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Activity Report 2014

## **Project-Team PHOENIX**

# Programming Language Technology For Communication Services

IN COLLABORATION WITH: Laboratoire Bordelais de Recherche en Informatique (LaBRI)

RESEARCH CENTER  
**Bordeaux - Sud-Ouest**

THEME  
**Distributed programming and Software engineering**



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## Project-Team PHOENIX

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## 2. Overall Objectives

### 2.1. Overall Objectives

A host of networked entities (devices and services) are populating smart spaces that become prevalent (*e.g.*, building management, personal assistance, avionics) and large scale (*e.g.*, train station, city, highway network). These smart spaces are becoming intimately intertwined with our daily life and professional activities, raising scientific challenges that go beyond the boundaries of single field of expertise.

To address these challenges, the Phoenix group conducts multi-disciplinary research that combines

1. Cognitive Science to study user needs and make a rigorous assessment of the services provided by a smart space;
2. Sensing and actuating expertise to support the user based on accurate and rich interactions with the environment;
3. Computer Science to support and guide all the development process of the services provided by a smart space.

The activities of the Phoenix group revolve around two main avenues of research.

First, a design-driven software development approach that leverages programming languages principles and techniques to guide and support the development of applications orchestrating networked entities. Second, cognitive digital assistance that exploits the capabilities of smart spaces to provide services that compensate or remediate cognitive difficulties.

In practice, Phoenix has developed DiaSuite, a tool-supported methodology for both the development and verification of applications orchestrating networked entities. DiaSuite is used to propose an assisted living platform named HomeAssist. This platform is deployed in our research apartment where a variety of scenarios are explored using a range of sensing/actuating capabilities and assistive applications. Moreover, a dedicated version of HomeAssist is now deployed at the home of 15 older adults in the Bordeaux area. Beyond the home, Phoenix studies mobile cognitive support based on tablet. In particular, we have developed cognitive assistive technology for the inclusion of children with Autism in mainstreamed environment.

## 3. Research Program

### 3.1. Design-Driven Software Development

Raising the level of abstraction beyond programming is a very active research topic involving a range of areas, including software engineering, programming languages and formal verification. The challenge is to allow design dimensions of a software system, both functional and non-functional, to be expressed in a high-level way, instead of being encoded with a programming language. Such design dimensions can then be leveraged to verify conformance properties and to generate programming support.

Our research on this topic is to take up this challenge with an approach inspired by programming languages, introducing a full-fledged language for designing software systems and processing design descriptions both for verification and code generation purposes. Our approach is also DSL-inspired in that it defines a conceptual framework to guide software development. Lastly, to make our approach practical to software developers, we introduce a methodology and a suite of tools covering the development life-cycle.

To raise the level of abstraction beyond programming, the key approaches are model-driven engineering and architecture description languages. A number of *architecture description languages* have been proposed; they are either (1) coupled with a programming language (e.g., [36]), providing some level of abstraction above programming, or (2) integrated into a programming language (e.g., [29], [37]), mixing levels of abstraction. Furthermore, these approaches poorly leverage architecture descriptions to support programming, they are crudely integrated into existing development environments, or they are solely used for verification purposes. *Model-driven software development* is another actively researched area. This approach often lacks code generation and verification support. Finally, most (if not all) approaches related to our research goal are *general purpose*; their universal nature provides little, if any, guidance to design a software system. This situation is a major impediment to both reasoning about a design artifact and generating programming support.

## 3.2. Integrating Non-Functional Concerns into Software Design

Most existing design approaches do not address non-functional concerns. When they do, they do not provide an approach to non-functional concerns that covers the entire development life-cycle. Furthermore, they usually are general purpose, impeding the use of non-functional declarations for verification and code generation. For example, the Architecture Analysis & Design Language (AADL) is a standard dedicated to real-time embedded systems [32]. AADL provides language constructs for the specification of software systems (e.g., component, port) and their deployment on execution platforms (e.g., thread, process, memory). Using AADL, designers specify non-functional aspects by adding properties on language constructs (e.g., the period of a thread) or using language extensions such as the Error Model Annex.<sup>1</sup> The software design concepts of AADL are still rather general purpose and give little guidance to the designer.

Beyond offering a conceptual framework, our language-based approach provides an ideal setting to address non-functional properties (e.g., performance, reliability, security, ...). Specifically, a design language can be enriched with non-functional declarations to pursue two goals: (1) expanding further the type of conformance that can be checked between the design of a software system and its implementation, and (2) enabling additional programming support and guidance.

We are investigating this idea by extending our design language with non-functional declarations. For example, we have addressed error handling [10], access conflicts to resources [34], and quality of service constraints [33].

Following our approach to paradigm-oriented software development, non-functional declarations are verified at design time, they generate support that guides and constrains programming, they produce a runtime system that preserves invariants.

## 3.3. Human-driven Software Design

Knowledge of the human characteristics (individual, social and organizational) allow the design of complex system and artifacts for increasing their efficacy. In our approach of assistive computing, a main challenge is the integration of facets of Human Factors in order to design technology support adapted to user needs in term of ergonomic properties (acceptability, usability, utility etc) and delivered functionalities (oriented task under user abilities constraints).

We adapt this approach to improve the independent living and self-determination of users with cognitive impairments by developing a variety of orchestration scenarios of networked objects (hardware/software) to provide a pervasive support to their activities. Human factors methodologies are adopted in our approach with the direct purpose the reliability and efficiency of the performance of digital support systems in respect of objectives of health and well-being of the person (monitoring, evaluation, and rehabilitation).

<sup>1</sup>The Error Model Annex is a standardized AADL extension for the description of errors [38].

Precisely, our methodologies are based on a closed iterative loop, as described in the figure below :

- Identifying the person needs in a natural situation (*i.e.*, desired but problematic activities) according to Human Factors Models of activity (*i.e.*, environmental constraints; social support networks - caregivers and family; person's abilities)
- Designing environmental support that will assist the users to bypass their cognitive impairment (according to environmental models of cognitive compensatory mechanisms); and then implement this support in terms of technological solutions (scenarios of networked objects, hardware interface, software interface, interaction style, *etc*)
- Empirically evaluating the assistive solution based on human experimentations that includes ergonomic assessments (acceptability, usability, usefulness, *etc*) as well as longitudinal evaluations of use's efficacy in terms of activities performed by the individual, of satisfaction and well-being provided to the individual but also to his/her entourage (family and caregivers).

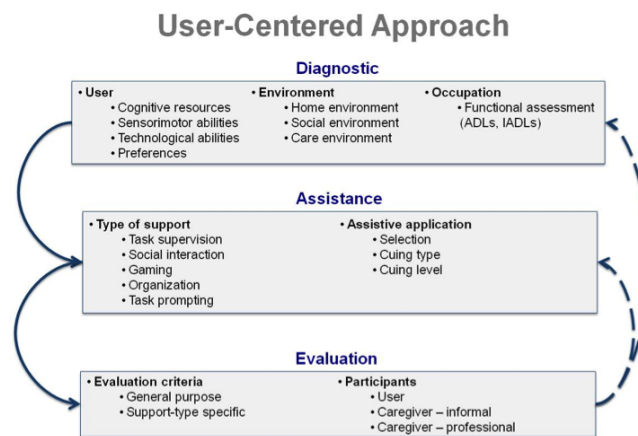


Figure 1. User-Centred Approach

## 4. Application Domains

### 4.1. Introduction

Building on our previous work, we are studying software development in the context of communication services, in their most general forms. That is, going beyond human-to-human interactions, and covering human-to-machine and machine-to-machine interactions. Software systems revolving around such forms of communications can be found in a number of areas, including telephony, pervasive computing, and assisted living; we view these software systems as coordinating the communication between networked entities, regardless of their nature, human, hardware or software. In this context, our three main application domains are pervasive computing, avionics and cognitive assistance.



## 4.2. Pervasive Computing

Pervasive computing systems are being deployed in a rapidly increasing number of areas, including building automation and supply chain management. Regardless of their target area, pervasive computing systems have a typical architectural pattern. They aggregate data from a variety of distributed sources, whether sensing devices or software components, analyze a context to make decisions, and carry out decisions by invoking a range of actuators. Because pervasive computing systems are standing at the crossroads of several domains (e.g., distributed systems, multimedia, and embedded systems), they raise a number of challenges in software development:

- **Heterogeneity.** Pervasive computing systems are made of off-the-shelf entities, that is, hardware and software building blocks. These entities run on specific platforms, feature various interaction models, and provide non-standard interfaces. This heterogeneity tends to percolate in the application code, preventing its portability and reusability, and cluttering it with low-level details.
- **Lack of structuring.** Pervasive computing systems coordinate numerous, interrelated components. A lack of global structuring makes the development and evolution of such systems error-prone: component interactions may be invalid or missing.
- **Combination of technologies.** Pervasive computing systems involve a variety of technological issues, including device intricacies, complex APIs of distributed systems technologies and middleware-specific features. Coping with this range of issues results in code bloated with special cases to glue technologies together.
- **Dynamicity.** In a pervasive computing system, devices may either become available as they get deployed, or unavailable due to malfunction or network failure. Dealing with these issues explicitly in the implementation can quickly make the code cumbersome.
- **Testing.** Pervasive computing systems are complicated to test. Doing so requires equipments to be acquired, tested, configured and deployed. Furthermore, some scenarios cannot be tested because of the nature of the situations involved (e.g., fire and smoke). As a result, the programmer must resort to writing specific code to achieve ad hoc testing.

## 4.3. Smart Cities

The Internet of Things (IoT) has become a reality with the emergence of Smart Cities, populated with large amounts of smart objects which are used to deliver a range of citizen services (e.g., security, well being, etc.) The IoT paradigm relies on the pervasive presence of smart objects or “things”, which raises a number of new challenges in the software engineering domain.

### 4.3.1. *The Object’s World project*

There are an abundance of research and industry initiatives that have been undertaken with the aim of promoting the emergence of IoT [1]. In line with this goal, the Object’s World project brings together stakeholders from different domains to build and support the emergence of an IoT sector in France and beyond. The project is lead by SIGFOX, the world’s first cellular network operator dedicated to low-bandwidth wireless objects. The cooperation between industry and research partners (e.g., sensor manufacturers, computer science and electrical engineering research labs) is of uttermost importance in overcoming technological barriers. This issue is currently hindering the development of an IoT sector. The main objectives of this project are the development of:

- expertise in the low-bandwidth network sector,
- low-cost transmitter/receiver chips,
- low-energy autonomous sensors, and
- software frameworks which cover the entire lifecycle of IoT applications.

Network infrastructures which support huge numbers of objects open up a range of opportunities for innovative services. Critically, these new opportunities rely on the ability to address the software engineering challenges of this new sector. We promote an approach that revolves around software frameworks. In areas such as mobile and web development, this approach has already been shown to facilitate software development by abstracting over implementation details and guiding the programmer.

#### 4.4. Assistive Technology for Cognition

Cognitive impairments (memory, attention, time and space orientation, etc) affect a large part of the population, including elderly, patients with brain injuries (traumatic brain injury, stroke, etc), and people suffering from cognitive disabilities, such as Down syndrome.

The emerging industry of assistive technologies provide hardware devices dedicated to specific tasks, such as a telephone set with a keyboard picturing relatives (<http://www.doro.fr>), or a device for audio and video communication over the web (<http://www.technosens.fr>). These assistive technologies apply a traditional approach to personal assistance by providing an equipment dedicated to a single task (or a limited set of tasks), without leveraging surrounding devices. This traditional approach has fundamental limitations that must be overcome to significantly improve assistive technologies:

- they are not adaptable to one's needs. They are generally dedicated to a task and have very limited functionalities: no networking, limited computing capabilities, a limited screen and rudimentary interaction modalities. This lack of functionality may cause a proliferation of devices, complicating the end-user life. Moreover, they are rarely designed to adapt to the cognitive changes of the user. When the requirements evolve, the person must acquire a new device.
- they are often proprietary, limiting innovation. As a result, they cannot cope with the evolution of users' needs.
- they have limited or no interoperability. As a result, they cannot rely on other devices and software services to offer richer applications.

To break this model, we propose to offer an assistive platform that is open-ended in terms of applications and entities. (1) An online catalog of available applications enables every user and caregiver to define personalized assistance in the form of an evolving and adapted set of applications; this catalog provides a community of developers with a mechanism to publish applications for specific daily-activity needs. (2) New types of entities (whether hardware or software) can be added to a platform description to enhance its functionalities and extend the scope of future applications.

## 5. New Software and Platforms

### 5.1. DiaSuite: a Development Environment for Sense/Compute/Control

#### Applications

**Participants:** Charles Consel [correspondent], Milan Kabac, Paul Van Der Walt, Adrien Carteron, Alexandre Spriet.

Despite much progress, developing a pervasive computing application remains a challenge because of a lack of conceptual frameworks and supporting tools. This challenge involves coping with heterogeneous devices, overcoming the intricacies of distributed systems technologies, working out an architecture for the application, encoding it in a program, writing specific code to test the application, and finally deploying it.

DIASUITE is a suite of tools covering the development life-cycle of a pervasive computing application:

- *Defining an application area.* First, an expert defines a catalog of entities, whether hardware or software, that are specific to a target area. These entities serve as building blocks to develop applications in this area. They are gathered in a taxonomy definition, written in the taxonomy layer of the DIASPEC language.
- *Designing an application.* Given a taxonomy, the architect can design and structure applications. To do so, the DIASPEC language provides an application design layer [35]. This layer is dedicated to an architectural pattern commonly used in the pervasive computing domain [31]. Describing the architecture application allows to further model a pervasive computing system, making explicit its functional decomposition.
- *Implementing an application.* We leverage the taxonomy definition and the architecture description to provide dedicated support to both the entity and the application developers. This support takes the form of a Java programming framework, generated by the DIAGEN compiler. The generated programming framework precisely guides the developer with respect to the taxonomy definition and the architecture description. It consists of high-level operations to discover entities and interact with both entities and application components. In doing so, it abstracts away from the underlying distributed technologies, providing further separation of concerns.
- *Testing an application.* DIAGEN generates a simulation support to test pervasive computing applications before their actual deployment. An application is simulated in the DIASIM tool, without requiring any code modification. DIASIM provides an editor to define simulation scenarios and a 2D-renderer to monitor the simulated application. Furthermore, simulated and actual entities can be mixed. This hybrid simulation enables an application to migrate incrementally to an actual environment.
- *Deploying a system.* Finally, the system administrator deploys the pervasive computing system. To this end, a distributed systems technology is selected. We have developed a back-end that currently targets the following technologies: Web Services, RMI, SIP and OSGI. This targeting is transparent for the application code. The variety of these target technologies demonstrates that our development approach separates concerns into well-defined layers.

This development cycle is summarized in the Figure 2.

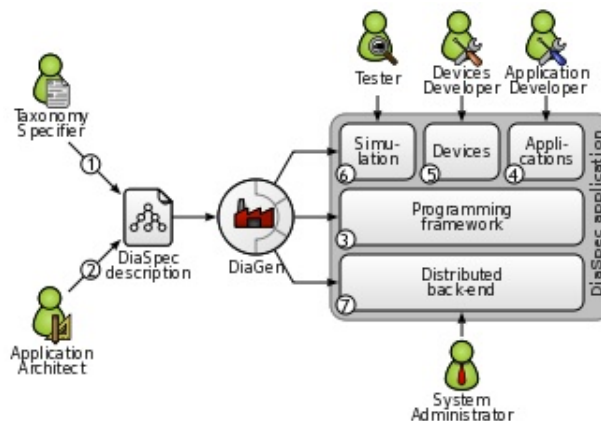


Figure 2. DIASUITE Development Cycle

See also the web page <http://diasuite.inria.fr>.

### 5.1.1. DiaSpec: a Domain-Specific Language for Networked Entities

The core of the DIASUITE development environment is the domain specific language called DIASPEC and its compiler DIAGEN:

- DIASPEC is composed of two layers:
  - The *Taxonomy Layer* allows the declaration of entities that are relevant to the target application area. An entity consists of sensing capabilities, producing data, and actuating capabilities, providing actions. Accordingly, an entity description declares a data source for each one of its sensing capabilities. As well, an actuating capability corresponds to a set of method declarations. An entity declaration also includes attributes, characterizing properties of entity instances. Entity declarations are organized hierarchically allowing entity classes to inherit attributes, sources and actions. A taxonomy allows separation of concerns in that the expert can focus on the concerns of cataloging area-specific entities. The entity developer is concerned about mapping a taxonomical description into an actual entity, and the application developer concentrates on the application logic.
  - The *Architecture Layer* is based on an architectural pattern commonly used in the pervasive computing domain [31]. It consists of context components fueled by sensing entities. These components process gathered data to make them amenable to the application needs. Context data are then passed to controller components that trigger actions on entities. Using an architecture description enables the key components of an application to be identified, allowing their implementation to evolve with the requirements (e.g., varying light management implementations in a controller component to optimize energy consumption).
- DIAGEN is the DIASPEC compiler that performs both static and runtime verifications over DIASPEC declarations and produces a dedicated programming framework that guides and eases the implementation of components. The generated framework is independent of the underlying distributed technology. As of today, DIAGEN supports multiple targets: Local, RMI, SIP, Web Services and OSGI.

### 5.1.2. DiaSim: a Parametrized Simulator for Pervasive Computing Applications

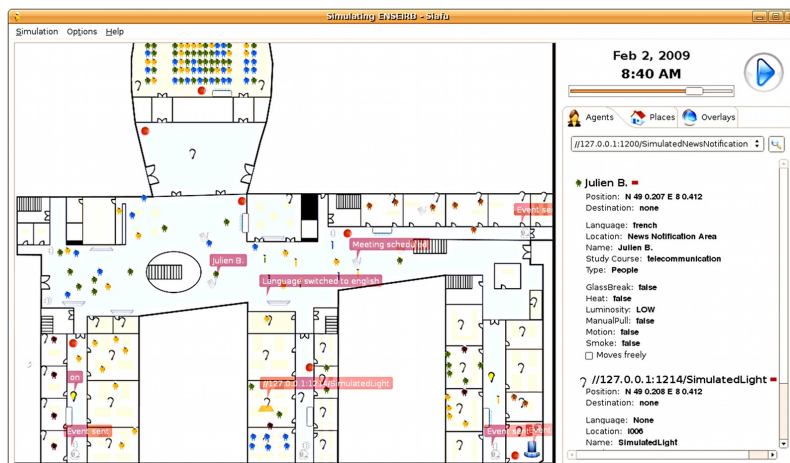


Figure 3. A screenshot of the DIASIM simulator

Pervasive computing applications involve both software and integration concerns. This situation is problematic for testing pervasive computing applications because it requires acquiring, testing and interfacing a variety of software and hardware entities. This process can rapidly become costly and time-consuming when the target environment involves many entities.

To ease the testing of pervasive applications, we are developing a simulator for pervasive computing applications: DIASIM. To cope with widely heterogeneous entities, DIASIM is parameterized with respect to a DIASPEC specification describing a target pervasive computing environment. This description is used to generate with DIAGEN both a programming framework to develop the simulation logic and an emulation layer to execute applications. Furthermore, a simulation renderer is coupled to DIASIM to allow a simulated pervasive system to be visually monitored and debugged. The simulation renderer is illustrated in Figure 3.

## 5.2. DiaSuiteBox: an Open Orchestration Platform

**Participants:** Charles Consel, Adrien Carteron, Alexandre Spriet, Milan Kabac.

The DiaSuiteBox platform runs an open-ended set of applications leveraging a range of appliances and web services. Our solution consists of a dedicated development environment, a certifying application store, and a lightweight runtime platform. This solution is based on the DIASUITE project.

### 5.2.1. DiaSuiteBox platform architecture

The DiaSuiteBox platform can be embedded in a small plug-computer or deployed in the cloud. Thanks to the application store and the developer community, the platform is fed by a full offer of new innovative applications. During the submission process, an application is automatically analyzed and checked in order to be certified. The user is ensured the behavior of its applications are innocuous and correct with respect to the provided information. Finally, DiaSuiteBox provides an extensible software architecture. This allows the easily connect new device technologies to the platform. For example, the support for new wireless communication technologies such as Zigbee, Z-Wave or Sigfox can be easily added to the DiaSuiteBox platform.

More details can be found on the web page <http://diasuitebox.inria.fr>.

The iQSpot startup uses DiaSuiteBox as a software platform to ease the management of Smart Buildings. In this project, the DiaSuiteBox platform is first used to host building management functionalities such as lighting management, heating/ventilating/air conditioning management, energy efficiency monitoring. It is also used to host software drivers that allow the building management functionalities to interact with the connected devices deployed in buildings. These devices can use wired communication technologies such LonWorks, BACNet or KNX, as well as wireless communication technologies such as Z-Wave or Zigbee.

## 5.3. School+ Apps: Assistive tablet applications for school Inclusion

**Participants:** Charles Consel [correspondent], H el ene Sauz eon, Charles Fage, C ecile Magnier.

School+ is a package of 7 applications. Three applications are assistive applications, guiding the child doing specific tasks. Three others are training applications made as serious games, addressing specific skills. The last application is a meta-application, comprising a link to the three training applications, with an access to statistics of their usage. For each application, data are separated from the design, meaning that every element of each application (pictures, texts, settings, etc.) can be changed at any time. Each application records a log file containing all the interactions performed by the child.

### 5.3.1. Assistive applications:

- *Routines application.* This application shows a list of tasks, with a short description. After clicking the starting button, a specific slideshow is shown; it decomposes a task into steps. For each step, a text and a picture can be displayed. Thumbnail of previous and next steps are also displayed. This application guides the child through classroom situations: entering classroom, taking school materials out of a backpack, writing notes, handling agenda, leaving the classroom.

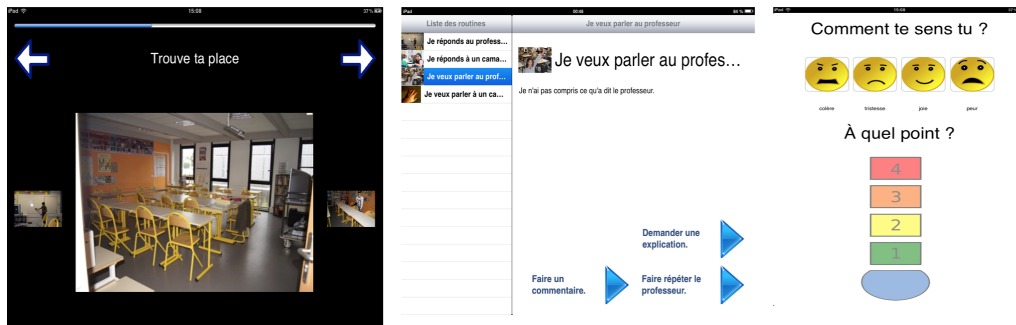


Figure 4. Assistive applications

- *Communication application.* With the same design, the assistance provided by this application targets to communicating situations inside the classroom. The application covers four scenarios addressing two interaction situations (initiating and answering the interaction) and two types of interlocutors (professor and classmate). For each scenario, different slideshows guide the child, depending on the goal of the interaction.
- *Emotion Regulation application.* This application aims to assist the child to self-regulate his/her emotions. Four simplified emoticons are proposed to the child to choose from: anger, sadness, joy and fear. Then, (s)he selects a level of intensity via a thermometer with a scale from 1 to 4. In response, the application delivers different multimedia contents according to the level selected to help the child regulate his/her emotions. Typically, a text (breathing instructions) are shown at level 1, pictures at level 2, a video at level 3 and another text at level 4.

### 5.3.2. Training applications:

These three applications are serious games with increasing levels of difficulties, reachable after a ratio of good answers has been attained.

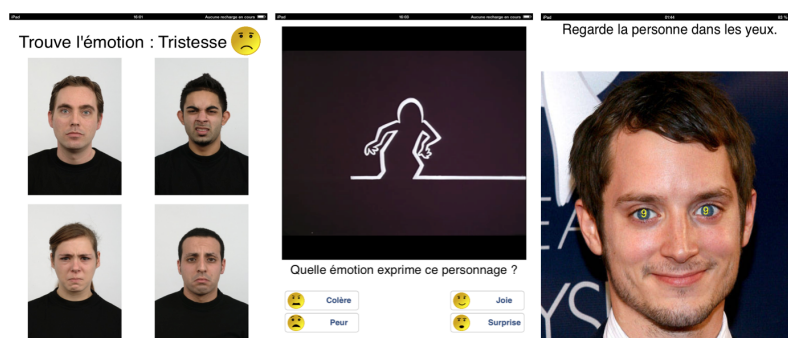


Figure 5. Training applications

- *Emotion Recognition application: pictures.* In this application, the child is instructed to identify a specific emotion among 4 pictures showing different people exhibiting an emotion. Seven emotions

are involved in this application: joy, sadness, fear, anger, surprise, disgust and neutral. The emotion to be recognized is displayed together with its simplified emoticon. The type of pictures changes with the difficulty level: level 1 contains pictures of unfamiliar people and level 2 contains pictures of friends and relatives of the child.

- *Emotion Recognition application: videos.* In this application, the child is presented with a fragment of an animated cartoon. At some point, the video stops and the child is asked to identify the emotion of the character. Four emotions are involved in this application: joy, sadness, fear and anger. Videos are slowed down, with a speed percentage that can be changed at each level. Videos change with difficulty level: level 1 contains videos of a very basic cartoon (only one cartoon character drawn by basic form un-textured), level 2 contains a video of more sophisticated cartoons and level 3 contains movies with actors.
- *Attention Training.* In this application, the child is presented a picture of a face and asked to make eye contact with it. Second, a symbol appears briefly in the eyes of the character. Third, the child is asked to identify the symbol shown in the previously displayed picture, to make sure he kept eye contact. The speed at which the symbol appears and disappears is changed according to the difficulty level. Types of pictures also change with the level : level 1 contains pictures of faces and level 2 contains pictures of classroom situations.

## 5.4. HomeAssist: A Platform for Assistive Living

**Participants:** Charles Consel, Loïc Caroux [correspondent], Thomas Freslon, Adrien Carteron, David Daney, Lucile Dupuy, Geoffrey Escojido, Bernard N’Kaoua, H el ene Sauz eon, Alexandre Spriet.

The HomeAssist platform proposes a systemic approach to introducing an assistive technological platform for older people. To do so, we formed a trans-disciplinary team that allows (1) to identify the user needs from a gerontological and psychological viewpoint; (2) to propose assistive applications designed by human factors and HCI experts, in collaboration with caregivers and users; (3) to develop and test applications by software engineers; (4) to conduct a field study for assessing the benefits of the platform and assistive applications, in collaboration with caregivers, by deploying the system at the actual home of elders.

The HomeAssist platform is implemented on top of the DiaSuiteBox platform, using a suite of tools, namely DiaSuite, that have been designed, developed and tested by our research group at Inria. The DiaSuite tools include a dedicated integrated development environment that enables applications to be developed quickly and safely. This technology has been successfully applied to a variety of domains where environments consist of networked objects that need to be orchestrated.

### 5.4.1. Applications

HomeAssist offers an online catalog of applications. Using this catalog, the user and the caregiver determine what and how activities should be assisted by selecting the appropriate assistive applications and configuring them with respect to the user’s requirements and preferences. The resulting set of applications forms a personalized assistive support. Additionally, to respond to evolving needs, our platform allows to stop/remove applications easily and to install new ones from the online catalog.

This platform proposes many applications in three domains of everyday life:

- Daily activities: including activity monitoring, light path, and a reminder.
- Home or personal safety: including entrance monitoring, stove monitoring, and warning if no movements are detected after a certain amount of time.
- Communications and social activities: including collaborative games, videoconference, information about local events, TV programming, *etc.*

For video presentations of HomeAssist, see the following:

- <http://videotheque.inria.fr/videotheque/media/23705>. Title: “Dia Suite Box”. Produced in 2013.
- <http://videotheque.inria.fr/videotheque/media/29998>. Title: “DomAssist : L’assistance num erique   la personne”. Produced in 2014.



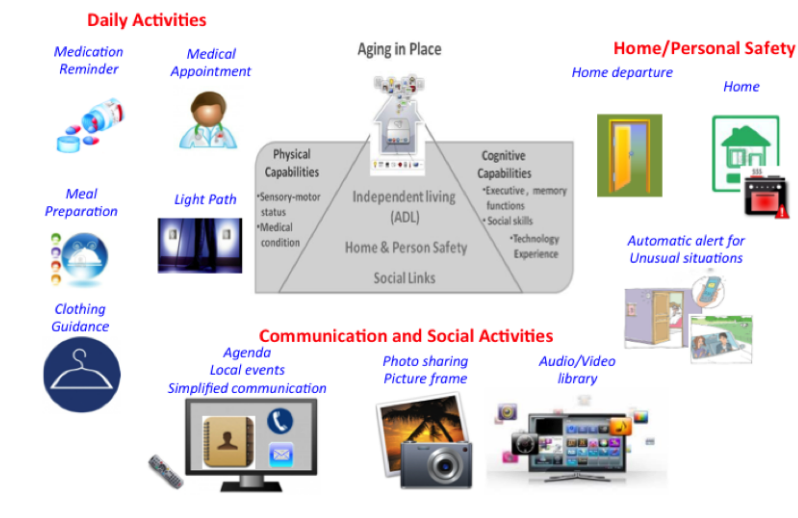


Figure 6. The HomeAssist platform and applications

#### 5.4.2. Devices

Several entities have been identified to deliver an assistive support. These entities include (1) technological devices: wireless sensors (motion detectors, contact sensors and smart electric switches), and two tablets, and (2) software services (agenda, address book, mail agent, and photo agent) to monitor everyday activities and propose assistive applications. Sensors are placed in relevant rooms in the house: kitchen, bedroom, bathroom, and around the entrance.



Figure 7. HomeAssist devices

#### 5.4.3. Experimental validation



A field study is currently being conducted with elderly people. The major purpose of this study is to identify the benefits of using HomeAssist for this population in an ecological framework. We selected 24 elderly people with different levels of autonomy (GIR scores). The HomeAssist technology has been installed in their house during 9 months. Twenty-four non-equipped elders were also selected to participate to the study, as control participants.

The expected impact of HomeAssist reflects the trans-disciplinary nature of the project. We aim to deliver results in the domain of (1) elderly care, (2) ergonomics and human factors, and (3) pervasive computing.

The major expected results are that HomeAssist (1) prolongs ageing in place, improves well-being of the users, and improves the efficiency of the caregiving environment; (2) is a cognitively low-cost assistive technology, and is well accepted and perceived as useful and usable by the users; (3) is technologically robust, and is a validated assistive platform

First results are expected in January 2015.

#### **5.4.4. External Partners**

The HomeAssist platform is being developed with support from the following partners:

- Équipe “Handicap et Système Nerveux” (EA 4136), Bordeaux University
- Chaire TSA, Université du Québec Trois-Rivières
- CRIUGM, Université de Montréal
- UDCCAS Gironde
- CARSAT
- Conseil Général 33
- Conseil Régional d’Aquitaine

### **5.5. DiaSwarm: a Development Environment for orchestrating smart objects at a large scale**

**Participants:** Charles Consel [correspondent], Milan Kabac, Adrien Carteron, Eugène Volanschi.

The development of orchestrating applications which are responsible for large numbers of smart objects raises a number of challenges. We have addressed these by introducing a new design language called DiaSwarm, which is an extended version of the DiaSpec language.

#### **5.5.1. Service discovery**

Standard service discovery at the individual object level does not address the needs of applications orchestrating large numbers of smart objects. Instead, a high-level approach which provides constructs to specifying subsets of interest is needed. Our approach allows developers to introduce application-specific concepts (e.g., regrouping parking spaces into lots or districts) at the design time and then these can be used to express discovery operations. Following our design-driven development approach, these concepts are used to generate code to support and guide the programming phase.

#### **5.5.2. Data gathering**

Applications need to acquire data from a large number of objects through a variety of delivery models. For instance, air pollution sensors across a city may only push data to the relevant applications when pollution levels exceed tolerated levels. Tracking sensors, however, might determine the location of vehicles and send the acquired measurements to applications periodically (e.g., 10 min. intervals). Data delivery models need to be introduced at design time since they have a direct impact on the application’s program structure. In doing so, the delivery models used by an application can be checked against sensor features early in the development process.

### 5.5.3. Data processing

Data that is generated from hundreds of thousands of objects and accumulated over a period of time calls for efficient processing strategies to ensure the required performance is attained. Our approach allows for an efficient implementation of the data processing stage by providing the developer with a framework based on the MapReduce [30] programming model which is intended for the processing of large data sets.

More details on this software platform can be found in the special issue on Smart Cities of the journal ERCIM News [18], 2014.

## 6. New Results

### 6.1. Highlights of the Year

- A best paper award was obtained at ASSETS 2014 (The 16th International ACM SIGACCESS Conference on Computers and Accessibility), by the 5 authors of the paper "Tablet-Based Activity Schedule for Children with Autism in Mainstream Environment" .

BEST PAPER AWARD :

[26] **Tablet-Based Activity Schedule for Children with Autism in Mainstream Environment in ASSETS 2014 - The 16th International ACM SIGACCESS Conference on Computers and Accessibility**. C. FAGE, L. POMMEREAU, C. CONSEL, E. BALLAND, H. SAUZÉON.

### 6.2. Technological Support for Self-Regulation of Children with Autism

Children with Autism Spectrum Disorders (ASD) have difficulties to self-regulate emotions, impeding their inclusion in a range of mainstreamed environments. Self-regulating emotions has been shown to require recognizing emotions and invoking specific coping strategies.

In the context of the School+ research project, we have developed an application dedicated to self-regulating emotions in children with ASD. Ten children with ASD have experimentally tested this tablet-based application over a period of three months in a mainstreamed school. A collaborative learning approach, involving parents, teachers and a school aid, was used 1) to train students to operate the tablet and our application autonomously, and 2) to facilitate the adoption of our intervention tool.

This study shows that our application was successful in enabling students with ASD to self-regulate their emotions in a school environment. Our application helped children with autism to recognize and name their emotions, and to regulate them using idiosyncratic, parent-child, coping strategies, supported by multimedia contents.

This work is in the context of the School+ national research project funded by the French Ministry of National Education.

A best paper award was obtained at ASSETS 2014 (The 16th International ACM SIGACCESS Conference on Computers and Accessibility) for this work in October 2014, by the 5 authors of the paper "Tablet-Based Activity Schedule for Children with Autism in Mainstream Environment" [26]: Charles Fage, Léonard Pommereau, Charles Consel, Emilie Balland, and H el ene Sauz eon.

### 6.3. A Low-Cost approach to the Verification of Daily Activities of Elders

Activities of Daily Living (ADL) are abilities defining the functional status of an individual. Verifying what ADLs are performed by an elder is a decisive factor to determine what kinds and what levels of assistance are needed for an individual and whether aging in place is desirable. The importance of this issue has led a number of researchers to develop a range of Ubicomp approaches that can monitor activities.

In this study, we take these prior results one step further and apply them to the needs of caregiver professionals to monitor elders at their home. Specifically, our approach relies on the following key observation: as people age their daily activities are increasingly organized according to a routine to optimize their daily functioning. As a result, their activities do not need to be recognized but should rather be verified. Deviations are a warning sign of degradation.

We have developed an approach to activity verification. This approach relies on a technological infrastructure that is simple, low-cost and non-intrusive. This infrastructure was deployed in four homes of elders of 83 years of age on average. The same set of sensors was used in the four homes and was placed at strategic locations with respect to their routines to verify the target activities. The analysis of the data collected during five weekdays show that they follow very strict routines that can easily be associated with their main activities.

This work is in the context of the DomAssist project, funded by the following partners: UDCCAS, CG33, CRA, CNSA, Chambre des métiers. A report of the work has been published at the 16th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS 2014) [25].

## 6.4. Using virtual reality for studying everyday-like memory and its cognitive correlates

This work consisted in a pilot-study with a comparison approach between aging and traumatic brain injury (TBI) to investigate everyday object memory patterns using a virtual HOMES test.

- **Methods:** Sixteen young controls, 15 older adults and 15 TBI patients underwent the HOMES test and traditional tests.
- **Results:** Older adults and TBI patients exhibited similar HOMES performances: poor recall, a greater recognition benefit, high false recognitions, but intact clustering and proactive interference effects. The age-related differences for HOMES measures were mainly mediated by executive functioning, while the HOMES performances in the TBI group were correlated with memory measures.
- **Conclusion:** The differential cognitive mediating effects for a similar everyday-like memory pattern have been discussed by highlighting the need for more cautious interpretations of cognitive mechanisms behind similar behavioral patterns in different populations especially in clinical and rehabilitation settings.
- **Implication for Rehabilitation:**
  - Virtual reality might provide ecological scenarios to assess the multiple processes of everyday memory in elderly people as well as in TBI patients.
  - A similar pattern of Everyday-like memory failures might result from different cognitive origins among different neuropsychological patients.
  - The assessment of specific cognitive origins of Everyday-like memory impairments deserves consideration for drawing up relevant rehabilitative programs that match the specific cognitive needs of patients for performing everyday memory tasks.

This work has been published in the journal "Disability and Rehabilitation: Assistive Technology" in November 2014 [14].

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. HomeAssist: Platform for Assisted Living

The objective of this project is to provide an open platform of digital assistance dedicated to aging in place. This project is in collaboration with researchers in Cognitive Science (Bordeaux University) and the UDCCAS Gironde (Union Départementale des Centres Communaux d'Action Sociale) managing elderly care. This project includes a need analysis, the development of assistive applications and their experimental validation.

This work is funded by CARSAT Aquitaine (“Caisse d’Assurance Retraite et de la Santé au Travail”), Aquitaine Region and Conseil Général de la Gironde.

### **7.1.2. Cognitive Assistance for Supporting the Autonomy of Persons with Intellectual Disabilities**

The objective of this project is to develop assistive technologies enabling people with intellectual disabilities to gain independence and to develop self-determined behaviors, such as making choices and taking decisions. This project is in collaboration with the “Handicap et Système Nerveux” research group (EA 4136, Bordeaux University), the TSA Chair of UQTR (Université du Québec à Trois-Rivières) in Psychology and the Association Trisomie 21 Gironde (Down Syndrome). The TSA chair has recently designed and built a smart apartment that is used to conduct experimental evaluation of our assistive technologies in realistic conditions.

### **7.1.3. Certification of an open platform**

The purpose of this project is to define concepts and tools for developing certifying open platforms. This certification process must ensure a set of critical properties (e.g., safety, confidentiality, security) by certifying each tier application. These guarantees are essential to ensure that openness does not come at the expense of the user’s well-being. To preserve the innovation model of open platforms, this certification process should also be as automatic as possible. Indeed, the success of open platforms is mainly due to the low development cost of a new application. The case study of this thesis will be the domain of home automation. The results of this thesis will be put into practice in the DiaSuiteBox open platform.

This project is funded by Aquitaine Region.

### **7.1.4. ANDDI**

Five percent of the population have Intellectual Disabilities (ID). Individuals with ID have significant socio-adaptive limitations in a variety of daily activities, at home (task planification and execution, medication, home safety, etc.) as well as outside (route planning, itinerary in public transportation, etc.). Individuals with ID, their families, health institutions, caregiving services, and dedicated organizations strive to find ways in which these individuals can live as independently as possible, while promoting their social inclusion in every respect of their life (housing, professional training, employment, leisure, culture, etc.).

The research project ANDDI leverages the abilities of individuals with ID and the recent technological advances to develop a variety of assistive services addressing their daily needs. These services draw on our expertise in cognitive science and computer science, dedicated to assisting users with technologies. In particular, we use our platform, named HomeAssist, dedicated to the independently living of older adults. This platform relies on DiaSuite, our suite of tools for developing applications that orchestrate networked objects, and DiaSuiteBox, our platform that runs an open-ended set of applications, sensors, actuators and web services.

ANDDI addresses users with Down syndrome aiming to live independently; it pursues the following goals:

1. determining the key obstacles to perform daily activities autonomously and collecting the needs in assistive support expressed by individuals with ID and their family and caregivers;
2. developing and adapting assistive services available in HomeAssist across an iterative assessment (period of 6 months) of experiences of each individual;
3. evaluating the efficacy of our developed assistive services across the stages experienced by individuals progressively becoming independent in their daily life (pre-post comparison after 12 months of HomAssist intervention).

This project is funded by the “Conseil Régional d’Aquitaine” and “Trisomie 21”.

## 7.2. National Initiatives

### 7.2.1. *Objects' World: design-driven development of large-scale smart spaces*

The goal of this project is to develop an innovative communication technology, allowing the emergence of a new economic sector for large-scale smart spaces. Our objective is to propose concepts and tools for developing reliable applications orchestrating large-scale smart spaces of networked entities. The industrial partners of the Objects' World project will provide us with real-size case studies in various application domains (e.g., smart cities, tracking of vehicles, healthcare, energy management).

This work is funded by the OSEO national agency.

### 7.2.2. *School Inclusion for Children with Autism*

The objective of this project is to provide children with assistive technologies dedicated to the school routines. This project is in collaboration with the "Handicap et Système Nerveux" research group (EA 4136, Bordeaux University), the PsyCLÉ research center (EA 3273, Provence Aix-Marseille University) and the "Parole et Langage" research laboratory (CNRS, Provence Aix-Marseille University).

This work is funded by the French Ministry of National Education.

## 7.3. International Initiatives

### 7.3.1. *Inria Associate Teams*

#### 7.3.1.1. *OPALI*

Title: OPen Assistive-technology platform for independent LIVING

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Trois Rivières (CANADA)

Duration: 2013 - 2015

See also: <http://phoenix.inria.fr/opali>

The goal of the OPALI project is to develop an Open Platform for Assisted Living targeting users with cognitive disabilities. It is a cross-disciplinary project combining expertise in (1) Computer Science focusing in development of applications orchestrating networked devices and (2) Psychology focusing in assistive technologies for users with cognitive disabilities. Furthermore, this project will leverage a unique research vehicle created by the University of Trois-Rivières consisting of a full-fledged apartment equipped with a range of networked devices and dedicated to experimental studies. The outcome of the project will include a large catalog of assistive applications allowing to match each user's project life.

## 7.4. International Research Visitors

### 7.4.1. *Visits of International Scientists*

Catherine Plaisant visited the Phoenix team during the month of November 2014. Catherine Plaisant is a Senior Research Scientist at the University of Maryland Institute for Advanced Computer Studies and Associate Director of the Human-Computer Interaction Lab.

## 8. Dissemination

### 8.1. Promoting Scientific Activities

#### 8.1.1. *Scientific events selection*

##### 8.1.1.1. *Member of the conference program committee*

Charles Consel:

- ICSE 2014, the 36th International Conference on Software Engineering. June 1-7, Hyderabad, India.
- ESOP 2015, the 24th European Symposium on Programming. April 11-15, 2015 London, United Kingdom.

Hélène Sauzéon:

- Conférence ITASD : des solutions numériques pour les personnes avec Autisme (Paris, Oct. 2014)
- Journées d'étude du vieillissement cognitif (Caen 2014)

#### 8.1.1.2. Reviewer

Loïc Caroux has reviewed papers for the following conferences:

- CHI 2015 (ACM Conference on Human Factors in Computing Systems)
- HFES 2014 (International Annual Meeting of the Human Factors and Ergonomics Society)
- IHM 2014 (Conférence Francophone sur l'Interaction Homme-Machine)

#### 8.1.1.3. Invited talks

- Consel C.: "Activity verification". Presentation at Northeastern University on human assistance, October 27, 2014.
- Sauzéon, H. and Caroux, L. (2014, Juillet). Plans expérimentaux et statistiques « pratiques ». Workshop of the Inria Project Lab Personally Assisting Living (IPL PAL), Talence, France.
- Sauzéon, H. and Consel, C. (2014) Projet DomAssist. 2ème Congrès Européen de Stimulation Cognitive – Technologies de compensation et Stimulation Cognitive, 22-23 septembre 2014, Toulouse.
- Sauzéon, H. and Consel, C. (2014) Assistance à domicile et aide à la réalisation des activités quotidiennes :le projet DomAssist. Technologies Appliquees Au Handicap : de la compensation à la participation - IFR Handicap PARIS – CNRS, 26 septembre 2014, Paris.
- Dupuy L., N'Kaoua B., Consel C., Aguilova L., and Sauzéon H. (2014). Role of cognitive reserve on everyday functioning among oldest old physically frail. XIIIème Colloque International sur le Vieillissement Cognitif – JEV, 15 et 16 septembre 2014, Caen, France.
- Congrès de Psychiatrie et de Neurologie de Langue Française Fage C., Consel C., and Sauzéon H., Collège+ : Un Assistant Scolaire pour Soutenir l'Inclusion Scolaire en Classe Ordinaire des Elèves avec Troubles du Spectre Autistique (TSA), CPNLF 2014 (Bordeaux, France, 2014).

### 8.1.2. Journal

#### 8.1.2.1. Reviewer

Loïc Caroux reviewed papers for the following journals:

- Computers in Human Behavior
- Behaviour and Information Technology
- Journal of Physical Education and Sport Management

Hélène Sauzéon reviewed papers for the following journals:

- Gerontology
- BMC Geriatrics
- Applied Psycholinguistics
- Experimental Aging Research
- Journal of Speech, Language, and Hearing Research

## 8.2. Teaching - Supervision - Juries

### 8.2.1. Teaching

Licence: H  l  ne Sauz  on, "General Cognitive Psychology", 36h, L2/L3, Universit   de Bordeaux, France

Licence: H  l  ne Sauz  on, "Neuropsychologie Cognitive", 14h, DU, Universit   de Bordeaux, France

Master: H  l  ne Sauz  on, "Sciences cognitives du langage", "Technologies du handicap cognitif", "Facteurs humains et IHM", 120h, M1/M2, Universit   de Bordeaux, France

Master: Lucile Dupuy, "Fonctions cognitives en situation", 18h, M1, Universit   de Bordeaux, France

Master: Charles Fage, "Handicap, autonomie et technologies", 15h, M2, Universit   de Bordeaux, France

Master: Charles Fage, "Environnement de la recherche", 12h, M2, Universit   de Bordeaux, France

Master: Charles Fage, "Troubles cognitifs et handicap", 10h, M1, Universit   de Bordeaux, France

Master: Charles Fage, "Facteurs humains et IHM", 8h, M1, Universit   de Bordeaux, France

Master: Charles Fage, "Handicap et nouvelles technologies", 25h, M1, Universit   de Bordeaux, France

### 8.2.2. Supervision

PhD: St  phanie Gatti, "Architecture en composants et qualification incr  mentale", finished in February 2014, supervised by Charles Consel and Emilie Balland

PhD in progress: Paul van der Walt, "Certification d'une plateforme ouverte", started in November 2012, supervised by Charles Consel

PhD in progress: Milan Kabac, "Orchestration    grande   chelle d'objets communicants", started in September 2012, supervised by Charles Consel

PhD in progress: Charles Fage, "Validation exp  rimentale d'un assistant num  rique d'inclusion scolaire d'  l  ves coll  giens porteurs d'autisme", started in September 2012, supervised by H  l  ne Sauz  on

PhD in progress: Lucile Dupuy, "DomAssist: Assistance domiciliaire pour la personne   g  e et son aidant formel bas  e sur la technologie DiaSuiteBox", started in September 2013, supervised by H  l  ne Sauz  on and Charles Consel

PhD in progress: Adrien Carteron, "A development environment dedicated to assistive application", started in October 2014, supervised by Charles Consel.

PhD in progress: C  cile Magnier, "Customized technology for autonomous schooling: on longitudinal effects for students with an autism spectrum disorder", started in November 2014, supervised by H  l  ne Sauz  on and Charles Consel.

PhD in progress: Quentin Chisin, "Digital home assistance for young adults with Down syndrome", started in December 2014, supervised by Bernard N'Kaoua and Charles Consel.

### 8.2.3. Juries

Charles Consel participated in the following juries:

- Committee of the best thesis award of the "GDR GPL" (Prix de la th  se GDR GPL 2013, 2014).
- Member of the AERES Research Evaluation committee of the LIG lab (Laboratoire d'Informatique de Grenoble), December 2014.
- Thesis defense committee for Arnad Sinha, Universit   de Rennes 1, 28 mai 2014.

Hélène Sauzéon participated in the following juries:

- Thesis defense committee for M. Abrame, Université Paris Descartes, december 2014.
- Thesis defense committee for C. Toczé, Université Tours, december 2014.

### 8.3. Popularization

Various members of the Phoenix Inria project team participated in the following events:

- Charles Consel. "Presentation of the DomAssist project". Journée du Numérique organisé par Inria à l'Assemblée Nationale, Paris, France, january 21, 2014.
- Charles Consel. "Presentation of the DomAssist project". Journée de lancement de la Silver Economie Aquitaine, Bordeaux, France, february 17 2014.
- Loïc Caroux. "Des besoins de la personne âgée pour son maintien à domicile à la solution DomAssist". Semaine Nationale des Retraités et des Personnes Agées, Carbon-Blanc, France. October 2014.
- Loïc Caroux, Alexandre Spriet. "DomAssist : Plate-forme d'assistance domiciliaire pour la personne âgée et son aidant formel". Journée de la Santé Connectée en Aquitaine, Bordeaux, France. October 2014.
- Charles Consel, Hélène Sauzéon. "Assistance numérique pour compenser les déficiences cognitives à tous les âges de la vie". 2e Assises nationales de la médiation numérique : le numérique dans votre quotidien. October 16-17, 2014, Bordeaux.
- Lucile Dupuy. "Presentation of the DomAssist project". Fêtes de la science, Bordeaux, France, september-october 2014.
- Charles Fage. Production of a video-presentation of the School+ assistive platform with the Inria Communication Service. <http://vimeo.com/93262450>.

In addition to the following popularization actions, the DomAssist project has been presented during 2014 in two french newspapers (Sud Ouest, La Croix), and in one television report on France 3 TV.

## 9. Bibliography

### Major publications by the team in recent years

- [1] E. BALLAND, C. CONSEL, H. SAUZÉON, B. N'KAOUA. *A Case for Human-Driven Software Development*, in "ICSE'13: Proceedings of the 35th International Conference on Software Engineering (NIER track)", San Francisco, United States, May 2013, <http://hal.inria.fr/hal-00814296>
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## Publications of the year

### Articles in International Peer-Reviewed Journals

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- [14] P. ARVIND PALA, B. N'KAOUA, J.-M. MAZAUX, A. SIMION, S. LOZES, E. SORITA, H. SAUZÉON. *Everyday-like memory and its cognitive correlates in healthy older adults and in young patients with traumatic brain injury: a pilot study based on virtual reality*, in "Disability and Rehabilitation: Assistive Technology", July 2014, pp. 1–11 [DOI : 10.3109/17483107.2014.941952], <https://hal.inria.fr/hal-01027410>

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