of the users that have scanned the most items.

When a user uploads information about an object to the portal, a record is created that represents the object and associated meta-data. The resulting item record is initially listed on the user's item list, shown in Figure 1(a), as a private item and is not visible to other users. Users can choose to explicitly make items public to others using the check box associated with each item. The item list page also has several features to facilitate sharing items with others through email and RSS. Each item offers an "Email" link that composes an email containing the item's metadata, constructed links, and annotations. The page is also exposed as RSS 2.0, allowing blog aggregators to collect and display item details in applications like email browsers.

Clicking on the name of an item in the list opens an Item Information page with item details. This page, shown in Figure 1(b), includes a list of URLs for searches and content related to the item. For example, a book item will have a link directly to the page for the book on an online book ecommerce site. The Item Information page also has links for making private and public ratings and comments that will be associated with the item. Any public annotations and ratings on public items are visible to all other users of the system and may be displayed on the homepage and search pages.

4 AURA Field Study

To study how people use AURA, we conducted a five week field study from July 7, 2004 to August 11, 2004 with twenty participants. Our field study was motivated by these research questions:

- How do people use the system? Our design assumptions were that people will use AURA mostly for information access and comparison shopping.
- Do people find the system functional and useful? Our assumption was that the benefits of AURA outweigh the frustration of carrying an external scanner and coping with items AURA can not identify.
- Does the privacy model meet users' needs? Our design assumed a conservative privacy model to limit the chances that a user would make an item public by mistake.
- How do people use the sharing features? Our design assumed that the ability to share object information with others was important.

In the rest of this section we first describe our methodology and then our study findings organized by our research questions.

4.1 Methodology

We recruited participants from an internal company email distribution list for people enthusiastic about Pocket PCs. Based on a screening survey that asked about users' experience with Pocket PCs and the devices they owned we selected twenty participants (16 male, 4 female). We did not know the participants before the study and to the best of our knowledge they did not know each other. We chose participants that owned and used a Pocket PC with either cellular or WiFi connectivity to the Internet so that we could evaluate AURA with people already familiar with connected handheld devices. Our selection criteria were driven by a desire to avoid the sometimes nontrivial usage problems associated with connecting a mobile device to wireless networks. We recognize the self-selection effects on our user population and plan to replicate the studies with less technically savvy users as the technology evolves.

Each participant started the study by attending a training session where we loaned them a barcode scanner and assisted them in installing the AURA client software on their device. We also gave the participants an overview of the system and led them through a training guide to practice using the core features of the system: scanning, uploading, and commenting.

During the first four weeks of the field study participants used AURA as they wished. We then asked participants to complete two specific tasks, with the goal of stimulating sharing through ratings and comments since there was greater likelihood that they would scan similar items. The first task, emailed at the beginning of the final week of the study, instructed participants to take AURA home and scan at least five items on their refrigerator shelves. Thirteen of the twenty participants completed this task. The second task, sent at the end of the final week of study, instructed participants to scan at least five items on their bookshelves over the weekend. This final task was unfortunately sent after people had probably gone home for the weekend, which may have contributed to the fact that only five participants completed this task. However, it is also possible that the low participation rate could have been caused by a lack of perceived value from AURA or by fatigue from the long field study, which finished at the beginning of the next week. At the end of the study all participants were compensated with a coupon for a free coffee. We also held drawings for a fifty dollar Amazon gift certificate each of the last three weeks of the study. Any participant that scanned at least one item during a week was eligible for that week's drawing.

4.1.1 Data Collected

During the field study we collected data using surveys, experience sampling, ethnographic observations, and logging usage of the AURA Web Portal.

Pre-Survey: We surveyed the participants before the field study to gather information about personal technology usage and shopping habits. Nineteen of the 20 participants completed the pre-survey. The majority of pre-survey respondents (78%) used their Pocket PC's several times a day and most for more than 30 minutes a day (68%). Twelve of the nineteen respondents (63%) primarily used the WiFi network to connect to the Internet and the remaining seven (37%) primarily used the Cell network. Almost 90% of participants stated they did a significant amount of shopping for their household with on average two shopping trips for groceries and other retail items in a week. This was important to us since we wanted participants who were likely to engage in retail shopping.

Post-Survey: On the post-survey we asked participants about their experience using AURA and their ratings of existing and potential features. All 20 participants completed the post-study survey.

Experience Sampling Method (ESM): To explore the motivations and settings for our participants' use of AURA at the moment they scanned and uploaded objects we used event contingent experience sampling [1]. We presented participants with an experience survey after every fifth item they uploaded to the Web Portal. The survey asked participants why they scanned an item, what they planned to do with information about the item, where they were, and who they were with. To keep the survey easy to complete, we provided a list of possible responses, but always included the option of "other." Participants completed 173 experience surveys out of the 231 times (75%) we presented the survey to them. Of our twenty participants, eighteen participants completed at least one experience survey.

Ethnographic Field Observations: We conducted ethnographic field observations for eight of our twenty participants, four men and four women. For each of these eight participants the same researcher first conducted a semi-structured interview in their office and then later accompanied the participant on a shopping trip to a retail store selected by the participant. Although we selected the participants to observe before they started using the system, picking the four women and randomly selecting four men, we were pleased that these participants turned out to represent well the different levels of engagement our participants had with AURA.

Usage Logs: We instrumented the Web Portal to record details of each user's uploaded items (due to our privacy model we can only log information about items explicitly uploaded by participants). We also logged comments and ratings made by participants on uploaded items.

4.2 How do people use the AURA system?

We explored how our participants used AURA by examining the number of items they uploaded, what they scanned, why they scanned the objects, and where they were when they scanned. While usage varied considerably among participants, many encountered problems scanning objects that could not be recognized by AURA. Among objects AURA did recognize, books and music were popular and the experience survey results suggest participants were often scanning at home to inventory a collection of objects.

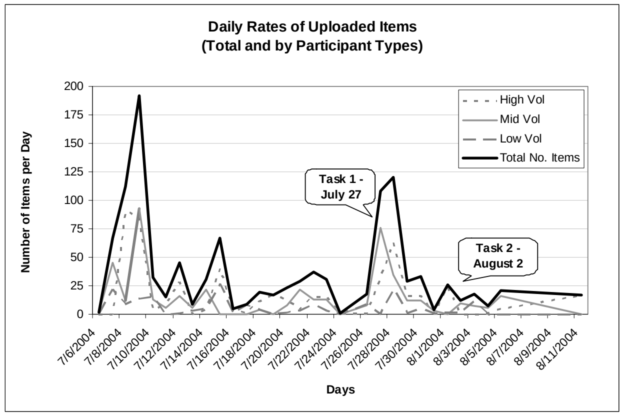


Fig. 2. Daily rate of the number of items scanned and uploaded by participants during the field study. There was self-directed usage until Task 1 was introduced on July 27 where we see a usage spike

4.2.1 How many items did users scan?

During the five week field study our participants uploaded a total of 1,156 items (excluding items uploaded during training) out of an unknown number of scanned items. As shown in Figure 2, we saw a novelty effect with much of the activity occurring shortly after the beginning of the study and following the first task request. There was a wide range in the number of items scanned and uploaded by different study participants from 1 to 199 (median = 48.5, mean = 57.8, SD = 55.6). To understand the experience of different types of study participants, we classified them into three groups based on the number of items they scanned and uploaded.

- **High volume scanners:** the three participants who scanned and uploaded 100 or more items during the course of the study. One of these participants was part of the ethnographic observation.
- **Mid volume scanners:** the seven participants who scanned and uploaded 51 – 99 items during the course of the study. Three of these participants were part of the ethnographic observation.
- **Low volume scanners:** the ten participants who scanned and uploaded 50 or fewer items during the course of the study. Four of these participants were part of the ethnographic observations.

Table 1 presents statistics about the participant types including days active, number of items uploaded, and number of public and private items. Figure 3 shows that the number of items uploaded by individual users follows a power law distribution. Overall, participants were active on average five out of a total of thirty-five days in the study, with the high volume participants active an average of fifteen days. All high volume participants and one mid-volume participant scanned and uploaded items each of the five weeks of the study. The other sixteen participants were less consistent in their involvement. The median for mid and low participants was scanning at least one

Table 1. Statistics about items uploaded by participants during the field study

Activity by Participant Types (N) Median (SD, Mean)				
Activities	**High (3)**	**Mid (7)**	**Low (10)**	**All (20)**
Days Active	15 (1, 14)	5 (2, 6)	4 (2, 4)	5 (4, 6)
Total # of Items	170 (26, 172)	69 (7, 66)	15 (13, 18)	49 (56, 58)
Public Items	60 (70, 81)	8 (20, 18)	7 (11, 10)	10 (37, 24)
Private Items	88 (83, 91)	55 (20, 48)	8 (7, 8)	16 (43, 34)

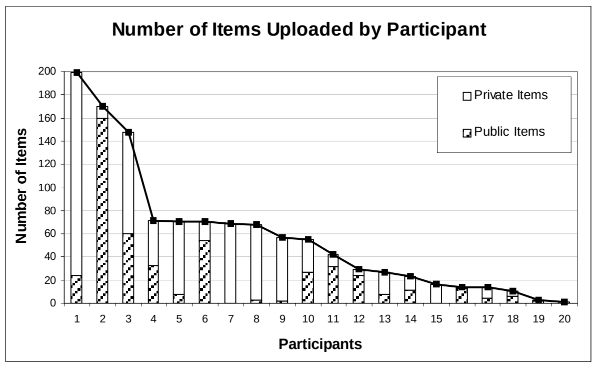


Fig. 3. Number of items uploaded by each participant

item during three weeks of the study. The number of items uploaded by the high, mid and low participant groups was significantly different based on an ANOVA. ($F(2, 17)=158$, $p < 0.01$, follow-up Bonferroni analysis all $p < 0.01$). The number of days active of the high participants compared to the other two groups was also significantly different. ($F(2, 17) = 36.3$, $p < 0.01$, follow-up Bonferroni analysis all $p < 0.01$).

Of the 1,156 total items uploaded (685 private items, 471 public items), we found that about a fifth of the items had ratings or comments associated with them. Overall, participants made slightly more ratings than comments, with 130 ratings and 116 comments. For both ratings and comments, participants made considerably more public contributions than private ones. Nine percent (107) of the total items received public ratings compared to 2% (23) that received private ratings. Similarly, participants made public comments on 8% (90) of the total items uploaded and private comments on only 2% (26) of uploaded items.

4.2.2 What did they scan?

The usage log data showed us what types of items participants uploaded to the AURA web portal. Twenty-four percent of the items uploaded could not be recognized by the resolution services for UPC and ISBN currently implemented in the AURA system. The percentage of unresolved objects (24%) is no doubt artificially deflated because it does not capture those objects that were unrecognized, but not uploaded. Given the questionable value of uploading unrecognized data it is possible that many more objects were not recognized by our system. We discuss frustration with unrecognized objects in Section 4.3.2.

To categorize the items recognized by the resolution services, three researchers first independently put the items in categories and then resolved any differences through discussion. The top three categories of recognized objects were Print Media items (books and newspapers) with 23% of items, followed by Music and Video items (19%), and Grocery items (18%). These three categories accounted for 60% of uploaded objects. The other categories of uploaded items were Household items (8%), Computer Software (4%), Consumer Electronics (2%), Office Products (1%) and Company Art (1%).

4.2.3 Why and where did they scan?

The data from the 173 experience surveys gives us insight into why participants scanned items and where they were. The primary reason participants reported for scanning and uploading an item was to "inventory a collection of items" (61%). Other less popular responses included: "make a note of the item for later review" (10%), "do a price comparison" (10%), and "order it online" (3%). Respondents chose the "other" response option 16% of the time. Post-survey responses corroborate these results. When asked what they used AURA for, the only option to receive a median response of "Often" was "to inventory a collection of items."

When asked how they would use information about the items they scanned and uploaded, the most common responses on the experience survey were "do nothing" (34%), and "get more information about this item" (27%). Respondents also chose the "other" response option 24% of the time. Less popular responses were "buy this item" (8%) and "email this item to someone else" (8%).

Participants told us on the experience surveys that they were primarily scanning in their homes (67%). However, several participants did try AURA in other locations. Fourteen of the twenty participants (including all high volume participants) scanned items in two or more locations and seven participants scanned in three or more. After the home, the participant's office was the next most popular scanning location reported on the experience survey (13%), followed by other people's offices (5%), grocery stores (4%), bookstores (4%), DVD/Video stores (2%), and somebody else's home (1%). Respondents chose the "other" response option 5% of the time. Post-survey responses agreed with the experience survey results. When asked how often they used AURA in these locations, only "your home" received a median response of "Often", while work, grocery and bookstore had median responses of "Sometimes." All other locations had a median response of "Never."

4.3 Do people find the AURA system functional and useful?

From the usage log data, post-survey responses and our observations we believe our participants had a mixed reaction to their use of AURA. Perhaps not surprisingly our

Table 2. Responses to post survey questions about participants' experience with AURA. Responses on a 5 point scale (1 = Strongly Disagree … 5 = Strongly Agree)

Post Survey Questions	**Reactions by User Type Median (SD, Mean)**			
	High (3)	**Mid (7)**	**Low (10)**	**All (20)**
1. Found AURA easy to use	5 (1, 5)	4 (1, 3)	4 (1, 3)	4 (1, 4)
2. Enjoyed using AURA	5 (0, 5)	4 (1, 4)	4 (1, 4)	4 (1, 4)
3. Found AURA useful	4 (1, 4)	3 (1, 3)	4 (1, 3)	4 (1, 4)
4. The benefits of the system out weighed any frustrations experienced	4 (2, 4)	3 (1, 3)	4 (1, 3)	3 (1, 3)
5. The external barcode scanner was easy to use	5 (0, 5)	4 (1, 3)	3 (1, 3)	3 (1, 3)
6. Remembered to carry barcode scanner with me	5 (0, 5)	4 (1, 3)	4 (1, 4)	4 (1, 4)
7. Found it easy to scan items	5 (0, 5)	4 (1, 4)	4 (1, 3)	4 (1, 4)
8. Enough items resolved to make AURA useful	3 (2, 3)	3 (1, 3)	3 (1, 3)	3 (1, 3)

three high volume scanners had the most positive reaction. On the post-survey the median responses for high volume scanners were "Strongly Agree" for the questions related to ease of use and enjoyment (Table 2, Q. 1 & 2), and "Agree" that they found AURA useful and that the benefits of the system out-weighted any frustrations experienced (Table 2, Q. 3 & 4). All questions shown in Table 2 were positively phrased and asked on a 5 point Likert scale from Strongly Disagree to Strongly Agree.

Mid volume scanners were the least enthusiastic on the post-survey with median responses of "Neutral" when asked if they found AURA useful and whether the benefits of the system outweighed any frustrations experienced (Table 2, Q. 3 & 4). In this section we discuss the some of the main factors that contributed to our participants' problems using AURA: challenges while scanning, frustration with unrecognized items, issues with connectivity and offline mode, and lack of value when shopping for low engagement objects.

4.3.1 Challenges when Scanning

During interviews and shopping trips with the eight participants observed in the field the researcher saw that participants found the external barcode scanner cumbersome and that it was harder for some participants to carry their device with the barcode scanner attached. The researcher observed and participants verbalized that it was difficult to manage both their mobile device and a shopping cart or basket. Participants that brought along others on their shopping trip found it convenient to have the additional person who could manage the shopping cart while they scanned items. Issues with the external barcode readers were also reflected to some degree in the post-survey responses. The median response of low volume scanners (half our participants) was "Neutral" when asked if the external barcode scanner was easy to use. In contrast, the median response for mid volume scanners was "Agree" and high volume scanners was "Strongly Agree" (Table 2, Q. 5), so those participants may have had fewer problems.

During the observations three participants forgot the external barcode scanners at work or home. In these cases, we loaned them one to make the observation possible, but wondered how common this might be. While potentially difficult to illicit on a survey, where people might be reluctant to fully disclose, we did see that four participants responded “Disagree” and three responded “Neutral” when asked whether they remembered to carry the barcode scanner with them.

The act of scanning also sometimes posed challenges for the participants, as they had to learn to position the scanner at the appropriate distance and orientation to achieve a successful scan. The barcode scanners we used require fairly bright lighting conditions, and have a hard time with barcodes printed on shimmering and curving surfaces (like drink cans). The researcher also observed that many participants had turned their device’s volume off, either by mistake or because they did not want to be heard scanning, and thus did not receive any audible feedback about successful scans which may have contributed to usage difficulties.

Some participants mentioned a fear of being seen scanning items in stores. They disclosed different reasons for this including: not wanting to be seen as stealing information, not wanting to be seen by or as a store employee, and general shyness. In practice, the researcher found that once participants were in the store and with someone else, most participants were not as embarrassed as they thought they would be.

4.3.2 Frustration with Unrecognized Items

We knew before the field study that there were several types of items that our existing resolution services could not resolve, including items that are not national brands or in stores that maintain their own private barcode numbering schemes. However, our belief was that by handling the UPC and ISBN identifiers AURA would do a reasonable job recognizing most of the items likely to be scanned by participants, particularly books, music and items in major chain stores.

Unfortunately, during the observations the researcher saw that participants were noticeably frustrated when items that they scanned did not resolve and unrecognized items occurred more frequently than we hoped. For observed participants the existing set of resolution services functioned best in book stores and was less useful in grocery stores where many of the scanned items were not recognized. When asked on the post-survey data if enough items resolved to make AURA useful, the median was “Neutral” (Table 2, Q. 8). When asked to rate the priority of proposed features, the median response for “recognize more types of items” was “High Priority” (Table 3, Q. 2).

Participant comments also highlighted the need to recognize more items or at least support a user defined resolution service where participants could input their own information for unrecognized items. Comments included: “It rarely resolved items. Made it fairly useless” and “It [AURA] didn't recognize enough things -- it would have been better if when it didn't recognize it, I could tell it what it was.” Allowing users to provide and edit information received a median response of “Medium Priority” on the post-survey (Table 3, Q. 6).

Other challenges in recognizing items observed by the researcher involved locating the barcode to scan initially. Some items have multiple barcodes, other barcodes were

Table 3. Survey respondents' ratings of possible new features for AURA on a scale from 1 (Not Needed), 2 (Very Low Priority), 3 (Low Priority), 4 (Medium), 5 (High Priority), and 6 (Very High Priority)

Potential New Features	Preference by Participant Type (N) Median (SD, Mean)			
	High (3)	Mid (7)	Low (10)	All (20)
1. Improve the offline scanning experience	5 (1, 5)	6 (1, 6)	6 (1, 5)	6 (1, 5)
2. Recognize more types of items	6 (1, 5)	6 (1, 5)	5 (1, 5)	5 (1, 5)
3. Provide additional details about items	6 (1, 6)	5 (1, 5)	5 (1, 5)	5 (1, 5)
4. Expand the number and types of devices that AURA runs on	4 (1, 4)	4 (1, 4)	5 (1, 4)	4 (1, 4)
5. Improve the search option	4 (1, 4)	5 (1, 4)	4 (1, 4)	4 (1, 4)
6. Allow users to provide and edit item information	4 (1, 4)	4 (1, 4)	5 (2, 4)	4 (1, 4)
7. Allow users to organize items by adding category tags and labels	4 (1, 4)	5 (1, 4)	4 (2, 4)	4 (1, 4)
8. Integrate location awareness	4 (1, 4)	4 (1, 3)	4 (1, 4)	4 (1, 4)
9. Allow subscriptions to items scanned by others	3 (1, 3)	4 (1, 3)	4 (1, 4)	4 (1, 4)

out of reach to the user due to the item's position on a display shelf and in other instances the barcodes were on the outer package for a group of items rather than on the single item on display (for example, for bars of soap).

4.3.3 Issues with connectivity and offline mode

Initially we expected participants to primarily use AURA when connected to a wireless network; however on the post-survey the median response was that most participants used AURA "About equally online and offline." This is perhaps a reflection of the frequent use of AURA to create inventories of objects.

During the observations the researcher found that connectivity, whether WiFi or cellular, was not uniformly available or reliable. On the post-survey, when asked how much they were affected by connectivity delays, only one respondent said "Never." Of the other sixteen people who answered this question, six were affected "rarely," four "sometimes," two "often," and four "a lot." Thus, many participants needed to use offline mode. When asked to rate the usefulness of current AURA features on the post-survey, the median response by participants for offline scanning was "Can't live without it," the highest possible response.

Unfortunately, when participants did use offline mode, they found that it lacked several features they wanted including a batch mode for uploading several items together when connectivity was restored, clearer feedback when an item scanned offline had been uploaded to the web portal, and the ability to associate additional information such as categories with items scanned offline. On the post-survey, improving the offline experience received the highest possible median response of “Very High Priority” across all participants (Table 3, Q. 1). When asked to comment on the worst thing about AURA, several participants mentioned the offline experience. Comments included: “missing powerful offline experience,” “inability to edit items in offline mode,” and “offline: upload is very tedious.”

4.3.4 Lack of Value for Low Engagement Objects

We envisioned several different usage scenarios for AURA including retrieving information while shopping for groceries, books, or electronics. Observations in grocery stores and other retail stores made it clear that other scenarios may “fit” better than grocery shopping. In general, AURA did not prove very useful when participants shopped for *low engagement objects* like groceries because most participants purchased the same items and had no interest in researching them.

During the observations participants described features that would potentially make AURA more valuable for them during shopping. Users seemed more likely to use AURA for *high engagement objects* like books or CDs – objects that require users to make fine grain distinctions about exactly which object they are seeking. One user mentioned that she always had trouble remembering the names of her vacuum cleaner refill bags when she goes out shopping and could never remember to write them down. She would like to scan all such items and create a list which she can access when she is in the store. Similarly users also wanted the ability to create personal categories and organizations for their item collections and to create wish lists that they could share with various people.

4.4 Does the privacy model meet users’ needs?

We implemented what we felt was a conservative privacy model that explicitly asks a user to take two steps to publicly expose information about the objects they are scanning, first uploading item details to the Web application and then making an item public. During the study, one of our research questions centered on whether the privacy model would meet user needs. Other possible privacy models, for example, automatically uploading scanned items or having only public items on the web portal, would require fewer steps for users to make items public and we wondered if users would find the privacy model appropriate or cumbersome.

The data from the post-survey and usage logs suggest that the conservative privacy model worked for our participants. We found during the field study that 17 out of 20 participants chose to explicitly make items public so they could be seen by others rather than leaving all items in their default private state. Overall, 41% of the items uploaded were made public while 59% remained private. Thirteen participants made fewer than 50% of their items public and 7 participants made 50% or more of their items public. Even though participants seemed eager to share at some level, it is clear that many of them thought about what they were willing to make public. On the post-survey the median response across all participants was ‘Agree’ when asked “I am comfortable with the privacy options provided by AURA." Our experience suggests other object triggered information systems may wish to consider a similarly conservative privacy model.

4.5 How do people use the sharing features?

One of the goals for the AURA project is to facilitate a community where people can easily share comments and ratings about the items they scan with others. During the field study one of our research questions focused on whether and how our participants used the sharing features provided

When asked about the usefulness of public rating, the median response was "Very Useful" and for public commenting the median response was "Somewhat Useful." We believe that some of the utility of the rating and commenting features suffered from a problem of critical mass, as post-survey comments highlighted that there was not enough shared content to make the comments and rating features useful. As one participant commented, "It needs lots of people using it to make it worth while - I can see the potential, but when there is little overlap of items being scanned & commented it becomes little more than a tool to facilitate googling." Our log data also reflected this lack of overlap in items uploaded by our participants. As general user populations grow or the AURA application is deployed into more cohesive groups with a common annotation task, we believe that public commenting and rating features may become more valuable.

Our system's other sharing options were used very infrequently. The majority of our post-survey respondents (15) told us they had "Never" emailed an item to someone, and publishing an RSS feed of items had a median response of "Not Useful."

5 Discussion

We now discuss the improvements to AURA and similar systems suggested by our field study. We then reflect on our experience and the implications for others that seek to deploy ubiquitous computing applications.

5.1 Realizing the AURA Vision

While our high volume scanners found some value in using AURA, the experiences of our participants highlight a number of considerations for AURA and other object triggered information systems.

Handle Groups of Items: In our original usage scenarios and those of many other similar systems [e.g. 10], users interact with one item at a time, scanning it and then retrieving information. In contrast, participant feedback during the ethnographic observations and on the post-survey stressed the importance of working with groups of items. For example, a participant could scan a number of interesting books and then upload them together to a wish list.

Robust Offline Experience: Our field study experience showed us that even with participants screened for devices with internet connectivity there are times when users may not be able or even wish to connect. To ensure the usability of object triggered information systems, they must provide a reasonably robust offline experience.

Integration with Current Practices: Our observations, particularly in grocery stores, highlighted just how much difficultly the form factor of the handheld device caused when participants were shopping. In addition, the external barcode scanner is bulky and one more thing to remember to carry. The use of certain cell phone cameras by some existing systems [e.g. 9] to recognize barcodes gives us encouragement that the integration of object triggered information system into devices users already carry could lead to widespread adoption of object triggered information systems relatively soon.

User Input for Unrecognized Items: There will always be the potential for unrecognized items in object triggered information systems. So our main focus will be handling unrecognized items more gracefully by providing participants the opportunity to enter their own information. This raises the exciting prospect of encouraging sharing of user defined item information, but also the interesting challenge of handling instances where conflicting information is provided.

Desire for Context: Participant feedback suggested that participants found the information they provided for the experience surveys valuable and wanted the option for AURA to remember this type of context information for all the objects they scanned. It may also be worth exploring whether users find information that could be automatically recorded by the system, such as location, valuable.

End-To-End Support for Applications: We built AURA as a platform to support applications that sense physical objects and then provide related online services and information. While this approach gave AURA the flexibility to be used in a variety of ways, we saw during the field study that participants wanted better end-to-end support for certain applications. The observations of our users suggest that applications for creating inventories and shopping for high engagement objects would be more valuable to our users than applications related to grocery shopping.

5.2 Reflections on our Experience

While we believe that field studies such as this one are crucial for evaluating potential ubiquitous applications with real people in real settings, they also require a considerable amount of effort. We share reflections about our experience, both positive and negative, with the hope that others may benefit from them.

Provide Hardware: In our study we made a conscious choice to recruit people who already had Pocket PC devices and thus only needed to be provided the barcode scanner. We wanted people to experience AURA on the devices they were already carrying. In retrospect, this decision caused considerable pain for us as we ended up with participants on a variety of platforms. In future studies we plan to provide the entire hardware platform so that we have more control over the usage environment and would recommend that others consider this approach. Note, that cell phone SIM cards offer an interesting option to provide hardware and allow people to keep their phone number and service plan, as Smith et al. [15] did in their study.

Prepare for Connectivity Issues: The vision of ubiquitous access to the internet is becoming more of a reality each day, but what we found still leaves a lot to be desired. Although all our users work on a corporate campus with WiFi, we were aware of potential connectivity challenges and strove to recruit participants who either used the cell network to connect to the Internet and/or had WiFi at home. Had we fully realized the extent to which our users would encounter problems with connectivity we would have also provided users with subscriptions to a variety of WiFi access services and improved offline mode earlier.

Consider Ways of Creating Critical Mass: We had hoped that the tasks we asked the users to complete would lead to an overlap of scanned items and interest in sharing with others. However, for several of AURA's features related to sharing, we believe critical mass was an issue. While it is unlikely that we will be able to deploy in a field study situation with enough users to overcome this problem directly, we are exploring ways to work around this problem by selecting participant populations that already know each other and thus have things in common that may motivate them to share with each other or find each others scanned items interesting. We also plan to call more attention to the lists on the web portal homepage that highlight recent and notable patterns of activity in hopes of generating additional public contribution. We encourage others whose systems contain features that work best with large population of participants to think carefully about ways you might work around this constraint.

Multiple Data Sources are Valuable: We collected data using multiple methods. Having several sources of data, particularly the ethnographic observations, helped us build a more complete picture of how our participants used AURA. For example, we followed-up on the post-survey about problems we saw in the observations. The agreement between different sources, such as the post-survey and experience survey results also increased our confidence in our results.

6 Concluding Remarks

AURA is one of many systems that connect physical objects to information online. Moving beyond limited usage and demonstrations to deploy AURA in the real world with 20 participants over five weeks shattered several of our usage assumptions and discovered a number of important features and issues that developers of other object triggered information systems may wish to consider. The number of issues we encountered deploying a relatively simple system like AURA highlights the importance of evaluating ubiquitous applications in real world setting to test design assumptions. For AURA, the field study showed us the importance of allowing users to work with groups of items, the necessity of a robust offline experience, and the need to allow users to identify the products they scanned that AURA could not recognize. Despite these issues, several participants did use AURA a fair amount suggesting that with further refinement mobile object triggered information systems are viable ubiquitous computing applications. We are currently addressing the short-comings highlighted by the field study and hope to release the revised client for public download.

Acknowledgements

We gratefully acknowledge our field study participants and the AURA development team: Howard Hwa, Paul Johns, Dany Rouhana, and Jane Wei. We also appreciate the valuable feedback we received from our reviewers and Geraldine Fitzpatrick.

References

1. Barrett, L.F., Barrett D.J.: An Introduction to Computerized Experience Sampling in Psychology. Social Science Computer Review, 19, 2 (2001), 175-185
2. Beeline Shopper, http://www.beelineshopper.com/
3. Bellamy, R.K.E., Brezin, J., Kellogg, W.A., Richards, J.T.: Designing an e-grocery application for a Palm computer: Usability and interface issues. IEEE Personal Communications 8, 4 (2001), 60-64
4. Brody, A., Gottsman, E.: Pocket Bargain Finder: A Handheld Device for Augmented Commerce. Proc. HUC 1999, ACM Press (1999), 44-51
5. Coulouris, G., Kindberg, T., Schiele, B., Schmidt, A., Rehman, K.: What makes for good application-led research in ubiquitous computing. Pervasive 2005 Workshop http://www.cl.cam.ac.uk/~gfc22/ubiappws/
6. CueCat: Digital Convergence, http://www.cuecat.com/
7. Delicious Library: http://www.delicious-monster.com/
8. Fano, Andrew E.: Shopper's Eye: Using Location-based Filtering for a Shopping Agent in the Physical World. Proc. Agents 1998, ACM Press (1998), 416 - 421
9. Gizmodo: Amazon Japan Cell Phone Fancypants Service. http://www.gizmodo.com/gadgets/cellphones/amazon-japan-cell-phone-fancypants-service-026198.php
10. Konomi, S.: QueryLens: Beyond ID-Based Information Access. Proc. Ubicomp 2002, Springer (2002), 210-218
11. Ljungstrand, P., Redström, J., Holmquist, L.E.: Webstickers: Using Physical Tokens to Access, Manage and Share Bookmarks to the Web. Proc. DARE 2000 (2000) 23-31
12. Newcomb, E., Pashley, T., Stasko, J.: Mobile Computing in the Retail Arena. Proc. CHI 2003. ACM Press (2003), 337-344
13. QR Code: Wikipedia, http://en.wikipedia.org/wiki/QR_Code
14. Smith, M., Davenport, D., Hwa, H.: AURA: A mobile platform for object and location annotation. Demo. Ubicomp 2003. Seattle WA
15. Smith I., Consolvo, S., Lamarca, A., Hightower, J., Scott, J., Sohn, T., Hughes, Iachello, G. Abowd, G.: Social Disclosure of Place: From Location Technology to Communication Practices. Pervasive 2005, Lecture Notes in Computer Science, Vol. 3468
16. Socket OrganizerIT: http://www.socketcom.com/product/SW1216-560.asp
17. Want, R., Fishkin, K., Gujar, A. Harrison, B.: Bridging Physical and Virtual Worlds with Electronic Tags. Proc. CHI 1999, ACM Press (1999), 370-377