SMART THINGS

Ubiquitous Computing User Experience Design

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CHAPTER 6

INFORMATION SHADOWS

Every master goldsmith shall have a mark by himself.

King Edward III, 1363 (Chaffers and Markham, 1905)

King Edward III of England did not require London goldsmiths to identify their wares because he liked collecting the objects they made or promoting individual artisans. No, his motives were regulatory. He wanted to be able to track and punish smiths whose wares glittered, but were not quite gold.

However, King Edward's system of hallmarks (Figure 6-1) came to be much more valuable. As one of the earliest instances of cataloged metadata associated with manufactured goods, this system of hallmarks enabled a much different relationship between people and their possessions. Hallmarks re-associate objects with their origins. They systematically and consistently connect two people (the owner and the maker) through an object. The silver knife in Figure 6-1 is not anonymous: if we can decode the hallmark, we know who made it, when and where it was made, and out of what material. In encoding information into objects, hallmarks link those objects to data.

That linkage has continued to prove valuable and important in unexpected ways. Identifying individual objects in the world builds a bridge between any given object and the available information about that object. It allows for physical, everyday objects to act in the world of symbolic data and vice versa.

Before ubiquitous computing, only expensive things such as precious metals, currency, or large machines[1] were individually identified with any regularity. Only the cost of the item — or the social cost if the item went untracked (as with firearms) — justified the labor and monetary expense of labeling individual items and maintaining the metadata. Ubicomp includes a number of item-level tracking and identification technologies (see Sidebar: Item-level Identification Technologies) that dramatically lower the cost of adding machine-identifiable codes to objects and employing devices to read those codes automatically. Other information aggregation services can then build on these technologies to cross the gap between what a thing is and the meanings people give it.

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[1]Such as vehicle identification numbers, building addresses, and serial numbers. Brock (2001-1) had a good list of earlier identification schemes, their format, and the motivation for their creation.

Figure 6-1

Silver hallmark indicates that Aaron Hadfield of Sheffield, England, made this knife in 1834. (Courtesy Leopard Antiques, Cape Town)

6.1 AN EARLY SUCCESS IN ITEM-LEVEL IDENTIFICATION

Creating good user experiences by using item-level identification is not new. The early history of the Borders Books chain of bookstores is a good example of how a small amount of automated identification and information processing can profoundly change customer experiences and how a business operates.

Borders Books started as a university town bookstore in Ann Arbor, Michigan. It was not significantly different from other bookstores in the town, except for a small innovation. Louis Borders, who founded the company with his brother Tom in the 1970s, had studied computer science. Thanks to this exposure to the power and mechanics of information processing, he realized that putting a unique computer punch card in every book in his bookstore would automatically identify the book when a computer read the card (Raff, 2000). The punch card system allowed Borders Books to take a near instantaneous inventory of their store to identify which books had sold and when. Other bookstores conducted laborious annual inventories, at best. But Louis and Tom Borders could accomplish the same thing quickly and anytime they wanted.

Here is how it worked:[2]

- Every book had a punch card inserted into it, like a bookmark.
- Cashiers removed the punch cards and set them aside while ringing up a purchase.
- Periodically, all the collected punch cards went to a computing center, which generated a report on the sold books.
- Using the report, company managers could track books sold at which stores and when they sold.
- This allowed store managers and book buyers to identify buying patterns and anticipate shortages.

This seemingly small change gave Borders a significant advantage over its competitors, because they could sell a much wider variety of books, keep the popular ones perpetually in stock, and cater to local buying tastes and trends. They did not have to shut down and count all their books like other stores, and they did not have to rely on their hunches to figure out which books sold well

[2]This description is based on written descriptions of Borders systems (such as by Raff, 2000) and on my experience as a customer in the 1980s. One of their first stores outside Ann Arbor opened near where I grew up and I regularly shopped at the Ann Arbor store as a University of Michigan student in the late 1980s.

in which stores. They soon outgrew their original Ann Arbor store and founded a software company, Book Inventory Systems, that sold their system to other bookstores. Today, they are a huge international chain.[3]

[3]Borders Books, it should be noted, is now struggling to compete with online book retailers whose advantages are created with many of the same technologies Borders itself pioneered.

Item-level identification gave Borders a competitive advantage because it linked the physical object, a book, to important information about it. Some of that important information was permanent, such as the name of the book and its author. Other important information was contextually generated when the book sold, such as the store location and date of purchase. Equally important is that Borders Books was able to integrate the information tracking smoothly into the shopping experience. Most Borders customers may have never known how the punch card in every book, casually removed and put away by the cashier, was the lynchpin of their bookstore's success.

6.2 INFORMATION SHADOWS

> Then Wendy saw the shadow on the floor, looking so draggled, and she was frightfully sorry for Peter. "How awful!" she said, but she could not help smiling when she saw that he had been trying to stick it on with soap. How exactly like a boy! Fortunately she knew at once what to do. "It must be sewn on," she said, just a little patronizingly.
>
> Peter and Wendy, *by J. M. Barrie (1911)*

An Amazon product listing (Figure 6-2) shows a lot of information, but there is much more information about the product than just the official specs. An enormous quantity of user-generated content exists on the Internet tied to nearly every product. Virtually everything made or grown has been reviewed, discussed, photographed, mocked, praised, prodded, measured, disassembled, and hacked. Until the Internet, little of this social life was available; now there is a flood.


Product Details

Product Dimensions: 8.1 x 11 x 15 inches ; 3.8 pounds

Shipping Weight: 3 pounds (View shipping rates and policies)

Shipping: Currently, item can be shipped only within the U.S. and to APO/FPO addresses. For APO/FPO shipments, please check with the manufacturer regarding warranty and support issues.

ASIN: B0015KOFZK

Item model number: L9049

Our Recommended Age: 18 months and up

Manufacturer Recommended Age: 18 months and up

Batteries: 6 AA batteries required. (included)

Amazon.com Sales Rank: #10 in Toys & Games (See Bestsellers in Toys & Games)

Popular in these categories: (What's this?)

#1 in Toys & Games > Preschool > **Toddler Toys**
#1 in Toys & Games > Stuffed Animals & Plush > **More Stuffed Toys**

Average Customer Review: (30 customer reviews)

Figure 6-2
Amazon listing for Tickle Me Elmo, showing manufacturer metadata.

The digitally accessible information about an object can be called its information shadow.[4] Nearly all industrially created objects have rich information shadows, even if those shadows are invisible to their owners and users.

Wine bottles, for example, have very rich information shadows. Along with the traditional bottle-level data (such as when it was bottled, what grapes were used, who bottled it, etc.), wines have a huge social life generated by thousands of Web sites, blogs, rating services, and books. Wine enthusiasts probably spend as much time discussing wine as they do drinking it, and they have created a lot of content that is available through easily findable identifiers, namely the vineyard and vintage.[5]

Everyday objects have been separated for a long time from their information shadows, as Peter Pan was from his actual shadow. The complexity of finding, organizing, and accessing this information divided the world of objects and the world of information shadows. Even if accessible through a computer, information shadows were unavailable when they could provide the most value: in choosing between different products to buy, or in figuring out how to use a new tool. For example, barcodes are not human-readable. So for a long time, only those with barcode readers and access to specialized databases could use them,[6] which basically only included retailers and their employees. Even then the kinds of data available to retailers were limited. Standard Universal Product Code (UPC) barcodes identify classes of products, not individual things. Moreover, there is no universal database of barcodes. So a retailer's information about a given object is limited to data it has bought or generated on its own. Typically, like the early Borders Books system, retailers only keep enough information around to price items and order more.

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[4]The use of "shadow" to describe a relationship between physical objects and digital information goes back to Westin's (1967) description of "data shadows." My use is closest to the way Greenfield (2006) used it: "the significance of technologies like RFID and 2D barcoding is that they offer a low-impact way to 'import' physical objects into the datasphere, to endow them with an informational shadow."

[5]Bruce Sterling described the kind of social relationship we can have with wine in *Shaping Things*, his 2005 book-length essay on ubiquitous computing and design:

> Consider the wide variety of ways I am being invited to interact with this wine bottle. I don't just merely drink the contents. I could just drink it — but if I lift my eyes just a little — then I am invited to learn how to pronounce a foreign language, how to set up a social gathering with my friends, how wine is made, and how to expand my oenophilic knowledge of grape varieties.
>
> This is no accident. There is nothing frivolous or extraneous about this sudden explosion of information intimacy between myself and a bottle of wine.
>
> […] This is gizmo wine. It is offering me more functionality than I will ever be able to explore. This wine aims to educate me — it is luring me to become more knowledgeable about the people and processes that made the bottle and its contents. It wants to recruit me to be an unpaid promotional agent, a wine critic, an opinion maker — it wants me to throw wine-tasting parties and to tell all my friends about my purchase.

[6]This is no longer the case, as barcode reading cameraphone applications have proliferated in recent years, but that is a recent phenomenon relative to the 30-year history of barcodes in use.

A few industries have systematically generated and employed more extensive information shadows. In particular, the manufacturing and shipping industries have been tracking and identifying individual objects for years. In those industries every mile traveled by every piece of inventory directly affects revenue. So manufacturing and shipping systems provide fine-grained information shadows to identify and locate objects. For example, Wal-Mart and the American military — two organizations that ship a huge variety of things to a dizzying number of locations — have enthusiastically adopted identification technology (Myerson, 2006) to increase efficiency.

For consumers, ubiquitous computing attaches the information shadow to the object, like Wendy does to Peter Pan's shadow. It does this using three key technologies:

1. Inexpensive, machine-readable item-level identification technologies (see Sidebar: Item-level Identification Technologies) uniquely mark every object.
2. Wireless networking makes the information shadow of objects accessible to devices in more places.
3. Networked information aggregation services create a standard way of accessing information shadows that are produced simultaneously in many places at once.

Combining these technologies makes the information shadow of an object no longer abstract and secondary — something to check when you are hoping for a FedEx package to arrive — but a key part of the user experience of interacting with manufactured goods.

Sidebar: Item-level Identification Technologies

There are many technologies for identifying individual items. The most basic identification consists of a unique number or code associated with metadata about an object. This is how serial numbers on computers and cars work. More interesting effects appear when devices can read identifying codes without human intervention. Here is a sample of such machine-readable identification technologies.

- Barcodes. These are most commonly seen representing the UPC on most retail packaging. They are used to uniquely identify items in corporate inventory systems and in certain niche markets, such as wine storage.
- 2D barcodes. These come in many styles, from the Datamatrix code found on postal service package labels, to exotic fiducial markers used in motion sensing applications. QR Code markers (Figure 6-3), designed for easy reading using mobile device cameras, are increasingly popular.

Figure 6-3

QR Code that reads "Ubiquitous Computing User Experience Design" when decoded.

- Radio frequency IDs (RFIDs). These (**Figure 6-4**) come in many shapes and sizes — from subway access cards, to paper and metal stickers, to ceramic cylinders that sit in the stomachs of cows. Small radios inside them broadcast a unique identifying number. Because radio waves can transmit through solid materials, RFIDs can be embedded inside other objects (shipping palettes, clothing tags, and animals). Passive RFIDs, the most common kind, gather energy from radio broadcasts received from RFID readers and reflect that energy back to the readers in the form of a wireless stream of data

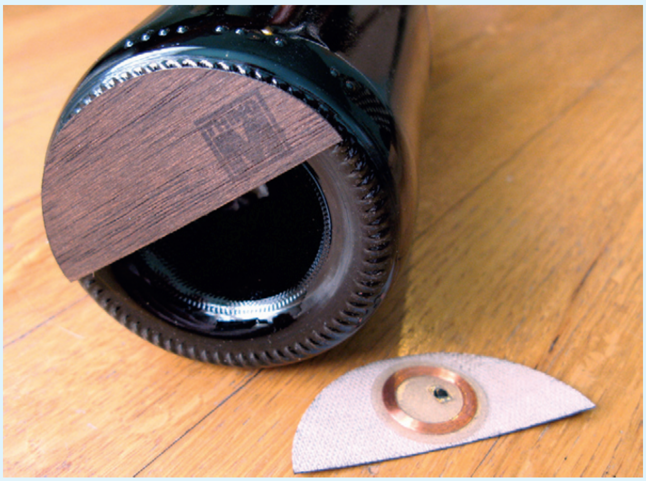

Figure 6-4

An RFID attached to a wine bottle. (Photo © 2007 by Tod E. Kurt, with permission) communicating their unique identifier. They do not need their own source of power to function, but consequently work only within relatively short distances. Active RFIDs use their own power sources to transmit data farther, but are more expensive and often require batteries.

- Smart cards. SIM cards are small processors packaged inside plastic cards (**Figure 6-5**). They transmit a unique identifier when in direct contact with a reader. Because they contain an active processor (typically powered through contact with a reader), they are capable of more complex interaction. Thus, they can encrypt information, require authentication before transmitting their identifier, poll sensors, etc. Smart "buttons" that resemble coin cell batteries are a similar technology. These buttons also communicate through contact with a reader that also acts as a power source.
- Magnetic stripes are familiar from credit cards and hotel entry cards. They are an established technology, and are easily created or changed, but are neither as compact, convenient, or secure as some of the others on this list.
- IPv6. For devices that are actively communicating through a network, IPv6 is an extension to the familiar Internet Protocol standard designed to uniquely identify trillions of devices. It was formally defined in the mid-1990s, and while uncommon in current Internet devices, it will likely become an identification standard for smart devices communicating over a network.

It is important to remember that unique identification and machine-readability are different functions enabled by separate technical choices. The methods previously listed frequently combine the two, but

Figure 6-5

A standard telephone SIM card that uniquely identifies a subscriber to a phone network. (Author photo) readability and identification do not depend on each other. A single identification code can be either machine-readable or -unreadable and remain unique. An IPv6 address written on a Post-It and stuck to the side of a machine is still unique, but not easily machine-readable. Similarly, it is technically possible for multiple RFIDs to transmit the same identification code.

6.3 POINT-AT THINGS

Systems of information shadows are created by promoting standard methods for associating a physical object and information about it. Experience designer Tom Coates coined the term *point-at things*[7] while compiling ways to organize BBC's program directory.[8] In that project, he realized that

> "once you [uniquely identify] a programme episode then something really significant happens — you can give it a name, make it addressable, you can — for the first time point at it. Better still, you can move from pointing at something to gluing handles onto it. And once you have such a handle, then you can pick up the programme and throw it around and stick labels on it and join it together with other programmes."
>
> *Tom Coates (2004)*

His realization, which translates directly to organizing information shadows, is that when a unique identifier is attached to an object, it becomes possible to collect the metadata about that object into a single information shadow. That unique identifier is the leverage point with which to access and manipulate the whole information shadow *in relation to similar shadows.*

For example, when the online retailer Amazon branched out from selling books to selling other kinds of products, they needed a way to identify every item they sold. Extending the International Standard Book Number (ISBN) they were already using, they created the Amazon Standard Identification Number (ASIN), which uniquely identified each product they sold. This allowed all of these items to become, using Coates' term, point-at things. It became possible to precisely identify exactly which product was being linked, discussed, etc. That precision allowed for a wide degree of flexibility and power, which other services could use to build upon Amazon's inventory systems. As of late 2009, programmableweb.com lists more than 300 services that use Amazon's ASIN

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[7]A similar term is *spime*, a Bruce Sterling (2005) neologism that merged space and time, because those are two key data points in an object's identity. As Sterling puts it, "every object worthy of human or machine consideration generates a small history. These histories are not dusty archives locked away on ink and paper. They are informational resources, manipulable in real time. [...] The key to the spime is identity. A spime must therefore be a thing with a name. No name, no spime."

[8]See British Broadcasting Corporation (2000) for the information architecture standard the BBC produced as part of the process described in this section.

system to create additional services.[9] Pickii.com, for example, uses ASINs, Amazon's list of categories, and user ratings for individual products to create a top 10 best reviewed list for virtually every Amazon product category.

[9]Using Amazon's eCommerce API.

Ulla-Maaria Engeström and Matt Biddulph, one of Coates' colleagues at the BBC, took this idea further. While useful, Amazon's ASIN was limited to products Amazon sold. What about the "many small producers especially in developing countries [who] do not have access to create unique identifiers" (Mutanen and Biddulph, 2006)? "Their products are not equally visible or recommendable online."

In response to this observation Engeström created Thinglink, "a service where anybody can register unique identifiers for objects that they want to identify as unique." The service generated a unique alphanumeric identifier (Figure 6-6), and served as the metadata clearinghouse to "aggregate online discussion around particular objects, track the history and transformation of objects, [and] socialize around particular objects." (Biddulph and Mutanen, 2006) In other words, Thinglinks were designed to create point-at things out of any object by using user-generated unique identifiers to connect single items to their information shadows.[10]

[10]As of the end of 2009, the service is still running at thinglink.com, but has shifted its focus from products created by small producers to high design objects.

Figure 6-6

Unique item on Thinglink, showing Thinglink ID in the lower right-hand corner of the photo.

Figure 6-7

Nokia 3220 with the NFC shell, the first mass-market mobile phone with a built-in RFID reader. (Courtesy Nokia)

When data network access seems almost everywhere, the movement of information about objects within groups of people then intersects with their physical movements. Friends' recommendations, for example, can affect buying choices and preferences, while purchasing an object creates a data event that feeds up through the store's inventory, to the distributors, and all the way back to the manufacturer. Along the way, humans and automated systems make decisions that affect what happens to the object, whether the object is bought, sold, gifted, destroyed, or perhaps refurbished, extending the object's social life.

As optical identifiers, such as 2D barcodes, became more popular,[11] devices such as the RFID reader on the Nokia 3220 (Figure 6-7) became inexpensive. This symmetry means that nearly everything can be uniquely identified on the cheap. Coates initially used point-at things to refer to digital objects, but it may soon be common to literally "point at things" to access their information shadows.

[11] There are more than 60 barcode and 2D barcode scanners in Apple's iPhone App Store.

6.4 THE INTERNET OF THINGS

> The Center's mission is to create an "Internet of Things" that will: merge the centuries old "network of atoms" (the production, distribution, sale, use and disposal of products) with the "network of bits" (the Internet).
>
> *Kevin Ashton, executive director of the MIT Auto-ID Center, 1999*

Figure 6-8
FedEx SenseAware. (Courtesy FedEx)

The concept of information shadows is intertwined with the "The Internet of Things," a term coined by the staff of the MIT Auto-Id Center in 1999. The familiar Internet of bits is still made of *things*, but these things are primarily computational devices (routers, modems, etc.) whose purpose is to store, manipulate, and transmit data. These things generate the form of the Internet, not its content. People experience the Internet, however, through its content. This content, for now, exists for most people only through general purpose digital devices such as laptops and mobile phones.[12]

In 1999, MIT Auto-Id Center's vision was that non-electronic things should also have digital identities. The center's main focus was automatic identification,[13] rather than the digital social life such identification creates for things. Information shadows, however, enable richer experiences than just identifying non-digital objects, as economically and socially powerful as that is. The Internet of Things has by now taken on a broader meaning. It describes the collection of all objects with information shadows and whether or not their relationship to the Internet is asymmetrical (as in the case of identification and tracking) or symmetrical.

The possibilities created by feedback between an object and its information shadow are immense. A shipped object can conceal its actual destination, only revealing the next step in its path to a shipper and dynamically adjusting its route if diverted. It can validate its authenticity and refuse to function if the person holding it is unauthorized using the list stored in its information shadow. A FedEx SenseAware smart tag (Figure 6-8), for example, reports not just the location of its package, but also the environmental conditions of its transfer. As it travels, it adds its location, temperature, pressure, humidity, and whether or not (and when) its box has been opened to its information shadow. In a more speculative scenario,[14] a SenseAware-equipped box could theoretically reroute itself if storage conditions were likely to have caused its contents to spoil.

Despite its roots in shipping, an Internet of Things could use information shadows in a wide variety of ways. A motorcycle could have a strain gauge built into its chain, and store both the status of the chain and the specifications for a replacement, in its information shadow. When the chain was stretched to the point where it needed replacement (an important part of motorcycle maintenance that can lead to very dangerous conditions if not performed), the motorcycle could log that state in its information shadow. This, in turn, could trigger

[12]Even specialized net-aware devices (game consoles, ATMs, home security systems, etc.) are clearly presented as digital products whose connection to an electronic network is no surprise.
[13]Leading to a number of visionary proposals for how such identification would work (Brock, 2001-1, 2001-2).
[14]FedEx does not offer this service as this scenario is speculative only.

an alert on the motorcycle owner's phone and on the motorcycle's dashboard. The repair shop could interrogate the motorcycle for the kind of chain last used and the chain performance characteristics indicated based on sensor data taken since the last replacement.

6.5 DESIGN WITH INFORMATION SHADOWS

Designing with information shadows means using devices, such as RFIDs, that may have specific, limited functionality and capabilities. However, as with the FedEx example, designing with information shadows often requires global service design. Information shadow user experience design must simultaneously consider (1) what happens when every object is automatically tracked and (2) how to associate those objects with all available digital information about them.

A systematic approach to user experience design can reduce the vertigo of multiplying two such nearly infinite sets. Despite the speed and novelty of changing technologies, people's underlying needs and desires change slowly. What has changed is that a new powerful tool is now available to address those needs.

The use of information shadows is still in its infancy, but several interesting design properties of information shadows have emerged. As a design material, information shadows:

- Simplify the design of certain kinds of devices
- Allow designers to treat dedicated devices like physical embodiments of Web services and create mashups
- Allow mass customization of experiences without mass customization of objects
- Allow devices to be self-disclosing for disposal and recycling
- Blur the line between devices and services

These are described in more detail below.

6.5.1 INFORMATION SHADOWS SIMPLIFY DEVICES

When an object no longer has to display all of the human-readable metadata needed by users, its design can be simpler. The labels on bags of chocolate chips only have room for one or two recipe suggestions. Now, the chocolate chips can have their own cookbook, and the label is used only to point to it. Similarly, devices can be simplified down to the single thing they do best. You might want to use a pedometer to track miles walked each day for a week. The pedometer interface can be quite minimal if devices, such as a mobile phone, can access that pedometer's information shadow. The pedometer just needs a power button, status indicator, and walking progress display. Other devices, with larger screens and more computing power, can focus on helping users make sense of information about their exercise plans.

6.5.2 PHYSICAL/NETWORK MASHUPS

> Ubicomp mashups attempt to move computation off the desktop and integrate it with the artifacts of everyday life. They extend beyond the Web and combine the functionality of both software and hardware components.
>
> *Hartmann et al. (2008)*

Many Web-based services have published APIs (application programming interfaces) that allow other services to use their information and computational capabilities in novel ways. Google Maps, the classic of the genre, allows developers to layer information over map images that Google provides. Physical/network mashups create novel experiences that merge the power of simple, lightweight devices with the power of existing Web services (see Chapter 17 for a discussion of mashup techniques).

The Tweet-a-Watt project (Figure 6-9) by Fried and Torrone (2009) is one such mashup. It posts electricity use to Twitter, using the same API that normally

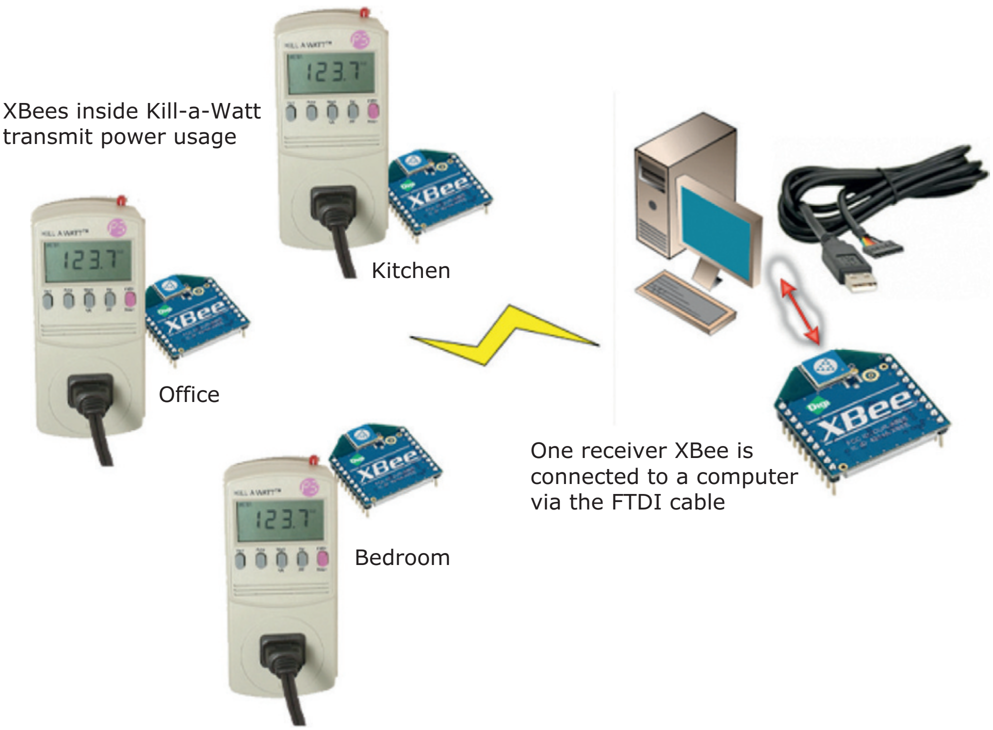

Figure 6-9

Tweet-a-Watt. (From Fried, L. and Torrone, P., "Tweet-a-watt," http://www.ladyada.net/make/tweetawatt/, 2009. With permission.)

carries people's Twitter posts about their own activities. But Twitter can easily broadcast information shadow changes, making hour-by-hour updates about energy use accessible to humans and readable by software.

Ubicomp device user experience designers can hook up information about objects to data sources on the Internet using the same APIs and protocols used by Web site mashups.[15] These physical/network mashups build on existing Web design methods and provide a familiar set of Web concepts to describe how physical objects and online information can interact through a device's shadow.

6.5.3 MASS CUSTOMIZATION

The digital information shadow associated with an object is much easier to change than its physical form. Mass customization of experiences gets much easier when the majority of the customization happens digitally. For example, the Webkinz toy line (see Chapter 7) connects toys that physically differ only slightly (like Cabbage Patch dolls of an earlier generation), but have rich online personalities.

Conversely, merging information shadows with rapid manufacturing techniques such as 3D printing allows instantiation of data in a physical, purchased object. Materialise, a Belgian 3D printing firm, sells a line of intricate designer lamps for the high-end furniture market (under the .MGX brand). Each lamp is individually printed. When first introduced, every lamp came with a disk containing a CAD file describing how to recreate that lamp. This disk is the lamp's DNA and part of its information shadow. Since Materialise keeps copies of the files, the lamps are, in effect, immortal: if a lamp is broken, they can print another one. Each lamp can be unique or replicated as often as a buyer wants.

What happens to "mass production" when an object's physical form is based on a unique digital file? In a sense, we can now go back to a pre-Industrial Revolution era of unique objects. But now the uniqueness stems not from the imperfections and unpredictability of handcrafted processes, but from a manufactured object's relationship with its informational shadow.

6.5.4 SMART DISPOSAL AND RECYCLING

Information shadows can contain many different kinds of information including instructions for how to dispose of the object they shadow.[16] They can self-disclose

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[15]Bleecker (2005) took it further and defined the term *blogject* to describe devices that act like people on the Internet. They can blog, they can post to Twitter, and they can reply to human conversation. For Bleecker, "blogjects become first class, A-list producers of conversations in the same way that human bloggers do — by starting, maintaining, and being critical attractors in conversations around topics that have relevance and meaning to others who have a stake in that discussion."

[16]I first heard this idea in a lecture by Bruce Sterling. In Sterling (1999) he wrote "Smart garbage doesn't fester in darkness, ignorance and denial. It becomes a resource."

not just what information they collect and use (as per Greenfield, 2006), but how to fix, disassemble, and recycle them.

For example, information about the materials from which the object is made can be mashed up with a database of municipal recycling rules to generate instructions for how to locally recycle the object. San Francisco, where I live, has an advanced recycling program that automatically distinguishes between many materials. However, I still do not know if I can put a steel car part, Styrofoam, or shoes with a “recycle” logo on the sole in my recycling bin. The rules of what is acceptable and how to prepare it change regularly. An information shadow mashup linked to each object could clarify that question instantly, directing me to take my esoteric recyclable to a specific location or to treat it in a specific way.

Similarly, complex items, such as consumer electronics or robotic toys, are difficult to recycle because they require disassembly and contain unknown materials. For the municipality, these information shadows could contain disassembly instructions and complete materials lists. With more information, city systems would have an alternative to disposing old toys other than sending them to the dump.

6.5.5 INFORMATION SHADOWS ENABLE NEW KINDS OF SERVICES

See Chapter 8 for a more general examination of this topic.

By giving objects unique identifiers, shadows allow these objects to become the subjects of services that track them and interact with them. Everyday objects can become subscription services.[17]

In the days before the breakup of AT&T, Americans did not own their own telephones. They leased them from the phone company. Although “Ma Bell” limited the range of phone choices, the phone company was required to repair broken equipment. The company could update the whole system systematically and thoroughly whenever it wanted. Though not ideal, the system had its benefits. It was also nearly impossible to replicate without the resources of an enormous company like AT&T. Information shadows could facilitate similar, but not so resource-intensive, actions for many other kinds of products and consumers.

For example, WEXLA, an Austrian shoe company, developed a shoe to sell by subscription.[18] The shoe easily disassembles, yet is sturdy and comfortable. Buying the shoe means buying into a subscription for that shoe. As one part wears out, or as fashions change, the shoe can be disassembled and mailed to a central warehouse, which mails back a replacement part. The shoe’s information shadow says exactly which replacement it requires.

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[17]Again Sterling got here first. In Sterling (2001) he described a furniture subscription system that creates one-off customized furniture on demand.

[18]In collaboration with REGIONAL, a service design consultancy. Thanks to Joshua Kauffman of REGIONAL for this example.

More directly, unique item-level identification allows for services that determine authenticity and trace provenance. In some parts of Africa, 30% of pharmaceuticals are counterfeit. mPedigree is using unique identifiers, printed under a scratch-off material, to identify authentic drugs (Schenker, 2008). Sending the number by text message to a trusted central location checks the authenticity, and then the expiration date, of the pharmaceutical. If the identification number is valid and the medicine's shelf-life has not expired, the system sends back another text message with a simple affirmation. Similarly, a purchaser can use the information shadow of a grocery item to trace its progress back to the farm where it was made and verify whether their farming practices are sustainable and humane. Similarly, an expensive designer handbag can be quickly authenticated.

The service possibilities of information shadows are enormous.

6.5.6 ENTERTAINMENT

Once an object is identifiable and trackable, it can become a token in a game. One of the earliest such games was "Where's George?" (wheresgeorge.com), which traces the passage of one dollar bills across the world using the bills' serial numbers. Many people find it fascinating to see where the bill they are holding has been and where bills they entered into the system have gone.

This is just the tip of the iceberg. Mediamatic, a technology design organization, challenged a group of designers at the PICNIC 08 conference in Amsterdam to create social games using the RFID tags every conference participant was given (Mediamatic, 2008). After a week of hacking, the thirty people in the workshop had created ten functioning games (Table 6-1).

These games represent a completely new genre of play: one that mixes physical objects (like scissor lifts, couches, and breathalyzers) with online information (profiles and Google ranks) and computation. The possibilities implicit in this one-week exercise are fascinating and exciting. They imply that information shadows can touch all aspects of everyday life.

6.5.7 EXAMPLE: WineM

In 2007, my company, ThingM, used these ideas to design a smart wine rack, WineM (Figure 6-10). It was created to demonstrate one endpoint of a service based on wine information shadows. Every bottle of wine in it has an RFID tag (Figure 6-4) with an RFID reader in every cell of the rack. The rack, in turn, connects to an online information shadow service. This service aggregates wine information from the Internet and all of the racks that are connected to it.[19]

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[19]As this was a proof of concept, we implemented only bare-bones functionality and worked with a wine data aggregator (Inertia Beverage) to verify that we could get appropriate information in a production environment.

Table 6-1

*Games Developed Using ikTag RFID Tags After a Week of Hacking by Groups at the PICNIC 08 Conference**

- ikRun. Run from the conference to the PICNIC Club and record your fastest time and finishing photo. Scan your ikTag at the start next to the E-Art dome, scan again to finish and win!
- Friend Drink Station. Free drinks for new friends! Mediamatic offers a free drink and a new friendship in the network. Just swipe your ikTag and push the button.
- Department. Use the ikTag to see what the Department of Information Security and Privacy (DISP) knows about you. The DISP is buying privacy and selling security.
- ikCam. Swipe your ikTag to add your portrait to your profile, or gather up to 20 friends with ikTags and make snapshots!
- Breathalyzer. Use the ikTag, blow into the straw, and test your alcohol intake. The outcome will be published on your profile. Compare your drinking skills with others at PICNIC.
- ikWin! Use your ikTag to challenge someone in a battle for Google ranking. Two scissor lifts will go up, the more hits, the higher you go.
- Mobile Massage Couch. Sit down on the two-seater with a new friend, use your ikTag to get a free massage. You can win bonus time as a gift from the crowd.
- DuckRace. 2 players start their race cars with their ikTag. The race track is based on your profile and network. The audience will influence your race car with their ikTag.
- Breedrs. Drop your ikTag in the Breedrs Pond and see it evolve into a creature with DNA based on your profile. Is this love or war?
- Vbird. Contact the Vbird with your ikTag, help it fly, meet new friends, and find the interactive film in your profile.

*The text is from a flyer printed by Mediamatic, the organizer of the hacking week.

When someone associates an RFID with a specific wine bottle, the service connects it to all of the other wines of the same type. Many wine management services can already analyze a wine collection and recommend wines resembling those in the collection. Our service went one step further: every bottle could serve as a subscription to a data feed from the winery and to a social network of enthusiasts with similar interests. A winery could have a sale for existing owners, or recent drinkers, of its wines. Then, every rack that contained a bottle of that wine would get a message and light up the wine in a specific color, or send a text message that said “Your 2004 Domaine Roger Perrin Chateauneuf-du-Pape has mail!”

WineM is an experiment to understand how the potential of information shadows can be expressed in a good user experience. It is designed to keep the user experience focused on the experience of choosing and drinking wine. It minimizes the presence of a full-purpose computer while still providing the full power of Internet information exchange.

For example, the interface is a faceted classification browser (Figure 6-11). Every click adds another constraint to the search set and lights up the appropriate bottles in the rack. Thus, it is possible to organize the wine not just by year or grape, but also by current market price or number of bottles in stock (or all of the above).

Hallmarks took the difficult process of identifying the manufacturer of a given piece of flatware by its style, and instead made it a matter of matching a small stamp to pictures in a catalog. Similarly, this kind of information exploration would have been very difficult with a traditional wine rack. However, once the bottles had their information shadows stitched to them using RFIDs and a simple database connected to the massive amounts of wine information online, it was relatively easy.

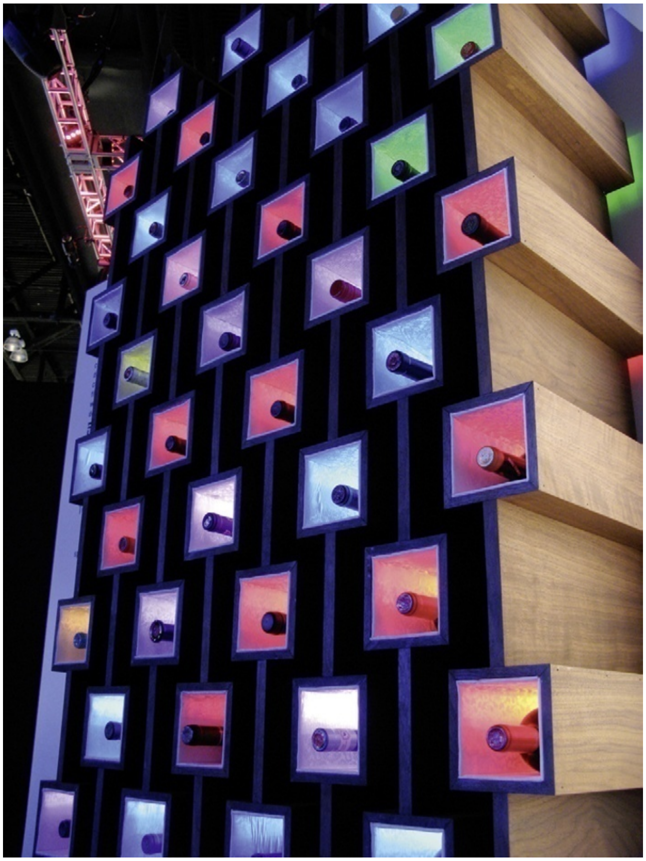

Figure 6-10

ThingM's WineM smart wine rack. (Photo © Tod E. Kurt, used by permission)

Figure 6-11

WineM control panel (prototyped on a Nokia 770 tablet.)