Activity Report 2014

Team TACOMA

TAngible COMputing Architectures

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Distributed programming and Software engineering

Table of contents

1. Members **1**
2. Overall Objectives **1**
3. Research Program **2**
3.1. Using and Programming Context 2
3.2. Coupled objects 3
4. Application Domains **4**
4.1. Pervasive applications in Smart Home 4
4.2. Metamorphic House 4
4.3. Pervasive applications in uncontrolled environnements 5
5. New Software and Platforms **5**
6. New Results **6**
6.1. Self-describing objects and tangible data structures 6
6.2. Pervasive support for RFIDs 6
6.3. Context-aware dynamic Smart Home Platform 7
6.3.1. Towards dynamism using OSGI 8
6.3.2. Automated configuration of sensors 9
6.4. Towards Metamorphic Housing: the on-demand room 9
7. Partnerships and Cooperations **10**
7.1.1. Pervasive_RFID 10
7.1.2. GLIE - Guidage Lumineux par l'Intelligence de l'Environnement 11
8. Dissemination **11**
8.1. Promoting Scientific Activities 11
8.2. Teaching - Supervision - Juries 11
8.2.1. Teaching 11
8.2.2. Supervision 11
8.2.3. Juries 11
8.2.4. Internship 12
9. Bibliography **12**

Team TACOMA

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

Creation of the Team: 2014 January 01.

1. Members

Research Scientist
Paul Couderc [Inria, Researcher]

Faculty Members
Frédéric Weis [Team leader, Univ. Rennes I, Associate Professor, HdR]
Yoann Maurel [Univ. Rennes I, Associate Professor]

Engineers
Michele Dominici [Univ. Rennes I]
Aurélien Richez [Inria]
Arnab Sinha [Inria, until Mar 2014]

Post-Doctoral Fellows
Nebil Ben Mabrouk [Inria]
Andrey Boytsov [Inria, until Jan 2014]

Administrative Assistant
Virginie Desroches [Inria]

Others
Salim Bahram [Inria, Student Univ. Rennes I, from Jul 2014 until Aug 2014]
Abdelhak Chaabi [Inria, Student Univ. Rennes I,, from Jun 2014 until Aug 2014]
Victor Petit [Inria, Student Univ. Rennes I, from Apr 2014 until Aug 2014]

2. Overall Objectives

2.1. Overall Objectives

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, 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, cellular networks, 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, 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* 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 TACOMA group is addressing research from one main angle: *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*.

3. Research Program

3.1. Using and 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. 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. Application Domains

4.1. Pervasive applications in Smart Home

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*. TACOMA 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.

4.2. Metamorphic House

The motivation for metamorphic houses is that many countries, including France, are going through socio-demographic evolutions, like growth of life expectancy and consequent increase in the number of elderly people, urbanization and resource scarcity. Households experience financial restrictions, while housing costs increase with the raise of real estate and energy prices [5].

Important questions arise concerning the future of housing policies and ways of living. We observe novel initiatives like participative housing and developing behaviors, including house-sharing, teleworking and longer stay of children in parents' homes.

To tackle the challenges raised by these emerging phenomena, future homes will have to be modular, upgradeable, comfortable, sparing of resources. They should be integrated in the urban context and exchange information with other homes, contribute to reducing the distances to be covered daily and respect the characteristics of the territory where they are located.

To reach these goals, metamorphic domestic environments will modify their shape and behavior to support activities and changes in life cycle of occupants, increase comfort and optimize the use of resources. Thanks to Information and Communication Technologies (ICT) and adaptive building elements, the same physical spaces will be transformed for different uses, giving inhabitants the illusion of living in bigger, more adapted and more comfortable places.

4.3. Pervasive applications in uncontrolled environnements

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.

RFID technology is to avoid missing tags when reading multiple objects, as reading reliability is affected by various effects such shadowing or wave power absorption by some materials. The usual applications of RFID operate in a controlled environment in order to reduce the risk of missing tags while scanning objects.

In pervasive computing applications, a controlled reading environment is extremely difficult to achieve, as one of the principle is to enhance existing processes "in situ", unlike the controlled conditions that can be found in industrial processes. Consider for example a logistic application, where RFID tags could be used on items inside a package in order to check for its integrity along the shipping process. Tags would likely be placed randomly on items inside the package, and reading conditions would be variable depending on where the package is checked.

RFID operation in uncontrolled environments is challenging because RFID performance is affected by multiple parameters, in particular:

- Objects materials (on which tags are attached to),
- Materials in the surrounding environment,
- RFID frequency spectrum,
- Antenna nature and placement with respect to the tags.

In controlled environment, the difficulty to read tags can be limited by using the appropriate parameters to maximize the RFID performance for the application. But in many cases, it is needed to read large number of objects of various nature, arranged randomly in a given area or container. Most pervasive computing applications fall in this context. At the software level, RFID inventory reliability issue is usually addressed by anti-collisions mechanisms and redundancy mechanisms. Anti-collisions protocols limit the risk of data corruption when multiples tags have to reply to an inventory request. Redundancy is often implemented in RFID readers by aggregating the results of multiple inventory requests over a time frame, to give the tags multiple opportunities to reply. While useful, these strategies cannot ensure that a given inventory is valid or not (in other words, one or more tags may be missing without being noticed).

5. New Software and Platforms

5.1. THEGAME

Context-aware applications have to sense the environment in order to adapt themselves and provide with contextual services. This is the case of Smart Homes equipped with sensors and augmented appliances. However, sensors can be numerous, heterogeneous and unreliable. Thus the data fusion is complex and requires a solid theory to handle those problems. The aim of the data fusion, in our case, is to compute small pieces of context we call context attributes. Those context attributes are diverse and could be for example the presence in a room, the number of people in a room or even that someone may be sleeping in a room. For this purpose, we developed an implementation of the belief functions theory (BFT). THE GAME (THeory of Evidence in a lanGuage Adapted for Many Embedded systems) is made of a set of C-Libraries. It provides the basics of belief functions theory, computations are optimized for an embedded environment (binary representation of sets, conditional compilation and diverse algorithmic optimizations).

THE GAME is published under apache licence (https://github.com/bpietropaoli/THEGAME/). It is maintained and experimented by Aurélien Richez within a sensor network platform developed by TACOMA since June 2013.

6. New Results

6.1. Self-describing objects and tangible data structures

Participants: Nebil Ben Mabrouk, Paul Couderc [contact], Arnab Sinha.

A development in the line of the coupled objects principles are self-describing objects. While previous works enabled integrity checking over a set of physical objects, these mechanisms were limited in two aspects: expressiveness and autonomy. More precisely, coupled objects support the detection of special conditions (such as a missing element), but not the characterization of these conditions (such as describing the problem, identifying the missing element). Moreover, this compromises the autonomous feature of coupled objects, which would depend on external systems for analyzing these special conditions. Self-describing objects are an attempt to overcome these limitations, and to broaden the application perspectives of autonomous RFID systems.

The principle is to implement distributed data structure over a set of RFID tags, enabling a complex object (made of various parts) or a set of objects belonging to a given logical group to "ÃÂÃÂself-describe" itself and the relation between the various physical elements. Some applications examples includes waste management, assembling and repair assistance, prevention of hazards in situations where various products / materials are combined etc. The key property of self-describing objects is, like for coupled objects, that the vital data are self-hosted by the physical element themselves (typically in RFID chips), not an external infrastructure like most RFID systems. This property provides the same advantages as in coupled objects, namely high scalability, easy deployment (no interoperability dependence/interference), and limited risk for privacy.

However, given the extreme storage limitation of RFID chips, designing such systems is difficult:

- Data structures must be very frugal in terms of space requirements, both for the structure and for the coding.
- Data structures must be robust and able to survive missing or corrupted elements if we want to ensure the self-describing property for a damaged or incorrect object.

In the context of RFID system, the resiliency property of such data structures enables new information architecture and autonomous (offline) operation, which is very important for some RFID applications. On this topic, a generic graph structure applicable to RFID systems for supporting self-describing objects is proposed in Arnab Sinha's thesis document [1], and was published in [4].

6.2. Pervasive support for RFIDs

Participants: Nebil Ben Mabrouk, Paul Couderc [contact].

In situations where we have to read large collection of objects of various types, the performance is difficult to predict but may still be adequate for a given application. For example, some application can tolerate missing some tags, provided that miss read probability could be characterized. In some cases, read reliability could be improved using mechanical approaches, such as introducing movements in objects or antenna to introduce radio diversity during read. Finally, distributed data structure can be used over a set of tags to be used to mitigate the impact of mis-read (by using data redundancy) and to help the reading protocol by integrating hints about the tag set collection being read.

Our objective here is to study extensively by experimentation the behaviour of existing RFID solutions in the context of uncontrolled environment (meaning, random placement of tags on objects mixing various materials) in order to characterize their real-world performance regarding the parameters of such as tags numbers, density, frequencies, reader antenna design, dynamicity of objects (movements), etc. From these experimentations, we would like to identify the conditions that are favorable to acceptable performance, and the way where there are hopes of improvement with specific design for these difficult environments. These results should also allow improving the performance: high level integrity checks can guide low level operations by determining whether inventories are complete or not. This cross layer strategy can enable faster are more efficient inventory protocols.

An important milestone was completed in 2014, with the implementation of an experiment test bed in order to support the experiment campaign. This task involved a significant development and engineering effort. This testbed is currently deployed at the IETR (http://www.ietr.fr) building, and features a multi-axis mobile RFID antenna system driven by a software platform.

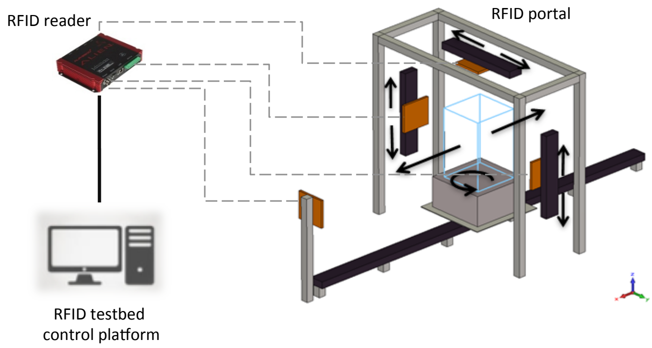

Figure 1. RFID testbed

This system allows both interactive testing as well as long running experiments of RFID reading protocols. The software platform was designed to allow fine control over all dynamic aspects influencing RFID readings: movements for target and antenna, RFID reader configuration, and smart antenna configuration (diversity and power control). Given this flexibility, this platform should be able to reproduce most of the situations found in real applications. In particular, it can be used to design custom reading set up optimized for various RFID portal applications [3].

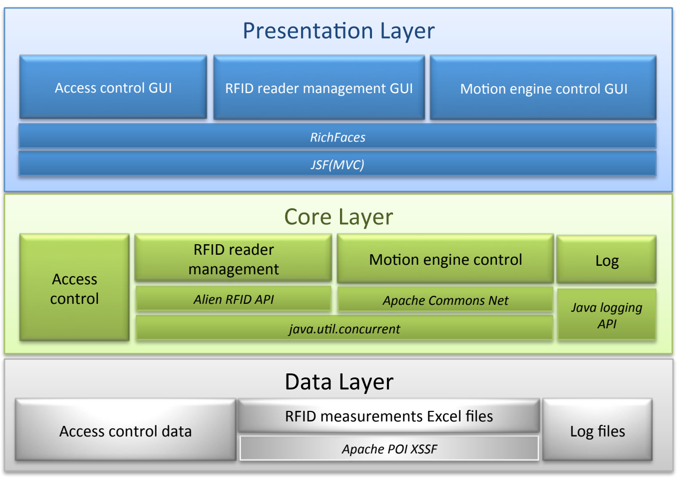

Figure 2. Software architecture of the RFID testbed

6.3. Context-aware dynamic Smart Home Platform

Participants: Andrey Boytsov, Aurélien Richez, Yoann Maurel, Frédéric Weis [contact].

Tacoma group is focussed on the conception and implementation of innovative services for the Smart Home. The range of considered services is broad : from "optimizing the energy consumption" to "helping users to find their way in a building". To provide such services, automation based on pre-set scenarios is ineffective: human behavior is hardly predictable and application should be able to adapt their behavior at runtime depending on the context. We focused on recognizing user's activities to adapt applications behaviours.

Building efficient and accurate context awareness was and is still a great challenge but we proved, through the use of dedicated algorithms and a layered architecture that it is achievable when the targeted Home is known - due to the specific and non automated calibration process we used. Among all the available theories, we decided to use the Belief Function Theory (BFT) [8] [9] as it allows to express uncertainty and imprecision. Although these results are very promising, great challenges still lied in (i) the support of the dynamic reconfiguration to face evolving hardware or software conditions and (ii) the deployment and the configuration of the layered architecture and sensors to allow the use of our approach in unknown environments.

One of our goals is to build a pervasive platform with constrained performance and cost [7]. The cost is particularly critical for sensors and actuators: we choose to limit our scope to inexpensive and non-invasive sensors *i.e.* no video camera. This past months, Tacoma has been working on the conception and implementation of a Smart Home Platform based on earlier prototypes inherited from ACES team. The prototypes were implemented as an hard-to-maintain monolithic code. The code also suffered from a lot of redundancy. More importantly the platform hardly supported dynamism and provided no support for reconfiguration and adaptation at runtime. With this in mind, during the re-writing of the platform the emphasis has been placed on the following aspects:

- supporting the dynamic discovery of heterogeneous sensors;
- enabling the dynamic deployment of applications at runtime ;
- enabling context-awareness by providing contextual information to these applications;
- enhancing the separation of concerns and code-reuse.

Our goal is to design and build a platform that is:

- **evolutive**: the Home environment is ever-changing and thus it is important to allow users to add new sensors or new services dynamically at runtime. It is also mandatory to recalibrate the sensors to face the change in the Home. This is mainly why we based our platform on OSGi;
- **maintainable and administrable**: we raised the maintainability by using a modular approach using C-modules or iPOJO components; the platform is itself modular to achieve a good separation of concerns (e.g., communication, module loading, discovery). We also built in-production monitoring interfaces that provides information on the belief functions that are used, the fusion process and the sensors values;
- **easy to configure**: alleviating the complexity of the platform configuration and maintenance is a prerequisite for the adoption of Smart-Home environments by consumers. Currently the BFT theories requires a huge calibration process. We focussed our efforts on the semi-automated building of mass functions, required by the theory, that have to be provided by each sensor.

6.3.1. Towards dynamism using OSGI

The development of our initial platform in C proved to be costly and hard to maintain. The dynamism is hard to achieved with a low-level language and requires an heavy development process. This led the team to investigate the use of OSGi as a based for our execution platform. OSGi is the specification of an execution framework developed on top of Java. It relies on the Java's dynamic features (dynamic and on demand class loading through class loaders) to provide a coarse-grained level of modularity. This choice was reinforced by our collaboration with the Adele team (LIG Laboratory in Grenoble). This team is using OSGi as a core for building Smart Home applications. Using OSGi would ease collaboration and code sharing.

One main concerns regarding the use of Java was the limited performances of the targeted hardware (raspberry pi). The Belief Function Theory (BFT) requires heavy computations and the embedded CPU could have been the bottleneck. Moreover, the JVM supported by the raspberry pi is limited compared to standard JVM. As a preliminary study, we choose to implement the core of the BFT library in Java and to compare the performances with the C implementation. Unexpectedly the Java implementation performed better than the C implementation in most of the case. This can be explained by three factors. First, the BFT theory is tedious to implement in low-level language. The C-implementation could probably be optimized but this will lower the readability of the source code and impact the maintainability. Second and conversely, using Java raised the code readability and allowed us to performed some optimization. Third, the JIT (Just In Time) compiler provided by the VM have been improved these past years and the optimization performed by the VM are sufficient to bring on par performances with the C implementation. As, the performances of the C platform were largely sufficient, this preliminary phase validated our decision to switch to OSGi.

6.3.2. Automated configuration of sensors

A previous defended in the group in december 2013 has shown promising results applying the BFT theory to the Smart Home Domain. It is currently possible to collect sensor values and extract belief functions from them. The platform can then extract a context from the belief functions and offer services to the user depending on what is happening. For instance, the user may be notified of an open window when he leaves the house.

The transition between a raw sensor value and a belief function is made through the use of a belief model which maps a sensor value to a belief function. The belief model is provided to the platform by us and a component is in charge of transforming a sensor value in a belief function. The fine tuning of a model can be a tedious task. It must be done by a specialist who understands the belief function theory and knows the behavior of the sensors. The model is often built iteratively by experimenting. This may take several hours or days.

Ideally, the calibration of the model should be as automatic as possible (few interaction with the user during calibration). The person setting up the sensors should not have to understand the belief function theory. The group is currently studying the possible use of clustering and classifications algorithm in order to ease the calibration of sensors. Yoann Maurel and Frédéric Weis supervised a project with a group of ENS student on this subject. The goal is to generate our belief model from a training set of sensor data. We mainly focus on two algorithms: k-nearest neighbors (KNN) and overlapping k-mean (OKM). A first experimentation with KNN and motion sensors showed that this algorithm is promising. We used a training data set to compute the presence belief model. We acquired a first set of data with someone present in the experimentation room and a second data set with nobody in the room, which gives us a labelled data set.

6.4. Towards Metamorphic Housing: the on-demand room

Participant: Michele Dominici [contact].

This research activity is supported by Fondation Rennes 1 through the chair "Smart Home and Innovation", since January 2014. During the first year, we focused on identifying the needs of the industrial partners and public authorities that fund the chair.

This activity is centered on the concept of metamorphic housing (see section 4.2). During this year, we introduced a solution of metamorphic housing addressing the goals of saving space and energy in an apartment building, while preserving residents' comfort: the on-demand room. It consists in a space that is physically shared by a small group of apartments, but is assigned for the sole use of one or few particular ones at the time, as illustrated in Figure 3. The room is designed so as to make occupants feel they did not leave their apartment at all. They seamlessly move from their dwelling to the on-demand room and conversely, without noticing the difference, as the room adapts to their preferences.

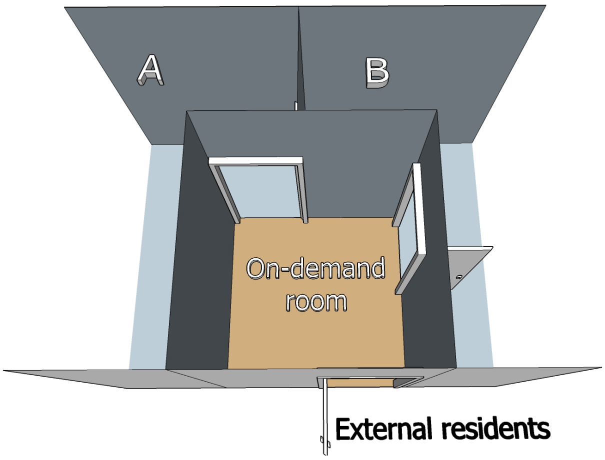

Figure 3. Floor plan for a metamorphic house

The underlying research problems are numerous. Dynamically "plugging" the room into a different apartment requires replacing the owner of the room's equipment, including appliances, heating, ventilation and air conditioning systems (HVAC), sensors, etc. The rights to control them and receive information from them must be dynamically reallocated. This must be done in a transparent fashion, so that off-the-shelf devices and appliances can be used.

In some cases, devices require dynamic reprogramming, like HVAC systems, because they must adapt to occupants' preferences and settings (e.g., ambient temperature set point).

Another research problem is the automatic learning of a schedule for the on-demand room. Regularities in users' requests for the room, duration of their occupation and privacy level can be discovered and learned. In this way, users do not have to manually book the room and usage conflicts can be prevented. We started investigating these research problems with an interdisciplinary approach and in collaboration with companies and public authorities [6]. We also started working on a prototype of the on-demand room solution, which will be presented as an immersive interactive virtual-reality application, leveraging the Immersia platform http://www.irisa.fr/immersia/.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Pervasive_RFID

- Partner: IETR
- Starting: July 2013; ending: July 2016

Pervasive_RFID is a joint effort (within the CominLabs initiative, see http://www.cominlabs.ueb.eu/) started in July 2013 with IETR (institut d'électronique et de télécommunications de Rennes) to study and design innovative RFID reading protocols in the context of pervasive computing applications. 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.

7.1.2. GLIE - Guidage Lumineux par l'Intelligence de l'Environnement

- Partner: OyaLight
- Starting: December 2014; ending: December 2015

GLIE is a collaborative projet with OYALIGT and TACOMA group. The objective of the project is to design and demonstrate a new service combining connected LEDs provided by OYALIGHT and a software tool developed by TACOMA. By integrating and analyzing data transmitted by the sensors integrated into LEDs , the service must be able to detect a given context and to react accordingly.

8. Dissemination

8.1. Promoting Scientific Activities

8.1.1. Scientific events selection

8.1.1.1. member of the conference program committee

- PC member for Ehpwas 2014: 2nd IEEE Int. Workshop on E-Health , 2014, F. Weis
- Member of the scientific committee of MC 2014 (Materiality in its contemporary form) Grenoble, February 2014, M. Dominici

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

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

Master : Ambient Computing and Mobile Communications, F. Weis, 6 hours, M2, university of Rennes 1

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

Master: Mobile and Pervasive Computing , P. Couderc, M2, University of Rennes 1

8.2.2. Supervision

PhD: Arnab Sinha, Pervasive control systems for smart waste management solutions, 14/12/10, M. Banâtre and P. Couderc, defended in April 2014

PhD in progress: Francisco Javier Acosta Padilla, Auto-adaptation for IoT, 31/01/13, Frédéric Weis and Johann Bourcier

8.2.3. Juries

Paul Couderc was in the following PhD examination committees:

Arnab Sinha, Pervasive control systems for smart waste management solutions, University Rennes 1 (co-director)

Tony Ducrocq, Auto-organisation des réseaux sans-fil multi-sauts dans les villes intelligentes, University Lille 1 (examiner)

Frédéric Weis was in the following PhD examination committees:

Ozan Gunalp, Déploiement continu des applications pervasives en milieux dynamiques, University Grenoble (PhD referee)

8.2.4. Internship

Master 1 Internship, 3 months: "Enhancing a Web Administration GUI for Smart Home using the Wisdom Framework", CHAABI Abdelhak

Master 1 Internship, 3 months: "Integration of Netatmo, Philipps Hue and Fibaro sensors into a Smart-Home platform", Bahram Salim

Master 1 Internship, 4 months: "Implementation of motion control for an RFID experimentation testbed", Victor Petit

9. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] A. SINHA. *Self-describing objects with tangible data structures*, Université Rennes 1, May 2014, https://tel.archives-ouvertes.fr/tel-01062441

International Conferences with Proceedings

[2] F. J. ACOSTA PADILLA, F. WEIS, J. BOURCIER. *Towards a Model@runtime Middleware for Cyber Physical Systems*, in "Proceedings of the 9th Workshop on Middleware for Next Generation Internet Computing", Bordeaux, France, December 2014, https://hal.inria.fr/hal-01090269

[3] O. RONCIÈRE, S. COLLARDEY, R. SAULEAU, N. BEN MABROUK, P. COUDERC. *Diversity contribution of a versatile UHF RFID antenna system in portal applications*, in "European Microwave Week", Rome, Italy, October 2014, https://hal.inria.fr/hal-01102874

[4] A. SINHA, Y. GLOUCHE, P. COUDERC. *Distributed Tree Structure for Composite Physical Objects*, in "The 5th International Conference on Ambient Systems, Networks and Technologies", Hasselt, Belgium, June 2014, https://hal.inria.fr/hal-01102358

References in notes

[5] R. BALDONI, M. BANÂTRE, M. DOMINICI, D. DUMORTIER, M. EL MANKIBI, M. FRÉJUS, B. KOLDEHOFE, M. MECELLA, K. ROTHERMEL, P. SUIGNARD. *Comfort-Oriented Metamorphic House (COMETAE)*, October 2012, n^{o} PI 1998, Publications Internes de l'IRISA ISSN : 2102-6327, https://hal.inria.fr/hal-00864884

[6] M. DOMINICI, M. BANÂTRE. *A case study of metamorphic housing: the on-demand room*, IRISA, January 2015, n^{o} PI-2026, 17 p. , https://hal.inria.fr/hal-01109341

[7] M. DOMINICI, B. PIETROPAOLI, F. WEIS. *Experiences in managing uncertainty and ignorance in a lightly instrumented smart home*, in "International Journal of Pervasive Computing and Communications", 2012, vol. 8, n^{o} 3, pp. 225-249 [*DOI :* 10.1108/17427371211262635], https://hal.inria.fr/hal-00787049

[8] B. PIETROPAOLI, M. DOMINICI, F. WEIS. *Propagation of Belief Functions through Frames of Discernment : Application to Context Computing*, in "The 26th International FLAIRS Conference", St. Pete Beach, United States, May 2013, https://hal.inria.fr/hal-00927088

[9] B. PIETROPAOLI, M. DOMINICI, F. WEIS. *Virtual Sensors and Data Fusion in a Multi-Level Context Computing Architecture*, in "16th International Conference on Information Fusion (FUSION 2013)", Instanbul, Turkey, July 2013, https://hal.inria.fr/hal-00927092