Ubiquitous Advertising:
The Killer Application for the 21st Century

Advertising will be the next major application for ubiquitous computing. Ads will support ubiquitous computing, and ubiquitous computing will support advertisers with ad targeting, ad feedback, customer awareness, and privacy.

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In 2001, John Laird and Michael van Lent, two artificial intelligence researchers at the University of Michigan, claimed that interactive computer games were the "killer application" for human-level AI.[1] This survey article makes a parallel claim that advertising is the killer application for ubiquitous computing. I argue that advertisers have goals that are largely aligned with much of existing ubiquitous computing research. Part of this argument is based on a prediction that many ubiquitous computing applications will be supported by advertising, continuing the trend of ad-supported Internet sites.

However, a more important connection between advertising and ubiquitous computing is apparent from some of the major problems that advertisers face: targeting potential customers, evaluating ads' effectiveness, customer awareness, and ensuring privacy. Ubiquitous computing can provide well-researched solutions to these problems, and it will eventually be embraced by advertisers. In fact, advertisers have already been experimenting with techniques that fall squarely in the realm of ubiquitous computing.

This article discusses the trend toward ad-supported ubiquitous computing as well as the problems advertisers face and how ubiquitous computing can solve them. It doesn't make a value judgment that ubicomp researchers *should* embrace advertising. Some may find this distasteful. However, the article does argue that such a connection is inevitable and, in fact, has already begun.

Advertising Supports Ubiquitous Computing

One of this article's predictions is that many ubicomp applications will eventually be supported by advertising. For example, imagine a mobile, nearby friend finder supported by ads that suggest meeting places in the vicinity, such as restaurants or coffee shops.

The main alternative to ad support is subscriptions, in which users pay a flat rate for access to a service. One predictor of the outcome of ads versus subscriptions in ubicomp comes from the same contest on the Web. In 2004, studies found that online ads brought in about 670 percent more money than paid-for online content,[2] meaning that ads were winning the business-model contest. More recently, *Advertising Age* magazine found that only 5.9 percent of people surveyed would be definitely willing or likely willing to pay US$4/month to see ad-free versions of their favorite Web sites.[3] The article concludes, "Consumers might 'hate ads,' but not enough to pay even as little as a few cents a day to avoid them."

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A more telling predictor of ubiquitous advertising is mobile ads, normally delivered as text messages on cell phones. This is an attractive platform for advertisers because estimates say that half the world's population has a cell phone.[4] Although mobile advertising is a small business now, it's predicted to grow quickly, with some anticipating it will surpass advertising on the Internet, television, radio, print, and billboards.[5] Google's CEO Eric Schmidt estimates that mobile advertising will be a larger business than Web advertising on PCs.[6] With cell phones as a popular platform for ubicomp services, mobile ads will be a natural fit.

Trading ads for services on cell phones already has precedent. One mobile operator in the UK and one in the US are trading ads for talk time.[5] As of this writing, Germany has three ad-supported, mobile navigation businesses.[7]

The definitive study on ad-supported ubicomp has yet to be done, but we can conclude that there are strong indications it's coming: consumers are generally more willing to accept advertising than pay for a service, and mobile advertising is expected to grow quickly, including trades of services for ads.

Ad Targeting

While ubicomp practitioners can use advertising to fund their services, advertisers will increasingly turn to ubicomp to increase their ads' effectiveness. The most obvious way for ubicomp to help is ad targeting.

Segmenting and Targeting

Advertisers want to maximize their ads' effectiveness by paying to have them shown to only those most likely to respond positively, and they want their ads designed to be especially effective for their intended recipients. Traditionally, the first step is to segment the population into different groups in hopes that some groups will be better targets. Segmenting is often done by characteristics such as demographics, life stage, location, psychographics, behavior, and benefits sought, with demographics broken down as age, gender, family type, race and ethnicity, occupation, income, sexual orientation, religion, education, and household size.[8] Different segments will be exposed to different types of media and respond to different types of advertising. Age is the dominant factor that advertisers currently use for targeting ads. As an example, a Harris poll found that of the four age groups they surveyed, those aged 59 and older were more likely than any other age group to watch network television news.[9]

A more abstract segmentation is VALS (Values and Lifestyles), which puts potential customers in categories of different psychological traits that affect buying behavior.[10] Eight categories segment people by personality traits, such as thinkers, achievers, believers, and strivers. GeoVALS gives the proportions of VALS types in given geographic regions to help advertisers know whether to advertise in a certain area, and if so, to know which types of ads to run.

A more recent, better targeted advertising approach is behavioral targeting, in which ads are presented based on the the potential viewer's behavior. This is most easily done on Web pages, where the user's browsing history gives advertisers a clue to which ads would be most enticing. Google is experimenting with this approach, using browsing history to segment people into 600 different categories.[11] Whereas Google's browsing history is limited to sites using its AdSense technology, Internet service providers have experimented with "deep packet inspection" that looks at all of a person's online activity, including Web surfing, email, and downloading.[12,13]

These increasingly sophisticated targeting techniques show how much advertisers want their ads to be relevant to their audience. This has driven them to adopt some simple ubicomp techniques.

Targeting with Ubicomp

Ubicomp research has had little direct impact on advertising to date, but advertisers are still experimenting with ubicomp technologies to better target their audience. This demonstrates advertisers' appetite for ubicomp technology.

As an example, location sensing has always been a significant part of ubicomp, such as Intel Research's Place Lab project that uses a database of Wi-Fi access points and cell towers to allow wireless devices to compute their own location.[14] Skyhook Wireless has commercialized similar technology.[15] Skyhook claims that the click-through rate on its location-based ads are 10 times higher than otherwise similar location-insensitive ads.[16] Acuity Mobile uses location, both current and predicted, along with time of day and other context queues to deliver mobile ads.[17] Its technology includes AisleCaster to deliver location-sensitive ads to mobile devices indoors, such as malls and grocery stores. AisleCaster computes indoor location based on Wi-Fi access points, and similar technology has been a tool of ubicomp. The Locadio system is one example.[18]

Another form of context-sensitive, mobile advertising is traditional-looking ads that change as they move. Vert developed digital signs for the tops of moving taxis that can automatically change based on time and location. The company envisions special ads for "around universities during class times" or "in Spanish-speaking neighborhoods at lunchtime."[19] New York City is testing a similar idea: ads presented on video screens on the sides of moving transit buses.[20] The system, shown in Figure 1, is equipped with GPS to make the ads relevant to the local demographics, as well the time of day. On a smaller scale of location, shopping carts can be equipped with location sensors and digital displays to present ads depending on the cart's location in the store.[21]

Whereas taxi and bus signs can change depending on where they are, larger signs can't move. In 2002, Alaris Media Network erected 10 electronic billboards along California roads that change their ads depending on the

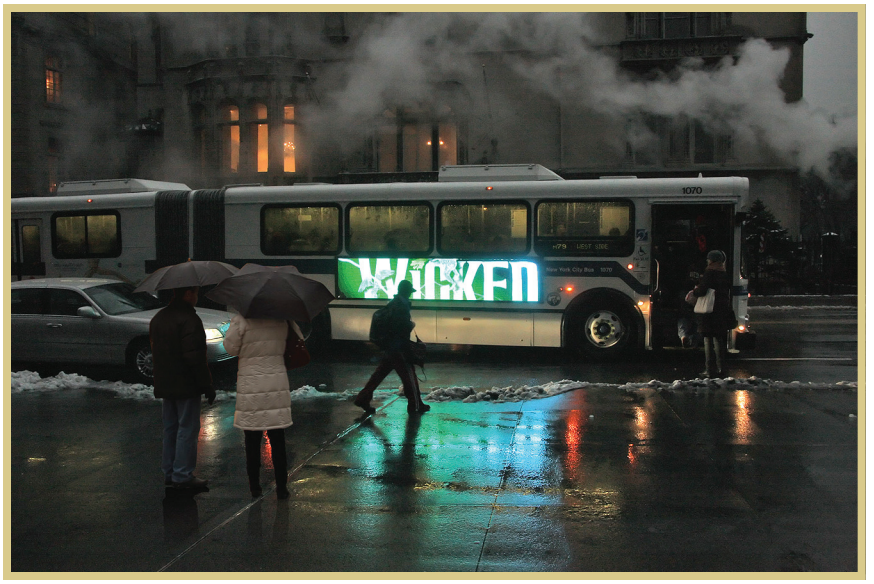

Figure 1. This digital sign from Titan Worldwide, on the side of a bus in New York City, can change depending on its location and the time of day.

demographics of people driving by.[22] The signs have sensors that detect which radio stations passing cars have tuned in. With radio stations as a proxy for demographics, the technology can then change the sign's message appropriately. Similarly, other companies equip eye-level, digital billboards with cameras to infer the age and gender of onlookers with a goal of targeting more relevant ads.[23]

These examples show that advertisers are already embracing traditional ubicomp technology for ad targeting, particularly context awareness. But ubicomp has more advanced technology to offer.

Ubicomp Technologies for Targeted Advertising

Ubicomp researchers have claimed the area of context-sensitive computing and continue to advance the state of the art in context sensing and inference. Context data like this will be extremely valuable to advertisers. Projects such as PlaceLab seek to sense simple events in the home, such as opening cabinets using embedded sensors,[24] then using this sensor data to infer the occupant's activities.[25] Although the stated goal of the Intel/MIT activity inference project is health monitoring,[25] an advertiser might be interested in some of the project's difficult-to-infer activities, such as washing dishes, meal preparation, and reading, to better target their ads. For instance, people who spend much time preparing meals might be more responsive to ads for expensive cooking utensils and less responsive to ads for fast-food restaurants.

Donald Patterson and colleagues showed how to infer a traveler's mode of transportation—walking, driving, bus, for example—based on GPS traces.[26] Frequent walkers are likely more often in the market for shoes, drivers need automobile maintenance, and bus riders might want MP3 players. Furthermore, location-based advertising targeted at someone driving a car could promote more distant retailers than ads targeted at people who are currently walking. Microsoft Research studies have shown that GPS traces can be used to predict a driver's destination,[27] opening the door for location-based ads that are sensitive to a person's future location.

Whereas these two projects used outdoor location from GPS for their inferences, researchers in Japan were able to use indoor location sensors to infer many properties about people working in an office building: age, work role, work group, work frequency, coffee drinker, smoker, work room, and which train station they used.[28] Clearly a person's propensity for drinking coffee and smoking is an invitation to targeted advertising.

Joe McCarthy and his research team showed what a ubicomp system could do with data about a person's interests.[29] Deployed at a ubicomp conference, their Ticket2Talk prototype was a large display that could detect nearby people based on RFID tags in their conference badges. It would display prespecified interests of people it detected in an attempt to spur conversation. Ticket2Talk was considered successful, and it's only a small leap to imagine how advertisers would alter the display based on the interests, either inferred or explicit, of nearby people.

One of the only ubicomp research projects to explicitly investigate targeted advertising is the work of researchers at PARC.[30] They envisioned a world in which real-time activity inferencing is common, then looked at how to target relevant ads. Instead of actually inferring activities, they relied on self-reports of their study participants. One targeting method consisted of submitting the raw text of the reported activity as a query to an advertising-based search engine, then presenting the resulting ads that automatically appeared adjacent to the Web search results.

A second method had a human intervene, attempting to convert the reported activity to a search query that would return relevant ads. Participants rated both the relevance and usefulness of the resulting ads. The study found that ads based on the raw text describing the activity were more relevant than random ads, but not more useful. Surprisingly, ads from the second method, using human intervention, were considered neither more relevant nor more useful than random ads.

Advertisers have shown their desire

for targeting based on aggregate demographic data that can be used to predict a consumer's sensitivity to a given ad. However, demographics is an impoverished projection of a consumer's true propensity for making a purchase. Hence, advertisers have turned to more innovative technologies to target ads, such as behavioral targeting and simple context sensitivity based on time, location, and real-time demographic estimates. Looking forward, ubicomp provides powerful, deep behavioral inferencing that advertisers could exploit to their advantage.

Advertising Feedback

Advertisers are famously uncertain about their ads' effectiveness, illustrated by the classic quote from John Wanamaker, an early 1900's Philadelphia department store baron: "I know half my advertising is wasted, but I don't know which half." A Forrester report says that only a third of marketers consider their marketing effective,[31] and it's estimated that only 41 percent of money spent on ads produces a sale.[32]

Verifying a direct causal relationship between a given advertisement and sales is difficult, so advertisers have adopted advanced technology to assess their ads' effectiveness. Again, the eye-level billboards equipped with cameras can analyze the images to infer the onlookers' gender and age, and, importantly, how long they looked at the ad.[23] Both Brickstream and VideoMining provide camera-based technology to brick-and-mortar stores to track customer behavior, including their stops at in-store display ads.

Despite efforts by advertisers, there is not yet widespread technology that connects buying behavior to ad exposure. Advertisers are anxious for more data on how potential consumers respond to ads. Although ubicomp can't yet read minds, its practitioners are in a position to deliver detailed logs of people's behavior. Context awareness "in the wild" generally depends on frequent measurements of a person's activities, and context researchers seek more sensed data for making inferences. For example, a mobile sensor package from Intel Research and the University of Washington, designed for activity sensing, includes a microphone, visible light sensor, infrared light sensor, three-axis accelerometer, barometer, thermometer, humidity sensor, compass, 3D magnetometer, and 3D gyro.[33]

Some activities are too hard to infer with sensors, so ubicomp researchers have developed mobile toolkits for "experience sampling" that occasionally pose questions on a mobile phone, asking about the subject's current activity or attitude. Jon Froehlich's MyExperience is an example.[34] In fact, the PARC experiment with activity-triggered ads used a software tool called Proactive Experience Sampling Tool (PEST) to pose questions about the subject's location and activity and the mobile ad's relevance and usefulness.[30]

For ad feedback, advertisers are most interested in the connection between ad exposure and buying behavior. With targeted ads increasingly delivered on ubicomp devices such as mobile phones and digital kiosks, the research community will be in a position to easily detect ad impressions. While credit cards and shopper loyalty cards can be used to detect purchases, ubicomp researchers have already looked at using shopping receipts to find lists of what people buy, such as Jennifer Mankoff and colleagues' nutritional awareness network[35] and the MyGROCER project that looked at enhancing the shopping experience.[36]

One can easily imagine a combination of ubicomp technologies providing ad feedback, such as a sensor package that can tell if someone is lingering in front of an ad, incentivized experience sampling to ask about an ad's impact, and the correlation of ad exposure with purchase data. Thus, ubicomp technology is poised to resolve much of advertisers' uncertainty about their advertising's effectiveness.

Knowing the Customer

When developing an advertising strategy, marketers need to know how consumers make buying decisions. As an example, some new home-cleaning products were found to be especially slow-selling in Italy.[37] Researchers from the affected companies found that Italian women are particularly devoted to keeping their homes clean, and the women tended to avoid products that seemed to make the job too easy. One company changed its ads, emphasizing its product's strength as opposed to its convenience.

This exemplifies how advertisers are anxious to know their customers in order to position their products in an appealing way. Although some of this customer information can come from surveys, interviews, or focus groups, direct observation reveals behaviors that consumers can't always remember or articulate.

The observational methods that marketers use have close parallels in ubicomp.[8] The following examples show that both ubicomp researchers and advertisers are trying to understand how people behave, what they like, and why they do what they do.

Advertisers have turned to more innovative technologies to target ads, such as behavioral targeting and simple context sensitivity.

Diaries are a way for marketers to get a record of actual events in a subject's life, giving insight into the motivations behind certain behaviors, including buying and consuming. For instance, Dunkin' Donuts asked subjects to record details about when they thought

about having coffee, such as the time, day, and more open-ended questions like why.[8] The diaries led to a new espresso-enhanced, iced coffee to satisfy the diarists' desire for a quick shot of caffeine. In ubicomp, researchers have used diaries to study mobile information needs[38] and to assess whether or not a mobile phone is a good proxy for a person's location.[39] The MyExperience experience sampling tool was built to facilitate diaries about a subject's activities and motivations.[34]

The field study is another observational technique both advertisers and ubicomp practitioners use. For example, ad researchers used a field study of people in New York's LaGuardia airport to study the effectiveness of airport advertising signs. The study found, not surprisingly, that passengers busy with security or boarding were less likely to remember ads than those browsing airport shops.[40] Ubiquitous computing researchers have developed considerable expertise with field studies.[41] Two examples are studies surrounding the CareNET ambient display for monitoring an elder's activities[42] and the TeamAware system that had basketball players wearing jerseys that can display game-related information.[43]

Finally, both advertisers and ubicomp researchers make use of ethnography to learn more about how people behave in their natural settings. Ethnographers engage in direct observation of their subjects, which means they don't have to rely on conclusions drawn from surveys or artificial lab settings. An example from advertising is the effort of Eight O'Clock Coffee to understand the role of coffee for people just waking up in the morning.[44] Marketers videotaped 14 families around Chicago and Pittsburgh, finding that people generally stumble around in the morning, depending on coffee to push them along. This study led to two commercials showing people struggling to perform until they drink Eight O'Clock's product. Ubiquitous computing researchers also use ethnography, but with the goal of understanding how technology might be used in people's everyday lives. For example, researchers at the University of Nottingham reported on long-term, ethnographic studies of 22 family homes across England with the goal of seeing how family communication is organized.[45] As another example, Intel ethnographers studied the use of mobile devices by 28 young professionals in London, Los Angeles, and Tokyo, finding that their subjects were remarkably similar in how they accessed people, places, and services.[46]

Each of these three methods of studying people—diaries, field studies, and ethnography—has been successfully used by both advertisers and ubicomp researchers. Both fields are trying to discover people's habits and preferences. For the ubicomp studies, it's easy to imagine the research as a precursor to a marketing campaign, in which the study can reveal which aspects of products are most likely to appeal to potential buyers. This close alignment in methods and goals suggests that ubicomp has the right expertise to aid advertisers in future studies of these types. By its nature, ubicomp is especially well positioned to study people in situ as it attempts to bring technology to bear on even the mundane parts of life.

Privacy

Privacy is an issue for advertisers as they attempt to gather more detailed information about their target subjects in an attempt deliver ever more tailored, personalized messages.

Shopper loyalty cards are a well-studied indication of privacy concerns about targeting advertising. A loyalty card benefits the consumer with discounts, coupons, and rebates in return for the consumer giving up their purchase history whenever they use the card. The cards are popular, with 76 percent penetration in Canada, 85 percent in the UK,[47] and 90 percent in the US.[48] Seventy-two percent of the participants in the US study knew their purchases were being tracked, indicating that there is not yet much public concern over advertising privacy. Although this ambivalence about privacy might be disturbing, it does bode well for advertisers' ability to entice consumers to give up their context data.

Despite the lack of public concern, there was a recent investigation by the US government into companies that track Web surfing behavior in an effort to target customers.[13] This has led to promises of new online privacy laws.

Ubicomp researchers have been actively creating privacy systems that are both easy to configure and transparent to the user, such as Marc Langheinrich's PawS.[49] The PawS system, designed for a smart environment full of potentially data-gathering devices, enables the devices to digitally announce their data-use policies. It also lets users track the storage of their personal information. Jason Hong and James Landay's Confab toolkit provides customizable privacy mechanisms for building ubicomp applications, including the ability to notify users whenever an outside entity requests their personal information.[50] Both these systems are applicable to advertisers trying to gather behavioral data from people's digital devices.

Whereas advertisers might consider privacy an annoying obligation, ubicomp researchers have been addressing the issue with technical solutions that enhance privacy and preserve convenience—solutions that advertisers will eventually adopt for their own systems.

A Ubiquitous Advertising Scenario

The following scenario illustrates how ubiquitous advertising might appear in a typical person's day. Ned wakes to the smell of coffee—coffee recommended to him based on similar purchases by his friends. He ambles into the bathroom where a video screen embedded in his mirror greets him with a chirpy, "Good morning!"

The video screen was a free upgrade

Figure 2. Ned experiences ubiquitous advertising during his day. (Figure by Jim St. George, Microsoft Research.)

to Ned's apartment, provided by a consortium of advertisers. However, they've discovered that Ned resents early morning ads, so the current programming is limited to weather and sports scores.

In the kitchen, Ned sips his coffee, while cooking himself some bacon. His cell phone smells the bacon and prepares to deliver Ned a health note later in the day, when Ned will be more receptive.

This is a Saturday, so it will be a day of errands for Ned. He climbs into his car, greeted by a message on the dashboard display. Based on his past Saturdays, the car has correctly guessed that Ned will begin his errands with a drive to the grocery store. The display suggests walking to the store instead of driving, persuading Ned with a forecast of agreeable walking weather. This type of persuasion allows the car's manufacturer to advertise higher effective fuel efficiency for cars so equipped. Sufficiently persuaded, Ned climbs out of the car and begins walking to the grocery store (see Figure 2).

Listening to ad-supported music on his walk, Ned hears a reminder that his mother's birthday is on Wednesday. "Your mother loves gardening, and your brother already bought her some gardening tools. Since you're heading to Piggly Wiggly for groceries anyway, maybe you want to buy her some tulip bulbs there." Ned appreciates the reminder and the suggestion.

The accelerometer in Ned's cell phone has picked up a slow change in his walking gait. Nearing the grocery store, Ned glances up to see one of the city's last remaining billboard signs. "That is so quaint," thinks Ned, "but why would they advertise dog food when everyone knows I'm a cat lover?" Inside the store, his ad-supported cell phone buzzes with an alert: "Have you noticed that a lot of people have iPhones? There are four near you right now." Ned glances around and immediately sees three. "That is uncanny," thinks Ned.

Ned has tulip bulbs in his shopping cart, and he's about to add a package of bacon. Sensing the package's RFID tag, his cell phone recognizes the opportunity it's been waiting for, informing Ned that regular bacon is high in fat and suggesting turkey bacon as a healthier alternative.

After a day of errands, Ned puts a frozen TV dinner in the microwave. The microwave responds, "Remember how much fun you had at T.G.I. Friday's last month? Why don't you put the TV dinner back in the freezer, put on a clean shirt, and go out? It's all-you-can-eat buffalo wings tonight." Ned complies, because, yes, it was fun last time.

At home again, Ned is getting ready to go to bed. His bathroom mirror display recognizes that now is the time to play an ad, and it knows just what to do, displaying a pair of walking shoes and saying, "Ned, your accelerometer readings show that your gait has changed significantly over the past four months. It could be your shoes. Take a look at these beauties." Ned thinks to himself, "Not a bad idea. You know, I guess if we have to live with ads, they might as well be helpful like this one."

This article is not advocating for or against the use of ubicomp technology in advertising. Instead, the central message is that this is inevitable. Advertisers are already adopting ubicomp in small ways, which serves to show that advertisers will continue to embrace it.

Given the inevitability, what can ubicomp researchers do to prepare? Below are some suggestions:

- Design for ad-supported ubicomp.

If some ubicomp services will eventually be supported by advertising, there must be underlying system protocols for accessing and presenting ads that are smoothly integrated into the experience.

- Alternate business models. If you find the idea of ad-supported ubicomp undesirable, seek different business models and prove their feasibility. Alternatives include open source, one-time fees, subscriptions, and donations.
- Seek to make ads more tolerable. Not surprisingly, a study showed that mobile ads considered entertaining or informative were perceived as most acceptable.[51] With its emphasis on context awareness, ubicomp has the potential to make ads that inform at the right time.
- Understand consumers' privacy concerns. Advertisers want to know a lot about potential customers, but we need to understand how much information customers are willing to give about themselves.
- Be aware of what advertisers want. This article outlines some advertiser goals: targeting, feedback, knowing the customer, and consumer privacy. Also, it's important to understand that although many ads overtly try to induce a purchase, advertisers are interested in more subtle persuasion. Advertisers try to build positive brand awareness, attempt to induce certain behavior (including nonbuying behavior such as quitting smoking), and assure consumers after a purchase.

Ubicomp technologies provide many things that advertisers want, whether or not this has been their intention. For our research field, the arrival of advertising gives us the chance to affect the future of advertising. We are in a position to increase the effectiveness of advertising, for better or for worse, but also to make advertising more helpful and private from the consumer's point of view. P

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