Activity Report 2018

Team EASE

Enabling Affordable Smarter Environment

Inria teams are typically groups of researchers working on the definition of a common project, and objectives, with the goal to arrive at the creation of a project-team. Such project-teams may include other partners (universities or research institutions).

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Distributed programming and Software engineering

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Team EASE

Creation of the Team: 2018 January 01, updated into Project-Team: 2019 March 01

The EASE *EASE project-team will be created in March 2019, in partnership with IMT Atlantique Bretagne-Pays de la Loire and the Université Rennes 1, and in collaboration with the IRISA.*

Keywords:

Computer Science and Digital Science:

A1.2. - Networks
A1.2.5. - Internet of things
A1.2.6. - Sensor networks
A1.2.7. - Cyber-physical systems
A1.3. - Distributed Systems
A1.4. - Ubiquitous Systems
A2.3. - Embedded and cyber-physical systems
A2.3.2. - Cyber-physical systems
A2.5.1. - Software Architecture & Design
A2.5.3. - Empirical Software Engineering
A2.5.4. - Software Maintenance & Evolution
A2.6. - Infrastructure software
A2.6.1. - Operating systems
A2.6.2. - Middleware
A4.8. - Privacy-enhancing technologies
A5.11. - Smart spaces
A5.11.1. - Human activity analysis and recognition
A5.11.2. - Home/building control and interaction

Other Research Topics and Application Domains:

B3.1. - Sustainable development
B3.1.1. - Resource management
B4.4. - Energy delivery
B4.4.1. - Smart grids
B4.5.2. - Embedded sensors consumption
B6.1. - Software industry
B6.1.1. - Software engineering
B6.1.2. - Software evolution, maintenance
B6.2.2. - Radio technology
B6.3.3. - Network Management
B6.4. - Internet of things
B7.2. - Smart travel
B7.2.1. - Smart vehicles
B7.2.2. - Smart road
B8.1. - Smart building/home
B8.1.1. - Energy for smart buildings

B8.1.2. - Sensor networks for smart buildings
B8.2. - Connected city
B8.5.2. - Crowd sourcing
B8.5.3. - Collaborative economy
B9.8. - Reproducibility
B9.10. - Privacy

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2. Overall Objectives

2.1. Presentation

The technologies necessary for the development of pervasive applications are now widely available and accessible for many uses: short/long-range and low energy communications, a broad variety of visible (smart objects) or invisible (sensors and actuators) objects, as well as the democratization of the Internet of Things (IoT). Large areas of our living spaces are now instrumented. The concept of Smart Spaces is about to emerge, based upon both massive and apposite interactions between individuals and their everyday working and living environments: residential housing, public buildings, transportation, etc. The possibilities of new applications are boundless. Many scenarios have been studied in laboratories for many years and, today, a real ability to adapt the environment to the behaviors and needs of users can be demonstrated. However mainstream pervasive applications are barely existent, at the notable exception of the ubiquitous GPS-based navigators. The opportunity of using vast amount of data collected from the physical environments for **several application domains** is still largely untapped. The applications that interact with users and act according to their environment with a large autonomy are still very specialized. They can only be used in the environment they had especially been developed for (for example "classical" home automation tasks: comfort, entertainment, surveillance). They are difficult to adapt to increasingly complex situations, even though the environments in which they evolve are more open, or change over time (new sensors added, failures, mobility etc.).

Developing applications and services that are ready to deploy and evolve in different environments should involve significant cost reduction. Unfortunately, designing, testing and ensuring the maintenance as well as the evolution of a pervasive application remain very complex. In our view, the lack of resources by which properties of the real environment are made available to application developers is a major concern. Building a pervasive application involves implementing one or more logical control loops which include four stages (see figure 1-a): (1) data collection in the real environment, (2) the (re)construction of information that is meaningful for the application and (3) for decision making, and finally, (4) action within the environment. While many decision-algorithms have been proposed, the **collection** and **construction** of a reliable and relevant perception of the environment and, in return, **action** mechanisms within the environment still pose major challenges that the TACOMA/EASE project is prepared to deal with.

Most current solutions are based on a massive collection of raw data from the environment, stored on remote servers. Figure 1-a illustrates this type of approach. Exposure of raw sensor values to the decision-making process does not allow to build relevant contexts that a pervasive application actually needs in order to shrewdly act/react to changes in the environment. So, the following is left up to the developer:

- To characterize more finely raw data beyond its simple value, for example, the acquisition date, the nature of network links crossed to access the sensor, the durability and accuracy of value reading, etc.
- To exploit this raw data to calculate a relevant abstraction for the application, such as, whether the room is occupied, or whether two objects are in the same physical vicinity.
- To modify the environment when possible.

Traditional software architectures isolate the developer from the real environment that he oftentimes has to depict according to complex, heavy and expensive processes. However, objects and infrastructure integrated into user environments could provide a more suitable support to pervasive applications: description of the actual system's state can be richer, more accurate, and, meanwhile, easier to handle; the applications' structure can be distributed by being built directly into the environment, facilitating scalability and resilience by the processing autonomy; finally, moving processing closer to the edge of the network avoids major problems of data sovereignty and privacy encountered in infrastructures very dependent on the cloud. We strongly believe in the advantages of specific approaches to the fields of **edge computing** and **fog computing**, which will reveal themselves with the development of Smart Spaces and an expansive growth of the number of connected objects. Indeed, ensuring the availability and reliability of systems that remain frugal in terms of resources will become in the end a major challenge to be faced in order to allow proximity between processing and end-users. Figure 1-b displays the principle of "using data at the best place for processing". Fine decisions can be made closer to the objects producing and acting on the data, local data characterization and local processing de-emphasize the computing and storage resources of the cloud (which can be used for example to store selected/transformed data for global historical analysis or optimization).

EASE aims at developing a comprehensive set of new **interaction models** and **system architectures** to considerably help pervasive application designers in the development phase with the side effect to ease the life cycle management. We follow two main principles:

- Leveraging local properties and direct interactions between objects, we would be able to enrich and to manage locally data produced in the environment. The application would then be able to build their knowledge about their environment (perception) in order to adjust their behavior (eg. level of automation) to the actual situation.
- Pervasive applications should be able to describe requirements they have on the quality of their environment perception. We would be able to achieve the minimum quality level adapting the diversity of the sources (data fusion/aggregation), the network mechanisms used to collect the data (network/link level) and the production of the raw data (sensors).

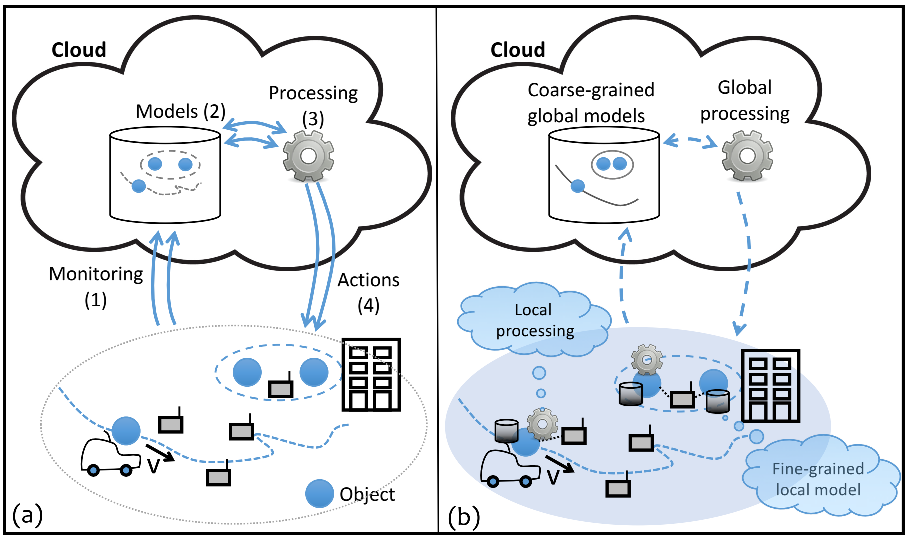

Figure 1. Adaptation processes in pervasive environments

3. Research Program

3.1. Collecting pertinent information

In our model, applications adapt their behavior (for instance, the level of automation) to the quality of their perception of the environment. This is important to alleviate the development constraint we usually have on automated system. We "just" have to be sure a given process will always operate at the right automation level given the precision, the completeness or the confidence it has on its own perception. For instance, a car passing through a cross would choose its speed depending on the confidence it has gained during perception data gathering. When it has not enough information or when it could not trust it, it should reduce the automation level, therefore the speed, to only rely on its own sensors. Such adaptation capability shift requirements from the design and deployment (availability, robustness, accuracy, etc.) to the **assessment of the environment perception** we aim to facilitate in this first research axis.

Data characterization. The quality (freshness, accuracy, confidence, reliability, confidentiality, etc.) of the data are of crucial importance to assess the quality of the perception and therefore to ensure proper behavior. The way data is produced, consolidated, and aggregated while flowing to the consumer has an impact on its quality. Moreover part of these quality attributes requires to gather information at several communication layers from various entities. For this purpose, we want to design **lightweight cross-layer interactions** to collect relevant data. As a "frugality" principle should guide our approach, it is not appropriate to build all attributes we can imagine. It is therefore necessary to identify attributes relevant to the application and to have mechanisms to activate/deactivate at run-time the process to collect them.

Data fusion. Raw data should be directly used only to determine low-level abstraction. Further help in abstracting from low-level details can be provided by **data fusion** mechanisms. A good (re)construction of a meaningful information for the application reduces the complexity of the pervasive applications and helps the developers to concentrate on the application logic rather on the management of raw data. Moreover, the reactivity required in pervasive systems and the aggregation of large amounts of data (and its processing) are antagonists. We study **software services that can be deployed closer to the edge of the network**. The exploration of data fusion technics will be guided by different criteria: relevance of abstractions produced for pervasive applications, anonymization of exploited raw data, processing time, etc.

Assessing the correctness of the behavior. To ease the design of new applications and to align the development of new products with the ever faster standard developments, continuous integration could be used in parallel with continuous conformance and interoperability testing. We already participate in the design of new shared platforms that aims at facilitating this providing remote testing tools. Unfortunately, it is not possible to be sure that all potential peers in the surrounding have a conform behavior. Moreover, upon failure or security breach, a piece of equipment could stop to operate properly and lead to global mis-behavior. We want to propose conceptual tools for **testing at runtime devices in the environment**. The result of such conformance or interoperability tests could be stored safely in the environment by authoritative testing entity. Then application could interact with the device with a higher confidence. The confidence level of a device could be part of the quality attribute of the information it contributed to generate. The same set of tools could be used to identify misbehaving device for maintenance purpose or to trigger further testing.

3.2. Building relevant abstraction for new interactions

The pervasive applications are often designed in an ad hoc manner depending on the targeted application area. Ressources (sensors / actuators, connected objets etc.) are often used in silos which complexify the implementation of rich pervasive computing scenarios. In the second research axis, we want to get away from technical aspects identifying **common and reusable system mechanisms** that could be used in various applications.

Tagging the environment. Information relative to environment could be stored by the application itself, but it could be complex to manage for mobile application since it could cross a large number of places with various features. Moreover the developer has to build its own representation of information especially when he wants to share information with other instances of the same application or with other applications. A promising approach is to store and to maintain this information associated to an object or to a place, in the environment itself. The infrastructure should provide services to application developers: add/retrieve information in the environment, share information and control who can access it, add computed properties to object for further usage. We want to study an **extensible model to describe and augment the environment**. Beyond a simple distributed storage, we have in mind a new kind of interaction between pervasive applications and changing environment and between applications themselves.

Taking advantages of the spatial relationships. To understand the world they have to interact with, pervasive applications often have to (re)built a model of it from the exchange they have with others or from their own observations. A part of the programmer's task consists in building a model of the spatial layout of the objects in the surrounding. The term *layout* can be understood in several ways: the co-location of multiple objects in the same vicinity, the physical arrangement of two objects relative to each other, or even the crossing of an object of a physical area to another, etc. Determining remotely these spatial properties (see figure 1-a) is difficult without exchanging a lot of information. Properties related to the spatial layout are far easier to characterize locally. They could be abstracted from interaction pattern without any complex virtual representation of the environment (see figure 1-b). We want to be able to rely on this type of spatial layout in a pervasive environment. In the prior years, the members of EASE already worked on **models for processing object interactions** in the physical world to automatically trigger processing. This was the case in particular of the spatial programming principle: physical space is treated as a tuple-space in which objects are automatically synchronized according to their spatial arrangement. We want to follow this approach by considering **richer and more expressive programming models.**

3.3. Acting on the environment

The conceptual tools we aim to study must be *frugal*: they use as less as possible resources, while having the possibility to use much more when it is required. Data needed by an application are not made available for "free"; for example, it costs energy to measure a characteristic of the environment, or to transmit it. So this "design frugality" requires **a fine-grained control** on how data is actually collected from the environment. The third research axis aims at designing solutions that give this control to application developers by **acting on the environment**.

Acting on the data collection. We want to be able to identify which information are really needed during the perception elaboration process. If a piece of data is missing to build a given information with the appropriate quality level, the data collection mechanism should find relevant information in the environment or modify the way it aggregates it. These could lead to a modification of the behavior of the network layer and the path the piece of data uses in the aggregation process.

Acting on object interactions. Objects in the environment could adapt their behavior in a way that strongly depends on the object itself and that is difficult to generalize. Beyond the specific behaviors of actuators triggered through specialized or standard interfaces, the production of information required by an application could necessitate an adaptation at the object level (eg. calibration, sampling). The environment should then be able to initiate such adaption transparently to the application, which may not know all objects it passes by.

Adapting object behaviors. The radio communication layers become more flexible and able to adapt the way they use energy to what is really required for a given transmission. We already study how beamforming technics could be used to adapt multicast strategy for video services. We want to show how playing with these new parameters of transmissions (eg. beamforming, power, ...) allows to control spatial relationships objects could have. There is a tradeoff to find between the capacity of the medium, the electromagnetic pollution and the reactivity of the environment. We plan to expend our previous on interface selection and more generally on what we call **opportunistic networking**.

4. Application Domains

4.1. Pervasive applications in Smart Building

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

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

4.2. Automation in Smart City

The domain of Smart Cities is still young but it is already a huge market which attracts number of companies and researchers. It is also multi-fold as the words "smart city" gather multiple meanings. Among them one of the main responsibilities of a city, is to organize the transportation of goods and people. In intelligent transportation systems (ITS), ICT technologies have been involved to improve planification and more generally efficiency of journeys within the city. We are interested in the next step where efficiency would be improved locally relying on local interactions between vehicles, infrastructure and people (smartphones).

For the future autonomous vehicle are now in the spotlight, since a lot of works has been done in recent years in automotive industry as well as in academic research centers. Such unmanned vehicle could strongly impact the organisation of the transportation in our cities. However, due to the lack of a definition of what is an "autonomous" vehicle, it is still difficult to see how these vehicles will interact with their environment (eg. road, smart city, houses, grid, etc.). From augmented perception to fully cooperative automated vehicle, the autonomy covers various realities in terms of interaction the vehicle relies on. The extended perception relies on communication between the vehicle and surrounding roadside equipments. This help the driving system to build and maintain an accurate view of the environment. But at this first stage the vehicle only uses its own perception to make its decisions. At a second stage, it will take advantages of local interaction with other vehicles through car-to-car communications to elaborate a better view of its environment. Such "cooperative autonomy" does not try to reproduce the human behavior anymore, it strongly relies on communication between vehicles and/or with the infrastructure to make decision and to acquire information on the environment. Part of the decision could be centralized (almost everything for an automatic metro) or coordinated by a roadside component. The decision making could even be fully distributed but this put high constraints on the communications. Automated vehicles are just an example of smart city automated processes that will have to share information within the surrounding to make their decisions.

4.3. Pervasive applications in uncontrolled environnements

Some limitations of existing RFID technology become challenging: unlike standard RFID application scenarios, pervasive computing often involves uncontrolled environment for RFID, where tags and reader have to operate in much more difficult situations that those usually encountered or expected for classical RFID systems.

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

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

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

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

In controlled environment, the difficulty to read tags can be limited by using the appropriate parameters to maximize the RFID performance for the application. But in many cases, it is needed to read large number of objects of various nature, arranged randomly in a given area or container. **Most pervasive computing applications fall in this context**.

5. New Software and Platforms

5.1. THEGAME

KEYWORD: Contextual service

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

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

FUNCTIONAL DESCRIPTION: THEGAME is a set of software services for detecting different types of situation in a building (presence in a room, activity level, etc.) based on a set of raw data sourced from all sorts of sensors. Written in C or Java, it can be integrated in an embedded computer: tablet, smartphone, box, etc., and can be connected to different sensor networks. It can be used to implement context-aware services: for example, to alert the user if s/he forgets to close a window when leaving the building, or to turn off the heating in an empty room, etc.

- Participants: Aurélien Richez and Bastien Pietropaoli
- Contact: Frédéric Weis
- URL: https://github.com/bpietropaoli/THEGAME/

5.2. Platform Pervasive_RFID

SCIENTIFIC DESCRIPTION

The RFID experiment testbed has been designed and deployed in collaboration with IETR (see Figure 2). This system allows both interactive testing as well as long running experiments of RFID reading protocols. It comprises a software platform allowing fine control over all dynamic aspects influencing RFID readings: movements for target and antenna, RFID reader configuration, and smart antenna configuration (diversity and power control).

KEYWORDS: Composite objects - RFID

- Participants: Paul Couderc and Anthony Blair (Univ. Rennes 1)
- Partner: Univ. Rennes 1 (IETR - lab bringing together researchers in the electronics and telecommunications)
- Contact: Paul Couderc

5.3. ISO/IEC 15118-2 Open source Implementation

SCIENTIFIC DESCRIPTION

The ISO/IEC 15118 standard, named "Road vehicles – Vehicle-to-Grid Communication Interface", defines how an electric vehicle and a charging station should communicate. It enables the Smart Charging of electric vehicles by allowing them to plan their charging sessions. As we want to be able to manage the charge of electric vehicles in our micro Smart Grid systems, we decided to implement the protocol defined by this standard. The goal is also to participate actively in the design of the new version of this protocol. During a charging session the charging station provides the vehicle with the status of the electric power grid. The vehicle is then able to plan its sharing session accordingly. It sends back its charge plan to the charging station, so that the Smart Grid is aware of it. The protocol also provides security and authentication features.

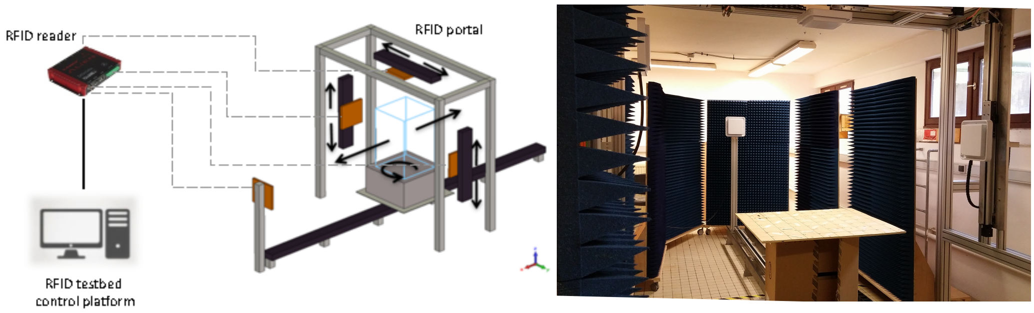

Figure 2. RFID testbed

This software platform was implemented onto small PCs, and was used to control the charge in a small and portable demonstration platform, to demonstrate how it is possible to interconnect this high level decision and communication software with low level components, such as a Battery Management System (BMS), and a battery charger. In 2016, in the context of the Greenfeed project our software has been demonstrated to control the charge of the electric vehicle during the final demonstration of the project. The integration work has been done in collaboration with VeDeCom [1].

KEYWORDS: Smart Grid - Intelligent Transport System

- Partner: IMT Atlantique
- Participants: Guillaume Le Gall
- Contact: Jean-Marie Bonnin

6. New Results

6.1. Smart City and ITS

Participants: Indra Ngurah, Christophe Couturier, Rodrigo Silva, Frédéric Weis, Jean-Marie Bonnin [contact].

The domain of Smart Cities is still young but it is already a huge market which attract number of companies and researchers. It is also multi-fold as the words "smart city" gather multiple meanings. Among them one of the main responsibilities of a city, is to organisation the transportation of goods and people. In intelligent transportation systems (ITS), ICT technologies have been involved to improve planification and more generally efficiency of journeys within the city. We are interested in the next step where efficiency would be improved locally relying on local interactions between vehicles, infrastructure and people (smartphones).

For the future "autonomous" vehicle are now in the spotlight, since a lot of works has been done in recent years in automotive industry as well as in academic research centers. Such unmanned vehicle could strongly impact the organisation of the transportation in our cities. However, due to the lack of a definition of what is an "autonomous" vehicle it remains still difficult to see how these vehicles will interact with their environment (eg. road, smart city, houses, grid, etc"). From augmented perception to fully cooperative automated vehicle, the autonomy covers various realities in terms of interaction the vehicle relies on. The extended perception relies on communication between the vehicle and surrounding roadside equipments. This help the driving system to build and maintain an accurate view of the environment. But at this first stage the vehicle only uses

[1] http://www.vedecom.fr/

its own perception to make its decisions. At a second stage, it will take benefits of local interaction with other vehicles through car-to-car communications to elaborate a better view of its environment. Such "cooperative autonomy" does not try to reproduce the human behavior anymore, it strongly rely on communication between vehicles and/or with the infrastructure to make decision and to acquire information on the environment. Part of the decision could be centralized (almost everything for an automatic metro) or coordinated by a roadside component. The decision making could even be fully distributed but this puts high constraints on the communications. Automated vehicles are just an of smart city automated processes that will have to share information within the surrounding to make their decisions.

In the continuation of our previous activities on the SEAS project, we contributed to the specification of the hybrid (ITS-G5 + Cellular) communication architecture of the French field operation test project SCOOP@F. The proposed solution relies on the MobileIP family of standards and the CALM architecture we contributed to standardize at IETF and ISO. On this topic our contribution mainly focussed on bringing concepts from the state of the art to real equipments. This includes the proposal of provisioning mechanisms to automatically configure and update security materials (ie. certificates and pseudonyms) to ensure an acceptable balance between confidentially, non repudiation and privacy. Extending these works on the On Board Unit (OBU) side, Rodrigo Silva's proposed an architecture and a decision making algorithm to optimize the binding of data flows to available networks while cars are moving [2]. In another field of applications, Indra Ngurah proposed a new routing algorithm for Delay Tolerant Application the context of smart cities[7].

6.2. Opportunistic and local communication/information sharing

Participants: Yoann Maurel, Jules Desjardin, Paul Couderc [contact].

Smart spaces (Smart-city, home, building, etc.) are complex environments made up of resources (cars, smartphones, electronic equipment, applications, servers, flows, etc.) that cooperate to provide a wide range of services to a wide range of users. They are by nature extremely fluctuating, heterogeneous, and unpredictable. In addition, applications are often mobile and have to migrate or are offered by mobile platforms such as smartphones or vehicles. To be relevant, applications must be able to adapt to users by understanding their environment and anticipating its evolutions. Communication between devices and information sharing is a key to achieve this goal. In recent years, many products have been developed based on the cloud. This raises privacy and network access issues.We believe that communication and information sharing should be able to take place directly when possible, more efficient, confidential, or when the network is not available. To achieve this, applications must be provided with technologies that enable the opportunistic and rapid exchange of information based on simple and widespread technologies.

Applications such as pervasive games (for ex. Pokemon Go), on the go data sharing, collaborative mobile app are often good candidates for opportunistic or dynamic interaction models. But they are not well supported by existing communication stacks, especially in context involving multiple technologies. Technological heterogeneity is not hidden, and high level properties associated with the interactions, such as proximity/range, or mobility-related parameters (speed, discovery latency) have to be addressed in an ad hoc manner.

We think that a good way to solve these issues is to offer an abstract interaction model that could be mapped over the common proximity communication technologies, in a similar way as MOM (Message Oriented Middleware) such as MQTT abstract communications in many IoT and pervasive computing scenarios. However, they typically requires IP level communication, which far beyond the capabilities of ultra low energy proximity communication such as RFID and BLE. Moreover, they often rely on a coordinator node that is not adapted in highly dynamic context involving ephemeral communications and mobile nodes.

To ease communication, we developed an opportunistic communication system that does not need any connection between participants, nor any preexisting infrastructure (e.g. WiFi network). The only condition for participants to exchange information is that they are close enough to each other. The communication protocol has been implemented over Bluetooth Low Energy advertisement packets. This protocol has been ported to ESP8266, ESP32 and Android platform. To ease information sharing, we started the implementation of an associative memory mechanism over BLE, as it is a common ground that can be shared with passive or semi passive communications (RFID, NFC). Such mechanism, although relatively low level, is still a very useful building block for opportunistic applications: it enables opportunistic data storage/sharing and signaling/synchronization (in space in particular). This approach is fully in line with more general trend developed in the team to build smart systems leveraging local resources and data oriented mediation. The communication protocol has been extended to allow REST-like operations. The implementation in C of the protocol and a storage base was done in such a way as to take little memory and run on small chips (ESP8266, ESP32). The storage base can be accessed either opportunistically using the BLE protocol or via a COAP protocol for longer or bigger exchanges.

We have started validation work with a few applications, in particular regarding energy aspects and scalability with respect to the communication load. We also tested the system for building opportunistic games (e.g, capture the flags) and information sharing mechanism (e.g, sharing information when two devices cross paths). We are currently working on structuring knowledge information in the continuity of what has been done in the team in the past and provide encryption mechanism.

This should lead to publishing on both infrastructure and application level aspects of the approach.

6.3. Modeling activities and forecasting energy consumption and production to promote the use of self-produced electricity from renewable sources

Participants: Alexandre Rio, Yoann Maurel [contact].

This work began in 2017 and is carried out as part of a broader collaboration between EASE, the Diverse Team and OKWind, a company specialized in the production of renewable sources of energy. OKWind proposes to deploy self-production units directly where the consumption . It has developed expertise in vertical-axis wind turbines,photovoltaic trackers, heat pump and energy storage devices. An interesting aspect of renewable energies is that they can be produced locally, close to the consumers, thus considerably reducing infrastructures and distribution costs.The autonomy of sites with micro-generation capabilities is then greatly increased by self-consumption of locally produced energy.

Designing solutions in favor of self-consumption for small industries or city districts is challenging. It consists in designing an energy production system made of solar panels, wind turbines, batteries that fit the annual weather prediction and the industrial or human activity. This raises several issues. How to precisely assess the consumption and production of energy on a given site with changing conditions? How to adequately size energy sources and energy storage (wind turbine, solar panel and batteries)? What methods to use to optimize consumption and, whenever possible, act on installations and activities to reduce energy costs?

We aim to design an integrated tool-suite to assist the engineers in dimensioning an Energy Management System (EMS) for an isolated site to reduce the construction of new network infrastructure and reduce its dependence on the grid. We advocate that the MDE is a very good candidate to integrate the various technological and business knowledge on the renewable energy production and consumption forecasting techniques, the planning of processes, energy costs, grid, and batteries. The development of a DSL to describe the relationships between activities, their planning, and the production and environmental factors would make possible to simulate a given site at a given location, to make assumptions on sizing, and would be a basis to forecast energy consumption so as to provide recommendations for the organization of activities. Using a DSL and components that clearly separate the different concerns would avoid code redundancies and would facilitate the work of domain experts.

In 2018, we developed a prototype of the Energy Management System (EMS) and a complete DSL that enables experts to quickly integrate their knowledge and algorithms, and to provide a library of reusable components and algorithms. The DSL reflects the different aspects of site modeling: batteries, producers, grid, machines used, and activities performed. It provides the necessary information and constraints so that the EMS can propose an arrangement of activities that optimizes the consumption of renewable energy. The system can be improved by extending existing components or adding new ones. Some of these components are also able to play back historical data, which is a common use for sizing purposes. The prototype is made of 4500 lines of Java code, 1300 loc of Lua and 78k loc of generated files.

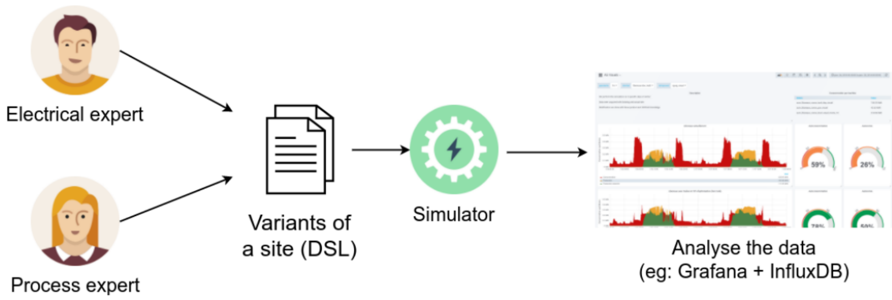

Figure 3. Experts express their concerns using the same DSL and can simulate various scenarios

This prototype has been tested in production to model agricultural sites. The great interest of our tool is that it enables to simulate easily a very wide range of situations and thus allows to determine quickly the best options. If we compare with the company's past practices, engineers mainly used homemade excel sheets and R script: sharing information among experts was very difficult and detecting errors in site modeling was challenging. Building this domain specific language and its associated simulator saves lots of time and produces more precise results compared to the traditional manual approaches used before (see figure 3).

We are now conducting an experiment at several sites to see how adapting activities can improve production equipment profitability. This experience over a long period should provide us with relevant feedback on what can and cannot be requested from a site operator. This should allow us to use our tool not only to simulate upstream but also to make observations and recommendations on a weekly basis. We also want to improve the constraint systems to integrate the modeling of more resources (hot and cold water, number of employees, machine availability). Finally, we would like to explore how this model can be used as a basis for artificial intelligence algorithms to manage real-time operations.

This work has been published in the conference Models 2018 [11].

6.4. Location assessment from local observations

Participants: Yoann Maurel, Paul Couderc [contact].

Confidence in location is increasingly important in many applications, in particular for crowd-sensing systems integrating user contributed data/reports, and in augmented reality games. In this context, some users can have an interest in lying about their location, and this assumption has been ignored in several widely used geolocation systems because usually, location is provided by the user's device to enhance the user's experience. Two well known examples of applications vulnerable to location cheating are Pokemon Go and Waze.

Unfortunately, location reporting methods implemented in existing services are weakly protected: it is often possible to lie in simple cases or to emit signals that deceive the more cautious systems. For example, we have experimented simple and successful replay attacks against Google Location using this approach.

An interesting idea consists in requiring user devices to prove their location, by forcing a secure interaction with a local resource. This idea has been proposed by several works in the literature; unfortunately, this approach requires ad hoc deployment of specific devices in locations that are to be "provable".

We proposed an alternative solution using passive monitoring of Wi-Fi traffic from existing routers. The principle is to collect beacon timestamp observations (from routers) and other attributes to build a knowledge that requires frequent updates to remains valid, and to use statistical test to validate further observations sent by users. Typically, older data collected by a potential attacker will allow him to guess the current state of the older location for a limited timeframe, while the location validation server will get updates allowing him to determine a probability of cheating request.The main strength is its ability to work on existing Wi-Fi infrastructures, without specific hardware. Although it does not offer absolute proof, it makes attacks much more challenging and is simple to implement. The Figure 4 illustrates the basic architecture of the system.

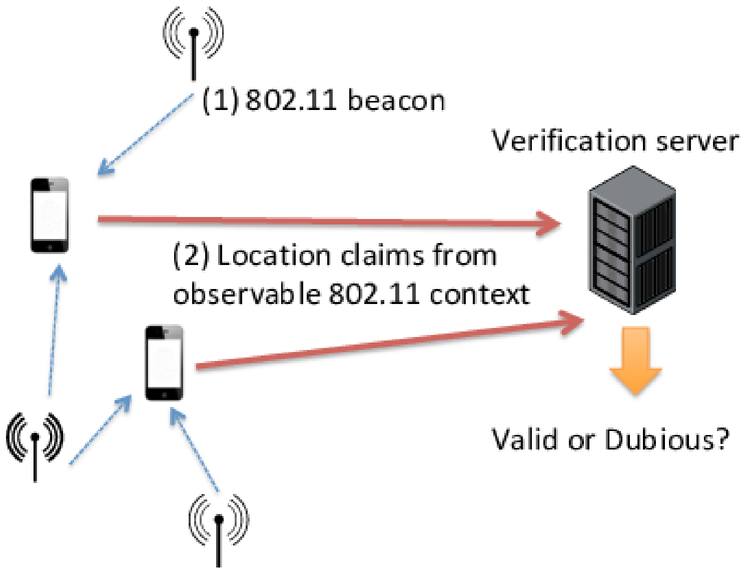

Figure 4. Location assessment from local observations: architecture

This work was accepted for publication and will be presented at CCNC'2019 [5]. Several aspects would be interesting to further investigate, in particular using other attributes of Wi-Fi traffic beside beacon timestamps, and combining the timestamp solution with other type of challenges to propose a diversity of challenges for location validation servers.

6.5. Introducing Data Quality to the Internet of Things

Participants: Jean-Marie Bonnin, Jean-François Verdonck, Frédéric Weis [contact].

The Internet of Things (IoT) connects various distributed heterogeneous devices. Such Things sense and actuate their physical environment. The IoT pervades more and more into industrial environments forming the so-called Industrial IoT (IIoT). Especially in industrial environments such as smart factories, the quality of data that IoT devices provide is highly relevant. However, current frameworks for managing the IoT and exchanging data do not provide data quality (DQ) metrics. Pervasive applications deployed in the factory need to know how data are "good" for use. However, the DQ requirements differ from a process to another. Actually, specifying/expressing DQ requirements is a subjective tasks, depending to the specific needs of each targeted application. As an example this could mean how accurate a location of an object that is provided by an IoT system differs from the actual physical position of the object. A Data Quality of 100% could mean that the value represents the actual position. A Data Quality of 0% could mean that the object is not at the reported position. In this example, the value 0% or 100% can be given by a specific software module that is able to filter raw data sent to the IoT system and to deliver the appropriate metric for Dev apps. Building ad hoc solutions for DQ management is perfectly acceptable. But the challenge of writing and deploying applications for the Internet of Things remains often understated. We believe that new approaches are needed, for thinking DQ management in the context of extremely dynamic systems that is the characteristic of the IoT.

In 2018, we started to define DQ software services that are able to query data and retrieve a collection of DQ metrics that the developer need. The goal is to enable developers to access, configure and tweak any DQ mechanisms in an easy way. Facilitating embedding of DQ capabilities will demand a new type of "endpoint" services, deployed to industrial pervasive environments. We obtained first results of our work towards establishing metrics and tools to enable IoT developers to know and use the quality of data they obtain from the IoT. Our approach combines continuous data analytics with modeling expected behavior of sensors in order to weight the inputs of different sensors to reduce the overall error. Key challenges of our work are semantic modeling of the data quality and modeling the expected behavior of sensors. We illustrated our approach at the example of localizing production robots in a factory. We demonstrated the potential of our first solutions with a demonstration at the AdHoc Now conference (see figure 5). We managed to significantly reduce the error introduced by faulty sensors. This should lead to publishing on both DQ and programming aspects of our approach.

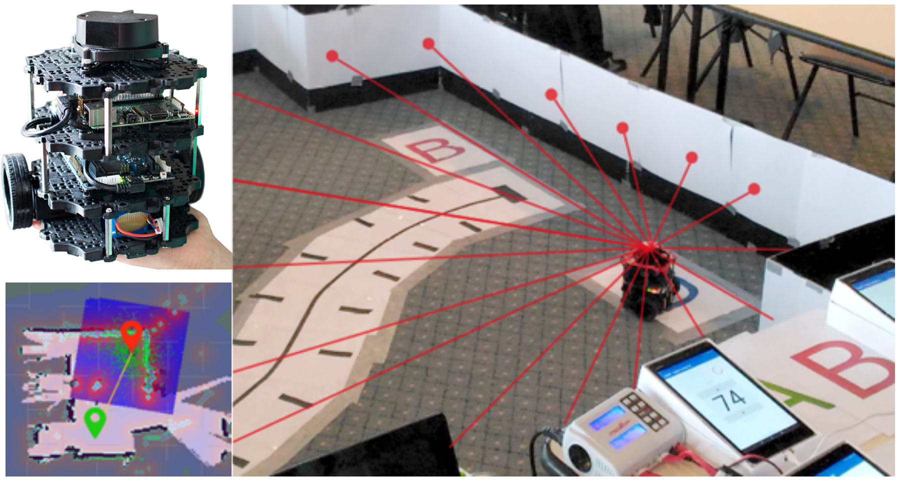

Figure 5. Demonstration at adhoc now 2018

This work has been done in collaboration with Technical University of Munich.

6.6. Risk Monitoring and Intrusion Detection

Participant: Jean-Marie Bonnin [contact].

Cyber-attacks on critical infrastructure such as electricity, gas, and water distribution, or power plants, are more and more considered to be a relevant and realistic threat to the European society. Whereas mature solutions like anti-malware applications, intrusion detection systems (IDS) and even intrusion prevention or self-healing systems have been designed for classic computer systems, these techniques have only been partially adapted to the world of Industrial Control Systems (ICS). This is most notably due to the fact that these industrial systems have been deployed several decades ago, when security was not such a big issue, and have not been replaced since. As a consequence, organisations and nations fall back upon risk management to understand the risks that they are facing. Today's trend is to combine risk management with real-time monitoring to enable prompt reactions in case of attacks. We provided techniques that assist security managers in migrating from a static risk analysis to a real-time and dynamic risk monitoring platform. Risk monitoring encompasses three steps [1]: the collection of risk-related information, the reporting of security events, and finally the inclusion of this real-time information into a risk analysis. The first step consists in designing agents that detect incidents in the system. They can either interpret the output of existing security appliances (such as firewalls), or monitor (part of) the system on their own. An intrusion detection system has been developed to this end, which focuses on an advanced persistent threat (APT) that particularly targets critical infrastructures. The second step copes with the translation of the obtained technical information in more abstract notions of risk, which can then be used in the context of a risk analysis. In the final step, the information collected from the various sources is correlated so as to obtain the risk faced by the entire system. A novel dependency model ties all parts together and thus constitutes the core of the risk monitoring framework we developed. The model is loosely based on attack trees, and can be intuitively visualized with boxes and arrows. Despite its visual simplicity, it allows risk assessors to encode the interdependencies of complex risk scenarios, and to quantify the risk originating from the former.

This work has been done in collaboration with University of Luxembourg.

6.7. Secure design of WoT services for Smart Cities

Participant: Jean-Marie Bonnin [contact].

The richness and the versatility of WebRTC, a new peer-to-peer, real-time and browser- based communication technology, allowed the imagination of new and innovative services. We analyzed the capabilities required to allow a participant in a WebRTC session to access the smart things belonging to his own environment as well as those of any other participant in the same session. The access to such environment (a Smart Space (SS)) can be either passive, for example by monitoring the contextual information provided by the sensors, or active by requesting the execution of commands by the actuators, or a mixture of both. This approach deserves attention because it allows to solve in an original way various issues such as allowing experts to remotely exercise and provide their expertises. From a technical point of view the issue is not trivial because it requires a smooth and mastered articulation between two different technologies: WebRTC and the Internet of Things (IoT) / Web of Things (WoT) [6].

We defined from scratch, of an architecture allowing a junction between WebRTC and the WoT. This architecture is illustrated through a set of innovative use cases. The latter relies essentially on a gateway connecting the two technologies. Since WebRTC is natively secure, its analysis allowed us to propose a set of mechanisms to secure the link between the gateway and the WebRTC client together with the access control to the SS. The implementation of an experimental prototype validates the feasibility of this approach. We also proposed a new smart home architecture encompassing several services, among them the healthcare and the energy management. The overall work targets the introduction of a real smart home, based in Aalborg University labs. Finally, we introduced an SDN controller in order to manage the various SSs that can be involved in a WebRTC session. The main idea consists in allowing an end-user to own more than one SS while keeping their management simple and effective. The principle of our approach consists in centralizing the decisions concerning the management of the various SSs. Due to the fact that routing concerns are intimately intertwined with those of security, the SDN clearly appears as a promising tool to solve these issues.

This work has been done in collaboration with IRISA-OCIF team.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

Project: SIMHet

Partner: YoGoKo

Coordinator: JM. Bonnin

Starting: Nov 2015 - Ending: October 2018

Abstract: The SIMHet project is performed in partnership with YoGoKo, a start-up that develops innovative communication solutions for cooperative intelligent transport systems. The SIMHet project aims to develop a decision making mechanism that would be integrated in the ISO/ETSI ITS communication architecture. It will allow mobile devices or mobile routers to choose the best network interface for each embedded application/flow. For example, in a vehicular environment this mechanism could manage global (Internet) and local connections for each on board device/application, in order to ensure that applications and services are always best connected. Aware that "best" concept is context-dependent, such a decision making mechanism should take into account requirements from different actors (e.g., applications, user, network administrators) and contextual information. One of the difficulties is to take advantage of the knowledge the system could have about near future connectivity. In the vehicular context such information about the movement and the availability of network resources is available. If taking into account the future makes the decision making more complex, this could allow a better usage of network resources when they are available. Once current solutions in the market are based on very simple decisions (use WiFi if available and 3G elsewhere), this smart mechanism will give competitive advantage for YoGoKo over its competitors.

7.2. Bilateral Grants with Industry

OKWIND

Coordinator: Y. Maurel

Starting: April 2017 - Ending: April 2020

Abstract: OKWind [2] is a company specialized in local production of renewable energy. This project, with Inria DiverSE and EASE teams, aims at building a system that optimizes the use of different sources of renewable energy, choosing the most suitable source for the current demand and anticipating future needs, so as to favor the consumption of locally produced electricity. The system must be able to model clients' activities. It must also trigger actions (local consumption vs. local storage). The final goal is to use " locally produced" energy in a smarter way and to tend towards a self-consumption optimum. This contract funds Alexandre Rio's PhD grant.

Orange Labs

Coordinator: JM. Bonnin

Starting: Jan 2016 - Ending: Jan 2019

Abstract: The objective of this thesis is to propose a new management architecture for optimizing the upstream bandwidth allocation in PON while acting only on manageable parameters to allow the involvement of self-decision elements into the network. To achieve this, classification techniques based on machine learning approaches are used to analyze the behavior of PON users and specify their upstream data transmission tendency. A dynamic adjustment of some SLA parameters is then performed to maximize the overall customers' satisfaction with the network. The proposed architecture comes with two major contributions. First, it can be directly and easily integrated in the PON management system without a need to modify the resources allocation mechanism itself in the equipment. Second, as it focuses only on manageable parameters, the proposed approach gives us the opportunity to apply the autonomic and cognitive paradigm in order to enrich the network with self-decision capabilities that leave the task of the dynamic reconfiguration of the SLA parameters to the network itself with the minimum of direct human intervention. This contract funds Nejm Frigui's PhD grant, co-supersized with Tayeb Lemlouma (IRISA OCIF team).

[2] http://www.okwind.fr/

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Collaborations

We have a long-term collaboration with the CAOR lab at Mines ParisTech. We developed an open source IPv6 communication stack for ITS applications. We also participate together in standardisation at IETF, ETSI ITS and ISO TC204 to develop a comprehensive set of standards. A start-up named YoGoKo has been launched in June 2014 to exploit the outcomes of this collaboration.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Project: SCOOP@F part 2

Partners: MEDE, Renault, PSA, IMT Atlantique

Starting: Jan 2016; Ending : Dec 2019

Coordinator: JM. Bonnin

Abstract: SCOOP@F is a Cooperative ITS pilot deployment project that intends to connect approximately 3000 vehicles with 2000 kilometers of roads. It consists of 5 specific sites with different types of roads: Ile-de-France, "East Corridor" between Paris and Strasbourg, Brittany, Bordeaux and Isère. SCOOP@F is composed of SCOOP@F Part 1 from 2014 to 2015 and SCOOP@F Part 2 from 2016 to 2019. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance. The project includes the validations of Cooperative ITS services in open roads, cross border tests with other EU Member States (Spain, Portugal and Austria) and development of a hybrid communication solution (3G-4G/ITS G5). We are involved in the project to study the security and privacy properties of the hybrid architecture that allow to use non dedicated communication networks (WiFi, 5G) as well as the vehicular dedicated communication technologies (G5). The second phase of SCOOP will end up in 2019. As a partner of the InDiD consortium, we proposed a follow up for this project to the EC for the period 2020-2023.

Project: SCHIEF

Partners: TUM (Technical University of Munchen), IMT Atlantique, Eurecom

Starting: Sept 2016; Ending : Dec 2018

Coordinator: JM. Bonnin

Abstract: In SCHEIF, we create a pilot for an enabler platform for the industrial Internet of Things. We envision a three-layered architecture with Sensors and actuators on the lowest layer. This layer includes industrial robots. On top of this hardware layer we envision site-local processing of data. Such a processing is beneficial since it allows keeping latency boundaries on the one hand and being in full control of all data on the other hand. The latency is relevant for enabling diverse time-critical operations as they often happen in industrial production environments. The local processing is relevant for protecting data. A privacy-conform processing is required to protect company secrets and to protect the privacy of workers. The third layer comprises data processing in the cloud. We envision mostly local data processing. However, offloading computing tasks to public or private clouds will be relevant for compute-intense tasks and those tasks that require coordination between production sites. The main scenario of SCHEIF is an industrial production site where mobile robots and human workers coexist. The focus is providing the data required to manage and optimize the production process always at the most suitable quality. The suitability of data relies on the requirements of the data producers and consumers. A planned demo scenario is a provoked system crash that leads to reprioritization of data streams to mitigate from the failure.

8.3. International Initiatives

8.3.1. Informal International Partners

Two years ago we initiate a collaboration with Valerie Gay and Christopher Lawrence (UTS / Australia) on adapting smart spaces for eHealth applications. We continue the collaboration and Jean-Marie Bonnin visited UTS last August. As a result a first position paper has been published in OZCHI 2017, the 29th Australian Conference on Human-Computer Interaction held in Brisbane 28th November -1st December, and a second paper this year at ICOST 2018 (July 2018, Singapore) [4]. Christopher Lawrence visited us in April 2018 and gave an invited talk. Jean-Marie Bonnin visited UTS last August and participated in the deployment of the MyMob Mobile App in several indigenous communities.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Christopher Lawrence, Associate Professor, University of Technology Sydney, visited the team in April 2018
- Marc-Oliver Pahl, Research Associate, Technischen Universitat Munchen (TUM), visited the team in July 2018

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. Member of the Organizing Committees

- Local Arrangement Chair, AdHoc Now 2018, F. Weis

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

- PC member of AdHoc Now 2018, F. Weis
- PC member of VTC 2018, ICIN 2018, AdHoc Now 2018, ICON 2018, JM. Bonnin

9.1.3. Journal

9.1.3.1. Reviewer - Reviewing Activities

- Mobile Networks and Applications, IEEE transactions on Mobile Computing, Simulation Modeling Practice and Theory, Computer Standards & Interfaces, an international journal on Engineering Science and Technology, JM. Bonnin

9.1.4. Invited Talks

- Invited talk at Mairie de Paris (June 2018): "Open Environment: Coopération par interactions locales", C. Couturier
- Invited talk at Inria/INRA Workshop (Feb. 2018), "Environnements auto descriptifs : une approche alternative pour l'IoT", P. Couderc
- Invited in a round table at IoT World (March 22, Paris) : "Voitures connectées : quels défis technologiques pour la mobilité urbaine?", JM. Bonnin
- Invited talk at IoT Tunisia workshop (April 26, Tunis), JM. Bonnin
- Keynote Speech at IoT Tunisia forum (April 27, Tunis): "L'IoT au service de la mobilité", JM. Bonnin

- Invited at a round table (May 24, Rennes) in the "Cybersécurité des Véhicules Autonomes et Connectés" workshop organized by Id4Car, JM. Bonnin
- Invited talk at summer school "Cooperative Interacting Vehicles" (September 2018, Loire Valley, France) : "Communication for cooperation", JM. Bonnin
- Invited talk at Automotive 2018 (October 18, Versailles), JM. Bonnin
- Invited lecture at Department of Electrical Engineering and Postgraduate Program in Electrical Engineering, Faculty of Engineering Udayana University (October 24, Bali) : "Autonomous Vehicle in the Smart City Ecosystem", JM. Bonnin
- Keynote speech at ICSGTEIS'2018 (October 25, Bali) : "Smart City: A Digital Mobility (R) Evolution", JM. Bonnin

9.1.5. Scientific Expertise

- Head of the scientific committee of InOut 2018, JM. Bonnin
- Member of the scientific council of the GIS ITS, JM. Bonnin
- Member of the scientific council the Id4Car cluster, JM. Bonnin
- Scientific advisor of the YoGoKo startup, JM. Bonnin
- Co-head of "the pole Digital Society of the MSHB" (Maison des Sciences de l'Homme de Bretagne), JM. Bonnin
- Project evaluation for ANR, Belgium, Quebec, Id4Car, BPI, JM. Bonnin
- Expert for CSV board of "Pôle Images et Réseaux", projects reviewing and selection, strategic roadmap definition, P. Couderc

9.1.6. Research Administration

- Head of the Networks, Telecommunication and service department at IRISA, JM. Bonnin
- Member for the IRISA Laboratory Council, JM. Bonnin
- Member of the scientific council of ECAM (Engineering school), JM. Bonnin

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

- L2/L3: network computing (lectures, tutorials, labs), 250 hours, F. Weis, Univ. Rennes 1
- Master 2: Wireless LANs, F. Weis, 30 hours, M2, IMT Atlantique
- Master 2: Pervasive computing and IoT system architectures, 4 hours+48 hours including project supervision, P. Couderc, Univ. Rennes 1
- Master 1: Network programming (lectures, tutorial, labs), 78 hours, Y. Maurel, Univ. Rennes 1
- L3/M2: network communications protocol for building automation (lectures, labs), 80 hours, Y. Maurel
- Master 2: Software engineering (lectures, tutorial, labs), 82 hours, Y. Maurel
- Master 2 : Mobility management in the Internet, JM. Bonnin, IMT Atlantique
- Master 2 Smart Mobility : Communications for ITS, JM. Bonnin, IMT Atlantique
- Master 2 IoT: Smart City, JM. Bonnin, ENSI Tunis
- Continuous training: Communications for Autonomous and Cooperative vehicle, Communications for ITS, JM. Bonnin, IMT Atlantique
- Master 1: Network programming (lab and project), 72 hours, C. Couturier, IMT Atlantique
- Master 1: IP networks (lectures, tutorial), 24 hours, C. Couturier, IMT Atlantique
- Master 2: Enterprise Network Design, 12 hours, C. Couturier, IMT Atlantique

- Master 2: Bid to Call for Tender, 12 hours, C. Couturier, IMT Atlantique
- Master 2: Supervision of the Networking and Telecom curriculum of FIP3A, C. Couturier, IMT Atlantique
- Master 2: Tools for cloud computing , 18 hours, C. Couturier, IMT Atlantique

9.2.2. Supervision

PhD: Zaineb Lioune, "Une Architecture pour des Services e-Santé évolutifs dans le cadre des Maisons Intelligentes", Frédéric Weis, Tayeb Lemlouna (UR1) and Philippe Roose (University of Pau), Defended on June 30, 2018

PhD: Steve Muller, "Risk Monitoring and Intrusion Detection for Industrial Control Systems", Jean-Marie Bonnin, co-supervision with Y. Le Traon at University of Luxembourg, defneded on March 26, 2018

PhD: Saad El Jaouhari, "A secure design of WoT services for Smart Cities", Jean-Marie Bonnin, co-supervision with IRISA OCIF group, defended on Dec. 13, 2018

PhD in progress: Indra Ngurah, Car-based Data Collection for Low Energy Devices (Car-based DC4LED), May 2016, Jean-Marie Bonnin

PhD in progress: Christophe Couturier, "Frugal networking for cooperative autonomy", Nov. 2016, Jean-Marie Bonnin

PhD in progress: Alexandre Rio, "Modélisation des activités de site consommateur d'énergie", Octobre 2016, Olivier Barais (UR1) and Yoann Maurel

PhD in progress: Rodrigo Silva, "Mécanisme de décision multi-critères pour le placement de flux en environnement hétérogène et changeant", Nov. 2015, Jean-Marie Bonnin

PhD in progress: Nejm Frigui, "Maintenance autonomique du réseau programmable d'accès optiques de très haut débit", Jan. 2016, Jean-Marie Bonnin

9.2.3. Juries

PhD: Rania Ben Hadj, "Gestion des conflits dans une plateforme ubiquitaire orientée services", Univ. Grenoble, F. Weis, referee, April 2018

PhD: Rania Ben Hadj, "Gestion des conflits dans une plateforme ubiquitaire orientée services", Univ. Grenoble, Y. Maurel, examiner, April 2018

PhD: Mouna Gassara, "Proactive Security in new Generations of Wireless Networks", National Engineering School of Sfax, Tunisia, Jean-Marie Bonnin, referee, Nov. 2018

PhD: Mourad Lesious, "Highlight and Execute Suspicious Paths in Android Malware", IMT Atlantique, examiner, Dec. 2018

HDR: Emmanuel Bertin, "La transformation numérique des télécoms : synthèse et perspectives", Université Paris-Sorbonne, referee, Feb. 2019

HDR: Sonia Mettali Gammar, "Approches pour le routage dans les réseaux 802.11 et les réseaux orientés contenus", referee, Dec. 2018

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Publications of the year

Articles in International Peer-Reviewed Journals

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[2] R. SILVA, J.-M. BONNIN, T. ERNST. *AD4ON: An ITS-based Decision Making Architecture for Opportunistic Networking*, in "International Journal On Advances in Networks and Services", June 2018, vol. 11, n^{o} 1-2, pp. 11-21, https://hal.inria.fr/hal-01889967

International Conferences with Proceedings

[3] Y. ANDALOUSSI, M. D. EL OUADGHIRI, Y. MAUREL, J. M. BONNIN, H. CHAOUI. *Access control in IoT environments: Feasible scenarios*, in "The 9th International Conference on Ambient Systems, Networks and Technologies (ANT 2018)", Porto (Portugal), France, May 2018, vol. 130, pp. 1031-1036 [*DOI :* 10.1016/J.PROCS.2018.04.144], https://hal.inria.fr/hal-01954066

[4] J.-M. BONNIN, V. GAY, F. WEIS. *Creating Smarter Spaces to Unleash the Potential of Health Apps*, in "Smart Homes and Health Telematics, Designing a Better Future: Urban Assisted Living", Singapore, France, M. MOKHTARI, B. ABDULRAZAK, H. ALOULOU (editors), 16th International Conference, ICOST 2018, Singapore, Singapore, July 10-12, 2018, Proceedings, Springer, July 2018, pp. 134-145 [*DOI :* 10.1007/978-3-319-94523-1_12], https://hal.inria.fr/hal-01954045

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[8] N. E. FRIGUI, T. LEMLOUMA, S. GOSSELIN, B. RADIER, R. LE MEUR, J.-M. BONNIN. *Optimization of the Upstream Bandwidth Allocation in Passive Optical Networks Using Internet Users' Behavior Forecast*, in "ONDM 2018 - 22nd International Conference on Optical Network Design and Modeling", Dublin, Ireland, IEEE, May 2018, pp. 59-64 [*DOI :* 10.23919/ONDM.2018.8396107], https://hal.archives-ouvertes.fr/hal-01760252

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[9] N. I. ER, K. D. SINGH, J.-M. BONNIN. *Contact Strategy for VDTN Data Collection in Smart Cities*, in "ICSGTEIS 2018 - International Conference on Smart-Green Technology in Electrical and Information Systems", Bali, Indonesia, October 2018, https://hal.archives-ouvertes.fr/hal-01894540

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