Location-based Support for Commerce using Multiagent Negotiation

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Abstract. Location-aware information systems is one of the most rapidly developing areas in IT. Location technologies, like GPS and cell-triangulation, offer to mobile devices possibilities for accessing information depending on its physical current location, giving the opportunity for new location-aware information services. In this paper we propose a method and a multiagent architecture for supporting impulse commerce (clients buy as they physically move through stores) by providing a negotiation brokering service. Mobile devices would act as personalized shopping guides for buyers, and merchants could "push" offers to clients, according to their actual in-stock merchandise and their sales policies. A basic working prototype illustrating our proposal is reported.

1 Introduction

Location-aware mobile information systems is one of the most rapidly developing areas in IT [1–3]. This is understandable because it combines both a need (to relate information systems with the physical world) and the technological feasibility for physically locating devices. Though location technologies are not mature enough to become mainstream, some of them are making their way to become both usable and economically practical. In particular, GPS devices and cell-triangulation technologies are being actively developed and make rapid progress [4]. We can expect in the near future the availability of inexpensive and widely available position-location mobile devices, possible integrated to other mobile devices like cell phones or PDAs. This would offer to mobile devices possibilities for accessing information depending on its physical current location, giving the opportunity for new location-aware information services.

While hardware location technology is advancing, the software counterpart is lagging behind. Though thousands of new useful services could benefit from location-awareness, just the most elementary of them have been developed, like restaurant location [5].

One of the most promising areas for location-aware information services is impulse commerce [5], where buyers wander through physical stores, eventually entering one of them to buy something. In this context, a mobile position-aware device, connected to an information system, could act as a "shopping guide",

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providing the user information about the surrounding stores. This kind of information service will be for sure available in the short term, together with other location-associated services like hotels, restaurants etc., linked to a mapping service.

We consider extremely important the information personalization for specific users, giving them better focused -and thus more valuable- information. As we will see later in this paper, individual client profile management should be a key component of a useful location-aware information service.

But beyond static location-aware information services, we envision the possibility of more dynamic services, where a real-time interaction is possible between the stores (including restaurants, hotels, etc.) and the potential clients. These dynamic services would have several advantages over their static counterparts, as:

- It would be possible for the store to give information about actually available items, such as cloth sizes in stock;
- It would be possible for stores to propose special offers;
- More flexible pricing policies would be practical for stores, like reducing one price when buying another item;
- A higher degree of personalization would be possible for clients.

In this paper we propose a method and a multiagent architecture for supporting impulse commerce (clients buy as they physically move through stores) by providing a negotiation brokering service. Mobile devices would act as personalized shopping guides for buyers when they want so, and merchants could "push" offers to clients, according to their actual in-stock merchandise and their sales policies.

The structure of this paper is as follows: after this introduction, we present LOBSTER (LOcation-Based SupporT for commERce) in section 2; then a working prototype is reported in section 3 and, after, some comparison with related works in section 4. We conclude in section 5 reporting some final conclusions.

2 LOBSTER description

Imagine that a hypothetical John Smith has a cell phone with GPS-like location capabilities. John uses this device as a shopping guide, because it is connected to the LOBSTER service, which allows it to locate in real-time products he needs, according to his profile, and bargains as he travels by car through the city.

The mobile shopping guide shows on its screen a simplified, but physically accurate, map of vendors nearby, represented by special icons, presenting on screen just merchants fitting John's personal interests, stored in a *personal profile* that John uploaded to the system. This personal profile, which includes things as clothes sizes, food tastes, prices ranges, and many other preferences, is continually enriched with John's traveling habits and buying history, but John can choose to keep it private or either to deactivate it. The cell-phone like shopping assistant can work both in "pull" mode, when he asks, for instance, for the

nearest chinese restaurant [1] and in "push" mode, where the merchant agent, who is alerted of the potential customer presence, advertises its product or even proposes a special deal. In his personal profile, John indicated whether he wants to be alerted about products (and which products), as well as special offers. In particular, John established this morning that he would not receive any advertisement from LOBSTER except if it is an offer about for digital cameras or shoes. In the personal profile it was established John's shoe size, so he will only be alerted of a store actually having his shoe size in stock at that particular moment. LOBSTER participating stores have a permanent connection with the system so they can give warranty about their actual merchandise in stock. John can make temporal profile modifications when, for instance he needs to find a gift for somebody else –who will of course have different clothes sizes, etc.

When John approaches a shoe store having his size and preferred style, his shopping assistant phone vibrates and shows on screen the store's location. Then, John can click on the store's icon to read the offer's details.

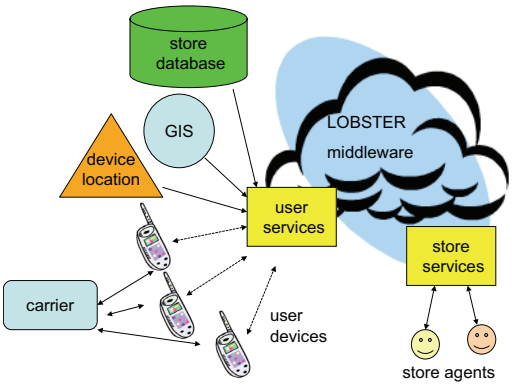


Fig. 1. Lobster's general architecture

As you can see from the above example, this vision requires much more than hardware location technologies. It requires an entire brokering service, which would be a middleware accessed both by the user's cell phone carrier, and by connected stores. We decided that it is necessary to provide clients and merchants the maximum negotiating capabilities and flexibility, and we think that this can be achieved by giving stores and clients their respective negotiating agents, taking advantage of agent technology's flexibility [8]. Those agents communicate with the LOBSTER middleware brokering service, which eventually manage costs of usage, both for stores and for clients. In figure 1 we show the main components of the LOBSTER service, including, of course, cell phones,

[1] This level of service has already been implemented, for instance in [6, 7, 4].

location hardware, a GIS system for storing and managing store's locations, and LOBSTER middleware, including client services and stores services.

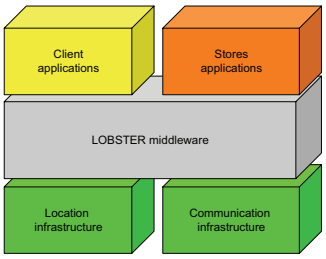


Fig. 2. Lobster's layered software architecture

In very broad terms, the system works as follows:

- The cellular phone sends its relative geographic position to a communication system (usually administered by the telecommunication company). The way in which this position is determined is not discussed here and it is assumed that it is already part of the service offered by the carrier.
- This position is received and the preferences, likes and dislikes the user may have are matched to those services, goods and store products, within a predefined range of action, that are being offered.
- Using this filtering process, sets of stores that comply with the requirements the user has are created. There are as many sets as products and services the user wants.
- With this sets, a negotiation process can take place, as long as the user's profile says so. Stores send their offers, based on their own policies, to the user. This offers are ranked and evaluated, setting up the utility that such values represent to the client and to the participant stores, so that the client can make a decision about what to do with them.
- If no decision is made then the stores have the option to send a better offer or do whatever their policies state.
- Finally, once a client has selected an offer, this one is saved by the system and the transaction is made for this specific product.

In order to fulfill these tasks, an agent-based architecture was designed implementing not only the basic agent architecture but also the rules for negotiation, evaluation and decision making in order to maximize utilities [9]. In the following sections such characteristics of our proposal are presented.

3 A multiagent Prototype

We have developed a working prototype for simulating the LOBSTER main ideas. This prototype is based on a multiagent architecture and has been implemented using a multiagent programming platform [10]. The multiagent architecture tries to simulate the real life conditions found in an everyday purchase action [4]. As such, there are four kinds of agents in our system, each one of them with a specific role and following a distributed paradigm [11]. In other words:

CellPhone Agent It represents the person in the negotiation process, using the preferences already established by the user. It also keeps track of the negotiations that go on and the geographic position where the user is. There are as many as registered users are.

Store Agent It represents the store that may evetually make an offer to the person who is within the range of work, following bargain policies according to the ones the store has. Similarly to the previous one, there are as many as registered stores are in the system.

Broker Agent It evaluates the offers on behalf of the user sending the information to the cellular phone for the person to make a decision. It also informs the stores about the results of the evaluation so that they can make better offers. This agent is only created once a negotiation process is instantiated and there are as many as products and interests the user has.

Server Agent Basically, it is in charge of the papework in the system. It matches the profiles the users have to those of the stores, creating as such the sets for the negotiation so it is the one that has direct access to the database of the system along with the tasks related to data maintenance. It also keeps track of the negotiations and their outcomes.

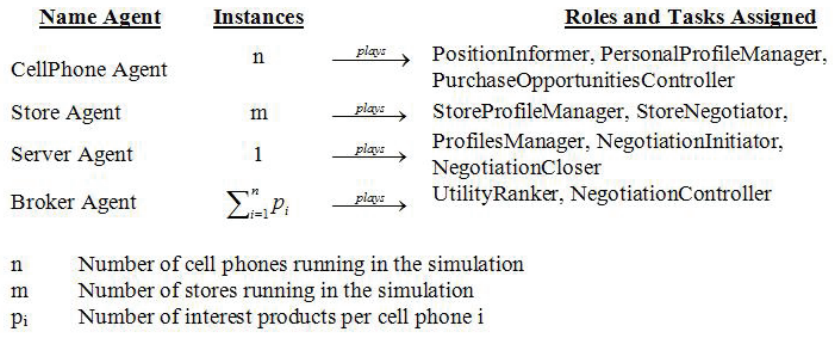


Fig. 3. Lobster's Agent Model

In the proposed system these roles are represented in Figure 3. From this, it is not hard to see how the communication among agents and the flow of

information goes; this is shown in Figure 4. It is important to notice that this represents the middleware, the software that would go under the machinery of the communication system. This is done so since such part of the system is the core for any further development in the field of value-added service in LBS technology [12].

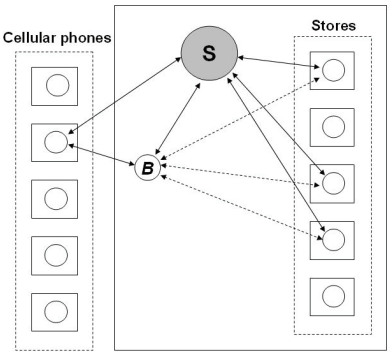


Fig. 4. Lobster's Architecture

3.1 Negotiation, Evaluation and Decision Making Processes

Since this report presents our first attempt to a working commerce-middleware; the negotiation, offer evaluation and decision making processes are quite simple. However, they are built in such a way that allow further development, enhancing as such the negotiation capabilities, offers filtering and decision making stages in an easy and scalable way.

In the present prototype all the above tasks are performed as described below:

Negotiation As mentioned earlier, the negotiation starts once that at least one store that matches the user's profile has been found; then, the *Broker Agent* is instantiated and waits for offers. This agent auctions "the client" asking for offers and, then, for even better ones. Every time new offers arrive, a new negotiation takes place since new proponents may appear; so new bids are received and evaluated for the user to make a better decision.

Evaluation It is performed by the *Broker Agent* using the offers received from the stores and normalizing them in order to give a score to every offer. Such scoring is sent to the user so that it is displayed on the cellular phone's screen, varying degrees of color to represent the evaluation given to each offer.

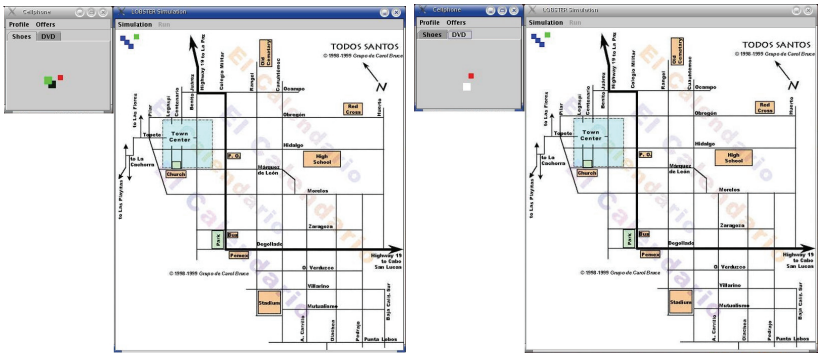
Decision Making The user, of course, is the one who makes the decision, choosing from continuing receiving more offers or accepting one to stop receiving more proposals. In any case, the outcome of the decision is stored in the database of the system and is administered by the server.

In the following sections, the results of executing this system in a simulated environment are presented and analized.

3.2 Prototype testing

In order to check the validity of our approach, a simulated environment was built. This environment represents any given city as shown in Figure 6(a) where the three squares in the up left position represent the stores and the one in the middle represents the user (i.e., the cellular phone). As explained earlier, these entities are running in the system as agents.

The *Cellphone Agent* sends its position to the *Server Agent* for it to match the profile the user has with those profiles of services and products stores have. If stores that match the user's profile are found, then the negotiation is begun and the process is displayed in the cellphone screen as shown in Figure 5(a) and 5(b); opening as many tabs as matched products are in the negotiation set.



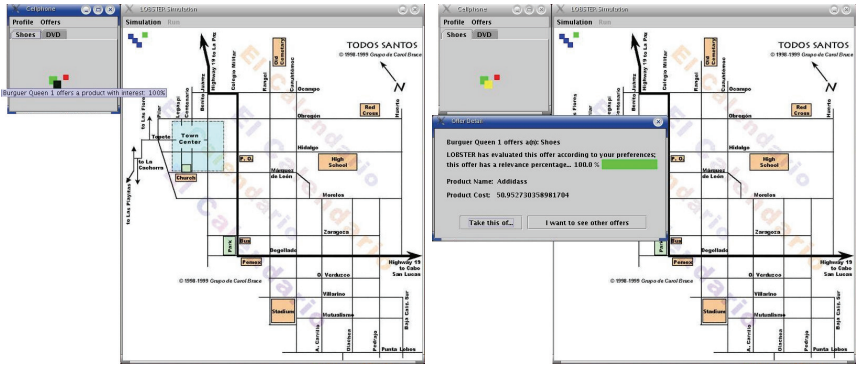
(a) Incoming Offers for Shoes (b) Incoming Offers for DVD

Fig. 5. Offers Received by the User

The relevance of these offers are represented in the cellphone screen varying the degrees of color, going from lighter to darker colors, and by messages on the screen, see Figure 6(a). The user can access this pictured information and see himself the complete message of the chosen product, 6(b).

The offers come in as the user moves adding any new store that fits the services and products list the user has. Every cycle a new set of evaluated (i.e., negotiated) offers is displayed on the screen for the user to check.

Moreover, and being this a dynamic system, the user can update the preferences he has by accessing the database (i.e., through the *Server Agent*); adding or deleting products or services, or changing his degrees of interest for each entry. The capability of updating profiles is also added to the stores that are in the



(a) Simple Displayed Information

(b) Complete Displayed Information

Fig. 6. Displayed Offers' Information

system (i.e., *Store Agents*), by changing the policies, proper of the store, that administer the offers and the negotiation procedures. All these database utilities are done in real time and considered for future negotiations in the system.

Furthermore, new and more participants, both clients and stores, can be added to the environment and, thus, be part of a future negotiation by setting each agent's profile through the user's interface. Finally, and for simulation purposes, the system offers extra tools that help visualize the system running, such as running the agents a chosen number of times, following a step-by-step execution or setting the speed in the system.

The observed results after running the system showed that our approach offers not only opportunities to the person (i.e., client) but also to the store. This is accomplished thanks to the negotiation in which agents engage once an opportunity is found. In general, a more personalized service is what has been added to the everyday purchase process; following the traditional bargain that is applied by humans, though. This feature makes the negotiation a powerful tool in the system since allows people pay the true value of what they are looking for and makes stores set up policies where client-oriented services are of high importance [13].

The agent-based brokering proved to be a powerful tool, providing information that many times is hidden to the normal person. This new information helped user (i.e., buyers) make a faster decision when deciding what to do about an item. Moreover, the system allows people to cancel any ongoing negotiation and set his agent *off* when he may not be interested in anything.

4 Related work

This paper relates to work on location-based services in general, and specifically work within learning personal agents with wireless devices [14], and e-commerce applications [15]. Location-aware applications are becoming increasingly popular as a consequence of the growing availability of consumer-oriented wireless networks and the emergence of locating technologies [8]. This fact is increased because of the wide range of services that rely on users' location information [3]. As such our paper is also related to these ones differing mainly that not only location is taken into account [6] but also the profile users and stores keep in the database.

There are numerous ways to exploit location to provide more relevant information, or derive new services. It can be particularly powerful when combined with other user profile information to offer personalized and location sensitive responses to customers [3], distinguishing between emergency services, mobile network operator services, and value-added services (VAS), focusing on the latter category as the primary e-commerce opportunity. It is in the VAS category that our work is in; however, differing [8] in the sense that our system is open to add a multi-attribute store profile and users' preference list enabling multiple negotiations.

Compared to the above mentioned proposals, our system provides:

- A *push* mode for bargains and special offers, which complements the more widespread "pull" proposals;
- A flexible negotiation architecture, which gives to individual stores the possibility of programming original negotiation strategies;
- Highly personalized services for the clients.

5 Conclusions

We presented an agent-based approach based on a middleware capable of brokering merchants –which are connected to the system in real-time– and clients –who can access in a highly personalized way the available offers from a mobile location-aware device.

We presented a first prototype of LOBSTER, in which the lower software and hardware layers are simulated, but which is useful for illustrating the capabilities of our architecture.

Being this our first prototype, there are still some things left to be done to enhance the capabilities of the Lobster System. Basically, these tasks are:

- Add more filtering characteristics in the user profile when looking for a product or service. This features may include cost, color, fabric, size, etc.; and personal settings such as age, gender, etc.; allowing the use of ontologies.
- Add more degrees of interest, in other words, the user should be able to choose intermediate levels of interest when setting up his profile. This will allow the "learning" of the profile by the system as time goes by.

- Using the previous features, create a more integrative utility function where this aspects are considered when ranking the offers and getting the highest *utility* for the client and the store. (e.g., finding an equilibrium among parts)
- Implement this system so that it can operate in a mobile device (i.e., cellular phones).

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References

1. Tsalgatidou, A., Veijalainen, J., Pitoura, E.: Challenges in mobile electronic commerce (2000)
2. O'Hara, K., Perry, M.: User centred opportunities for supporting consumer behaviour through handheld and ubiquitous computing (2003)
3. Steinfield, C.: The development of location based services in mobile commerce. Elife After the Dot.Com Bust (2004) 177–197
4. Varshney, U., Vetter, R.: Mobile commerce: Framework, applications and networking support. Mobile Networks and Applications **7** (2002) 185–198
5. Youll, J., Morris, J., Krikorian, R., Maes, P.: Impulse: Location-based agent assistance (2000)
6. Fano, A.E.: Shopper's eye: Using location-based filtering for a shopping agent in the physical world. In: Proceedings of the 2nd International Workshop on Autonomous Agents. (1998)
7. Youll, J., Morris, J., Maes, P.: Impulse: Location-based agent assistance. In: Proceedings of the 4th International Conference on Autonomous Agents. (2000)
8. Tewari, G., Youll, J., Maes, P.: Personalized location-based brokering using an agent-based intermediary architecture. Decision Support Systems **34** (2003) 127–137
9. Holtkamp, B., Gartmann, R., Weissenberg, N., Han, Y., Li, G.: Situation-aware service selection from large offers. Technical report, Fraunhofer ISST (2004)
10. Bellifemine, F., Poggi, A., Rimassa, G.: Jade - a fipa-compliant agent framework. In: Proceedings of PAAM99, London. (1999)
11. Rieger, A., Cissée, R., Feuestack, S., Wohitorl, J., Albayrak, S.: An agent-based architecture for ubiquitous multimodal user interfaces. In: Proceedings of the 2005 International Conference on Active Media Technology. (2005)
12. Loke, S.W., Zaslavsky, A.: Integrated ambient services as enhancement to physical marketplaces. In: Proceedings of the 37th Hawaii International Conference on System Sciences. (2004)
13. Hermann, F., Bieber, G., Duesterhoeft, A.: Egocentric maps on mobile devices. In: Proceedings of the 4th International Workshop on Mobile Computing - IMC 2003. (2003) 32–37
14. Rao, B., Minakakis, L.: Evolution of mobile location-based services. Communications of the ACM **46** (2003) 61–65
15. Ratsimor, O., Korolev, V., Joshi, A., Finin, T.: Agents2go: An infraestructure for location-dependent service discovery in the mobile electronic commerce environment. In: Proceedings of the 1st International Workshop on Mobile Commerce. (2001) 31–37