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PERSONALIZED UBIQUITOUS COMMERCE: AN APPLICATION PERSPECTIVE

1. INTRODUCTION

1.1 The Rise of Ubiquitous Commerce

To many people, the term “e-commerce” conjures up the image of the dot com madness of the late 1990’s. As we know well by now, Amazon.com has not made brick-and-mortar bookstores obsolete; neither did electronic exchanges replace physical supply chains. However, e-commerce as a utility function has become an integral part of as well as a permanent fixture to businesses of all sizes, large and small. With the proliferation of devices such as cell phones and personal digital assistants (PDAs), as well as digital cameras, embedded microprocessors, miniature sensors, radio frequency identification (RFID) tags, and wireless networks like 802.11 and Bluetooth, we are currently witnessing a trend in which technology is moving away from desks into our pockets, purses and even onto our walls and furniture. Traditional products ranging from cars, refrigerators, to toys and alarm clocks also begin to acquire computing, sensing, and communications capabilities. In short, technology is increasingly blending into our everyday environments, following us every step of the way, creating a world that is always on, always active and always aware. We coin the term “ubiquitous commerce,” or u-commerce for short (Gershman, 2002), to refer to this new reality, which promises, and perhaps ultimately demands, that businesses be available at the times and places where people use these products and services rather than just through the Web or at physical stores. This emerging reality also presents a new set of challenges and opportunities, and redefines what we mean by personalization.

1.2 Personalization for Ubiquitous Commerce

The Web is a highly customisable medium. Many Web-based applications support some level of personalization. My Yahoo, for example, allows us to explicitly select and customize content types, sources, and presentation formats. Amazon.com recommends books and music that are potentially of interest to us based on our past purchasing history. While features like these are useful, they are far from adequate to many people for three important reasons. First, most of these customisations are based on the static profile specified by the user, e.g., My Yahoo preferences. As these preferences change, the user must remember to explicitly

make corresponding changes to the system. In the real-world, however, few users are disciplined enough to do so. As a result, these profiles often become obsolete and useless very quickly. Second, while past transactions reveal much about our interests, the current representation of such history is fragmented. Amazon.com, for example, might make excellent recommendations of books and music based on what I've bought from them during the past six months. However, their recommendations could be totally off mark by not taking into account of my purchases from other stores, especially their competitors, both online and offline. Perhaps most importantly, most existing e-commerce applications have little or no awareness of the current tasks in which the user is involved. As a result, they cannot adapt their offerings dynamically to the present need of the user. For example, Amazon.com may recommend a new childcare book because I bought a similar book two months ago. However, what they may not realize is that I'm currently involved in a home improvement project and thus more interested in books on this topic.

In the world of ubiquitous commerce, user task context is more readily available, and thus may be used for further personalization of services. One very common type of context, for example, is the user's real-time location. With inexpensive Global Positioning Systems (GPS) built-into cars, cell phones, PDAs, and other products, it is now possible to provide a wide range of location-based services, ranging from navigation and roadside assistance, to personalized advertising and shopping. A roadside billboard owner, for example, may dynamically change the advertising message based on the number of cars currently passing by, the type of car, and even the type of driver. This is made possible by integrating real-time context information from various sources, including GPS embedded in those vehicles. As sensors like GPS, RFID, and digital cameras become ubiquitous, more user context will be available electronically. This in turn will open the door to a new generation of ubiquitous commerce applications that support a much richer and more personalized experience.

Thus, personalization in ubiquitous commerce involves more than just static user profiles and online transaction histories. It calls for automatic sensing of the user identity, the task, and the surrounding physical environment in which the current task is taking place. As illustrated by the applications described throughout this chapter, the novel use of sensors and personalized devices is essential to seamless tracking of dynamic user contexts in the physical world and, ultimately, to achieving a higher level of personalization.

1.3 The Organization of this Chapter

For the remainder of this chapter, we will describe four research prototypes of personalized ubiquitous commerce: MAGIC MEDICINE CABINET, ONLINE WARDROBE, REAL-WORLD SHOWROOM, and VIRTUAL HANDYMAN. Each of these applications addresses a different task domain, and thus provides its own unique set of features. One common thread among them is that they all attempt to create a new kind of commerce experience, especially on the personalization front, by integrating a number of emerging technologies, including RFID, biometrics, speech, wireless

networks, mobile devices, miniature cameras, and Web services. Collectively, these prototypes highlight some important trends in personalization; they also paint our vision for future e-commerce. While some of these technologies are not widely adopted yet, we believe most of them will be in 3-5 years. Just like concept cars, our focus here is primarily to show what is possible in terms of new user experience and business opportunities when some of these new technologies come together. We recognize that privacy issues are ultimately important to considering personalized systems, but we will not address this topic in great detail in this chapter.

2. MAGIC MEDICINE CABINET

2.1 Introduction

In recent years, we have heard much about smart appliances, such as Internet microwaves and refrigerators. Most of these appliances, however, are little more than their traditional counterparts with an Internet connection—a connection whose utility is dubious at best. There is almost no integration between the newly added functionality and what the appliance already does. For instance, with Web browsing available through a microwave front panel, one can perform many functions we use our desktop computers for: home banking, electronic shopping, and even online gaming. But despite the versatility, these functions have little to do with what the microwave's function: speed cooking and reheating of food. We believe that closer integration between the traditional use of an appliance and Internet capabilities related to that use will result in smarter appliances.

We view healthcare in two distinct terms: *informational* and *physical*. Activities such as finding out the side effects of a particular drug, or scheduling an office visit with one's physician, fall into the first category. Taking a pill or measuring one's blood pressure is a physical activity. With the advent of the Internet, we have witnessed an explosion of healthcare information. According to a recent survey, two-thirds of Internet users use the Web to search for health information (Williams, 1997). While the increasing accessibility of health information is essential to the future of healthcare, it represents only one part of the equation. To achieve the dual purposes of lower cost and higher quality of care, consumer-initiated physical care, especially at home, must be encouraged and explicitly supported. Our goal here is to create an application that enables better consumer-centred situated care by integrating the growing array of Internet resources with home health appliances.

2.2 The Prototype

MAGIC MEDICINE CABINET (MMC) (Wan, 1999) is a smart appliance that supports both informational and physical aspects of consumer healthcare. It embeds a number of technologies that, together, enable consumers to perform routine physical care, such as ensuring that you take the right medication, tracking vital signs, accessing up-to-date personalized health information, and interacting with

online care providers, including physicians, hospitals, and pharmacists. Our implementation incorporates the following capabilities:

- *Face recognition*: The build-in camera (see Figure 1) and face recognition software enables the medicine cabinet to automatically recognize the person in front of it, and respond with proper services.
- *RFID-based smart labels*: Drug products stored in the medicine cabinet have smart labels attached to them, which lets the cabinet know its contents and in particular which bottles are being removed and returned.
- *Vital sign monitors*: One can use these monitoring devices to track a wide range of health indicators, such as blood pressure, heart rate, body weight, and cholesterol level.
- *Voice synthesis*: This allows auditory output to supplement what's shown on the cabinet display.

MMC has an embedded Mini-ITX system with Morex 2677 computer and Internet connection. As shown in Figure 1, the prototype looks much like a conventional medicine cabinet. One big difference is that the left panel of the cabinet has a built-in LCD display. The user interacts with MMC through its touch-sensitive screen, voice output, and the cabinet display.



Figure 1. MMC knows what medication is in the medicine cabinet, and warns you if you accidentally pick up the wrong bottle.

2.3 A Usage Scenario

Johnny, a 12-year old 6th grader, suffers from a severe allergy problem. In the morning, Johnny gets up and heads to the bathroom to get ready for school. As he picks up his toothbrush from the bathroom countertop, he hears a pleasant voice from his medicine cabinet:

“Good morning, Johnny. I have an allergy alert for you.”

Johnny looks up at his medicine cabinet display, and sees the pollen count in his area is dangerously high. He also sees big red flashing letters on the cabinet display reminding him to take his allergy medication.

Johnny opens the cabinet door, reaches on to the shelf, and picks up a medicine bottle:

“Wrong...you’ve picked up Liptor instead of Claritin!”

Johnny puts the bottle back and picks up another one:

“Great...now you have the right medicine.”



Figure 2. MMC not only reminds but allows you to measure your blood pressure and other vital signs and, if necessary, share that information with your care providers securely over the Internet.

That evening, Johnny’s father, Dan, happens to come in front of the medicine cabinet. MMC senses Dan’s presence, and reminds him to measure his blood pressure. Dan opens the cabinet door and slips the cuff around his arm (see Figure 2). His medicine cabinet tells him that his blood pressure has gone a bit high since the previous reading, and suggests that he consult with his doctor. If he is so

inclined, Dan can schedule an office visit with his family doctor right there through his medicine cabinet!

2.4 *Discussions*

MMC embodies several novel personalization features. Unlike health portals such as WebMD, which sits far away from their users in the virtual world, MMC resides in the everyday space of its user, i.e., home. The medicine cabinet is traditionally a bathroom fixture for a reason: the bathroom is a highly frequented quarter in the house where many daily personal care activities take place. MMC takes advantage of the situated nature of the medicine cabinet, and extends it from a passive storage space into an interactive appliance. Because of that, the application is capable of sensing the user situation as it happens, e.g., time of the day, and offers them personalized information and reminders of actions at the point of need. The user thus does not have to break away from their normal activity flow to benefit from these services. Second, by using biometric sensing, e.g., face recognition, MMC automatically detects the presence of the user and initiates appropriate interactions. This proactivity increases spontaneity, and reduces the cognitive burden required of the user to remember to invoke the service. And finally, similar to (Want, et al, 1999), MMC shows how to bridge the gap between the physical world in which we live, and the virtual world on which we are becoming increasingly dependent. The prototype serves as a healthcare appliance that provides everything we need for individual healthcare: the right information, timely reminders of actions, vital sign monitoring, and the gateway to doctors, hospitals, pharmacies, and other care providers.

3. ONLINE WARDROBE

3.1 *Introduction*

In the world of shopping, retailers are confronted with two challenges: (1) how to use what consumers already own to help with what they are about to buy; and (2) how to transform buying from being an end in itself to reinforcing a long-term relationship between retailers and their customers. Today, people going to retail stores cannot bring the content of their living room, refrigerator, or wardrobe with them to the stores. As a result, they have to remember exactly what they already have so they avoid buying duplicate products or products that do not go well with what they already own.

By comparison, online stores such as Amazon.com can more easily track what their customers have bought. Based on this information, they are able to personalize their offerings. However, even these stores have no means of telling what their customers are buying from their competitors. The lack of access to their customer's complete, up-to-date buying history, which we call "buyer context" (Wan, 2000),

prevents consumers from having richer shopping experience and better relationships with retailers.

With technologies like radio frequency identification (RFID) tags and electronic product code (EPC) (Auto-ID Centre, 2000) it becomes increasingly feasible to keep track of buyer context. Lauded as the next generation bar code, EPC promises a fine-grained addressability of physical objects. While the bar code tracks products at the SKU or group level, the EPC's 96-bit code allows the unique identification of every individual product ever made. More importantly, the new product code may be embedded in tiny, inexpensive chips, which may in turn be manufactured into products themselves or affixed in their packages. Such tags require no line of sight, and are capable of communicating remotely using radio frequencies without human intervention. This unique ability makes it possible to automatically track the whereabouts of a product in real-time. The ubiquitous use of such tags will allow dynamic linking between physical products and the vast amount of online information about them. Ultimately, the convergence of RFID and EPC technologies and smart appliances will extend the Internet from the world of bits into the world of atoms. As a result, it will become possible to capture the rich context of people's day-to-day activities. The ready availability and easy access to such contexts opens up new ways by which businesses and their customers relate to each other.

3.2 *The Prototype*

ONLINE WARDROBE (Wan, 2000) is a prototype that shows how a traditional bedroom fixture like the wardrobe can be transformed into a new channel for interactive services. Its thrust is not that it offers yet another way of browsing the Web from your home. Rather, ONLINE WARDROBE provides a new kind of interface, i.e., the physical interface, to the online marketplace. Specifically, an embedded RFID sensor enables the wardrobe to detect what clothing products you own. It also detects what is being added or removed. With this capability, you can shop interactively from online stores by using what is in the wardrobe as the shopping context. For example, if you want to buy a dress shirt, you first pull out the pair of pants and jacket with which you would like to wear it. ONLINE WARDROBE uses the selected pants and jacket as the constraints to search online stores. It then returns a list of shirts that best match with the criteria. Depending on the search result, you may choose to tighten the constraints by pulling out additional pants you want the new shirt to go with, or broaden the search scope by dropping the jacket.

ONLINE WARDROBE also provides a new channel to the everyday space through which retailers and consumers can interact spontaneously and continuously. For example, when you bring home a brand new jacket you've just bought, ONLINE WARDROBE immediately recognizes it as a new arrival, and asks you whether you are interested in other products that would go well with the new jacket. Today, people already trust their grocers to automatically replenish their groceries by granting them remote access to their refrigerators. In the future, we will see consumers allowing their favourite department stores to access what they have in

their wardrobe so these stores can deliver exactly what their customers need at their doorsteps even before their customers realize they had a need.



Figure 3. As a physical interface to online stores, ONLINE WARDROBE has a built-in touch sensitive LCD, voice output, and an RFID sensor for detecting its contents.

To facilitate the interaction between the consumer and the online marketplace, ONLINE WARDROBE introduces four constructs:

- *My Wardrobe*: It corresponds to what you already have in the physical wardrobe. You may browse it and find out when and where a product was purchased, and how much you paid for it. You can also view products from the current marketplace that are similar to what you have. When you take out a product from the wardrobe, or put in a new one, *My Wardrobe* is updated instantly to reflect the current state of the physical wardrobe.
- *My Wish-List*: It contains the products you do not own but would like to. ONLINE WARDROBE periodically suggests products that may be of interest to you based on what you already have and what is on-sale in the marketplace. You may choose to buy the recommended products, ignore them, or, defer the decision by placing it on the *My Wish-List*.
- *My Store*: It contains a personalized list of merchandise from various online stores that ONLINE WARDROBE deems relevant to you based on such criteria as what you already have, your preferences in style and colour, season and price. ONLINE WARDROBE continuously updates *My Store* to reflect the current offerings from the marketplace.
- *The Market*: It consists of a listing of online stores that offer products typically found in your wardrobe. At times you may want to shop in the open market, as opposed to just those in *My Store*. In its idle mode, ONLINE WARDROBE also randomly displays products from *The Market*.

ONLINE WARDROBE is equipped with an embedded computer, Internet connection, and an RFID sensor. All apparel products in the wardrobe are affixed with tiny Texas Instruments' Tag-It™ smart tags that uniquely identify each of them. As shown in Figure 3, ONLINE WARDROBE looks just like an ordinary wardrobe. You interact with it through the touch-sensitive screen on the left, voice output, and the physical products in the wardrobe.

3.3 A Usage Scenario

After a quick shower in the morning, Dave pulls out a pair of casual pants and a shirt out of his wardrobe, and is ready to put them on. Then, he hears a voice from the wardrobe:

“Good morning! Dave. Don't forget you have a client meeting today. What you've picked is a bit too casual. You may want to consider some alternatives.”

As he glances at the wardrobe screen, Dave notices his morning schedule, including an important client meeting, and his selected attire (see Figure 4). Embarrassed by his own selection, he touches on the “Suggestion” button on the screen. In response, ONLINE WARDROBE brings up a recommendation that matches well with Dave's activity on that day. It also reminds Dave to remember to bring an umbrella, since it will be raining.

Later that evening, Dave checks in again with his ONLINE WARDROBE to find what it has in store for his upcoming vacation with his family. Since he had planned the vacation about two months ago, his wardrobe has been continuously monitoring market activities from various retailers. In response to Dave's request, his wardrobe comes back with a customized list of what to pack as well as what to buy in getting ready for the vacation.

3.4 Discussion

ONLINE WARDROBE provides two unique personalization features. First, it takes advantage of a situated nature of the wardrobe to bring personalized shopping from a store into your own bedroom. As such, it represents a new channel through which consumers and retailers can interact with each other. By using ONLINE WARDROBE, consumers may selectively make available the content of their wardrobe to certain trusted merchants. In return, they receive personalized offerings and timely reminders about products of interest. Because the wardrobe is in the everyday space, retailers can more easily deliver products and services to where their customers are, instead of having to lure them to their stores.

ONLINE WARDROBE also shows how to use buyer context to enhance the shopping experience. As one purchases apparel products tagged with RFID chips, it is quite easy to build a virtual wardrobe, called *My Wardrobe* here, which represents your buyer context for clothes shopping. When a new product is bought and added to the wardrobe, *My Wardrobe* is automatically updated. As a result, it stays synchronized with the physical content of the wardrobe. Preferred retailers may be granted access to this buyer context, and use it to recommend appropriate products. Since the buyer

context is available virtually, consumers can take it with them when they shop in stores. For example, when they visit in a brick-and-mortar store, they can bring up the content of *My Wardrobe* through an Internet connected kiosk. This buyer context would put the sales associate in a much better position to assist the customer. Alternatively, the kiosk application may automatically figure out what products the customer needs to look at based on what the customer already has and the store's current stock by programmatically applying a set of codified fashion rules.



Figure 4. ONLINE WARDROBE makes personalized recommendations on what to wear on a given day based on a person's schedule, weather, the current wardrobe content, and history.

4. REAL-WORLD SHOWROOM

4.1 Introduction

Despite recent growth in online retailing, shopping, as we know it, has not changed much. We still go to *stores*, online or offline. Shopping is a distinct activity. It is also an orchestrated process by the retailer to maximize sales and efficiency. The retailer maintains control over what to sell and how to sell it. For example, if a retailer wants to promote a product, he might place it more visibly on the shelf next to the checkout counter or on the Web site's front page.

Two subtle problems exist in such a seller-centred approach. Since it is difficult to accurately predict potential market demands, retailers often stock more

merchandise than they eventually end up selling. This practice, while widely accepted, leads to sub-optimal business performance because of inventory tie-up and inevitable markdowns. Moreover, customers must also spend extra time searching through a large array of products in order to find the few they really want. In many cases, this requirement leads to frustrated customers and lost sales.

As consumers, on the other hand, our needs for new products often arise serendipitously during our daily activities. For example, you are attending a party at a friend's house. You see a blue-stripe couch in their family room. Suddenly, you realize you need the exact couch for your own house! Today, when we encounter situations like this, we simply push what comes to us into our short-term memory, hoping we still remember it when we later visit a physical store or a Web site. For many people, such a time may never come. When it does come, we'd be lucky if we still remember what we set out to buy.

To address these two problems, we developed REAL-WORLD SHOWROOM, a research prototype that allows consumers to access real-time product information and to shop *as* they encounter these products during their normal course of activities. Its aim is to transform the world around us into a product showroom and our mobile devices into personalized checkout counters.

4.2 *The Prototype*

Imagine you're sitting in a café and a man passes by in a particularly sharp sweater. Rather than just admire his taste and wonder where he bought it, you pull out your PDA or cell phone, and press a button. Instantly, you have access to all the information about the sweater, including its brand, similar products, availability, and price (see Figure 5.) By pressing another button, the very sweater is yours, and will be on your doorstep next day.

Sounds like a science fiction? Not if you had REAL-WORLD SHOWROOM. The central tenet underlying this prototype is that, *commerce and consumer interactions take place serendipitously, when and where people see and use products, not just in a store or at a Web site.* To enable this spontaneous shopping experience, we link together two technologies: wireless devices and RFID tags. More specifically, we use a PDA equipped with an RFID reader and wireless Internet connection. The products in the surroundings are tagged with RFID chips. When you see a product that appeals to you, e.g., the lawn mower your next-door neighbour is using, you approach the product, point the device directly at it from a short distance away, and press a button. Immediately, all the relevant information is retrieved from a number of online sources and displayed on your PDA. With a few more button presses, you can buy the product, all without ever giving up whatever you happen to be doing at the time. With REAL-WORLD SHOWROOM, you can also easily verify the authenticity of the product in front of you, since the information stored in RFID tags is unique to each product, and almost impossible to tamper with. Just as the tags can distinguish between a coffee machine and a necktie, so can they easily tell a fake Versace sweater from the real thing. Furthermore, REAL-WORLD SHOWROOM allows you to find out the entire product history. Such a capability is especially useful for products

that are sensitive to their physical environments, such as pharmaceuticals, wines, and perishable goods.



Figure 5: REAL-WORLD SHOWROOM in Action

Our initial prototype is implemented on a Visor Prism, using an RFID Springboard module from ID Systems, Inc. (See Figure 5.) This PDA has one expansion slot, which is used for RFID. As a result, this version doesn't provide real-time wireless Internet connectivity. Instead, all the product information is stored in a database on the Visor itself. The initial database includes several dozens of products, such as clothing and furniture. All products have Texas Instruments' Tag-It RFID tags embedded. The database contains product information such as manufacturer, description, style, price, and availability. A production version of this application would require a server-based component, which performs real-time aggregation of product information from various sources on the Internet.

4.3 Discussions

REAL-WORLD SHOWROOM demonstrates two intriguing personalization capabilities; it shows how ubiquitous RFID tags and wireless mobile devices together can help transform the world around us into a personalized product showroom, and our PDAs or cell phones into personalized checkout counters. As consumers, this new environment enables us to see products in their real usage context and decide whether we want to buy them. Once we choose to buy a product, we can act on this intention instantly by simply pressing a few buttons on our PDA. In essence, we integrate everyday activity as part of shopping context. Put differently, with this application, shopping now becomes an integral part of what we do, rather than a distinctive activity. There is no more need to accumulate or

remember a long list of things to buy, nor make separate trips to the mall or Web sites.

With REAL-WORLD SHOWROOM, consumers are no longer just consumers; they also become the agents or personalized billboards for the products they use. Presumably, our family and friends exert even more influence on us than those celebrities in terms of what to buy. This has some interesting business implications. For example, if you buy a sweater because you like it when you see your friend Dean wearing it, Dean might get a commission. To retailers, their existing product owners now become channels for marketing and sales. And those owners are motivated to wear or use the merchandise so as to increase their commissions.

5. VIRTUAL HANDYMAN

5.1 Introduction

For most people who happen to be homeowners, home is perhaps the single most important physical asset and the biggest investment in their lifetime. It is also the place where they spend many of their waking hours engaging in a broad range of activities: entertainment, work, learning, and maintaining or decorating the space itself. Thus, it comes as no surprise that the home is a huge market for technology products and services, including telephones, television, fax machines DVD players, smart appliances, game consoles, home computers, digital cameras, cable modems, and so on. Despite the high penetration of such technologies and the increasing availability of wireless home networks (e.g., 802.11b) and broadband Internet access, direct virtual services to consumer homes still barely exist.

Just imagine a homeowner trying to install a lighting fixture. It doesn't go smoothly, so he needs expert assistance. What would he do? First, he'd look for help, possibly in a thick phone book or perhaps through a keyword search on the Internet, or ask a neighbor. He'd assess the possibilities (e.g., home improvement and hardware stores, private contractors, handymen) and make a choice. Then he'd make a call, try to describe the problem, and decide what to do. Maybe he'd take notes and go back up the ladder to give it another try. Maybe a repairman would eventually come to the house, lend a hand, and present a bill.

The above scenario represents a typical call for "micro services" – services that come at a highly granular level in terms of duration and cost. These services share three common characteristics. First, they involve a layperson and an expert. The task typically requires asymmetric collaboration between the two parties. While the first step in any service involves finding an appropriate service provider for the problem on hand, the difference is that the discovery cost for micro services is very high relative to the total cost for rendering the service. In the above scenario, for example, it may only take the electrician ten minutes to show the homeowner how to install a lighting fixture, but it would take much longer to find an electrician who is available and willing to provide such a service. And finally, micro services require a high

degree of spontaneity. In the above example, if getting the service requires the homeowner to go out of their way, e.g., waiting for 3 hours or learning a new application, chances are that the person would not end up using the service.

To address these unique challenges of micro services, we propose the concept of “micro services on tap,” which allows spontaneous service delivery by integrating several technologies, including miniature wireless cameras, Web services, wireless networks, and speech interface.

5.2 *Delivering Micro Services on Tap*

Here, we define services as composed of five distinct components: *discovery*, *invocation*, *interface*, *administration*, and *delivery*. The first step in any service involves discovery, or finding an appropriate provider based on the type of task on hand, and the price, availability, reputation, and technical capabilities of the service provider. Then, the service requestor and the provider must connect together, either face-to-face, or through telephone or another communications channel. In the case where the interaction is mediated by computer applications, these applications must also be linked up properly. Once the two parties are brought together, the user must describe the task and the help needed. Only then, can the provider render the required service. To conclude the process, the provider must get paid, and feedback may be gathered about the quality of service so future users may benefit.

It is worth noting that, four out of the five components above are fixed overhead, which means that, they are required for any service, large or small. The time and cost associated with accomplishing these steps are often independent of the size of services delivered. For example, fixing a malfunctioning electrical outlet may take an electrician five minutes. However, to find an appropriate electrician, and to bring him to one’s home would take much longer and cost quite a bit more. To make micro services economically viable, we must reduce the relatively high overhead cost associated with providing such services, in particular, the cost related to discovering an appropriate service provider for the task at hand, and interfacing the novice who performs the task and the expert who is supposed to help. Two key technologies, Web services and miniature wireless cameras (e.g., camera phones), provide great promise in accomplishing these goals.

Web Services are emerging open standards that enable applications of different sources, e.g., languages, platforms, and organizations, to find, link and interact with one another over the Internet, sharing data and performing tasks, all without human intervention. One important component of Web services is Universal Description, Discovery, and Integration (UDDI) (UDDI, 2002), which provides a standard framework for application publishing, discovery, and dynamic integration. With UDDI, it is possible for applications to automatically find and talk to each other, and thus greatly reduces the cost of discovery. Going back to the earlier scenario, the electrician may register his application in a centralized UUDI registry. When a home owner needs such a service, his application can search the registry, and automatically talk to and invoke the application when a right match is found.

One way to take advantage of the increasing availability of inexpensive miniature cameras is to use them as the remote eyes for the service providers at a different location. For example, to fix your leaking kitchen sink, you get connected over the Internet with a plumber at the other end of town. Through a miniature camera you have in your shirt pocket or a flashcam (see Figure 6.), the remote plumber is able to see with his own eyes exactly what's going on, and helps you fix the problem in just a few minutes. In situations like this, the interactions between a layperson and an expert could otherwise be difficult, because they tend to use different terminologies even when they are talking about the same thing. As the saying goes, "a picture is worth a thousand words." By using direct sensing through remote cameras, the level of time, effort, cost and, possibly, frustration is greatly reduced. As a result, it enhances the experience for both parties.



Figure 6. On the left, a 900 MHz wireless camera (courtesy of Super Circuits, Inc.) in a shirt pocket allows hand-free operations. On the right, the flashcam has built-in flashlight, wireless camera, and laser pointer.

5.3 *The Prototype*

VIRTUAL HANDYMAN is a research prototype that was developed to support micro services on tap for home improvement tasks. The prototype consists of three modules: *user*, *provider*, and *marketplace*. The three applications run on separate machines connected to a local area network. The user application includes a wireless microphone and a wireless miniature camera that measures .88 x .57 x .92 (inches) and with a range of up to 750 feet line of sight. We also custom built a flashcam (see Figure 6) that combines illumination, wireless video, and pointing device into a convenient form factor that can be used when working in poorly lit areas. The wireless camera and flashcam enable the provider at a remote location to see what the user is up to, and to give advice accordingly. The wireless microphone (i.e., Sony WCS-999) allows the user to freely roam around the home and still be able to

interact with the application on a home computer via speech recognition and synthesis.

Imagine that Randy is trying to replace an existing electrical outlet in a bathroom with a GFCI outlet. After purchasing all necessary supplies from a local hardware store, Randy is ready to embark on the task on his own. He turns off the switch on the main switchboard, opens up the socket, takes out the old outlet, and suddenly finds himself lost. He desperately needs some help. Below is a sample dialogue between Randy (R) and VIRTUAL HANDYMAN (V), as he seeks for help via a wireless microphone:

- R: *I need some help in installing my electrical outlet.*
V: *Do you want an electrician?*
R: *Yes.*
V: *I've found two service providers: Excel Home Centre and Jack's Electrical Shop.*
R: *Tell me more about Excel Home Centre.*
V: *Excel Home Centre offers virtual installation services for the products sold in its stores free of charge.*
R: *Connect me to Excel Home Centre.*
V: *Please wait while I'm binding to Excel Home Center...*

When Randy's request arrives at Excel Home Centre, the service provider is alerted through a pager-like device. He then walks over to a store kiosk or an in-vehicle PC. By simply entering the service ID, he immediately gets connected to the user. Figure 7 shows the view from the Excel Home Centre. The screen displays the recent history with the customer and a live view of Randy's task environment.

At the heart of VIRTUAL HANDYMAN is the marketplace application, which includes a private UDDI registry and a custom taxonomy for home improvement. For our prototype, the registry contains a dozen businesses and services. The Web services interface is implemented using Microsoft UDDI Server SDK. Aside from UDDI functions, the module integrates speech engines (e.g., IBM Via Voice and AT&T Natural Voices) so the user can use voice to interact with the system, as illustrated in the dialogue above. The module also includes a simple task model about home improvement so that it can map the user task at hand to a specific type of service. For example, when the user mentions the word "electrical outlet" or "lighting fixture," it knows that he is performing an electrical job, and thus replies, "Do you want an electrician?"

To complement the mobile solution, we also built an online workbench (see Figure 8) with an embedded camera, microphone array (Andrea DA-400), LCD display, and Internet connection. When a user carries out a task on the workbench (e.g., repairing a small appliance or creating a blueprint) and needs help, he can call up a service, just as described above. This time, however, he doesn't need to wear a microphone or camera, since both are built into the workbench. As a fixed-location interface to the service provider, the workbench can afford much richer experience. For example, if needed, the provider can direct the user to an instructional video or a Web page about a task, which is shown on the LCD display.

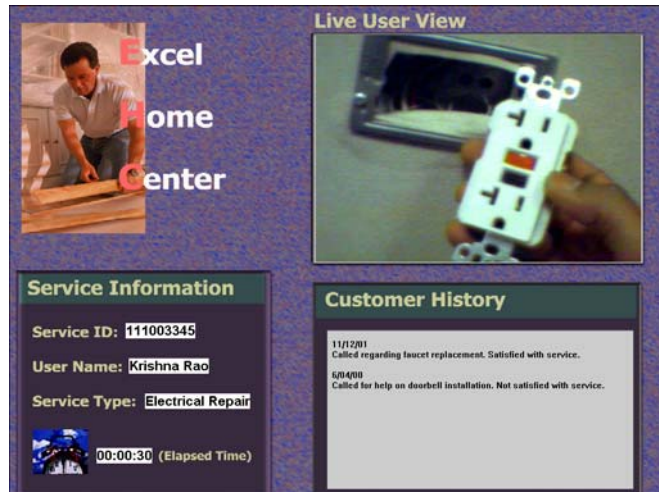


Figure 7. A service provider's screen shows a live view of the customer's task environment.



Figure 8. The online workbench (with built-in camera, microphone array, LCD display, and Internet connection) offers a fixed location interface between the user and the service provider.

5.4 Discussions

VIRTUAL HANDYMAN demonstrates how situated sensing (e.g., speech recognition, speaker identification, and wireless cameras) can help enable a new level of personalization and a new class of services, i.e., micro services on tap, through just-in-time personal interactions. First, it uses speech recognition to automatically activate the custom task model and the service provider list. For

example, when the user mentions the word “electrical socket,” it responds with a list of electricians instead of plumbers. Second, it relies on speech to identify who the current user is. Once the user is identified, it retrieves the preferences of that user (e.g., price, vendor reputation) from the database, and uses them to further narrow down the appropriate service provider. Third, it employs wireless cameras to enable the remote service provider to directly see the context in which the user is carrying out a task. As a result, the user doesn’t need to spend much time describing the situation. Services are discovered dynamically through Web Services and delivered automatically over the Internet. In so doing, the system offers the consumer more convenience, lower cost, empowerment, and better overall experience. At the same time, it provides businesses such as retailers a new option to connect with their customers, and enhance their bottom lines through additional revenue streams.

While VIRTUAL HANDYMAN focuses on home improvement tasks, the approach can be generalized to other service areas, such as cooking, fashion, personal security, travel, shopping, and so on, where personal interactions between a novice and an expert is needed. Take personal fashion, for example. With a smart wardrobe like (Wan, 2000) in your bedroom, any time you need advice on what to wear, your wardrobe can, *in real-time*, find and connect you to a live fashion advisor, who may help you select the best outfit for your specific occasion. Since the fashion advisor can see what you’re wearing through the built-in camera, and what you have in the wardrobe through the embedded RFID sensor, you don’t need to waste any time explaining or describing them. The service is fast, personal, and can be called upon any time.

Take travel as another example. Imagine you’re standing in front of an ancient monument in a foreign country. You’d like to know its rich history but you don’t speak the language. Now, you pull out your camera phone, which also is equipped with locationing capability. By pressing a few buttons, you get connected to a live tour guide, who knows not only your language, but also where you are, what you’re facing, and everything about the monument. You two spend next 15 minutes together, virtually. The cost is minimal, and the experience is seamless.

In sum, micro services on tap, as illustrated by VIRTUAL HANDYMAN, are all about being able to easily and spontaneously discover and interact with people who could be helpful for a specific situation. They necessitate automatic detection of the user’s current task context, and require situated sensing. With the proliferation of broadband wireless networks, Web services, and sensors like inexpensive miniature cameras, GPS receivers, RFID tags, and speech recognition, we expect such services to become even more widely available in the near future.

6. CONCLUSIONS

In this chapter, we introduced four research prototypes of ubiquitous commerce: MAGIC MEDICINE CABINET, ONLINE WARDROBE, REAL-WORLD SHOWROOM, and VIRTUAL HANDYMAN. Together, these applications highlight what we see as four important personalization trends in e-commerce: *physicalization*, *in-context*, *real-time*, and *micro services*. First, e-commerce activities no longer just take place

inside a computer or through a mobile device like a cell phone or PDA. Increasingly, they happen in the physical world around us, embodied in familiar objects and products. The automobile is an early example of this trend, where computing and communications technologies help transform cars from a means of transportation to a channel for a wide range of services, including navigation, shopping, safety, and so on. Similarly, familiar fixtures like medicine cabinets, wardrobes, and workbenches begin to acquire new commerce capabilities, and emerge as physical portals for various online services. This physicalization trend calls for an interface that goes beyond traditional keyboards and mice. As illustrated in MAGIC MEDICINE CABINET and ONLINE WARDROBE, the new interface needs to incorporate other modalities such as speech and touch. More importantly, it also needs to use biometrics, such as face recognition and speaker identification, to automatically initiate necessary interactions. In doing so, it helps reduce the user efforts, and increase spontaneity and the level of personalization.

With the proliferation of cheap sensors ranging from RFID and GPS, to miniature video cameras and microphones, it is increasingly feasible to track physical activities of a user and related contexts, including transactions in the physical world, movements, locations, and immediate surroundings, and automatically generate the corresponding “virtual double” (Ferguson, et al, 2002) with little or no additional cost. These virtual doubles typically serve as two types of context: *user* and *task*. A good example of user context is *My Wardrobe*, which is the virtual double of all your apparel shopping activities, a complete transaction history from both online and brick-and-mortar retailers. In VIRTUAL HANDYMAN, a picture of your half-finished electrical socket represents a task context. As demonstrated in these prototypes, the ready availability and accessibility of these virtual doubles, when and where we need them, greatly enhances our experience in the physical world.

As shown in REAL-WORLD SHOWROOM and VIRTUAL HANDYMAN, e-commerce has moved into real-time. This implies that businesses need to not only deliver their services at speed, but be capable of sensing what the customers’ needs are long before the customers realize it. With MAGIC MEDICINE CABINET, for example, a preferred healthcare provider can intervene in real-time when the reading of an individual’s vital signs exhibits any abnormality. The other implication of real-time commerce is that businesses must learn how to bring their products and services into their customers’ daily space so that they can meet their customers needs as these needs arise, just in time and in place.

Finally, e-commerce is primarily about services and, increasingly, micro services. While the need is always present, it is not economically viable in traditional commerce to offer micro services. With essential infrastructure such as Internet and Wi-Fi hot spots already in place, some attractive business capabilities begin to emerge. As demonstrated in VIRTUAL HANDYMAN, technologies like Web Services, 802.11 networks, camera phones, speech recognition, and inexpensive video cameras are making the interaction with micro services much easier. Instead of keyboards and mice, consumers can now interact naturally with appropriate service providers, just in time, and from the comfort of their current task settings, including

their homes. The combination of the economic viability and the ease of interface is bound to accelerate the continuing uptake of micro services.

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