EASISHOP: CONTEXT SENSITIVE SHOPPING FOR THE MOBILE USER THROUGH MOBILE AGENT TECHNOLOGY

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Abstract - The attractions of a stable, integrated, real world mobile automated shopping system are clear. For the shopper, the system acquires, on behalf of the user, a sought product without the user entering the retail outlet. For the retailer, transactions could occur cheaply, quickly and with minimum drain on the resources of the retailer. We describe an agent-based, location-aware, automated ubiquitous commerce (uCommerce) system. Within this paper we introduce a set of interoperating technologies to enable an automated uCommerce system using mobile agent interaction facilitated by the Bluetooth wireless radio transmission medium. We describe an architecture and a prototype - EasiShop - based on these ideas and illustrate the operation of the prototype in an example scenario.

Keywords – uCommerce, Mobile Agents, Context Sensitive Services, Bluetooth.

I. INTRODUCTION

Much of the recent research in intelligent shopping agents has been undertaken with a web-based scenario in mind. One of the most prominent of these systems, Bargainfinder [1], provides an online price comparison system for a particular product. The Web mining agent ShopBot [2] uses descriptions of domains and vendors as prior knowledge to compare vendors by an attribute (e.g. price) for a given characterization of the desired product. The substantial interest in this field is unsurprising. Online shopping is growing fast, and is projected to account for 8.6\% of worldwide sales of goods and services in 2004 [3].

The crucial commercial advantage that these systems offer is that they provide, in theory, a mechanism that delivers automated inter-retailer competiveness, offering comparison based shopping geared towards cost and availability, thus delivering a competitive deal to shopper and retailer alike. While these agent-based systems offer both the shopper and the retailer powerful commercial possibilities, they are limited in the extent with which they can exploit significant areas of consumer behaviour. As web-hosted systems, they ignore much contextual stimuli to which the shopper responds. It is recognised [4] that consumers want some kind of tangible contact with goods as they shop, demanding to “touch it, drive it, listen to it, or wear it before they buy it.” We can say that such systems, in terms of the users physical setting, are context agnostic.

Of the context aware retailing systems for the mobile user in development at present, most employ the usage of Global Positioning System (GPS) technology, in order to determine the user’s location. An example of this is the Shopping Jacket [5], developed at the University of Bristol, which combines a GPS receiver embedded in the fabric of the user’s jacket with data transmitted by retail outlets in order to notify the user when he or she is close to an outlet which may be of interest. The Wineguide [6] project adopts a similar approach, in which a Mobile Positioning System (MPS) enabled mobile phone is utilised to direct the user to an outlet where he/she can obtain a particular bottle of wine. These systems, however, while mobile, employ rudimentary and static database search routines when attempting to match the user to a product. The lack of inherent system intelligence means that real world operation would prove to be less enriching for shopper and retailer alike.

II. EASISHOP OBJECTIVES

Within this paper we introduce EasiShop. EasiShop aims to embrace the inherent advantages offered by both of the aforementioned system types. To this end, we incorporated elements of uCommerce, Multi-Agent Systems (MAS) and wireless technologies in order to develop proactive autonomous agents which facilitate automated retailing. Our approach was adopted to solve a number of related problems faced by the mobile shopper:

- To partially automate the shopping process, thus alleviating the user from what may be a difficult, time consuming or unpleasant task;
- To provide a means by which the shopper can be informed of optimum consumer conditions – i.e. cheapest price, fastest availability, best after sales service, geographic proximity etc. with minimal effort on the part of the shopper;
- To deliver a system architecture that facilitates multiple retailers and shoppers, interacting and competing in a dynamic, self-contained macro-economy, thereby benefiting the shopper.
For the retailer, we believe EasiShop could offer a useful source of increased revenue. Studies have shown that, in certain cases, if a shopper actually enters a shop and comes into physical contact with a sought product, he/she will be quite likely to purchase. In Why We Buy: The Science of Shopping [7], the author asserts that men, having tried on a pair of jeans, will purchase 65% of the time. With women the figure is 25%. The key advantage offered by EasiShop to the retailer is that it is known precisely when the shopper is outside a given retail outlet. This knowledge can represent valuable commercial information, activating enticement protocols to lure the shopper into a given outlet.

In the remainder of this paper, we discuss how we have attempted to achieve these objectives. We begin with some discussion on the agent-based aspects of the system, before explaining details of the communications medium. A description of the systems data formats then follows. We then present the system design schematics supported by an implementation description. Finally, some conclusions are provided.

III. THE EASISHOP SCENARIO

Let us first consider the typical EasiShop scenario as depicted in Figure 1 above. We characterise the EasiShop scenario as follows. Consider the shopper walking down a busy high street equipped with a Personal Digital Assistant (PDA). This PDA hosts an EasiShop Shopper Agent – an encapsulated semi-autonomous software entity - that is charged with the task of acquiring a predetermined set of items, the shopping list, for the given shopper.

Upon walking past retail outlets, the user enters EasiShop Catchment Zones (ECZ) within which interaction may take place between the Shopper Agent and Retailer Agents hosted upon wireless devices located at the shop entrance.

The size of such activation zones will vary according to the particular wireless technology adopted but would typically be of the order of 10-30 metres. A variety of push or pull technologies may be utilised. The Shopper Agent may interrogate the Retailer Agent in its pursuit of the shopping list, querying availability, price and delivery lead time, whilst Retailer Agents may proactively advertise special offers and stock clearances to the Shopper Agent. As the user walks the retail high street a macro-economy emerges based upon locality and proximity to the user. Retailer Agents compete for the Shopper Agents business whilst Shopper Agents compete to secure desired products at offer prices.

The interaction between shopper and Retailer Agents is however typically governed by the time the user remains within the catchment zone. At normal walking pace (approximately 5 kmph) this may be restricted to a few seconds. Thus, if the Shopper Agent identifies availability of the desired product, but the price is unacceptable, then negotiation may be appropriate or necessary. At this point a shopper barter agent resident upon the PDA and a retailer barter agent present at the retailer site would agree to rendezvous at the market place. The market place provides a forum where shopper and retailers alike can interact with impunity from the movements of the individual shopper. The market place would be arranged around a collection of stalls, each of which would deal with the sale of particular categories of products. Thus a given stall would act as the forum for retailers and potential purchasers of the particular product with a variety of purchase or sale protocols potentially available. The market place would correspond to a given network address to which these agents would temporarily migrate.
IV. EASISHOP SYSTEM DESIGN

In this section, we discuss aspects of the EasiShop system design, detailing how the various components operate and interact. We will first justify our agent-oriented approach before elaborating on exactly what kind of agents are utilised before providing some details on the communications functionality, agent migration techniques and database structures within the system.

In order to satisfy our explicit system requirements, a number of alternative design archetypes were considered. An agent-oriented approach was eventually decided upon. We assume IBM’s accepted definition of an agent as: Software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user’s goals or desires. An agent-oriented approach was adopted due to the inherent proactive, autonomous mobile and competitive nature of the constituent process. Initially, users specify their shopping requirements (shopping list) through a set of hard or soft constraints. These constraints relate to ‘must haves’ and ‘would like to haves’ and specify the price thresholds, delivery times, colours, brands, preferred suppliers, etc. In addition, the user, upon first registering with the system, will be asked to supply personal data relating to age, gender, preferences, nationality, hobbies and so forth. This initial data will be used to bootstrap the system and create an initial user profile. This will thereafter be dynamically updated to reflect observed user behaviour and infer user preferences.

Once the user has input the initial products of interest, software on the shopper side must communicate this information to the store system. It was seen to be beneficial if an autonomous, software-based entity could migrate from the shopper system to the store system, perform its shopping tasks and return to the Retailer Agent. Some of the benefits of this approach are:

• As an autonomous, goal-oriented entity, the Retailer Agent accomplishes the primary aim of alleviating the shopping workload from the shopper;

• Similarly, the design of the Retailer Agent is focused on enabling minimal effort on the part of the retailer in operating Easishop;

• The Agent-Oriented approach is object-oriented, thus enabling easy scalability and maintenance.

In addition to these benefits, the approach provides inherent stability advantages for EasiShop. This is due to the fact that whatever transmission medium we implement (e.g. Bluetooth, 802.11, etc.), we cannot be guaranteed that the shopper will remain in transmission range to ensure the completion of the transaction thread. The current (guaranteed) range of a standard class II Bluetooth device, for example, is 10 metres. It is possible that, during a product negotiation process, the user could move out of transmission range. With the inbuilt migration capability, the Retailer Agent could thus continue its operations and re-migrate back to the user at a later time.

A. The Agent Form

The agents we develop must essentially want to interact in a goal-driven marketplace, the Shopper Agent and Retailer Agent assuming the roles of purchaser and merchant, respectively. Within the EasiShop macro economy, subsets of agents are fundamentally benevolent (Shopper-Retailer), whilst others are fundamentally competitive (Shopper-Shopper and Retailer-Retailer). One problem faced by our agents in the EasiShop system is how do we represent what the agent wants to do to satisfy the goals of the user at any given point in time. By adopting the Belief-Desire-Intention (BDI) architecture, we can identify an agent as having: a set of beliefs about its environment and about itself; a set of desires which are computational states which it wants to maintain and a set of intentions which are computational states which the agent is trying to achieve. Furthermore, the agents must be enabled with a degree of mobility, thus delivering essential functionality of the system. It became clear that the best approach to implement such a mechanism could be achieved by employing mobile agents as described in Mobile BDI Agents [8]. We can specify and realise these constructs with the aid of the Agent Factory package. [9]

The Agent Factory System is an Agent Prototyping Environment (APE) founded on Shoham’s Agent-Oriented Programming (AOP) paradigm [10]. It was designed around two principle needs:

• The need for an environment that supports the delivery of agent-oriented applications;

• The need for a flexible and easy to use environment that supports the development and testing of heterogeneous agent designs.

B. Communications Infrastructure

A number of wireless data transmission technologies were investigated, with a view to incorporation into the EasiShop project. These included WAP via GSM or GPRS and Wireless LAN 802.11. Ultimately, the Bluetooth standard was adopted. Bluetooth offers a reliable catchment area of 10-30 metres based on standard class II Bluetooth technologies. Furthermore, it represents a low-cost, low-power consumption transmission technology. It has been predicted that millions of devices will be Bluetooth-enabled. Should this situation be realised, a large market of potential EasiShop users would exist.

Although Bluetooth was chosen as the principal communications protocol, a modular design ensures that an alternate protocol, such as Wireless LAN 802.11, could easily be incorporated in a plug and play manner.
Furthermore, consideration was made, ensuring that different EasiShop implementations using various communication protocol modules would be interoperable. For example, we could conceivably have two parallel EasiShop systems – one with a Bluetooth communications protocol and the other with a GPRS communications protocol.

A number of alternative software development systems, compatible with the Ericsson ROK 101 chipset were evaluated. These include cstack from Ogenek, the linux-based, open source Axis Bluetooth protocol and the Ericsson protocol stack and development environment, bundled with the EBDK hardware. The Ericsson kit was selected because of global support and tried and tested, readily available code. An Ipaq 3870 with the familiar linux kernel is used to house the Shopper Agent(s). The open source bluez stack is used to provide Bluetooth capabilities.

C. Agent Migration

Based upon our agent communication protocol, we are able to support agent migration. The form of agent migration offered is that of weak migration, where only the agent’s object state and code is captured and transmitted. In our case, this necessitates that capture of the agent mental state including the belief set, commitment set and the commitment rules. This is subsequently dispatched to the new destination whereupon arrival it announces itself and the system calls a known entry point in the code to restart the agent upon the new device. Field trials have revealed average agent migration times of 1.8 seconds.

An implicit assumption is that the recipient device has already installed an Agent Virtual Machine (AVM) that can execute the agent. At present we are happy to operate on the basis on this assumption. The weak migration model is inferior to that of the strong migration model, which would also transfer agent control state, enabling it to resume at the exact point from whence it left off.

D. Product and Stock Database Design

It became clear that, in order to provide precise and accurate product bartering system, a standardised product database would be required as a means of users expressing their shopping needs. A number of initiatives have been undertaken in an attempt to classify products in a standardised, coherent and logical manner. The Nomenclature générale des Activités Economiques dans les Communautés Européennes (NACE) and the North American Industry Classification System (NAICS) are the European and American versions, respectively. The United Nations version – United Nations Standard Product and Services Classification (UNSPSC) was seen to be more suitable for the needs of EasiShop, since it encodes a global market of 12,000 product codes and constitutes an evolving and open global standard. To create the main product database, an XML version of the complete UNSPSC scheme was obtained. This code was coerced into a Pointbase database structure. Pointbase was chosen as the database format for its ease of use, support for data migration and cross platform compatibility (through Java). Datasets are accessed using JDBC.

V. IMPLEMENTATION

We have simulated a shopping mall scenario, using 2 separate Ericsson EBDK kits to represent 2 competing retailer outlets. Typically, users specify product requirements using UNSPSC codes, along with associated constraints including \textit{interalia} price, delivery time and urgency. Figure 2 illustrates the intuitive user interface for product solicitation:

![Fig. 2. EasiShop User Interface.](image-url)

The Retailer Agent is implemented on the Ipaq using a java class (running in Jeode). The following screenshots illustrate a Retailer Agent in operation. The demonstration shows how a typical operation (buying one coat at a unit cost of thirty) is undertaken. Here we can see the belief and commitment sets of the Retailer Agent change over time. We see how once a belief is adopted (in this case to add a particular product – one coat at a cost of thirty to the agents shopping list), the commitment set of the agent is modified to reflect the new commitment that has been adopted. Note also that, in line with expected behaviour, commitment rules remain static.
VI. CONCLUSIONS

This paper has introduced EasiShop, a context sensitive uCommerce system that alerts potential users to services and products as they pass by retail outlets. In delivering its functionality, it embraces an agent based design philosophy. In particular, agents are developed using the Agent Factory APE. A research demonstrator has been developed which supports mobile agents hosted on mobile devices which can interact with each other based upon standard Bluetooth technologies.

We have described the EasiShop architecture together with the structure of EasiShop agents. In particular, we have discussed how an agent communication and migration protocol has been hosted on top of an industrial standard wireless communications technology – namely Bluetooth. This enables the provision of a wireless agent communication mechanism and a mobile agent capability. Subsequent work will involve trials in a shopping centre.

There are many areas in which the system can be refined, extended and improved. Studying Consumer Buying Behaviour (CBB) models should enable a more realistic, efficient functionality. Incorporated barcode support would benefit the system enormously. Security aspects need to be addressed. The principal work will involve making the constituent agents more intelligent, more responsive and more proactive, thereby enhancing negotiation protocol and delivering optimum benefits to shopper and retailer alike.

REFERENCES