Activity Report 2013

Project-Team PHOENIX

Programming Language Technology For Communication Services

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

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Project-Team PHOENIX

Keywords: Programming Languages, Object Oriented Programming, Verification, Software Engineering, Pervasive Computing, Assistive Technology

Creation of the Project-Team: 2005 September 08.

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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. 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.

2.2. Highlights of the Year

- Charles Consel was on sabbatical in Montreal at McGill Unversity for the academic year of 2012-2013. This sabbatical year has allowed us to strenghten our academic collaborations in the domain of assistive technology (e.g., Institut universitaire de gériatrie de Montréal, Université du Québec à Trois-Rivières).

- iQSpot, our technology-transfer project, has been rewarded by OSEO (15e édition du Concours national d'aide à la création d'entreprises de technologies innovantes, catégorie "En émergence") and accepted to the startup incubation program of the IRA (Incubateur Régional d'Aquitaine).

- David Daney, a researcher in Robotics, left the COPRIN project-team of CRI Sophia Antipolis-Méditerranée to join the PHOENIX project-team in September 2013. He will be investigating research topics such as system design, sensor deployment and data analysis.

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.,* [32]), providing some level of abstraction above programming, or (2) integrated into a programming language (*e.g.,* [26], [33]), 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 [28]. 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. [1] 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 [30], and quality of service constraints [29].

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 contraints).

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).

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[1]The Error Model Annex is a standardized AADL extension for the description of errors [34].

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)

- Design pro- against - environmental measures that will being support the digital assistance to bypass cognitive impairment (ie , according to environmental models of cognitive compensatory mechanisms); and then develop solutions in terms of technological support (scenarios of networked objects, hardware interface, software interface , interaction style, etc)

- Empirical evaluation 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).
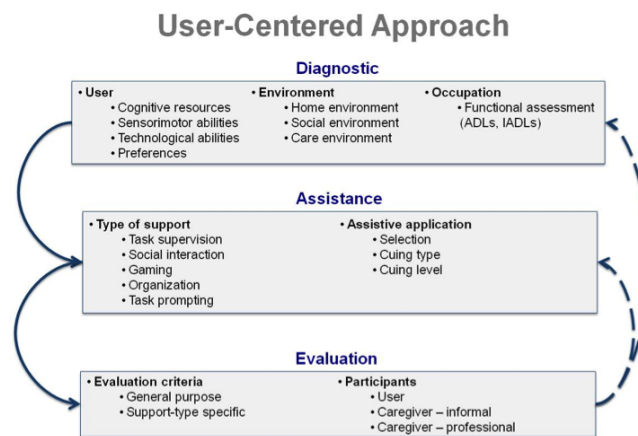
Figure 1. User-Centred Approach

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. Avionics

In avionics, an aircraft can be seen as an environment full of sensors (e.g., accelerometers, gyroscopes, and GPS sensors) and actuators (e.g., ailerons and elevator trim). For example, a flight guidance system controls the aircraft using data produced by sensors. In a critical platform such as an aircraft, software systems have to be certified. Moreover the safety-critical nature of the avionics domain takes the form of stringent non-functional requirements, resulting in a number of challenges in software development:

- Traceability. Traceability is the ability to trace all the requirements throughout the development process. In the avionics certification processes, traceability is mandatory for both functional and non-functional requirements.

- Coherence. Functional and non-functional aspects of an application are inherently coupled. For example, dependability mechanisms can potentially deteriorate the overall performance of the application. The coherence of the requirements is particularly critical when the software evolves: even minor modifications to one aspect may tremendously impact the others, leading to unpredicted failures.

- Separation of concerns. Avionics platforms involve the collaboration of several experts (from low-level system to software, safety, QoS), making requirements traceability significantly more challenging. Providing development methodologies that allow a clear separation of concerns can tremendously improve traceability.

Our approach consists of enriching a design language with non-functional decalarations. Such declarations allow the safety expert to specify at design time how errors are handled, guiding and facilitating the implementation of error handling code. The design is also enriched with Quality of Service (QoS) declarations such as time constraints. For each of these non-functional declarations, specific development support can be generated. We have validated this approach by developing flight guidance applications for avionics and drone systems.

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. Software and Platforms

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

Participants: Charles Consel [correspondent], Damien Martin-Guillerez, Milan Kabac, Paul Van Der Walt, Camille Manano, Adrien Carteron, Alexandre Spriet, Emilie Balland.

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 [31]. This layer is dedicated to an architectural pattern commonly used in the pervasive computing domain [27]. 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.

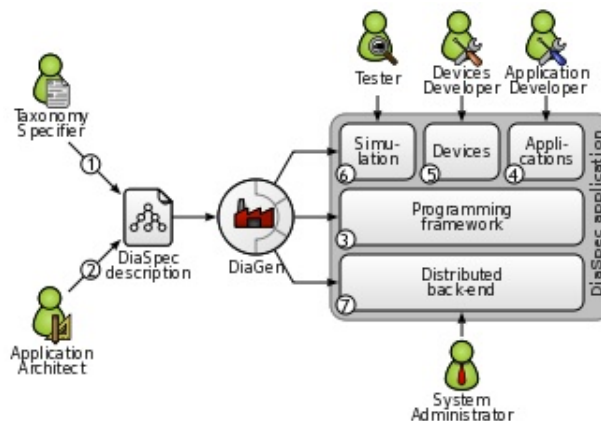This development cycle is summarized in the Figure 2.

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 [27]. 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.

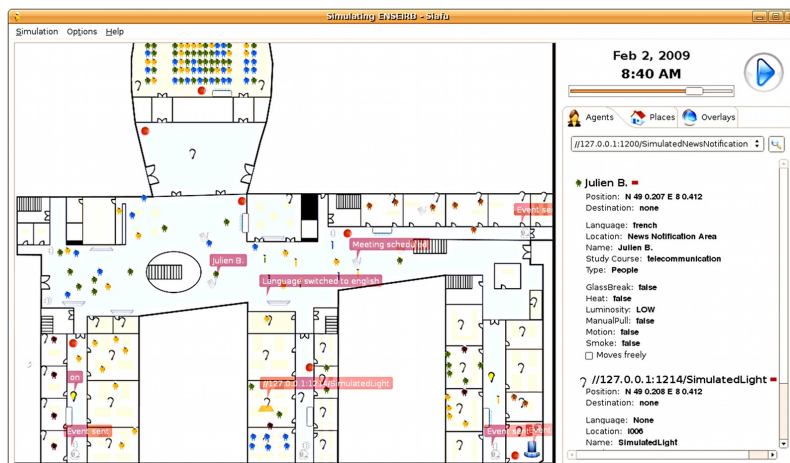### 5.1.2. DiaSim: a Parametrized Simulator for Pervasive Computing Applications

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: Julien Bruneau [correspondent], Damien Martin-Guillerez, Quentin Enard, Charles Consel.

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.

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], Charles Fage, Damien Martin-Guillerez, Camille Manano, Hélène Sauzéon.

College+ 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 every interactions performed by the child.

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.
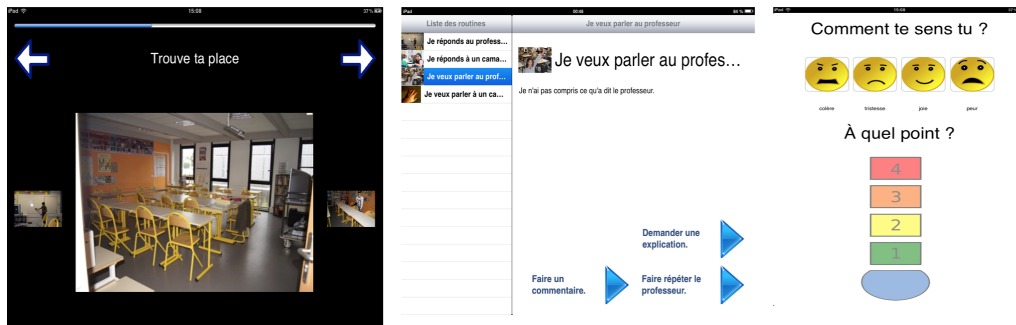
Figure 4. Assistive applications

- *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.

Training applications: These three applications are serious games with increasing levels of difficulties, reachable after a ratio of good answers has been attained.
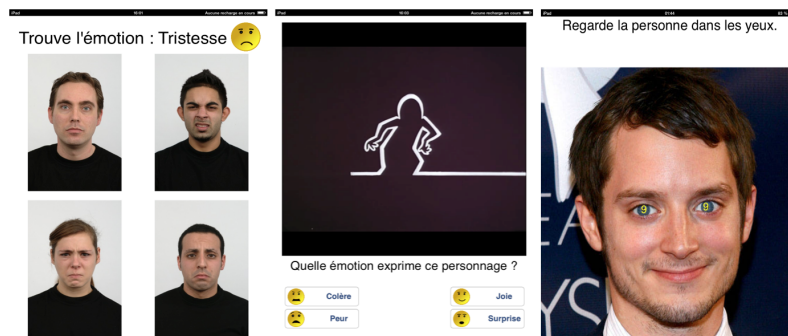
Figure 5. Assistive applications

- *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.

6. New Results

6.1. Design-Driven Development Methodology for Resilient Computing

Critical systems have to face changes, either to meet new user requirements or because of changes in the execution context. Often, these changes are made at runtime because the system is too critical to be stopped. Such systems are called *resilient systems*. They have to guarantee dependability despite runtime evolution. For example, in the domain of pervasive computing, building management systems (*e.g.,* anti-intrusion, fire protection system, access control) have to be resilient as they are in charge of people safety and have to run in a continuous way.

To mitigate faults at runtime, dependable systems are augmented with fault tolerance mechanisms such as replication techniques or degraded modes of operation. However, these mechanisms cover a large spectrum of areas ranging from hardware to distributed platforms, to software components. As a consequence, the need of fault-tolerance expertise is spread throughout the software development process, making it difficult to trace the dependability requirements. The fault tolerance mechanisms have to be systematically and rigorously applied in order to guarantee the conformance between the application runtime behavior and the dependability requirements. This integration becomes even more complex when taking into account runtime adaptation. Indeed, a change in the execution context of an application may require to adapt the fault tolerance mechanisms. For example, a decrease of the network bandwidth may require to change the replication mechanism for one requiring less network bandwidth (*e.g.,* Leader-Follower Replication instead of Primary-Backup Replication).

Without a clear separation of the functional and fault-tolerance concerns, ensuring dependability becomes a daunting task for programmers, whose outcome is unpredictable. In this context, design-driven development approaches are of paramount importance because the design drives the development of the application while ensuring the traceability of the dependability requirements. However, because most existing approaches are general purpose, their guidance is limited, causing inconsistencies to be introduced in the design and along the development process. This situation calls for an integrated development process centered around a conceptual framework that allows to guide the development process of a resilient application in a systematic manner.

In this work, we propose a novel approach that relies on a design language which is extended with fault-tolerance declarations. To further raise the level of abstraction, our development approach revolves around the Sense-Compute-Control paradigm. The design is then compiled into a customized programming framework that drives and supports the development of the application. To face up changes in the execution context, our development methodology relies on a component-based approach, allowing fine-grained runtime adaptation. This design-driven development approach ensures the traceability of the dependability requirements and preserves the separation of concerns, despite runtime evolution.

This work was funded by the Inria collaboration program (in french, actions de recherches collaboratives). The Serus ARC includes the Phoenix project-team (Bordeaux), the ADAM project-team (Lille) and the TSF-LAAS group (Toulouse). These accomplishments were part of Quentin Enard's PhD studies [14]. This work has been published at the International Conference on Component-based Software Engineering (CBSE'13) [23].

6.2. A Case for Human-Driven Software Development

Human-Computer Interaction (HCI) defines a range of principles and methodologies to design User Interfaces (UIs), aiming (1) to improve the interaction between users and computers, (2) to address how interfaces are implemented, leveraging techniques such as program generation and component architectures, and (3) to propose methods to evaluate and compare interfaces.

Despite the many successes of HCI, when it comes to software development, this domain expertise often does not go beyond guidelines (*e.g.,* ISO/TR 22411:2008 addressing the needs of the elderly and users with disabilities). Sometimes, guidelines are mapped into UI design artifacts. However, for a lack of tools, these artifacts remain contemplative. As a consequence, there exists a gap between UI design and software development. This gap is not typical of the HCI domain. Yet, its consequences are dramatically increasing in importance as software systems intertwine with our daily activities, both professional and domestic. Nowadays, a host of systems are playing a critical role for users in terms of safety, privacy, *etc*.

To bridge the gap between UI design and software development, our approach consists in making UI design a full-fledged dimension of software design. We introduce a language dedicated to designing UIs in a high-level manner, while capturing the key requirements of user interaction. We go beyond a contemplative approach and process a UI design artifact to produce a dedicated programming framework that supports the implementation of all the dimensions expressed in a design artifact. This programming framework guides the stakeholders during the development process, while ensuring the conformance between the UI design and its implementation over time.

This work has been published at the International Conference on Software Engineering (ICSE'13, NIER track) [21].

6.3. 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. This work is part of Charles Fage's PhD studies.

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" reserach 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's Syndrom). 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.

7.2. 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. European Initiatives

7.3.1. *FP7 Projects*

Program: FP7 - ICT - 2013.5.3

Project acronym: RAPP

Project title: Robotic Applications for Delivering Smart User Empowering Applications

Duration: From Dec-2013 until Dec-2016

Coordinator: Center For Research and Technology Hellas, CERTH/ITI, Greece

Other partners:

- Politechnika Warszarwska, WUT, Poland
- Sigma Orionis SA, France
- Ortelio LTD, United Kingdom
- Idryma Ormylia, Greece
- Fundacion Instituto Gerontologico Matia - Ingema, spain

Abstract: RAPP will provide a software platform in order to support the creation and delivery of robotics applications (RAPPs) targeted to people at risk of exclusion, especially older people. The open-source software platform will provide an API that contains the functionalities for implementing RAPPs and accessing the robot's sensors and actuators using higher level commands, by adding a middleware stack with added functionalities suitable for different kinds of robots. RAPP will expand the computational and storage capabilities of robots and enable machine learning operations, distributed data collection and processing, and knowledge sharing among robots in order to provide personalized applications based on adaptation to individuals. The use of a common API will assist developers is creating improved applications for different types of robots that target to people with different needs, capabilities and expectations, while at the same time respect their privacy and autonomy, thus the proposed RAPP Store will have a profound effect in the robotic application market. The results of RAPP will be evaluated through the development and benchmarking of social assistive RAPPs, which exploit the innovative features (RAPP API, RAPP Store, knowledge reuse, etc.) introduced by the proposed paradigm.

7.3.2. *Collaborations in European Programs, except FP7*

Program: SUDOE territorial cooperation program (Interreg IV B)

Project acronym: Biomasud

Project title: Mechanisms for sustainability and enhancement of solid biomass market in the space of SUDOE

Duration: July 2011 - June 2013

Coordinator: AVEBIOM

Other partners: UCE (Consumers Union of Spain), CIEMAT (Public Research Agency for excellence in energy and environment, Spain), CBE (Centro da Biomassa para a Energia, Portugal), CVR (Centro para la Valorización de Residuos, Portugal) and UCFF (Union Française de la Coopération Forestière, France)

Abstract: The goal of the Biomasud european project is to show the viability of the biomass-based energy model. The project aims to propose a certification and traceability process throughout the value chain of biofuel. Our objective is to design and implement a prototype of traceability system that will extract automatically traceability information based on sensors such as RFID tags, simplifying the certification process. This work will leverage our DIASUITE development methodology and will be evaluated by the Biomasud partners.

7.4. International Initiatives

7.4.1. *Inria Associate Teams*

7.4.1.1. *OPALI*

Title: OPen Assistive-technology platform for independent LIving

Inria principal investigator: Emilie Balland

International Partner (Institution - Laboratory - Researcher): University of Québec Trois-Rivières (Canada) - TSA Research Chair - Dany Lussier-Desrochers

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.

7.5. International Research Visitors

7.5.1. Visits to International Teams

- Charles Consel, sabbatical year at McGill University, Montreal, Canada (From August 2012 to July 2013)

8. Dissemination

8.1. Scientific Animation

We have organized the following workshops:
- HCAN'13: Workshop on Assistive Technologies - http://phoenix.inria.fr/hcan13
- International Workshop on "Assistance and Service Robotics in a Human Environment", in conjunction with the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'2013) - http://www.lissi.fr/iros-ar

Charles Consel has been involved in the following events as
- Program Committee member of
  – ACM/IEEE International Conference on Software Engineering (ICSE) 2013, the New Ideas and Emerging Results (NIER Track)
  – 10th International Conference on Autonomic Computing (ICAC). ICAC 2013 will be held in conjunction with the 2013 Usenix Federated Conference Week (FCW), and will take place on June 26th-28th, 2013, in San Jose, CA.
  – ICSE 2014
- Invited speaker at
  – Yale University March 29th (DiaSuite Approach)
  – Fraunhofer Ctr. for Exp. Soft. Eng., College Park, Maryland (DiaSuite Approach)
  – MAPLS Mid-Atlantic Programming Language Seminar, University of Maryland (UMD) (DiaSuite Approach)
  – HCIL seminar, University of Maryland (UMD) (Personalizing Assisted Living)
  – University of Montreal, Université du Québec à Montréal (QaM), University of Sherbrooke (DiaSuite Approach)
  – McGill University (Design-Driven Development of Dependable Applications: A Case Study in Avionics)
  – the David Schmidt Fest, Kansas State University Sept, 2013 (DiaSuite Approach)
  – Research Institute for Geriatrics of the University of Montreal (CRIUGM) (Personalizing Assisted Living)

Charles Consel is a member of Quebec Network for Research on Aging and he participate to the project "Dépistage précoce de la démence : Utilisation novatrice des environnements intelligents pour détecter les difficultés rencontrés dans la vie quotidienne" (2013-2015).

Emilie Balland has been involved in the following events as

- Program Committee member of
    - SLE'13: 6th International Conference on Software Language Engineering
    - GPCE'13: 12th International Conference on Generative Programming: Concepts & Experiences (collocated with SPLASH'13, incl. OOPSLA'13)
    - WGP'13: 9th ACM SIGPLAN Workshop on Generic Programming (collocated with ICFP'13)
    - WASDETT'13: 4th International Workshop on Academic Software Development Tools and Techniques (collocated with ECOOP'13)
- Invited speaker at
    - ETH Zurich, Switzerland, August 2013.

David Daney has been involved in the following events as

- Organizer and Program Committee member of
    - IROS 2013 workshop on Assistance and Service Robotics in a Human Environment, IROS'13, Tokyo.
- Invited speaker at
    - National Days of Robotics Research, JNRR'13, Annecy
    - 2nd Workshop of National Expertise Center in Robotics, Evry
    - Inria Scientific Day, Rennes

D. Daney is coordinator of the Inria Project Lab Personally Assisting Living (IPL PAL) – see http://pal.inria.fr

Hélène Sauzéon has been involved in the following events as

- Reviewer for the following journals
    - Gerontology
    - BMC Geriatrics
    - Applied Psycholinguistics
    - Experimental Aging Research
    - Journal of Speech, Language, and Hearing Research
- Invited speaker at
    - Workshop – Alzheimer, Approche pluri-disciplinaire :de la recherche clinique aux avancées technologiques, Toulouse, Jan. 2013.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Licence : David Daney, Industrial control systems, 48h, L3, ITII, Polytech Nice, France

Master : David Daney, Medical robotics, 22h, M2, Master of Bio-Medical , Univ. Nice Sophia Antipolis France.

Master : David Daney, Mathematics of robotics, 9h, M2, IPB, Bordeaux, France.

Master : David Daney, Health Technology, 10h, M2, IPB, Bordeaux, France.

Master : Hélène Sauzéon, UE Neuroscience cognitive, 6h, M2, Master NEURASMUS, Université Bordeaux Segalen, France

Diplôme Inter-Universitaire Antilles-Guyanne, Sciences neuropsychologiques, 30h, Université de médecine de Guadeloupe, France

8.2.2. *Supervision*

PhD : Quentin Enard, "Développement d'applications logicielles sûres de fonctionnement: une approche dirigee par la conception", University of Bordeaux, May 6, 2013, supervised by Charles Consel

PhD : Pengfei Liu, "Intégration de politiques de sécurité dans les systèmes ubiquitaires", University of Bordeaux, January 17, 2013, supervised by Hélène Kirchner and Charles Consel

PhD : Tsounil Prashant Arvind Pala, "Approche écologique de l'évaluation de la mémoire épisodique dans le vieillissement normal et les neuropathologies", University of Bordeaux Segalen, December 18, 2013, supervised by Hélène Sauzéon and Bernard N'Kaoua

PhD in progress : Stéphanie Gatti, "Architecture en composants et qualification incrémentale", started in February 2010, 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 and Emilie Balland

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

PhD in progress : Charles Fage, "Validation expérimentale d'un assistant numérique d'inclusion scolaire d'élèves collègiens porteurs d'autisme", started in September 2012, supervised by Hélène Sauzéon

PhD in progress : Lucile Dupuy, "DomAssist : Assistance domiciliaire pour la personne âgée et son aidant formel basée sur la technologie DiaSuiteBox", started in September 2013, supervised by Hélène Sauzéon and Charles Consel

8.2.3. *Juries*

Charles Consel has participated:

- in the thesis defense committee
  - Miruna Stoicescu, University of Toulouse, France
- in the thesis award committee of
  - Programming and Software of "Groupement de Recherche Génie de la Programmation et du Logiciel (GDR GPL)"

Emilie Balland has participated in the thesis defense committee of Jimmy Lauret, May 15, University of Toulouse, France.

David Daney has participated in the thesis defense committee of:

- Jorgé Alberto Rios Martinez, January 8, University of Grenoble, France
- Julien Alexandre Dit Sandretto, September 11, University of Nice, France
- Thibault Gayral, November 29, University of Nice, France

Hélène Sauzéon has participated in the thesis defense committee of Tsounil Prashant Arvind Pala, December 18, University of Bordeaux Segalen, France.

8.3. Popularization

Participation of the Phoenix Inria project team in the following events:

- Salon Aquitec, February 2013
- Accueil d'étudiants de terminale S option ISN, February 2013
- "Fête de la science" (national popular science event), October 2013
- Emilie Balland and Milan Kabac, Metro'Num, talk and demonstration of the HomeAssist project, September 2013
- Héléne Sauzéon, "Conférence prospective : Demain les objets sont connectés !", presentation of the HomeAssist project, 3ème Semaine digitale organized by the Bordeaux city hall, March 2013
- Hélène Sauzéon and Charles Fage, "Autisme et Numérique : Mise en place d'un assistant scolaire pour collégiens porteurs d'autisme", « Journée mondiale de sensibilisation à l'autisme » organized by Collectif Girondin des Associations Autour de l'Autisme, April 2013
- Hélène Sauzéon and Charles Fage, "Mise en place d'un assistant solaire Collège + pour les collègiens porteurs d'autisme", « Journée mondiale de sensibilisation à l'autisme » organized by Centre Ressource Autisme, CHU Poitiers, April 2013
- Hélène Sauzéon, presentation of the School+ project to Vincent Peillon, Point d'étape de l'entrée de l'École dans l'ère du numérique, Ministère de l'éducation Nationale, June 2013

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