Integrated Ambient Services as Enhancement to Physical Marketplaces

Seng Wai Loke and Arkady Zaslavsky
School of Computer Science and Software Engineering
Monash University, Caulfield East, VIC 3145, Australia
{swloke@csse.monash.edu.au,a.zaslavsky@monash.edu.au}

Abstract

Ambient services are services that are related to the surrounding physical environment of the user, and can be considered a form of location-based services. Different kinds of ambient shopping services have been developed to aid users including brokerage services, navigational services, comparison shopping, product search, location-based auctions, wireless advertising, and even informational services where a user can point a device to a particular product or shop to find out more about it. With mobile devices, these services are made available at the point when the user needs it, for example, when they are at a shopping mall or in a busy tourist shopping complex. This paper proposes a conceptual framework of how a set of locally useful ambient services can be meaningfully organized based on the user's physical location and intended tasks to enhance a physical marketplace such as a shopping street or a shopping mall. We also outline an architecture for the system and how rule-based service composition can be performed on the client-side.

1. Introduction

We envision e-marketplaces which are counterparts of physical marketplaces: we do not only have the scenario of one being in a physical marketplace down the street (e.g., a shopping mall) and able to access some global e-marketplace or store (e.g., Amazon.com) from our devices, but also the scenario of one being in a physical marketplace and able to access an e-marketplace that is locally relevant and enhances the experience in the physical marketplace itself. Such location-based e-marketplaces can transcend geographical boundaries too, except not necessarily spanning continents but spanning neighbourhoods, streets, buildings, or shops. We might have a virtual sports shopping mall, which is an e-marketplace representing all sports shops within a 2 km radius, or a virtual designer-jeans shopping mall representing shops selling such items along a famous street. Hence, there is, conceptually, a superimposing of e-marketplaces and physical marketplaces, with added value to vendors and potential customers. For example, there is opportunity to extend the boundaries of stores beyond the physical store space - proximity advertising can act as a kind of "tractor beam" to attract prospective customers to visit the shop [19]; people can turn their "sale radar" on (opting on) to be a prime candidate for location-based targeted marketing communications, reply to ads to pre-register or hold an item or pre-order for instant consumption, or get into a "virtual red carpet" shopping tour. This means that the "conceptual size" of shops increases and there can be multiple "conceptual organization" of shops. There is also opportunity for anytime, anywhere B2B collaboration – for example, several stores at nearby locations can combine resources to create instant packages to lure buyers, or several businesses can provide a package for a day event (e.g., a football day in some area). On the customer's side, the e-marketplace can provide a facility for customers to establish coalitions (perhaps on-the-fly) based on current locations (i.e., proximity) and common interests.

Indeed, using location technology in mobile commerce is not new and has been labelled location-based mobile commerce (*or l-commerce*) where location finding technology is used with mobile devices to enable or enhance commerce. Examples of such work include location-based advertising where advertising is targeted not only based on user profiles but also the user's location, geo-information and route finding (e.g., "Where am I now?", "Where is the nearest WestPac ATM?", "Where is Y now?") [22], intelligent shopping assistants which provide suggestions and are sensitive to the user's location [3] and provide services triggered by proximity [23].

Further examples of work to support shoppers anytime anywhere, some using intelligent software agents, include Shopper's Eye [3], Impulse [6], MyGROCER [12,16], location-based reverse auctions [14], mobile online auctions [25], E-CWE [15], CRUMPET [7], GPS based location-based services [8], Web Services in mobile ecommerce [17], e-parking [2], wireless advertising [10], ad hoc coalition formation, and others as reviewed in [24]. Hence, there is a huge range of services some of which might be useful for different tasks and at different locations, resulting in the need to organize such services for the user.

In the rest of this paper, we focus on *ambient services* which we view as services that relate to the surrounding physical environment of the user, have geographical boundaries for their relevance and utility, and can be considered a form of location-based services. Such ambient services are enabled by short-range wireless networking technologies [11], such as wireless local area networks (WLANs) (e.g., the IEEE 802.11b (or Wi-Fi) LANs) with access points having a limited range of roughly 100 metres) and wireless personal area networks (WPANs) (e.g., Bluetooth (http://www.bluetooth.com) with a limited range of roughly 10 metres). WLANs (or "hot-spots") are becoming ubiquitous and are starting to appear in homes, offices and public places such as shopping complexes, airports, hotels, parks, and restaurants - a list of 802.11 access points can be found at http://www.80211hotspots.com/ [1]. The Bryant Park Hotel in New York lets its staff service guests using information provided via wirelessly networked devices.[1] Starbucks cafe is providing WLAN services to customers, but so far these services are of a horizontal (general) nature (Web, email, etc) (http://mcommercetimes.com/Services/155). Also, Bluetooth public access points are emerging. Ericsson's Bluetooth Local Infotainment Point (BlipNet)[2] technology provide access points to information for Bluetooth enabled PDAs and cellphones, and has undergone trials in public areas such as cafes, railways, and gas stations. The vision of the ubiquitous short range networks is also articulated in the Point Servers concept (http://www.pointservers.org). More recent efforts (e.g., the Pass-One initiative (http://www.pass-one.org/)) will enable roaming across different WLANs and Bluetooth networks, and even WLANs and GSM networks [20]. For example, one could connect to a WLAN while within range of its access point, then hand-off to a lower speed wireless telecommunications service once out of range, and then reconnect to another access point in a different WLAN; for example, iConverse provides this (http://www.useit.com/alertbox/20010916.html). An individual can move out of one cafe (and so out of that cafe's network) into another cafe (and so into this cafe's network) while still being in some other network. It is also possible for a user to be (within the range of and) connected to multiple networks at the same time (with some networks containing, are contained in or overlapping with others), provided the user's device has that capability, or if the different devices on the user (themselves inter-connected by a WPAN) are each connected to different networks. For example, one could be in a cafe in a shopping complex in some town, and so, could then be within (and connected to) three networks at the same time: the café's WLAN, the shopping complex's WLAN, and the town's network (and perhaps even to a fourth one - a wide area mobile Internet).

We propose a framework in which ambient services might be classified according to geographical boundaries of relevance and suitability to the task within the user's shopping process, where the shopping process model is based on the stages of the consumer buying behaviour as used in [5].

The rest of this paper is organized as follows. Section 2 describes three dimensions into which ambient services are classified. Section 3 provides an overview of an architecture in which these dimensions can be realized, shows how the combination of geographical boundaries and shopping task boundaries are used in calculating services, and outlines rule-based composition on the client-side. Section 4 presents related work and Section 5 concludes with future work.

2. Organizing Ambient Services

We describe three dimensions for classifying ambient services, and then describe how they are used together to classify services.

2.1. Geographical Boundaries

The location of the consumer within a physical marketplace provides hints concerning the relevance and usefulness of services. For example, we can envision a scenario where a tourist in a room within a museum might access (via his/her mobile device) an information service (via a wireless access point) that provides descriptions about articles in the room he/she is looking at as well as access services relevant to the entire city (being still a tourist, albeit a museum visitor) (via a different access point) (e.g., to book a

[1] See http://www.mobileinfo.com/News_2001/Issue34/Symbol_Bryant.htm
[2] http://www.ericsson.com/about/innovation/venture_blip.shtml

taxi). Hence, a user might utilize the locally adapted services of different networks. Also, since we expect each such network to provide a set of services to its members, an individual might therefore be able to access some combination of the services offered by the networks in which the individual currently dwells.

More generally, such services will have location boundaries as illustrated in Figure 1.

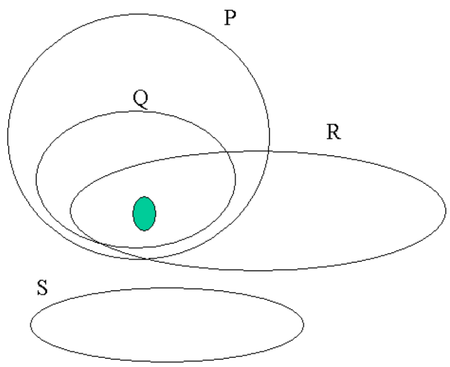

Figure 1. Boundaries P, Q, R, S for services.

In the illustration, we assume that a service p's boundary is P, i.e. only while a user U is in P is the service p active for U. Similarly, Q is the boundary for a service q, R is the boundary for a service r, and S is the boundary for a service s. The dark spot in Figure 1 represents a person located within the service boundaries P Q and R, and so is able to utilize services p, q and r, but is not able to utilize service s, not being within the boundary S of s. Such service boundaries might be located within another, for example Q is within P. Q could represent a service to obtain information about a particular museum exhibit, and P might be the boundary for services of the museum, and it is only when the user is 1m away from the exhibit is the user within Q. The argument here is that the developer of a service can use such service boundaries to demarcate, geographically, the area of relevance and utility of the service. Such boundaries also provides a filtering criteria for the user who then needs only be informed of services that he/she is currently within the boundaries of. We admit that not all services will have a meaningful geographical boundary of relevance but assume that ambient services, by definition, do.

As the user moves, he/she crosses service boundaries, moving beyond the boundaries of some services and moving within others. Hence, the set of services available to the user changes. The impact of such movements on the changing set of services was formally modelled in [13].

2.2. Task Boundaries According to the CBB Model

We use the CBB model which comprises seven stages, as described in [5] to classify ambient services, though some services might span several stages. The seven stages typically proceed sequentially.

1. *Need Identification*

In this stage, the consumer identifies a need for a product or service. Typically, this need can be stimulated via advertising, natural means (via conversations with other people), some user employed suggestion services, and peer recommendations. In the wireless environment, location-based advertising based on proximity to shops will fit into this stage, together with proximity-based "tractor beam" offers (as mentioned earlier). Otherwise, the need might simply come from the consumer himself or herself (e.g., the consumer feels thirsty or hungry).

2. *Product Brokering*

In this stage, the consumer determines what to buy to satisfy the identified need. Based on the consumer's criteria, a set of desirable products is created as a result of this stage, with information for evaluating product alternatives. In the wireless environment, various kinds of product comparison services might be invoked, or if permitted, access can be made to the greater Web concerning information required to make an informed decision. Given a user's criteria (including current location), services can be created which provide product recommendations to the user from shops in the neighbourhood. Friends in the neighbourhood might also be contacted to offer information about purchase suggestions. The consumer might also query shops in the neighbourhood concerning products available, for example, a virtual designer-jeans shopping mall, formed by a group of shops in the consumer's surroundings. If such a service is available, the consumer might be able to point to the product with his/her device and interrogate it for its price, make, etc, and also look it up in his/her cupboard to see if there are other matching products (e.g. in the case of clothings) (e.g. as in [4]). The consumer might also be able to show the product to friends via the device's built-in camera.

3. *Buyer Coalition Formation*

Coalitions among buyers might be formed on-the-fly to provide greater bargaining ability, but will require a service for buyers to communicate with each other concerning their buying intentions.

4. Merchant Brokering

In this stage, the consumer determines who to buy the product or service from. This stage involves merchant (or vendor) evaluation rather than product evaluation. Factors such as proximity of consumer from the shop can be utilized here, as well as delivery options – the user might decide to pick the item up him/her-self. Other factors taken into consideration, even in the non-mobile case, are price, reputation of merchant, and perhaps long standing relationships.

5. Negotiation

In this stage, the consumer discusses with the chosen merchant(s) (to reach an agreement on) the terms and conditions of the transaction. Such negotiation can occur one to one or involve multiple parties. For example, auctions might be carried out between multiple consumers for a product that a merchant is selling, or reverse auctions might be carried out between a consumer and multiple selected merchants.

6. Purchase and Delivery

In this stage, the consumer selects among payment options as acceptable to the merchant and makes payment. The delivery of the product is then performed.

7. Product Service and Evaluation

In this stage, the consumer provides feedback on the product or service to the merchant or to the product creators. Such feedback might be immediate or after a time.

The consumer can nominate to a system which stage he/she is currently at and in this way enable the system to suggest services that are relevant according to the specified stage. For example, if a consumer Jane is in the need identification phase, Jane can opt-in to receive wireless advertising concerning shops which are in the neighbourhood (or in the shopping mall, say), as well as receive suggestions from friends in the neighbourhood (if any) about what Jane might be interested in. Suppose Jane identifies a need. Then, in the product brokering stage, Jane might then utilize search services to find out where she can find particular items nearby, or send a query to friends who might recommend a suitable product or have seen it in the neighbourhood. Jane might also use an information service to find information (e.g., price, availability, etc) of alternative products sold in shops not more than several hundred metres away. Once Jane has narrowed her options down to one or several possibilities, she might then look for a suitable vendor (or it might have been found in the previous stage, as answers to product comparison queries) and compare alternatives. Negotiation or bargaining for the product from a chosen vendor might then proceed either via direct human communication or via technology (e.g., Jane makes a call, or her agent automatically negotiates on her behalf while she does something else). If Jane does not know where the vendor is located, she might utilize a navigation service that would lead her not only to the vendor but all the way to the product shelf. Note that Jane is free to change her mind and decides not to purchase a product or discovers that the need is no longer important. Subsequently, Jane organizes to pay or provide a down-payment for the product either at the vendor or via technology without needing to walk to the vendor's premises, and to arrange for pick-up.

There will be services that incorporates several stages of the above. For example, Jane might receive an advertisement concerning an offer for a type of Chinese food at a particular restaurant. She might then not have to consider other restaurants that sell the same food or alternative food and decide to take the offer up (and walks to the restaurant using the navigation services that came with the advertisement). Another example is the proximity-based reverse auctions [14], where the user issues a query such as "Who within a radius of 100m from me will sell me X for price P?" The system initiates a reverse auction among vendors within the specified area to answer this query, and so, via handling of this query, the merchant is determined and the price negotiated.

A consumer might not be shopping for a service or a product only but several. For example, a consumer leaves the house for a shopping mall, and employs parking services to negotiate and rent a parking space upon arrival. Thereafter, the consumer reenters the above stages but for a different product (e.g. tennis shoes). In addition, the consumer might be at different stages concurrently with regards to a number of products or services.

2.3. Task Boundaries According to Consumer and Shopping Roles

A consumer might become a provider (or when charging is used, a vendor) of a product or service. For example, an individual having some free time can begin to provide information services (e.g., navigational guidance, opinions, or help in product searches), in the context of a virtual community formed by mobile device users in a neighbourhood (e.g. as proposed in [13]). Moreover, an individual can also sell its digital screen estate to vendors who are willing to pay (in terms of monetary units or incentives) to have their advertisements on the user's device.

We note that further refinement of the consumer's shopping intentions can be made if the consumer also provides the shopping role as described in [21]. Examples of such roles include 'father of a teenage girl', 'son for mum's birthday', etc. According to this role, appropriate services can be selected to help the consumer. Such roles help in the need identification stage of the CBB model, by conveying hints about the reason for shopping.

2.4. The Service Classification Space

The three dimensions described above forms a service classification space as illustrated visually in Figure 2 below. There are services that extends over different portions of the space, when they are relevant in multiple stages, multiple locations and multiple roles.

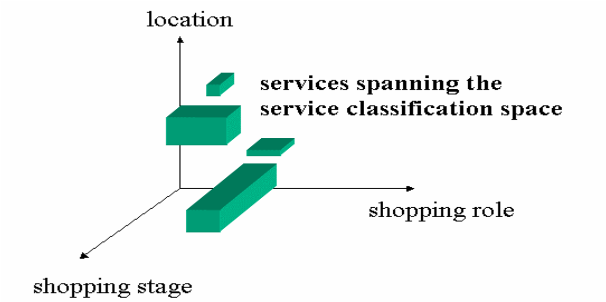

Figure 2. The three dimensions for organizing services. The solids represent services within the service classification space.

3. Overview of an Architecture for Integrated Ambient Services

In this section, we give an overview of a client-server architecture for integrated ambient services organized based on location and task boundaries. Figure 3 illustrates the main components of the architecture.

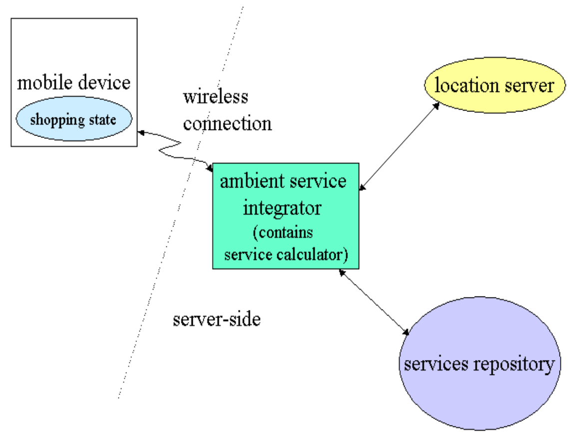

Figure 3. An Architecture for Integrated Ambient Services

In Figure 3, a client connects over the wireless network to a system we call the *ambient service integrator*. The ambient service integrator has access to a location server which tracks the location of the client mobile device. Note that there are a number of ways for obtaining location information such as GPS or WLAN-based methods. We assume in the above diagram the case of an overlapping wireless LAN infrastructure where the location of the client device can be obtained via triangulation by the location server of signals from at least three wireless access points. We did this in our prototype using the Ekahau Positioning Engine (www.ekahau.com) which is calibrated to map signal readings to logical locations.

3.1. The Service Calculator

The main function of the ambient service integrator, embodied in a module which we call the *Service Calculator*, is to calculate the set of services which should be available to the user at a current point in time, taking into account the user's location and shopping state (forwarded from the client device), which includes the user's shopping role and shopping stage for each service/product being considered. Note we assume a service-side calculator but store shopping state on the client side, where the shopping state is readily updateable by the user. The service calculator recalculates the user's services each time the user changes location (i.e., cross a service boundary) or each time it receives an updated shopping state from the client device (e.g., when the user manually changes his/her shopping role). The output of the service calculator which is the set of current services for the user is forwarded to the client device to be displayed. The service calculator accesses a database (the service repository) of associations where logical geographical areas are mapped to services, buying stages are mapped to services, and shopping roles are mapped to services, and depends on the location server to return the location of the client device (and therefore which services whose boundaries the user is currently within).

To illustrate the algorithm of the service calculator, we assume the following mappings (which differ between persons, depending on the degree of personalization):

1. *roleToServices* which maps a shopping role to a set of services related to this role.
2. *locationToServices* which maps a location to a set of services relevant to the location (For example, if the location of the user is such that it is within the boundaries of services p, q and r, then this function returns {p, q, r}. Note that this function would require a database of the service boundaries of services to compute its result.).
3. *stageToServices* which maps a buying stage to a set of services relevant to the stage.

We assume that the range set of the three functions above are the same. Such mappings might be stored in external databases and maintained by administrators. We envision that different locations might maintain their own set of services. For example, a shopping mall will maintain its own set of services for users in the mall, and a shop within the mall might maintain its own set of services. Hence, to evaluate *locationToServices*, the ambient service integrator also needs to query the appropriate servers (which we assume here, for simplicity, that it knows about).

In the expression below, the variable **curr_role** represents the current shopping role of the user, the variable **curr_location** represents the current location of the user, and the **curr_stage** represents the current buying stage of the user, then the Service Calculator computes (logically) the following set of services:

roleToServices(**curr_role**)
∩ *locationToServices*(**curr_location**)
∩ *stageToServices*(**curr_stage**)

The intersection suggests a filtering of services based on the three dimensions. **curr_role** and **curr_stage** are part of the shopping state. The user can choose not to utilize any one of these dimensions, and manually update these parameters, thereby effectively, composing queries to the system. When the value of **curr_location**, **curr_role** or **curr_stage** changes, the above expression is recomputed.

3.2. User's View

On the mobile device itself, the user views a list of services available as computed by the Service Calculator and forwarded from a server. The location and task boundaries can be used to structure the user's view. For example, the list can be categorized according to logical geographical areas (which can be, in turn, structured, according to a geographical containment relation), or according to the products/services being considered (the user might be at a different stage of the CBB model with regards to different products/services). Given a list of services, the user can select a service to invoke, connecting directly to the appropriate server (e.g. given the URL for a Web service).

3.3. Service Composition

Given that once a set of services have been forwarded to the client device, we can provide a feature to allow the user to initiate a search for interesting compositions of services. We intend to utilize a symbol rule-based method for this purpose, using forward chaining. For example, given the following rules:

X <u>requires</u> S1 and S2 and S3
Y <u>requires</u> S1 and S2
S1 <u>requires</u> S6 and S7

which indicate that a composite service X requires services S1, S2 and S3, service Y requires S1 and S2, and S1 requires S6 and S7, by forward-chaining, if services S6 and S7 are discovered, then S1 can be composed, and if S2 and S3 are too discovered, then X can be composed, and so, S1 and X can be added to the list of available services for the user. Similarly, Y too. So, the search for compositions of services is a forward-chaining procedure involving the "requires" rules, and the forward-chaining search can be initiated by the user or done automatically by the client-side part of the system. Activation of a composite service will activate the required component services according to the rules.

The rule-base can be forwarded or retrieved on-demand from the server-side. The advantage of client-side processing is not only to reduce server load but also permits the user to decide when and where to initiate such a search, and whether such a search is necessary.

4. Related Work

Service domains are similar to the notion of location contexts in the AROUND architecture [9] and so, can be viewed as a means of location-based service discovery where as the user moves, the service domains the user is in changes and consequently, the set of services "discovered" and made available for the user. Service domains are tightly associated with a set of services and effectively groups together services which have the same geographical area of relevance and utility. However, we address an issue mentioned but not addressed in [9] of computing services for a user in several service domains at the same time, i.e. when service domains overlap, and of incorporating other contextual information such as role and CBB stage.

There has also been a lot of work on composing Web services (e.g., [17]). Our work considers mobile Web services and is complementary to such work. We are not composing individual services but sets of services for determining what services should be available to a user.

Ambient Intelligence[3] is a recent project for building environments that are aware of the presence and context of people, and sensitive to their needs. Much richer context information is needed for their purpose but this paper has explored three aspects of ambient services, which is their geographical boundaries, roles, and CBB stages. Our approach is also usable in a variety of context-aware applications.

5. Conclusion and Future Work

The topic has been *ambient services* which we view as services that relate to the surrounding physical environment of the user, have geographical boundaries for their relevance and utility, and can be considered a form of location-based services. We believe that there will be a large variety and diversity of such services. Hence, our contribution in this paper is a conceptual framework of task boundaries (according to shopping roles and the CBB model) and geographical boundaries for organizing such ambient services, not just to structure the user's view of services to alleviate the cognitive load for the user on-the-move, but as inputs to a service calculator which can proactively determine for the user what services it thinks would be relevant and useful according to the user's location and shopping context. We admit there will be other services which might not fit into any shopping stage or role but will be location-dependent (e.g., weather or event services). We have also described a client-server architecture to realize integrated ambient services, where we pointed out the key ingredients for an implementation. We are currently prototyping the proactive update of ambient services based on the Ekahau WLAN-based location server technology (http://www.ekahau.com/), and .NET Compact Framework on a PocketPC to access Web services. We plan to use a rule-based system such as Jinni (http://www.binnetcorp.com/Jinni/) to do inferencing on a PocketPC.

Previously, we have developed a proximity-based reverse auction service [14] and a service for auctioning off screen estate using JADE-LEAP agents in the Java platform. Future work involves integrating these and other systems as Web services into the prototype. Management of services also need to be handled, when a user moves outside of the boundary of a service that has been invoked but not completed. We are considering DAML-S based metadata descriptions of services in our compositions. In the future as different kinds of networks become accessible using the same device, concurrently or otherwise, and services proliferate, we envision an even greater need to integrate services in a structured way to reduce the cognitive load on the user and a need for proactive suggestions and aid from a system. Privacy issues will also need to be considered.

[3] http://www.extra.research.philips.com/euprojects/ambience/

5. References

[1] Ahlund, C., Zaslavsky, A. and Matskin, M. Supporting Mobile Business Applications in Hot Spot Areas with Pervasive Infrastructure. In *Proceedings of the 1st International Conference on Mobile Business*, Greece, July 2002.

[2] Attane, M. and Papi, J. E-PARKING: User-Friendly eCommerce to Optimize Parking Space. In *Proceedings of M-Business 2002*. http://www.mobiforum.org/proceedings/papers/05/5.1.pdf

[3] Fano, A. SHOPPER'S EYE: Using Location-Based Filtering for a Shopping Agent in the Physical World. In *Proceedings of the International Conference on Autonomous Agents*, ACM Press, 416-421, 1998.

[4] Gershman, A., McCarthy, J., and Fano, A. Situated Computing: Bridging the Gap between Intention and Action. In *Proceedings of the 3rd International Symposium on Wearable Computers*, October 18 - 19, 1999, San Francisco, California.

[5] He, M., Jennings, N.R. and Leung, H. On Agent-Mediated Electronic Commerce. IEEE Trans on Knowledge and Data Engineering 15 (4), 2003. (to appear)

[6] Impulse: Location-based Agent Assistance, *http://agents.www.media.mit.edu/groups/agents/projects/impulse/*.

[7] IST-Crumpet. http://www.ist-crumpet.org/

[8] Jagoe, A. *Mobile Location Services: The Definitive Guide*, 2003, Prentice Hall.

[9] Jose, R., Moreira, A., Rodrigues, H., and Davies, N. The AROUND Architecture for Dynamic Location-Based Services. Mobile Networks and Applications 8, pp. 377-387, 2003.

[10] Kolmel, B. and Alexakis, S. Location Based Advertising. In *Proceedings of the 1st International Conference on Mobile Business*, Greece, July 2002.

[11] Leeper, D. G. A Long-Term View of Short-Range Wireless. *IEEE Computer*, 34(6): 39-44, 2001.

[12] Kourouthanasis, P., Spinellis, D, Roussos, G. and Giaglis, G. Intelligent cokes and diapers: MyGrocer ubiquitous computing environment. In *Proceedings of the 1st International Mobile Business Conference*, pages 150-172, July 2002.

[13] Loke, S.W. Modelling Service-Providing Location-Based E-Communities and the Impact of User Mobility. In *Proceedings of the 4th International Conference on Distributed Communities on the Web* (DCW 2002), (eds) J. Plaice, P.G. Kropf, P. Schulthess, J. Slonim. Sydney, Australia, April 3-5, 2002, pages 266 - 277, Springer-Verlag, Lecture Notes in Computer Science 2468.

[14] Loke, S.W. An Exploration of Agent Assistance for Physical Marketplaces: Proximity-Based Reverse Auctions. In *Proceedings of the 2003 International Conference on Intelligent Agents, Web Technologies and Internet Commerce* (IAWTIC 2003) (*to appear*). http://www.csse.monash.edu.au/~swloke/writings/W2.5-3.pdf

[15] Maamar, Z., Yahyaoui, H., Mansoor, W., and Vd Heuvel, W-J. Software Agents and Wireless E-Commerce. ACM *SIGecom Exchanges* 2(3), 10-17, 2001.

[16] MyGrocer Project. http://www.eltrun.aueb.gr/mygrocer/.

[17] Piccinelli, G., Finkelstein, A., and Williams, S.L. Service-Oriented Workflows: the DySCo Framework. In Proceedings of the Euromicro Conference, Antalya, Turkey, 2003. (to appear). Available at http://www.cs.ucl.ac.uk/staff/A.Finkelstein/papers/euromicro2003.pdf

[18] Pilioura, A., Tsalgatidou, S., and Hadjiefthymiades. Scenarios of Using Web Serivces in M-commerce. ACM *SigEcom Exchanges*, Vol. 3, No. 4, pp 28-36, 2003.

[19] Newell, F., and Newell, K. *Wireless Rules: New Marketing Strategies for Customer Relationship Management Anytime, Anywhere*, McGraw-Hill, 2001.

[20] Nikolau, N., Vaxevanakis, K., Maniatis, S., Venieris, and N. Zervos. Wireless Convergence Architecture: A Case Study Using GSM and Wireless LAN. *Mobile Networks and Applications* 7, 259-267, 2002.

[21] Stolze, M. and Ströbel, M. The Shopping Gate - Enabling Role- and Preference-Specific e-Commerce Shopping Experiences. In Web Intelligence: Research and Development, N. Zhong et al. (Eds.), Lecture Notes in Artificial Intelligence Vol. 2198, Springer Berlin, pp. 549-561, 2001.

[22] Tewari, G., Youll, J., and Maes, P. Personalized Location-Based Brokering Using an Agent-Based Intermediary Architecture. In *Proceedings of the International Conference on E-Commerce*, Seoul, Korea, 2000.

[23] Troel, A., Banatre, M., Couderc, P., AND Weis, F. Predictive Scheme for Approximate Interactions. In *Proceedings of the International Workshop on Smart Appliances and Wearable Computing* (IWSAWC'01), pp. 235 – 239, 2001.

[24] Varshney, U., and Vetter, R. Mobile Commerce: Framework, Applications and Networking Support. *Mobile Networks and Applications* 7, 185-198, 2002.

[25] Matthias Wagner, Wolf-Tilo Balke, and Werner Kießling. An XML-based Multimedia Middleware for Mobile Online Auctions. In J.Filipe, Sharp, B. and Miranda, P. (Eds.) *Enterprise Information Systems III*, pp. 259-269, Kluwer Academic Publishers, The Netherlands, 2002.