AURA: A mobile platform for object and location annotation

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ABSTRACT
In this paper, we describe a system used to link online content to physical objects implemented with commercially available pocket computers using integrated bar code scanners, wireless networks, and web services. We discuss our design goals and technical architecture and describe applications that have been constructed on this architecture. We describe the role of the related web site to create communities around scans collected by the handhelds.

Keywords
Laminated reality, mobile object annotation, communities, mobile devices, bar codes, machine readable object tags, wireless networks

INTRODUCTION
Every object has a story to tell. However, labels and signs can only tell part of this story; there is always an enormous amount more to learn than will fit on a label. Mobile devices are changing this, allowing physical objects to to be linked to associated online content. This dramatically expands the space for commentary and services related to the places, products, and objects that physically surround us.

The technical process of linking physical objects to online content has become increasingly straight-forward. Adding a tag reading device to a network connected portable computer shortens the gap between physical objects and places, and the digital information related to them. This enables wirelessly networked devices to cheaply and accurately recognize a wide range of objects and places, and offer access to information and services pertaining to those objects. It seems reasonable that some form or forms of tag detectors will eventually be common features of most networked information devices. Currently cameras and bar code readers are widely available for cell phones and pocket computers.

We created just such a system that combined widely available wirelessly networked Pocket PC handheld computers with a laser scanner for reading bar codes. Client software was created to integrate these components and connect them with servers available over the public Internet.

The resulting system has applications in many settings. Meta-data about objects with UPC codes, found on almost all consumer products in the United States, can be drawn from publicly accessible online data services. These services often provide the name of the object or product, its size (if it has one) and the name of its manufacturer in exchange for the object's bar coded identifier. Our system uses such a data service to retrieve meta-data that is then used to construct queries for search engines that yield useful and highly relevant results. Scanned objects quickly link back to the web sites for their manufacturers or online commerce sites that offer those objects for sale. Similarly, books often bear an ISBN number in the form of a bar code. These numbers can be used in queries to online book sellers, making the services offered there like book reviews, lists of related books, and, of course, purchasing available with just one scan and a tap.

Figure 1. Mobile device hardware platforms composed of a Toshiba e740 and a Socket Compact Flash Bar Code Scanner.

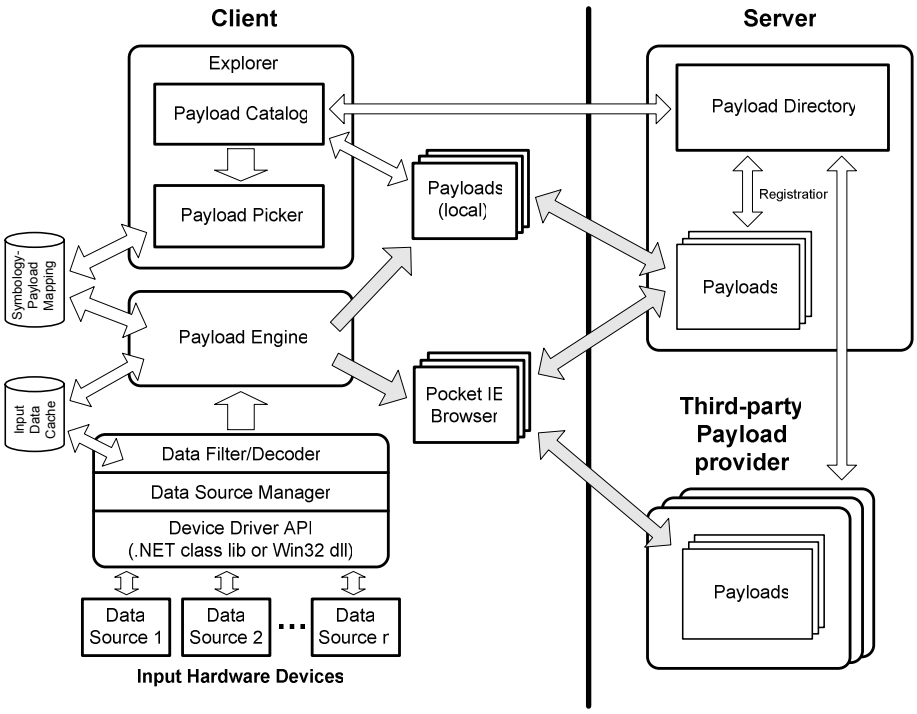

Figure 2. AURA Architecture diagram

RELATED WORK

Several projects have explored the ways objects and places can be linked to online content and services. Ljungstrand, *et al*. (2000) have built the WebSticker system to link barcodes to web pages. This was predominantly a desktop bound system. There is a large body of work on "context-aware" computing (Schilit, *et al.*, 1994). Context-awareness refers to the identification of a user's proximate environment for the delivery of computing content or services. Xerox's PARCTAB system uses custom built infrared transceivers to help palm-sized computers to identify their physical environments (Want, *et al.*, 1995). The Cyberguide uses Palm PDA's to provide map guides to tourists (Abowd, *et al.*, 1997). Positioning in Cyberguide is provided by a combination of custom applications based on infrared sensing (for indoor) and GPS (for outdoor). MIT LCS' Cricket System deploys custom built RF and ultrasound beacons for indoor navigation (Priyantha, *et al.* 2000).

The CoolTown Project at HP is building context-awareness technologies to provide web presences for people, places and things (Kindberg, *et al.*, 2000). Similar to the MIT Project Oxygen (MIT, 2002), CoolTown's main goal is to enable future "nomadic computing" such that computing resources follow the human user and customize the human-computing interaction based on the local human environment.

Our approach is a more modest and potentially more broadly deployable in the short term. Our goal is to enable a light weight way to both access information about physical objects and places and to add annotations to them. This focus is different from, but complementary to, efforts to link physical devices, like printers or projectors to device based user interfaces.

HARDWARE PLATFORM

The mobile component of our system integrates three core hardware features: a laser bar code scanner, a wireless network connection, and a PDA. There are a number of alternative sensors that could be usefully integrated into this system, including GPS and wireless network signal strength detection for location information and readers for the emerging technology of RFID tags. To date we have only made use of bar code readers but the system architecture is extensible, allowing these or other emerging sensor technologies to generate information that can be used to identify objects or places.

SERVER

The server is comprised of three components: a web service, runtime, and local and remote data stores. The Web Service is the channel the client uses to communicate with the backend server. This is accomplished entirely using remote method invocation over HTTP ("web services"). The web service is the interface to the backend runtime for the clients. The Runtime provides the business logic handling event tracing, retrieval, storage, rating

calculations, and other tasks. The local database stores contain user profiles, barcodes, ratings, written and speech annotations, which are stored in a SQL2000 database. Information on books and UPC's are provided by multiple remote data stores including the Amazon Web Service for books and music, and the ServiceObjects Web Service for UPC lookup.

MOBILE CLIENT SOFTWARE

The client is a standalone application on the Pocket PC (as opposed to a web front-end) to support improved user interactivity. Network connectivity is not assumed to be continuous for the mobile client. The client application provides queuing and retry services for the storage and retrieval of data to and from the backend servers. These services are not possible for a thin web based client. Caches or local stores on the client can dramatically reduce the demand on network access for content. In addition, a client side application allows for a richer user interface. This is especially true when considering delays and intermittent network connectivity.

CLIENT INTERFACE COMPONENTS

Users can login to the system by creating a unique username and password combination either from the mobile device or through the web portal interface. Without an account the device can be used to scan objects but the device creates an Anonymous User account and all the comments created in that context are by default public.

When a user sees an object that interests them and finds a bar code printed or affixed to it they point the head of the device at the bar code from a distance of about 6-12 inches and press the scan trigger button which we mapped to the thumb button normally used to invoke the voice recorder feature of the Pocket PC. If the device acquires the tag's data, the application gives the user feedback and based on some properties of the bar code data and sends a series of network queries out to appropriate web services.

We have initially created or linked to services to support three types of bar codes: tags created for a local art gallery, UPC (Universal Product Code) codes commonly used to tag consumer products and foods, and ISBN (International Standard Book Number) codes for books. Any number of additional or alternate payloads are possible within this framework to provide services for these or other forms of object identifiers.

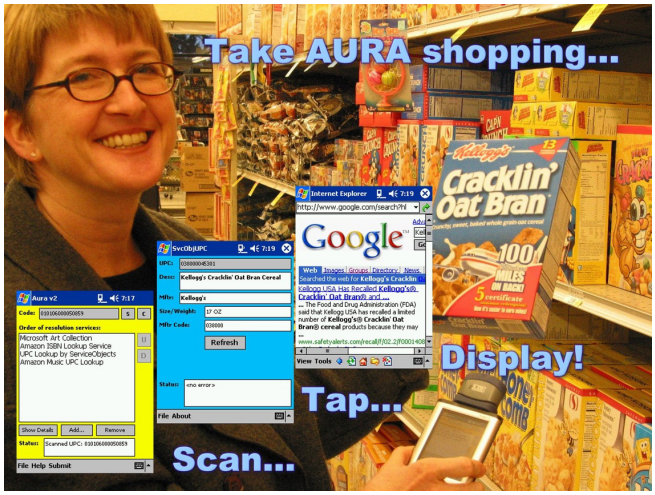

Figure 3. User scenario for grocery and related retail environments. Query highlighted the recall of the breakfast cereal by the FDA.

These payloads are linked to the resolution service registry which contains pairs of pattern matches and pointers to related web resources. When a tag is scanned it is matched to an appropriate payload on the basis of the structure of the identifier string. For example, ISBN codes start with "978" and have a total of 14 digits. All bar codes starting with that series of numbers with that number of digits are assumed to be an ISBN and are submitted to web services that are listed in the client's directory of resolution services that are registered as resolving such codes. We made use of a web service offered by Amazon.com that returns metadata about books and music when passed an ISBN number.

Figure 4. UPC Item Display Screen.

When objects with UPC codes are scanned the system recognizes that the code is not in other classes of codes and submits the identifier to a UPC mapping service. We made use of a UPC metadata service provided to the public by

ServiceObjects.Net, a commercial web service provider. This service returns a set of meta-data about the object and the client presents this data and creates hyperlinks to search engines based on the results. For example, when a box of breakfast cereal is scanned the resulting display provides two tap access to search results, the first of which notes that the product has been recalled due to food safety issues related to undocumented ingredients that might cause fatal allergic reactions for some people (figure 4 and 5).

Figure 5. Search results linked from UPC meta data

WEB PORTAL

Users can access the system through a web portal as well as the mobile device. Users can log into the web site and view their scan history sorted by various properties of the items. Scans can be sorted by time, by product category (books, food stuffs, etc.), or by the ratings or comments of other users or data found in other systems. This creates a simple way to assemble inventories of tagged objects, for example a collection of books, videos or music CDs. Alternatively, it creates a diary-like history of the series of objects scanned while, for example, browsing through a shopping mall or museum gallery.

CONCLUSION

A wave of annotation systems for physical objects is likely to be about to break. Cell phones are already integrating digital cameras and have the processing power needed to natively decode bar codes. As pocket computers merge with cell phones the resulting hybrids will no doubt combine a vision system with network connectivity and computation. The widespread distribution of such devices is likely to have dislocating effects in many sectors of life. Retail environments seem the most likely to change as consumers bring the power of the Internet to bear at the point of sale.

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