IN PARTNERSHIP WITH:
Université Rennes 1

Activity Report 2012

Project-Team ACES

Ambient computing and embedded systems

IN COLLABORATION WITH: Institut de recherche en informatique et systèmes aléatoires (IRISA)

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Distributed Systems and Services

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Project-Team ACES

Keywords: Ambient Computing, Pervasive Computing, Spatial Information Systems, Embedded Systems

ACES project has been evaluated in October 2012. No project renewal will be sought. For administrative and contractual reasons, we ask that the Aces project can be maintained until December 2013. Until then, the goal is to completely finish our current activities within the BinThatThink project and the collaboration with EDF, and also to continue exploring two longer-term themes that can possibly lead to the creation of a new project.

Creation of the Project-Team: January 01, 2003 .

1. Members

Research Scientists

Michel Banâtre [Senior Researcher Inria, Team Leader, HdR]
Paul Couderc [Junior Researcher, Inria]

Faculty Member

Frédéric Weis [Associate Professor, IUT de Saint-Malo, HdR]

Engineers

Sylvain Roche
Yann Glouche
Jean-Francois Verdonck [Inria grant, up to 30/09/2012]

PhD Students

Bastien Pietropaoli [Inria grant]
Michele Dominici [Inria grant, up to 31/12/2012]
Arnab Sinha [Inria grant]

Administrative Assistants

Evelyne Livache [up to 30/09/2012]
Virginie Desroches [since 1/10/2012]

2. Overall Objectives

2.1. Introduction

Three key phenomena have been changing the nature of computing over the last few years. The first is the popularity of portable devices such as mobile telephones and Personal Digital Assistants (PDAs). Today, around 80% of the French adult population possess their own mobile phone and there is a large variety of smartphones on the market that integrate PDA functionality. The second phenomenon is the large number of embedded systems; these are everyday devices that have their own processor and memory. Estimates suggest that more than 98% of the world's processor's are in embedded system [8], thus facilitating the deployment of a variety of information systems that control physical objects. The third phenomena is the increasing variety of wireless networks available for personal and embedded devices, e.g., Bluetooth, Wifi, GPRS, etc.

The combination of these three phenomena has permitted the emergence of context-aware person-centric applications and collaborative personal environments. These services complement a person's physical ability to interact with her/his environment. They are tailored to the needs, preferences and location of each person carrying a device, and are continually available. Services range from critical, e.g., remote health monitoring [11], to utility, e.g., navigational help, etc. to value-added, e.g., virtual museum guides, smart home, etc.

The domain of person-centric computing is known in research circles as *ambient computing* [12], and several significant research challenges remain. First, to facilitate mobility, ambient computing services should require minimal device manipulation by the device owner. It is crucial that the computing device operate as an extension of the person rather than as a tool. Second, there must be a way of modeling the physical environment so that applications can seamlessly import data from the environment and modify the environment when possible. Third, applications must be able to adapt to the rather limited storage and processing capabilities of mobile devices, as well as to variable and intermittent wireless network coverage.

The ACES (Ambient Computing and Embedded Systems) group is addressing research from two angles:

- *System Support for Continuous Ambient Service Delivery*. A user needs to be able to exploit ambient services as seamlessly as possible. In particular, he should be shielded from the effects of network breaks – something that can be quite common for wireless environments.
- *Programming Models for Ambient Computing*. We have looked at ways of modeling the physical environment in the virtual environment of programs in order to facilitate ambient application development. The goal is to be able to write programs that address and navigate through objects in the physical world as elegantly as a program traditionally manipulates a computer's main memory.

This document overviews our activities in more detail. The section *Scientific Foundations* gives some background to our work in person-centric computing. The section *Application Domains* describes the importance of our research agenda through the presentation of several applications, some of which are being developed in our group. The group's recent results are presented in the section *New Results*.

2.2. Highlights of the Year

Aces designed and developed several applications based on the coupled objects (see section 3.3). Our results have been recognized: the paper that presents the principle of "pervasive integrity checking" has received a best paper award in ANT 2011. And a part of Ubi-check software has been demonstrated at IEEE Percom 2012, and has received the Best Demo Award [7].

3. Scientific Foundations

3.1. Programming Context

The goal of ambient computing is to seamlessly merge virtual and real environments. A real environment is composed of objects from the physical world, e.g., people, places, machines. A virtual environment is any information system, e.g., the Web. The integration of these environments must permit people and their information systems to implicitly interact with their surrounding environment.

Ambient computing applications are able to evaluate the state of the real world through sensing technologies. This information can include the position of a person (caught with a localization system like GPS), the weather (captured using specialized sensors), etc. Sensing technologies enable applications to automatically update digital information about events or entities in the physical world. Further, interfaces can be used to act on the physical world based on information processed in the digital environment. For example, the windows of a car can be automatically closed when it is raining.

This real-world and virtual-world integration must permit people to implicitly interact with their surrounding environment. This means that manual device manipulation must be minimal since this constrains person mobility. In any case, the relative small size of personal devices can make them awkward to manipulate. In the near future, interaction must be possible without people being aware of the presence of neighbouring processors.

Information systems require tools to *capture* data in its physical environment, and then to *interpret*, or process, this data. A context denotes all information that is pertinent to a person-centric application. There are three classes of context information:

- The *digital context* defines all parameters related to the hardware and software configuration of the device. Examples include the presence (or absence) of a network, the available bandwidth, the connected peripherals (printer, screen), storage capacity, CPU power, available executables, etc.
- The *personal context* defines all parameters related to the identity, preferences and location of the person who owns the device. This context is important for deciding the type of information that a personal device needs to acquire at any given moment.
- The *physical context* relates to the person's environment; this includes climatic condition, noise level, luminosity, as well as date and time.

All three forms of context are fundamental to person-centric computing. Consider for instance a virtual museum guide service that is offered via a PDA. Each visitor has his own PDA that permits him to receive and visualise information about surrounding artworks. In this application, the *pertinent* context of the person is made up of the artworks situated near the person, the artworks that interest him as well as the degree of specialisation of the information, i.e., if the person is an art expert, he will desire more detail than the occasional museum visitor.

There are two approaches to organising data in a real to virtual world mapping: a so-called *logical* approach and a *physical* approach. The logical approach is the traditional way, and involves storing all data relevant to the physical world on a service platform such as a centralised database. Context information is sent to a person in response to a request containing the person's location co-ordinates and preferences. In the example of the virtual museum guide, a person's device transmits its location to the server, which replies with descriptions of neighbouring artworks.

The main drawbacks of this approach are scalability and complexity. Scalability is a problem since we are evolving towards a world with billions of embedded devices; complexity is a problem since the majority of physical objects are unrelated, and no management body can cater for the integration of their data into a service platform. Further, the model of the physical world must be up to date, so the more dynamic a system, the more updates are needed. The services platform quickly becomes a potential bottleneck if it must deliver services to all people.

The physical approach does not rely on a digital model of the physical world. The service is computed wherever the person is located. This is done by spreading data onto the devices in the physical environment; there are a sufficient number of embedded systems with wireless transceivers around to support this approach. Each device manages and stores the data of its associated object. In this way, data are physically linked to objects, and there is no need to update a positional database when physical objects move since the data *physically* moves with them.

With the physical approach, computations are done on the personal and available embedded devices. Devices interact when they are within communication range. The interactions constitute delivery of service to the person. Returning to the museum example, data is directly embedded in a painting's frame. When the visitor's guide meets (connects) to a painting's devices, it receives the information about the painting and displays it.

3.2. Spatial Information Systems

One of the major research efforts in ACES over the last few years has been the definition of the Spread programming model to cater for spacial context. The model is derived from the Linda [10] tuple-space model. Each information item is a *tuple*, which is a sequence of typed data items. For example, <10, 'Peter', -3.14> is a tuple where the first element is the integer 10, the second is the string ‘"Peter" and the third is the real value -3.14. Information is addressed using patterns that match one or a set of tuples present in the tuple-space. An example pattern that matches the previous tuple is <int, 'Peter', float>. The tuple-space model has the advantage of allowing devices that meet for the first time to exchange data since there is no notion of names or addresses.

Data items are not only addressed by their type, but also by the physical space in which they reside. The size of the space is determined by the strength of the radio signal of the device. The important difference between Spread and other tuple-space systems (e.g., Sun's JavaSpaces [9], IBM's T-Space [13]) is that when a program issues a matching request, only the tuples filling the *physical space* of the requesting program are tested for matching. Thus, though SIS (Spatial Information Systems) applications are highly distributed by nature, they only rely on localised communications; they do not require access to a global communication infrastructure. Figure 1 shows an example of a physical tuple space, made of tuples arranged in the space and occupying different spaces.

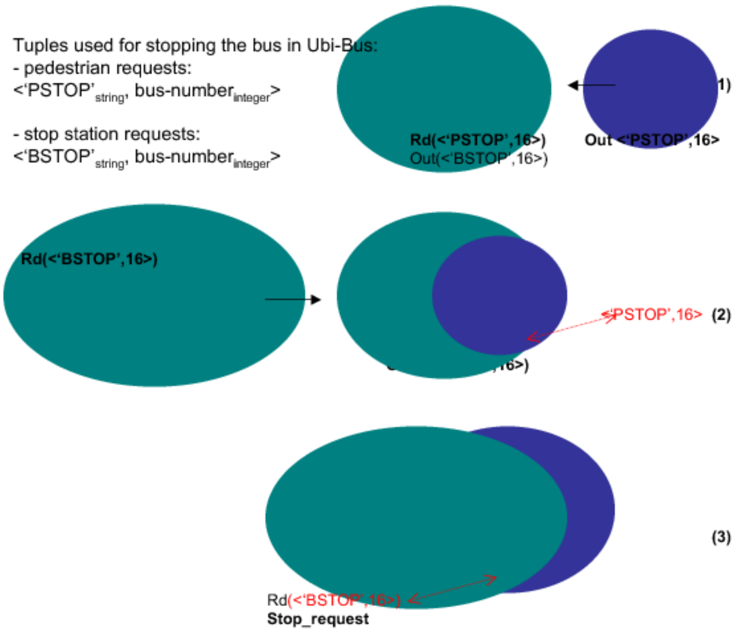

Figure 1. Physical Tuple Space

As an example of the power of this model, consider two of the applications that we have developed using it.

- *Ubi-bus* is a spatial information application whose role is to help blind and partially blind people use public transport. When taking a bus, a blind person uses his PDA to signal his intention to a device embedded in the bus stop; this device then contacts the bus on the person's behalf. This application illustrates how data is distributed over the objects of the physical world, and generally, how devices complement human means of communication.
- *Ubi-board* is a spatial information application designed for public electronic billboards. Travel hotspots like airports and major train stations have an international customer base, so bill-board announcements need to be made in several languages. In Ubi-bus, a billboard has an embedded device. When a person comes within communication range of the billboard, his device sends a request to the billboard asking it to print the message in the language of the person. In the case where several travellers are in proximity of the billboard, the board sends a translation of its information message to each person. The Ubi-board application illustrates personal context in use, i.e., the choice of natural language, and also how actions can be provoked in the physical world without explicit intervention by the person.

3.3. Coupled objects

Integrity checking is an important concern in many activities, both in the real world and in the information society. The basic purpose is to verify that a set of objects, parts, components, people remains the same along some activity or process, or remains consistent against a given property (such as a part count).

In the real world, it is a common step in logistic: objects to be transported are usually checked by the sender (for their conformance to the recipient expectation), and at arrival by the recipient. When a school get a group of children to a museum, people responsible for the children will regularly check that no one is missing. Yet another common example is to check for our personal belongings when leaving a place, to avoid lost. While important, these verification are tedious, vulnerable to human errors, and often forgotten.

Because of these vulnerabilities, problems arise: E-commerce clients sometimes receive incomplete packages, valuable and important objects (notebook computers, passports etc.) get lost in airports, planes, trains, hotels, etc. with sometimes dramatic consequences.

While there are very few automatic solutions to improve the situation in the real world, integrity checking in the computing world is a basic and widely used mechanism: magnetic and optical storage devices, network communications are all using checksums and error checking code to detect information corruption, to name a few.

The emergence of ubiquitous computing and the rapid penetration of RFID devices enable similar integrity checking solutions to work for physical objects. We introduced the concept of *coupled object*, which offers simple yet powerful mechanisms to check and ensure integrity properties for set of physical objects.

Essentially, coupled objects are a set of physical objects which defines a logical group. An important feature is that the group information is self contained on the objects which allow to verify group properties, such as completeness, only with the objects. Said it another way, the physical objects can be seen as fragments of a composite object. A trivial example could be a group made of a person, his jacket, his mobile phone, his passport and his cardholder.

The important feature of the concept are its distributed, autonomous and anonymous nature: it allows the design and implementation of pervasive security applications without any database tracking or centralized information system support. This is a significant advantage of this approach given the strong privacy issues that affect pervasive computing.

4. New Results

4.1. Spatial Computing approach and RFIDs

Participants: Michel Banâtre, Paul Couderc [contact], Yann Glouche, Arnab Sinha.

In the line of our previous research in pervasive computing, we are working on spatial computing approaches in the context of RFID. Spatial computing consists in data structures and computing processes directly supported by physical objects. RFID is an attractive technology for supporting spatial computing, enabling any object to interact in a smart environment. Traditionnal RFID solutions use a logical model, where the RFID tags are simple identifiers referring to data in a remote information system. In our approach, we use the memory of the tags to build self-contained data structures and self-describing objects. While featuring interesting properties, such as autonomous operation and high scalability, this approach also raises difficult challenges: the memory capacity of the tags is very limited, requiring compact and efficient data structures.

Our research in the context of domestic waste management is broadly investigating the use of RFID at item level to provide early waste sorting, to avoid incompatible mix of waste and to prevent hazards [3], [4]. Several innovative aspected are studied in this project. First, the design of an autonomous computing architecture for the waste items and smart containers, enabling early processing in the waste management: for example waste bags can be accepted or rejected accordingly to their content and its conformance with the recipient container. Hazard prevention and human operator safety can also be improved with the knowledge of the nature of the waste.

Autonomy is important as it would be possible to depend on a remote information system for each waste insertion, due to obvious scalability, energy and network costs. An ontology based system has been proposed to determine the possible interactions of tagged products based on their properties and the external conditions [6]. This ontological model is simple enough to be supported entirely by a low power embedded computer at the container level, but can still support the waste application requirements. An unconventional aspect in this architecture is that semantic properties are directly written in the RFID tags, instead of semantic-less identifiers typically used in most RFID applications.

A second innovative aspect of the research is to consider the set of containers in a city as a particular case of sensor network, and developing energy efficient protocol to enable information reporting to a supervising infrastructure.

In the context of this research, some limitations of existing RFID technology become challenging: unlike standard RFID application scenarios, pervasive computing often involves uncontrolled environment for RFID, where tags and reader have to operate in much more difficult situations that those usually encountered or expected for classical RFID systems. In a near future, we seek to work with a team who has a strong expertise in antenna design and radio signal behaviour.

4.2. Integrity checking with coupled objects

Participants: Michel Banâtre [contact], Paul Couderc, Jean-Francois Verdonck.

While the computing and telecommunication worlds commonly use digital integrity checking, many activities from the real world do not benefit from automatic integrity control mechanisms. RFID technology offers promising perspectives for facing this problem, but also raises strong privacy concerns as most of the RFID-based systems rely on global identification and tracking. In 2011, we have designed Ubi-Check to provide an approach aiming at coupling physical objects and enabling integrity control built on local interactions, without the support of a global information system. Ubi-Check led to the development of various novel applications running quite on the same technology. But the possibility of defining hierarchical couplings was lacking.

This is why we have studied and and designed the Ubi-Tree environment in 2012, which strives to deal with those new requirements. Ubi-Tree relies on a structure in which physical objects (also called fragments) are seen as external nodes of a tree that we call coupling tree. External nodes of a tree are called leaves. In the system, internal nodes are called coupling nodes. Each fragment embeds an RFID tag supporting coupling data. Coupling data stores the coupling tree. Each internal node can be checked, which means a lacking, illegally forged or corrupted node can be detected at any depth of a coupling.

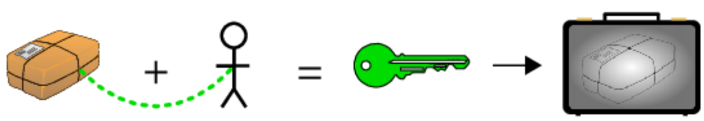

Figure 2. Key to a Ubi-Post briefcase

The Ubi-Tree environment has been experimented through a content-oriented security solution for high value shipping: the Ubi-Post briefcase. Sending sensitive documents or parcels over a delivery service can be a hazardous operation. Goods can be picked up by a fake courier, genuine items can be swapped with copies, the parcel may be received or opened by someone else than the supposed recipient and some items can be missing at the delivery time. As some very high value items are sent over such services, security is critical. We proposed the Ubi-Post briefcase system, a pervasive content-oriented security solution for high value shipping based on the Ubi-Tree physical object coupling software and RFID equipment. The aim of a shipping service is to provide transportation of goods from a sender to the recipient, so the system must ensure that the coupling would be handed over to the recipient. For that purpose, coupled tags will carry an identifier corresponding to the recipient as additional data. Then, the only way to unlock a Ubi-Post briefcase is to insert a recipient card which tag ID is the one expected by the coupling (see figure 2). The Ubi-Post briefcase embeds the same equipment as the coupling station, plus a battery, an HF near field card reader, and a locking mechanism (see Figure 3).

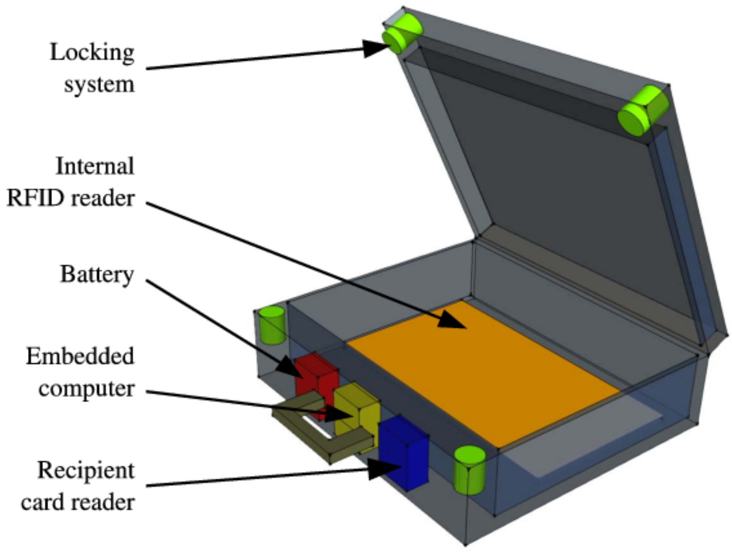

Figure 3. 3D view from the internal components of the Ubi-Post briefcase

We have produced an interface for users to be sure that the association between RFID tag and physical object is the one that is perceived by our coupling software. The key idea was to be able to identify in the right way the RFID tag associated to a physical object when we place one physical object onto the support of the antenna linked to the RFID reader. The position of this object, and the tag associated to this object, in the physical space is determined using a camera coupled with an image recognition algorithm. The result is displayed onto a touch screen. In that way, when we want to couple a set of physical objects, we place sequentially all these objects onto the support of the antenna, and from the image of these objects displayed onto the touch screen we touch those we want to couple and activate the coupling operation. This solution is now fully functional.

4.3. Pervasive support for Smart Homes

Participants: Michele Dominici, Bastien Pietropaoli, Sylvain Roche, Frédéric Weis [contact].

A smart home is a residence equipped with information-and-communication-technology (ICT) devices conceived to collaborate in order to anticipate and respond to the needs of the occupants, working to promote their comfort, convenience, security and entertainment while preserving their natural interaction with the environment.

The idea of using the Ubiquitous Computing paradigm in the smart home domain is not new. However, the state-of-the-art solutions only partially adhere to its principles. Often the adopted approach consists in a heavy deployment of sensor nodes, which continuously send a lot of data to a central elaboration unit, in charge of the difficult task of extrapolating meaningful information using complex techniques. This is a *logical approach*. ACES proposed instead the adoption of a *physical approach*, in which the information is spread in the environment, carried by the entities themselves, and the elaboration is directly executed by these entities "inside" the physical space. This allows performing meaningful exchanges of data that will thereafter need a less complicate processing compared to the current solutions. The result is a smart home that can, in an easier and better way, integrate the context in its functioning and thus seamlessly deliver more useful and effective user services. Our contribution aims at implementing the physical approach in a domestic environment, showing a solution for improving both comfort and energy savings.

Most existing smart home solutions were designed with a technology-driven approach. That is, the designers explored which services, functionalities, actions and controls could be performed exploiting available technologies. This led to solutions for human activity recognition relying on wearable sensors, microphones or video cameras. Those technologies may be difficult to deploy and get accepted in real-world households, because of convenience and privacy concerns. Many people have concerns on carrying equipments or feeling observed or recorded while living their private life. This could seriously impact the acceptability of the smart home system or reduce its diffusion in real households. To avoid such kind of issues, we designed our system with an acceptability-driven approach. That is, we selected technologies that respond to the constraints of a real-world deployment of the future smart home system, namely, convenience and privacy concerns. We decided to take a very conservative approach, choosing technologies that are as unobtrusive as possible, in order to explore the frontiers of what can be done in a smart home with a very limited instrumentation. Following the same considerations, the adopted technologies and techniques had to guarantee a fast and easy configuration, ultimately allowing a plug-and-play deployment.

4.3.1. Design and implementation of a system architecture

In 2012, we have designed and experimented a system architecture of a smart home prototype currently under development. It is the demonstrator of an interdisciplinary project that brings together industrials and researchers, from the fields of ubiquitous computing and cognitive ergonomics. The aim is to develop a smart home system that is able to prevent energy waste and preserve inhabitants' comfort. The key requirement is to provide functionalities that are seamlessly adapted to ongoing situations and activities of inhabitants, avoiding bothering them with inappropriate interventions. The architecture of such a system has been designed so as to respect the principles and constraints illustrated in the introduction of this section. Namely, we have chosen the necessary equipments among those that should guarantee privacy preservation and high acceptability. When designing the algorithms for context and situation recognition and the human-computer interaction aspects of the system, we have kept in mind the model of human activity described in the previous section. Finally, we have designed the architecture of the system so as to realize successive abstraction of contextual information and to allow uncertainty, imprecision and ignorance to flow between the layers [2].

4.3.2. Layered architecture

The system architecture relies on the principles of the ubiquitous computing paradigm. It also draws its inspiration from the work of Coutaz, who suggest a four-layer model to build context-aware applications. The first layer, "sensing", is in charge of sensing the environment. It is realized by augmented appliances and physical sensors. The augmented household appliances provide information about their state, while the sensors measure physical phenomena (sound level, motion, vibration, etc.). The second layer, called "perception", realizes the abstraction from the raw data. These are processed to obtain more abstract information about the context (e.g. the detection of presence in a room can be obtained combining motion, sound and vibration measures). "Situation and context identification", the third layer, identifies the occurring situations and the activities of inhabitants. For instance, the fact that a given moment a person is ironing can be modeled combining the information that a person is present in a room with the fact that the iron is on and that it is being moved. The top layer, called "exploitation", provides contextual information to applications. More specifically, the contextual information is used to adapt the behavior of the augmented appliances in a semi-automatic way and to allow lowly interruptive takeover by inhabitants.

4.3.3. Design and experimentation of the "perception" layer

In the second layer called "perception", raw sensor data are processed to obtain more abstract information about context called Context Attributes. These are small pieces of context easily understandable by humans and that can be provided to the upper layer. Examples of Context Attributes are the presence, the number of people in a room or the posture of someone. Some raw data are immediately exploitable, like temperature or light level. Others require data fusion in order to obtain more abstract contextual information, such as inhabitants' presence or movement. A certain number of sensors is necessary to obtain sufficient certainty when fusing data, as redundancy can significantly increase the reliability of the sources. Furthermore, heterogeneous sensors allow collecting different physical measurements that can enrich the data fusion process.

Data fusion is a large problem. Many theories offer tools to handle it. In our approach, the main aim of the perception layer is to abstract imperfect raw data to make it computable by higher level reasoning algorithms. Data may be imperfect for different reasons:

- Randomness, due to physical systems (in our case, sensors).
- Inconsistency, due to overload of data or conflicting sources.
- Incompleteness, due to loss of data which may easily happen with wireless communication.
- Ambiguity (or fuzziness), due to models or to natural language imprecision.
- Uncertainty, due to not fully reliable sources.
- Bias, due to systematic errors.
- Redundancy, due to multiple sources measuring the same parameter.

In order to manage many of those imperfections and respect the theoretical constraints, we decided to use as a first layer of abstraction the belief functions theory (BFT). The BFT can be seen as a generalization of the Bayesian theory of subjective probability. It can be used to model probabilities if only atomic focal sets are used in mass functions. Thus, it is totally possible to mix probabilities with real belief functions.

In our approach, we considered that sensors should duce belief for a certain amount of time after the measures because of the continuity of studied context. For instance, a motion sensor in a room could be able to induce a belief on the presence of someone for a longer time than the exact moment at which the measure has been obtained. It is a matter of physical system with inertia. In this example, it is easy to take into account that physical persons cannot move too fast and thus will certainly be there for some seconds before they can exit the room. Thus, this little example brings two questions: how to build evidence from raw data and how to take into account evidence over time? We proposed a simple method already existing to build belief functions from raw data and propose an improvement to take into account timed evidence [5].

4.3.4. Design and experimentation of the "situation and context identification" layer

"Situation and context identification", the third layer, identifies the occurring situations and the activities of inhabitants. For instance, the fact that a given moment a person is ironing can be modeled combining the information that a person is present in a room with the fact that the iron is on and that it is being moved. Having obtained the Context Attributes through abstraction from the raw sensor data, the system has to reason about context, in order to infer higher-level context information, needed to make decisions concerning the functionalities to offer to inhabitants. We needed a unified theory for modeling contextual information, also offering a generic framework for applying different reasoning techniques to infer higher-level context.

We adopted a situation-centric modeling and reasoning approach called *Context Spaces*, based on a unified context modeling and reasoning theory. Using this theory, interesting situations can be modeled as combinations of basic contextual information provided both by a sensor-data-fusion technique and by augmented appliances. Adapted functionalities can be provided when the interesting situations are triggered. The recognition of ongoing situations is made possible by reasoning about available context information. The Context Spaces theory allows managing and propagating uncertainty and ignorance, reasoning on ambiguous contexts and assessing the degree of uncertainty of the resulting inference. It also provides tools to reason on complex logical expressions that combine elementary situations. The use and the extension of the Context Spaces is the core of a PhD thesis that has been finished at the end of 2012 by Michele Dominici (to be defended in March 2013).

4.3.5. Uncertainty and ignorance management

Given the gap between contextual capture capabilities of our architecture and actual complexity of real-world human activities and context, an important issue arises: the management of uncertainty and ignorance. If contextual information has to be abstracted in successive steps, sources are not always reliable. In particular, uncertainty is intrinsic to the physical sensors that are used in the capture. Thus, the uncertainty of lower abstraction layers will negatively impact the inference and decisions of the upper layers. Furthermore, due to the contextual gap illustrated above, any computing model that tries to represent the complexity of real activity will be affected by a certain degree of uncertainty. This reflects on the recognition of the activity itself and can lead to wrong conclusions, which in turn negatively impact the provision of adapted functionalities to inhabitants. As a consequence, we considered that information about uncertainty and ignorance has to be propagated, cumulated and considered at every layer of our pervasive architecture. Whenever the level of uncertainty becomes excessively high, the system tried to evaluate the tradeoff between the potential benefit of providing the right functionality and the risk associated with an unsuitable functionality, which would be provided in case the situation has not been correctly recognized.

5. Bilateral Contracts and Grants with Industry

5.1. Bilateral Contracts with Industry

5.1.1. Energy saving mechanisms in smart homes using ambient computing principles

- Partner : EDF - R&D
- Starting: 01/06/2010, ending : 01/10/2013

This project is funded by EDF group, leading energy producer in Europe. It started in June 2010. Its ends in June 2013. Its goal is to study the use of ambient computing principles for the management of electricity consumption in residential habitat. It focusses on two main objectives: (1) to define scenarios based on home people activities, and (2) to propose an implementation of these scenarios using ambient computing mechanisms studied in the Aces project. The main results are presented in section 4.3.

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. Bin That Thinks

- Partners: ACES (Inria Rennes) and POPS (Inria Lilles), Veolia Propreté, and Etineo (a start up company focused on M2M communications and ambient networking)
- Starting: November 2010; ending: November 2013

Bin That Think is a research project funded by the ANR Ecotech program, which aims at sorting domestic waste at early stage in order to reduce costs and risks in waste sorting center, as well as helping citizens to adopt environment respectful. To this end, Bin That Think introduces a new system for (1) identifying the waste which involve a reject during waste collection, (2) detecting incompatible products and (3) implementing a reporting infrastructure enabling an efficient management/planning of the waste collecting process. Bin That Think will use RFID and embedded sensors to enable waste containers as an intelligent waste infrastructure and a network of smart sensors.

7. Dissemination

7.1. Scientific Animation

7.1.1. Program committees

- PC member for IE'12: 8th Int Conference on Intelligent environments, Guanajuato, Mexico, June 2012, M. Banâtre.
- PC member of the 15th International Symposium on Wireless Personal Multimedia Communications (WPMC'12), F. Weis.

7.1.2. Organizing and reviewing activities

Michel Banâtre is expert to the European Commission (FP7 program): reviewer member for SM4All and CONSERN projects.

7.2. Teaching - Supervision - Juries

7.2.1. Teaching

L2/L3: network computing (lectures, tutorials, labs), 250 hours, F. Weis, University Rennes 1 / IUT Saint-Malo

Master : Ambient Computing and Mobile Communications, M. Banâtre and F. Weis, 6 hours, M2, university of Rennes, France

Master : Distributed Systems, M. Banâtre, 18 hours, M2, Ecole des mines de Nantes, France

Master : Wireless LANs, F. Weis, 8 hours, M2, Telecom Bretagne, France

Master: Mobile communications and ambient computing, M. Banâtre, 8 hours, M2, ENSEIRB Bordeaux, France

Master : Mobile communications and ambient computing, M. Banâtre, 4 hours, M1, Ecole Centrale de Paris, France

7.2.2. Supervision

PhD in progress : M. Dominici, Context Management in Smart Homes, 01/11/09, M. Banâtre and F. Weis, to be defended in March 2013

PhD in progress : B. Pietropaoli, Proximate interactions and data fusion in Smart Homes, 01/10/10, M. Banâtre and F. Weis

PhD in progress : Minh Ho, Indoor localization mechanisms for ambient computing systems, 01/11/08, M. Banâtre and F. Weis, to be defended in May 2013

PhD in progress : Arnab Sinha, Pervasive control systems for smart waste management solutions, 14/12/10, M. Banâtre and P. Couderc

8. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

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