Impulse: Location-based Agent Assistance

Jim Youll, Joan Morris, and Pattie Maes
MIT Media Lab
20 Ames St., E15-305
Cambridge, MA 02139 USA
+1 617 253 9603
{jim, joanie, pattie}@media.mit.edu

Introduction

In the physical world, a person experiences products and places, explores physical surroundings, and participates in location-specific activities. A buying decision reached in the real world – such as which of several similar products to purchase – may be influenced by the opinions and actions of others present, by clues left by those who were recently in that place, or by personal interactions with goods. For example, a nearly sold-out item surrounded by similar, heavily-stocked items suggests that many shoppers selected one model over all the others. Discussions with other customers may reveal new information about the utility of a product. A buyer tries on clothing before deciding to purchase it. A chance walk past a store advertising a discount on a favorite item may trigger an impulse buy.

Electronic shopping on the Internet cannot replicate the physical shopping experience. While missing the hands-on experience of shopping in a bricks-and-mortar store, Internet shoppers have at their fingertips a wealth of valuable information not available to real-world shoppers. This information includes extensive product and vendor information, personalized recommendations, professional and community reviews and price comparisons.

How will people's approaches to purchases, moment-to-moment schedules, and negotiation, change when their actions in the physical world are continuously guided by information drawn from the virtual world?

The Impulse research project at the MIT Media Laboratory [1] and the several projects it has spawned cover a range of scenarios and technologies in which e-commerce meets brick-and-mortar commerce. These projects examine the merger of the rich experience of the physical world with powerful information resources available only through the Internet. We explore systems of buying and selling agents (representing individual consumers and retailers respectively) that engage in multi-parameter negotiations with counterparts discovered in the surrounding physical world. Rather than *replacing* real-world shopping with on-line shopping, we discuss assistance that may be delivered by computer systems we refer to as software agents.

In this research, *exploration* becomes a preferred mode of navigation and ad-hoc planning addresses the difficulties of scheduling amid uncertainty. Complex negotiations between buyers and sellers are the norm in this vision; those negotiations occur silently and continuously on behalf of all involved, interrupting users only when the software agents involved in the negotiations have news for the parties. Related research on learning agents within wireless devices [2] and the combined work of wearable computing[3] and ubiquitous computing [4] explore placing agents into our physical environment. Our work takes these previous explorations and introduces the idea of an agent that provides a user with personalized information dependent on his/her geographic location.

Impulse Scenario

Although net-based product information helps consumers make educated buying decisions from their homes and offices, consumers lack the resources to perform comparison shopping at the point of purchase. The consumer's personal digital assistant (PDA) can serve this immediate need, finding web-based product reviews and alternative offerings. In this setting, the consumer may direct a PDA-based agent to begin a negotiation with the present store (and others, including on-line stores) or simply add the product to a "want list" to enable ongoing negotiations and a later purchase, perhaps from another brick-and-mortar or on-line store.

At any time, the consumer may add products such as a CD player or a book to a "want list," noting preferences such as warranty terms, merchant reputation, availability, time limit for the purchase, and preferred price. As the consumer visits business districts, individual stores and shopping malls, the consumer's agent engages nearby merchants in a silent exchange seeking the items on the "want list" and opening negotiations on the terms of the sale, alerting its owner if a deal is reached.

Merchants' agents receive these agent-based queries and negotiate sales terms, considering such factors as loyalty, probability of an immediate sale, and the age and shelf-life of goods on hand, following guidelines set by the merchant. Through the negotiation process, the merchant gains valuable information about customers' purchasing

decisions. Questions such as "What factors motivate the consumer to make a purchase?" and "Why did we lose that sale?" can be answered using information obtained or inferred during the agent negotiation. We anticipate that merchants will learn and respond to localized consumer preferences through the analysis of aggregate data acquired through long-term negotiations with large numbers of customers and potential customers.

The ability of a consumer PDA to communicate with a retailer's sales system in a negotiation depends upon the retailer's willingness to incorporate the necessary network and software infrastructure to make such an exchange possible. We do not propose a solution to this constraint, but hypothesize that as such high-level of consumer-vendor interaction becomes possible, consumers will value these capabilities equally with traditional values such as reputation, price and variety. Consumer demand will lead merchants to participate in information exchange and negotiation, as customer demand has previously led them to adopt fax machines, e-mail and web sites.

The Role of Software Agents

Software agent technologies offer users valuable assistance on-line by personalizing searches and queries [5]. In the Impulse scenario and related projects, software agents are explorers, searching both the physical world and virtual worlds for information and guidance, assisting users with "real-world" interactions through the power of on-line information. We presume that agents of this sort will run on wireless mobile devices, such as IP-ready Palm devices. Consumers and merchants are both represented by agent intermediaries. These intermediaries meet one to one on roughly equal footing to seek agreement on the terms of a consumer purchase or information request.

Profiles

Customer profiles in the Impulse scenario belong to users, not to merchants or third parties. The user's agent, working with the user, determines what information will be released, and to whom. Impulse presents the use of both broad and tightly-focused user profiles together in one agent system. The broad profile may contain such general information as a person's preference for vendors who do not share customer information with others. A more focused element of a user profile may concern the particulars of the purchase of a single item.

Infrastructure: Wherehoo

An infrastructure component enabling the Impulse scenario, the Wherehoo Server [6,7] is a time-and-place storage system for digital media. Wherehoo binds digital artifacts, such as a web URLs, images or audio clips, to real-world locations and time intervals. The server's protocol and behavior support software agents and small *things that think* through conservative use of bandwidth, a lightweight TCP socket-based protocol, and delivery of meaningful metadata to help clients identify interesting records within large query results. Wherehoo supports *long-lived* records (such as buildings) and *transient* records (short-lived events and objects in motion such as subway trains).

Traditional location-search capabilities now on the Internet generally fall into one of four categories of underlying organization: by street address, by place name, through a binding graphical street map, or via a proprietary locator.

> *Street address:* Yahoo maps [8] are an example of a street-address-based location service. Entry of an address and zip code or city/state pair retrieves a map of that place, which may then be augmented with the locations of advertisers who pay to appear on the map.
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> *Place name:* Expedia maps site [9] offers name-based mapping of well-known places. For example, entering "Statue of Liberty" and selecting "Statue of Liberty [Statue of Liberty National Monument], New York" summons a map showing the New York Bay, New Jersey and Manhattan, centered around the Statue of Liberty.
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> *Graphical street map:* Mapblast [10] is an example of a site at which map-based exploration creates a primary interface. Clicking, zooming and panning allow a user to view streets on a map that may be augmented with the locations of commercial places such as gas stations and restaurants.
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> *Proprietary locators:* These include the sites of large companies such as Starbucks [11] that aid customers in search of a familiar brand in an unfamiliar place. Realty sites [12] help potential buyers to find homes for sale in neighborhoods rather than just at single addresses. These proprietary locators answer authoritatively, but do not enrich more broad-based, unfocused searches by agents that do not already know something about their surroundings.

In contrast to the location services discussed above, Wherehoo supports free exploration of the world by utilizing the most basic descriptors of place: latitude, longitude and height – the data provided by ordinary GPS receivers. Through optional query controls, explorations may be constrained to the world "ahead" of a user, for example, or limited to data of a single MIME type or accessible via a specific protocol. The location services surveyed above are read-only search engines that primarily index web pages; Wherehoo encourages read-write client interaction.

Impulse Project: StreetWise

StreetWise [13] combines a hand-held device with a software agent querying the Wherehoo server, to aid discovery of interesting places and goods near the user. Streetwise demonstrates the location-based query aspect of Impulse.

Streetwise Scenario

A person with a keen interest in architecture is visiting Barcelona for a conference. On this first trip to the city, he would like make sure he sees all the sights. He tells the agent on his hand-held device that he has an interest in Antoni Gaudi's work and the International style of architecture popular before WWII. This information is added to his profile. The agent also knows his preferred language is English.

As the visitor explores the city, his agent alerts him of relevant goods, services and points of interest in his physical vicinity. As he wanders through a shopping district, the agent finds a bookstore specializing in English-language books on architecture, and alerts the user. Having told the agent he wants to see Gaudi buildings, the agent returns with the location of Casa Batlló, Casa Milà and Sagrada Familia, three of Gaudi's most famous structures. When he approaches the Metrónom, his agent informs him there is a special temporary exhibit on architecture today. At lunchtime, while the visitor looks for a place to eat, his agent points him to a nearby restaurant where Mies van der Rohe ate during the 1929 World Exposition. In this last example, the agent proactively finds places that relate to both long-term interests ("architecture") and short-term interests ("lunch").

Streetwise Overview

We approach location-based computing by structuring our agent communication into four components: the User Agent, the Wherehoo Server, Provider Agents, and Providers. A *User Agent* represents a user's interests through interactions with *Provider Agents*. The *Wherehoo Server* is a search server with location as its primary criterion. *Providers* are physical resources such as businesses, services, attractions, events, or points of interest in the user's physical search domain, which have an Internet presence and have registered with the Wherehoo server. *Provider Agents* engage User Agents on behalf of Providers. This design allows a User Agent to answer such questions as "Is there 'coffee' near my present location?" through an exploration of the digital shadow of the physical world around the agent. By *location* we refer to physical coordinates, as contrasted with *context*, which may include more information such as actions, motivations, and interactions[14].

In one scenario, the User Agent receives its tasks from the user in the form of a list of goals or "Wants." Each Want consists of basic keywords entered by the user, a physical radius in which to search, and a target time during which the requested good or service should be available to the user. The User Agent uses the Want data to build an internal user profile that leads to queries of both the Wherehoo server and Provider Agents.

Streetwise presents an application in which geographically constrained queries enable a user's agent to give relevant, real-time alerts and suggestions. These suggestions are based on the user's interests, location and surroundings.

Conclusion

Wherehoo and Streetwise are the first instantiations of the Impulse scenario. We envision many projects and future applications that demonstrate our vision for combining on-line and off-line commerce. We are also building non-traditional interfaces, such as the Periscope browser [15], to support exploration of geo-referenced data. Future applications may incorporate ad-hoc agent negotiation for complex bundling of goods or ad-hoc collaboration between individuals. Our goal is to create applications and interfaces that connect information and collaborative activities in the digital realm with human exploration and discovery in the physical world.

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