Towards Integrating Agents with Objects Tracing Systems in AmI.

Sameh Abdel-Naby, Paolo Giorgini and Raian Ali

University of Trento,
Department of Information and Communication Technology,
Via Sommarive, 14 - 38100 Povo(Trento), Italy.
{sameh, paolo.giorgini, raian.ali}@dit.unitn.it.

Abstract. Innovative information systems related to *Asset Tracking*, *Inventory* and *Shelving* are often involving advanced monitoring technologies such as RFID. These technologies handle the user authentication and objects verification part of the general architecture. Some problems are observed while applying these technologies, for example, those related to privacy and security issues, and the system's disruptive behavior in case of crowd checkouts (e.g., Supermarket and Airports). We focus our research on resolving the jamming situations occur when many objects are moving at the same time and in the same direction toward a specific checkpoint. Addressing these disadvantages, we propose a possible integration between *Intelligent Agents* and existing RFID back-end systems. This integration would allow objects (e.g., passports or goods) with RFID tags in it to be better checked-out through the RFID-readers located in a particular environment.

1 Introduction

Software agents are characterized by two major characteristics, independency and intelligence. In a certain location - *where Agents techniques are applied*, users expect the delegated application to fulfill a set of requirements that are difficult to be realized alternatively. Existing literature is showing Agents capabilities to efficiently achieve a given goal or task autonomously and with minimum users involvements. For example, in ToothAgent [1] users of pocket devices are able to configure a preinstalled application to produce an agent that carries user's desire of a service, such as used books exchange. Relying on Bluetooth as a communication bridge, users can communicate with different network servers located in remote environments (e.g., university campus). As a result, a task is realized on behalf of the user and communicated with service participants for final decision.

ToothAgent and similar implementations [2] have always been involving the use of advanced communication methods such as Bluetooth and Wi-Fi to construct a relationship among users on the go. Another advanced and promising communication method, which is increasingly used in many markets and research areas, is the Radio Frequency Identification (RFID). Indeed, this technology is

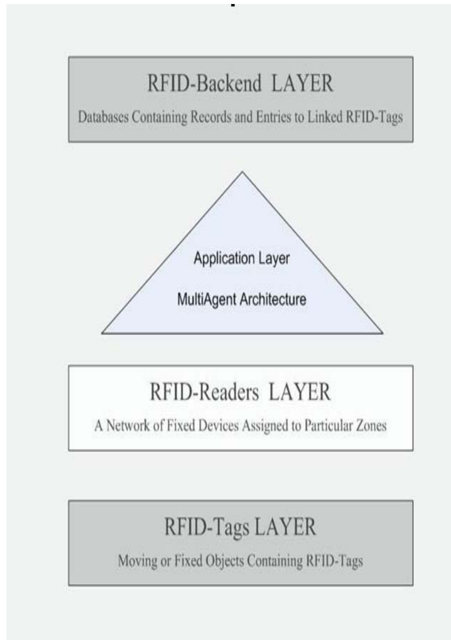

Fig. 1. Positioning Agents within the Standard RFID Design Architecture.

efficient and cost effective. Basically, using an RFID-Reader, standard radio frequencies are used to retrieve data that is stored on small devices or a chip, better known as tags. Some of these tags are sophisticated, editable, and used for vital applications such as E-Passports [3]. Other tags have simpler architectures and they are one-time edited upon manufacturing, and accordingly they are used only for cost-effective applications such as those of Supply Chain Management.

A simple RFID architecture contains three main parts: 1) The Tag that identifies a specific object (e.g., an animal [4] or a product); 2) The Reader that reads whatever data edited on the embedded tags and, 3) The Back-end System that has a single or a network of databases that converts the tag contents into useful application entries. We consider RFID as another emergent technology that has a great potential to integrate with a range of computer or pocket based applications. This integration - shown in figure 1 - would improve the identification of a particular environment surrounding objects and, it will establish a tangible communications with fixed or moving system entities that play a fundamental role in explicit service architecture.

To elaborate more on the exact problem we target, recently RFID became commonly used in stores to identify and checkout goods, and at the airports for borders check-in and check-out and documents verifications. Yet, in both cases human personnel is remarkably employed to follow and control the data obtained. If all of the products in the supermarket are tagged, all what a costumer will have to do is to pick what she/he wants and pass through a gate that is

RFID-Reader enabled. The system will quickly read the data previously stored, identify the objects, and electronically charge the costumers credit card or any other pre-defined payment method. Advantages like avoiding long queues and the automation of several daily life tasks are what make these architectures useful. Disadvantages like the scamming and jamming possibilities are what bring hesitation.

The core reflection of this paper is about tying together software agents and RFID-based applications so that objects carried by frequenters of a specific location are intelligently checked out earlier than expected.

This paper proceeds as follows: Section.2 Shows gives an overview of the general intentions to move towards a smart ambient that is highly dynamic and responsive. Section.3 explains the newly recommended architecture. Section.4 introduces the integration between Agents and RFID-based architectures. Section.5 describes the advantages of such integration. At last, we briefly demonstrate some of the related work.

2 Towards a Dynamic Responsive Environments (AmI)

Approaching an ambient that is perceptive, intelligent, and active will involve multiple disciplines to contribute in creating the final scene. Several researches are being done in AmI area, with some differences in emphasis and direction. Multiple terminologies are being used as this research is in its first steps. In the rest of this section, we will investigate the vision of Ambient intelligence (hereafter AmI), and try to capture a variety of disciplines that need to meet in order to achieve this vision.

Philips vision of AmI [9] is based on shifting computers into the background, and supporting the ubiquitous computing with more awareness capabilities. The vision is based on three elements, 1) the ubiquity, which refers to those computing devices intertwined with human environment anywhere, and functioning anytime, 2) the transparency of such computing systems, so they are hidden in the background, 3) and the intelligence; they should act instead of being only responsive to human commands. Such system relieves people of thinking about many repetitive needs and takes the initiative of doing what should be done in the correct moment and approach.

MIT vision of AmI [10] similarly views it as an unobtrusive integration of computing with our daily life. Such computing provides humans with relevant information and performs necessary tasks when needed on their behalf. Such ambient will be continuously careful, doing the suitable tasks in a transparent, invisible and intelligent way. Traditionally, computers work as an apparent messenger or mediator between humans and environment. In AmI, this relation is replaced by direct non-disruptive relation between humans and the environment they are located within. In short, AmI computing is no longer visible.

The vision of invisible disappearing computers was addressed by Weiser [11]. The vision expected ubiquitous existence of computing and communication capabilities anytime and anywhere. AmI focuses on assisting the intelligence and awareness of this ubiquity of interconnected computing devices, so computing starts to take the initiative on behalf of human. AmI is meant to orchestrate the variety of environment objects in a way they might interoperate to do more complex tasks as well. Ubiquity of computing is the basis an AmI is built on. However, the terms ubiquitous computing, pervasive computing, ambient computing, ambient intelligence are now used interchangeably with some differences in the context and emphasis.

AmI is now about integrating computing devices with the environment we all live in; it is then sitting on the opposite side of virtual reality which brings world inside computers [11]. This makes computers invisible and relieves people mind of even knowing about their existence. To arrive this point, computers has to adapt to user needs and character by contrast of the traditional scene in which user is supposed to adapt to computer systems. This is now of great importance because people spend increasingly more time to interact with computing systems. To people, it is becoming a source of stress being obligated to remember when and what and how to do tasks. With AmI, artefacts encapsulate implicitly the role of computer mediation. Artefacts will look as they have their own character, autonomy, and intelligence, they are more agents than normal objects.

Distributed intelligence is needed to cover this intelligent ambient, it is now composed of distributed intelligence units that we might call Agents. New hardware design is needed for embedding computing devices invisibly inside the surrounding physical environment. AmI system is situated within a highly dynamic environment that is open for changes, these changes need to be sensed and interpreted in a way that is timely fashion and relevant to what might serve user needs. The input now is coming implicitly, and continuously from a variety of sensors, cameras, and other kind of peripherals. Such environmental information need to be modeled and reasoned about in order to take the correct contextual decision.

Computer disappearance was considered by Weiser as one of the most profound technology features [11]. Apart from the physical disappearance of computing devices, there is that mental disappearance toward peace of mind in human life. To achieve such peace of mind, the interaction between human and computer is updated to direct interaction between human and environment [18]. New novel ideas of interaction design have to be invented to move from the explicit interaction to an implicit one [12]. The implicit interaction includes the notion of implicit input known more commonly as Context [13].

Context awareness [14][15] is an essential feature an AmI system has to tackle in order to act in adaptive and intelligent way. This context, that might be spatio-temporal, environmental, personal, social, and so on, needs to be modeled, captured, analysed and reasoned about [17]. Reasoning about context needs a model and formalization acts as a knowledge base, and enables inferring more high level knowledge. For example blood pressure and body temperature besides user current activity and location might reveal user current mood, this mood can be provided implicitly as an input, so AmI might take some actions as a response.

AmI is expected also to have the ability of learning and keeping track of human historical behavior. AmI embodies a high degree of personalization to human profiles and life styles. Software personalization is a standalone research now, but we might hardly consider AmI as a useful system if it behaves in the same way with different kind of people and characters. The social mobility of humans is another important issue an AmI application needs to consider. People normally play more than one social role; they should be accordingly supplied by tailored services and information considering their social context [16].

AmI arises many social issues that need to be studied and analysed before AmI can get acceptance in practice. The ubiquity of computing might relieve people mind in one hand and might have negative impacts as well. People will feel that they lost control, and might not trust technology. People have already lost some privacy providing that cellular phones enable other party of at least knowing their location, and the same for using credit cards. Instead of commanding computing, computing in AmI is supposed to control several aspects of people everyday life. An essential principle in this regard is that human do not feel that they lost control, and to enable them configuring their needs in a simple way, may be through some privacy patterns. However, we see many interesting practical domains that can benefit from AmI scenarios, such as the health care domain, in particular those specialized of caring old people, and supporting persons with dementia problems, where AmI might play the role of caregiver.

3 RFID Architectures: Different Perspective.

The RFID system design is basically about the communication established with mobile tags that are attached to all of the objects located in a zone, which is covered by RFID-Readers. These RFID-Readers are able to establish a channel of communication, read the tags and, and trace the move of these objects within a certain range - the coverage area. Data stored on these tags can later be converted into a machine-readable format and accordingly used by the machine. When an object carrying an RFID tag is checked into the back-end system, it corresponds to a particular set of data that distinguishes the tag-holder and an object's specific characteristics from others. Since the locations of these objects are already known, we can easily refer to each set of tags (e.g., using serial number or MAC address) according to the location.

Let us consider the example of a situation in a store where different product categories are arranged in different locations according to their origin and prices. It is quite common that a customer would go into a supermarket and to find all of the crackers in one side and the soda drinks in another, and so on for the rest of the goods. It is like having the floor of the store marked with different areas and each area has its own belongings. In a real-world situation, an RFID-Reader is located on top of a block of shelves and it communicates with the products located within its coverage area, so if the customer leaves the detergents section and he/she searches for a product in the sweets' one, the product he/she has picked first is no longer belonging to coverage range of the former RFID-Reader and now is located within the coverage range of another RFID-Reader (Freq.

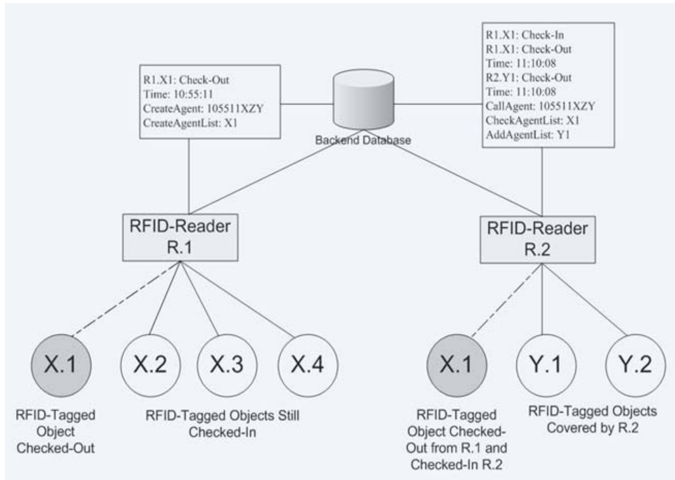

Fig. 2. RFID Architecture that uses Agents to early check-out its users.

13.56 MHz with Less than 5 M or Freq. 915 MHz with read range of 5 Meters).

When an object containing an RFID tag is scanned by one of the Readers, the data on this tag is communicated with the back-end system and verified for accuracy and, sometimes, related tasks are launched to determine some other characteristics (e.g., price, expiration and weight). This communication usually takes place when a product is being checked out of the system, or whenever an object is signed to be located out of the architecture coverage range. This process of sign-in and out can be adopted in similar smaller phases within the purchasing process. As we explained in the above-mentioned example, the RFID reader responsible for each zone sign the goods in and out depending on the availability of these objects within its marked area. A reader will be launching a review process for the assigned objects within a pre-defined timeframe (the average time for someone to decide about obtaining a product). Once a product is not available or is added to the list of assigned ones, the reader automatically recognizes the check-out or in for an object. Software agents can play a central role in this process by monitoring the check-outs and check-ins within a single RFID Reader whenever it is time to communicate with the back-end system to verify the new situation (see Figure.2).

During this communication with the back-end system a platform of agents can be installed. These agents will carry the data of the checked-out items from the list of assigned products of a specific RFID reader, and then hang in the network waiting for the same data to be checked somewhere else. This process can be realized by implementing a method that compares the data that the agent carries with the newly checked-in data within the overall system. This will help accumulate the objects list within a system having check-out from a zone and check-in from another, all in the exact time, which refers to a certain purchaser moving with his/her cart from a zone to another.

3.1 Agents Performance and Organization.

Considering the above-mentioned example, in which each product will be assigned an agent able to maintain its future and present statuses within a single environment (e.g., a supermarket), the agent will have to coordinate with other agents to form group of Agents which, would create a profile of a certain group of moving products - *accordingly identify a specific customer and his/her interests* - and link the products checking-in time and zone with the rest of the carried items. We finally shape a group of agents that are able to communicate and benefit the shopper in several ways. One advantage is reviewing the customer's accumulated product list and accordingly communicates with the customer through, for example, a Bluetooth mobile communication about similar promotions or newly-offered products.

Another advantage is that agents, while checking out, will be managing to have most of the products going through the checking out module on-the-fly with the customer move in a specific zone. This can take place simply by reviewing the already existing list every pre-defined time and update the list with the new products. Consequently, whenever it is time for the customer to be located near to the final checkout gate, RFID-Readers close to the checkout gate would launch a final comparison process of the two product lists; the one that the agents managed to establish while the customer moves in the zone and the other that the customer is leaving the place with. Therefore, a jamming by the checkout gates will be avoided.

An RFID-based early check-out system will be basically concerned with fulfilling two main functions. One is the RFID-tagged object that is checking-out of a certain zone and the other is the RFID-tagged object that will be checking-in in another zone. System inputs and outputs will be given, sent, and generally exchanged among these two actors. In turn; the connection between back-end system, RFID-Reader and RFID-Tag should be well-established and robust. The same should be done for the communication between the back-end systems, integrated with the Multiagent layer, and the zone-walker, providing the user with extra services (e.g. passport checkout gate directions and new product offers and promotions). A mobile-based application is chosen for these types of human-objects interactions, thus, standard mobile phones relations are taken as a method of communication. Nevertheless, and autonomous agents will be negotiating the check-out/check-in details and finally communicating the final results with the mobile user. Similar architecture - selling used books for student and carpooling - was described by scholars [1, 2] (see basic overview in figure 3).

3.2 Anticipation Strategy.

Autonomous agents that take part of a multiagent system that is basically built from a society of autonomous interacting agents are well-known with their capabilities to achieve difficult organization and negotiation tasks within a certain

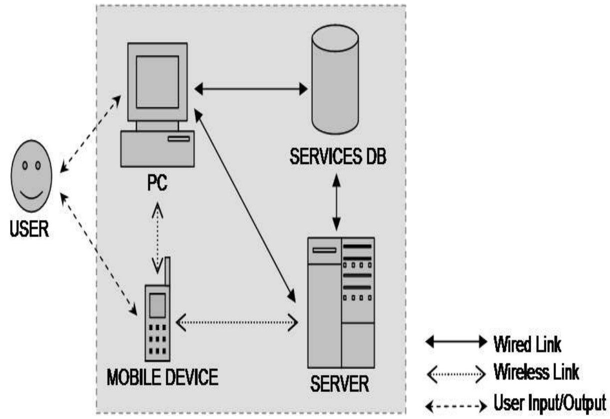

Fig. 3. Interactions of System Components in ToothAgent [1].

community. Consequently, the use of autonomous agents in RFID early check-out systems is a reasonable choice. Our suggested scheme will be using any-time algorithm suggested by scholars [8] that is expected to help us solve the problem of tasks allocation, which accordingly will help the check-out/check-in requests routing within a community of autonomous agents. As a result, agents are expected to shape an alliance to better perform a certain Tagged-Object request between multiple zones.

3.3 RFID Architectures - *a different perspective.*

The RFID Architecture in our case is composed of customized RFID features and new integration of technologies and capabilities on the software layer, like a Multiagent system, and on the hardware layer which consists of two components: the Device Layer and the Network Layer. On the Device Layer, it consists of the actual hardware and software of the individual RFID devices on the network. These devices can be any number of RFID-Readers and Location Servers. The increase of the number of the Readers available can be observed, as each reader will be responsible for a particular zone. The method of communication between the reader and the location server will be reliable enough not only to update object details, but also to exchange information requests and queries related to the move and the combination of a set of objects.

On the Network Layer, a middleware platform will be implemented, as it supports objects checking in and out, reading, writing, filtering, grouping and routing of data generated by RFID-Readers. Within this layer, the expected Multi-agent application would be developed so that readers can communicate with each other throughout the interactions and coordination of Agents, as if Agents are the language spoken among RFID-Readers. So at the end it is all made clear that the objects grouped in this shopper/walker profile are checking out of the system and they are adequately verified.

4 Integrating Agents and RFID.

Integration between cellular phones and RFID infrastructures is feasible. A previously proposed framework, SpatialAgent [5], aiming at providing mobile users with services based on their locations, utilized an RFID-based location model to identify objects and users' locations, and a location-information-servers (LISs) to manage location sensing systems and agent devices. In this system, agents have a graphical interface that allows their interaction with users who can freely customize them. Also, a related research, "follow-me" [6] - conducted by Cambridge University's Sentient Computing Project - assumed that a space is equipped with tracking systems (e.g., RFID Network) that help the location identification process of both users and objects.

These integrations open a window of opportunity for developing a service-oriented framework that can help a walker within a certain environment to better explore the surroundings. On the other hand, another window is open wide in offering commodities and showing promotions, which will help improve the management of a certain environment.

4.1 User-Profile Adaptation.

Tools to set up an accurate customer profile may include: 1) knowing what a shopper is interested in; 2) understanding what sort of products combinations he/she makes; 3) analyzing the sequence of moves he/she makes within a specific area, and 4) sound techniques of analysis. These tools will lead the RFID application layer to better manage the tagged objects to best fit in user profiles. Other advantages can also be realized.

For example, assume that the system record shows that three different shoppers in a supermarket have picked a certain tomato paste from zone A, that they have included in their list of objects a certain pasta brand from zone F, and that the same shoppers usually move from zone A to zone F and never the other way around. Based on this record, a restructuring process for the locations of the products can be made to facilitate the movement for shoppers, such as replacing zone F with zone B. On the RFID application layer, one of the possible integrations can be made with the Profile Extractor (PE) [7] which is a module that classifies users using supervised learning techniques. It can be used to discover users' preferences by analyzing data relevant to a user's interaction or data that are gathered from different sources (e.g. data warehouse or transactions), this happens so the system could suppose a set of regulations that help in relating this user's behavior.

4.2 Concept Generalization.

The RFID tags can transmit in different frequencies, a characteristic that makes it readable from different distances. A 13.56-MHz tag can be found by a RFID-Reader within 10 inches, but a 915-MHz tag can be read up to 10 feet away. This increases the probability that an object would be scanned on-the-run. Similar to WiFi networks or cellular phones, RFID tags are relatively easy to jam when using power at the right frequency. The electromagnetic or electrostatic coupling in the RF (radio frequency) part of the electromagnetic spectrum is used to transmit the signals. This coupling makes the RFID jamming occurs usually at the airport gates, as all arriving passengers rush to the exit at the same time.

A checkout process at airports is another area of interest where Agents techniques can be applied.

If a RFID-Tagged passport holder is moving from a zone to another inside the Arrivals Hall and the system records these movements and creates an Electronic-Passport (E-Passport) holder profile, an early checkout can be predicted and initiated. Moreover, a pre-defined checkout path can be taken into account, as mentioned above, by intelligent agents recording and learning from the frequent moves of E-Passport holders. When it becomes clear that a passenger is moving from point X1 to X2 and then checkout at X3, the system will be able to assume the probability for the check-out of this passenger, as if agents have their own virtual communities in which they learn from each other and facilitate the actions to be taken by the general framework. Also, agents will be able to predict passengers' movements within limited environments (airports).

5 Conclusions

This paper introduced a preliminary outline for Agent RFID integrations, a new technique for providing location-based services. When a pre-defined list of RFID-Tagged objects moving within a bordered zone, an agent is created for each walker or shopper, adding to its profile the objects he/she is picking, correlating the RFID tags check in and check out time from different zones with the moves taken inside this environment. We have discussed how this technique can be applied within a Multi-agent based architectures in order to facilitate the mission of concurrent customers check-out, avoiding the disadvantage of RFID-Reader Gates Jamming within a network of linked Readers and Back-end Systems. We illustrated a scenario where RFID technology is used to specify users' locations, then, finally, we demonstrated the possibility of integrating Agents and RFID structures to offer the customer an improved set of value added services.

Acknowledgment

We thank the ICT laboratory of ARS LOGICA for the unabated cooperation and support given to innovative and creative ideas. We also acknowledge the partial involvements and support of these projects: EU-SERENITY, PRIN-MEnSA, PAT-MOSTRO, PAT-STAMPS, and PAT-UNIQUIQUE SUUM.

References

1. Bryl, Volha and Giorgini, Paolo and Fante, Stefano. An Implemented Prototype of Bluetooth-Based Multi-Agent System. Proc. of WOA05, Camerino, Nov 2005.

2. Abdel-Naby, S. Fante, S. and Giorgini, P. Auctions Negotiation for Mobile Rideshare Service. In the Proceeding of the IEEE Second International Conference on Pervasive Computing and Applications (ICPCA07), July 2007, Birmingham, UK.
3. Ari Juels, David Molnar, and David Wagner, Security and Privacy Issues in Epassports, SecureComm, September 2005.
4. M. Rieback, B. Crispo and A.S. Tanenbaum; Is Your Cat Infected with a Computer Virus?; PerCom 06: 4th Annual IEEE International Conference on Pervasive Computing and Communications", in Pisa, Italy, 13-17 March 2006.
5. Ichiro Satoh: Mobile Agents for Ambient Intelligence, Proceedings of MMAS 2004: Kyoto, Japan, pp. 187-201.
6. A. Harter, A. Hopper, P. Steggeles, A. Ward, and P. Webster: The Anatomy of a Context-Aware Application, Proceedings of Conference on Mobile Computing and Networking (MOBICOM'99), pp. 59-68, ACM Press, 1999.
7. F. Abbattista, M. Degemmis, O. Licchelli, P. Lops, G. Semeraro, and F. Zambetta. Agents, Personalisation and Intelligent Applications. In R. Corchuelo, A. Ruiz Cortes, and R. Wrembel, editors, Technologies Supporting Business Solutions, Part IV: Data Analysis and Knowledge Discovery, Chapter 7, pages 141-158. Nova Sciences Books and Journals, 2003.
8. O. Shehory and S. Kraus Task Allocation via Coalition Formation Among Autonomous Agents, Proc. of IJCAI-95, pages 655-661, Montreal, August 1995.
9. Philips Research. Ambient Intelligence Research in ExperienceLab. http://www.research.philips.com/technologies/syst_softw/ami/
10. MIT Ambient Intelligence Research Group. http://ambient.media.mit.edu/
11. Mark Weiser. The Computer for the Twenty-First Century. Scientific American, pp. 94-10, September 1991.
12. A. Schmidt. Implicit Human Computer Interaction Through Context. Personal Technologies Volume 4(2&3), June 2000. pp191-199.
13. A. Schmidt, K.A. Aidoo, A. Takaluoma, U. Tuomela, K. Van Laerhoven, W. Van de Velde. Advanced Interaction in Context. The International Symposium on Handheld and Ubiquitous Computing (HUC99), Karlsruhe, Germany, 1999 & Lecture notes in computer science; Vol 1707, ISBN 3-540-66550-1; Springer, 1999, pp 89-101.
14. Anind K. Dey and Gregory D. Abowd. Towards a Better Understanding of Context and Context-Awareness. In the Proceedings of the CHI 2000 Workshop on The What, Who, Where, When, and How of Context-Awareness, The Hague, Netherlands, April 1-6, 2000.
15. Jolle Coutaz , James L. Crowley , Simon Dobson , David Garlan, Context is key, Communications of the ACM, v.48 n.3, March 2005.
16. K. Lyytinen , Y. Yoo. The Next Wave of Nomadic Computing: A Research Agenda for Information Systems Research. Sprouts: Working Papers on Information Environments, Systems and Organizations. Vol. 1, Issue 1, Article 1 - 2001.
17. Krogstie, J., et al. Research Areas and Challenges for Mobile Information Systems. International Journal of Mobile Communication, 2004. 2(3).
18. N. Streitz and P. Nixon. The Disappearing Computer. Communications of The ACM, March 2005/Vil. 48, No.3.

This article was processed using the LaTeX macro package with LLNCS style