Activity Report 2019

Project-Team FUN

self-organizing Future Ubiquitous Network

RESEARCH CENTER
Lille - Nord Europe

THEME
Networks and Telecommunications

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Other Research Topics and Application Domains:

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2. Overall Objectives

2.1. Overall Objectives

Context.

The Internet of Things [41] is a large concept with multiple definitions. However, the main definitions are the same in every vision and could be summed up as follows: *Imagine a world where every object has the capacity to communicate with its environment. Everything can be both analogue and digitally approached - reformulates our relationship with objects - things - as well as the objects themselves. Any object relates not only to you, but also to other objects, relations or values in a database. In this world, you are no longer alone, anywhere.* (Internet of Things council).

Future Ubiquitous Networks (FUN) are part of the Internet of Things. They are composed of tens to thousands heterogeneous hardware-constrained devices that interact with our environment and the physical world. These devices have limited resources in terms of storage and computing capacities and energy. They communicate through unreliable and unpredictable short-range wireless links and run on batteries that are not envisaged to be changed in current systems since generally deployed in hostile environments. Providing FUNs with energy saving protocols is thus a key issue. Due to these specific features, any centralized control is not conceivable, the new generation of FUNs must be autonomous, self-organized and dynamically adapting to their environment. The devices that compose CPNs can be sensors, small robots, RFID readers or tags.

Objects or things can now communicate with their environment through the use for instance of an RFID (Radio Frequency IDentification) tag that provides them a unique identifier (ID) and a way to communicate through radio waves.

In the case of a simple passive **RFID tag**, the thing only embeds a tag equipped with an antenna and some memory. To communicate, it needs to be powered by the electromagnetic field of an RFID reader. This reader may then broadcast the information read on tag over a network.

When this tag is equipped with a battery, it is now able to communicate with nearby things similar to itself that may relay its message. Tags can also be equipped with additional capacity and sensors (for light, temperature, etc.). The Internet of Things can thus now refer to a **wireless sensor** network in which each sensor sends the data it collects over its environment and then sends it to a sink, *i.e.* a special sensor node able to analyze those data. In every case, RFID tags or sensor nodes can **be moved unexpectedly** like hold by moving things or animals. We speak then about **'*undergone* mobility'**.

So far, things can thus communicate information about their environment. But when the capacity of sensors is extended even further, they can also act on their environment (for instance, the detection of an event (fire) may trigger an action like switching the light or fire hoses on). Sensor nodes become **actuators**. When this extended capacity is the faculty to move, actuators are also referred as actors or robots. In this latter case, the mobility is computed on purpose, we then speak about **'*controlled* mobility'**. Actuators are not moved but move by themselves.

The FUN research group aims to focus on self-organizing techniques for these heterogeneous Future Ubiquitous Networks (FUNs). FUNs need various self-organization techniques to work properly. Self-organization encompasses neighbor discovery (which what other devices a sensor/actuator can communicate directly?), communication, self-deployment, self-localization, activity scheduling (when to wake up, when to send data to save energy without being detrimental to the well behavior of the network, etc.)...

Solutions provided by FUN should facilitate the use of FUNs and rub away heterogeneity and difficulties. These techniques should be **scalable**, **energy-aware**, **standard-compliant**, should manage undergone **mobility** and take advantage of controlled mobility when available [53].

Solutions provided by FUN will consider vagaries of the realistic wireless environment by integrating cross-layer techniques in their design.
Motivation.

To date, many self-organizing techniques for wireless sensor networks and mobile ad hoc networks are proposed in the literature and also by the FUN research group. Some of them are very efficient for routing [46], [40], discovering neighborhood [51], [50], scheduling activity and coverage [48], localization [54], [38], [29], etc. Nevertheless, to the best of our knowledge, most of them **have not been validated by experimentation**, only by simulation and thus cannot consider the real impact of the wireless links and real **node mobility** in different environments. In addition, some of them rely on assumptions that are known not to be true in realistic networks such as the fact that the transmission range of a node is a perfect disk. Other may perform well only when nodes are static. None of them considers to **take advantage of controlled mobility** to enhance performances. Similarly, many propositions arise regarding self-organization in RFID networks, mainly at the middleware level [58], [47] and at the MAC layer level [52]. Although these latter propositions are generally experimented, they are validated only in static environments with very few tags and readers. To fit realistic features, such algorithms should also be evaluated with regards to scalability and mobility.

RFID and sensor/actor technologies **have not been merged**. Though, RFID readers may now be mobile and communicate in a wireless peer-to-peer manner either with other RFID readers or wireless sensor nodes and all belong to the same network. This implies a study of the standards to allow inter-dependencies in a transparent manner. Although such works have been initiated inside EPC Global working groups, research actions remain scarce.

FUN research group aims at **filling this scientific gap** by proposing self-stabilizing solutions, considering vagaries of wireless links, node mobility and heterogeneity of nodes in compliance with current standards. Validation by experimentation is mandatory to prove the effectiveness of proposed techniques in realistic environments.

FUN will investigate new protocols and communication paradigms that allow the **transparent merging** of technologies. Objects and events might interconnect while **respecting on-going standards** and building an autonomic and smart network being compliant with hardware resources and environment. FUN expects to rub away the difficulty of use and programmability of such networks by unifying the different technologies. In addition, FUN does not only expect to validate the proposed solutions through experimentation, but also to learn from these experiments and from the observation of the impact of the wireless environment, to take these features into consideration in the design of future solutions.

3. Research Program

3.1. Introduction

We will focus on wireless ubiquitous networks that rely on constrained devices, i.e. with limited resources in terms of storage and computing capacities. They can be sensors, small robots, RFID readers or tags. A wireless sensor retrieves a physical measure such as light. A wireless robot is a wireless sensor that in addition has the ability to move by itself in a controlled way. A drone is a robot with the ability to manoeuvre in 3D (in the air or in the water). RFID tags are passive items that embed a unique identifier for a place or an object allowing accurate traceability. They can communicate only in the vicinity of an RFID reader. An RFID reader can be seen as a special kind of sensor in the network which data is the one read on tags. These devices may run on batteries that are not envisaged to be changed or recharged. These networks may be composed of ten to thousands of such heterogeneous devices for which energy is a key issue.

Today, most of these networks are homogeneous, i.e. composed of only one kind of devices. They have mainly been studied in application and technology silos. Because of this, they are approaching fundamental limitations especially in terms of topology deployment, management and communications, while exploiting the complementarity of heterogeneous devices and communication technologies would enlarge their capacities and the set of applications. Finally, these networks must work efficiently even in dynamic and realistic situations, i.e. they must consider by design the different dynamic parameters and automatically self-adapt to their variations.

Our overall goal is represented by Figure 1. We will investigate wireless ubiquitous IoT services for constrained devices by smartly combining **different frequency bands** and **different medium access and routing techniques** over **heterogeneous devices** in a **distributed** and **opportunistic** fashion. Our approach will always deal with **hardware constraints** and take care of **security** and **energy** issues to provide protocols that ride on **synergy** and **self-organization** between devices.

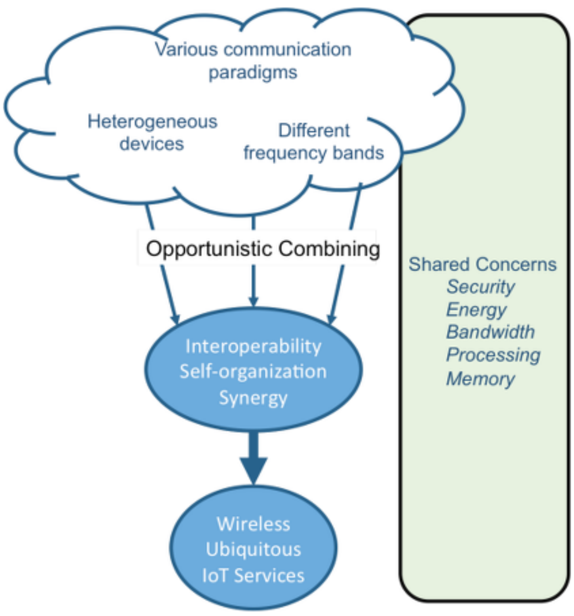

Figure 1. FUN's overal goal.

The goal of the FUN project team is to provide these next generation networks with a set of innovative and distributed self-organizing cooperative protocols to raise them to a new level of scalability, autonomy, adaptability, manageability and performance. We aim to break these silos to exploit the full synergy between devices, making them cooperate in a single holistic network. We will consider them as networks of heterogeneous devices rather than a collection of heterogeneous networks.

To realize the full potential of these ubiquitous networks, there is a need to provide them with a set of tools that allow them to *(i)* (self-)deploy, *(ii)* self-organize, *(iii)* discover and locate each other, resources and services and *(iv)* communicate. These tools will be the basics for enabling cooperation, co-existence and witnessing a global efficient behavior. The deployment of these mechanisms is challenging since it should be achieved in spite of several limitations. The main difficulties are to provide such protocols in a **secured** and **energy-efficient** fashion in spite of:

- dynamic topology changes due to various factors such as the unreliability of the wireless medium, the wireless interferences between devices, node mobility and energy saving mechanisms;
- hardware constraints in terms of CPU and memory capacities that limit the operations and data each node can perform/collect;
- lacks of interoperability between applicative, hardware and technological silos that may prevent from data exchange between different devices.

3.1.1. Objectives and methodology

To reach our overall goal, we will pursue the two following objectives. These two objectives are orthogonal and can be carried on jointly:

1. Providing realistic complete self-organizing tools *e.g. vertical perspective*.
2. Going to heterogeneous energy-efficient performing wireless networks *e.g. horizontal perspective*.

We give more details on these two objectives below. To achieve our main objectives, we will mainly apply the methodology depicted in Figure 2 combining both theoretical analysis and experimental validation. Mathematical tools will allow us to properly dimension a problem, formally define its limitations and needs to provide suitable protocols in response. Then, they will allow us to qualify the outcome solutions before we validate and stress them in real scenarios with regards to applications requirements. For this, we will realize proofs-of-concept with real scenarios and real devices. Differences between results and expectations will be analyzed in return in order to well understand them and integrate them by design for a better protocol self-adaptation capability.

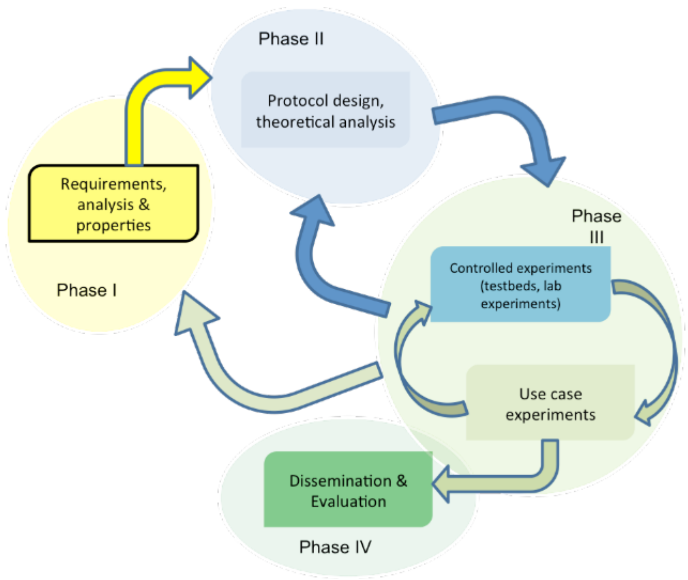

Figure 2. Methodology to be applied in FUN.

3.2. Vertical Perspective

As mentioned, future ubiquitous networks evolve in dynamic and unpredictable environments. Also, they can be used in a large scope of applications that have several expectations in terms of performance and different contextual limitations. In this heterogeneous context, IoT devices must support multiple applications and relay traffic with non-deterministic pattern.

To make our solutions practical and efficient in real conditions, we will adopt the dual approach both *top-down* and *bottom-up*. The *top-down* approach will ensure that we consider the application (such as throughput, delay, energy consumption, etc.) and environmental limitations (such as deployment constraints, etc.). The *bottom-up* approach will ensure that we take account of the physical and hardware characteristics such as memory, CPU, energy capacities but also physical interferences and obstacles. With this integrated perpective, we will be in capacity to design well adapted **cross-layer** integrated protocols [59]. We will design jointly routing and MAC layers by taking dynamics occurring at the physical layer into account with a constant concern for energy and security. We will investigate new adaptive frequency hopping techniques combined with routing protocols [59], [45].

This vision will also allow us to integrate external factors by design in our protocols, in an opportunistic way. Yet, we will leverage on the occurrence of any of these phenomena rather than perceiving them as obstacles or limitations. As an example, we will rely on node undergone mobility to enhance routing performance as we have started to investigate in [55], [37]. On the same idea, when specific features are available like controlled mobility, we will exploit it to improve connectivity or coverage quality like in [49], [57], [31], [25].

3.3. Horizontal perspective

We aim at designing efficient tools for a plethora of wireless devices supporting highly heterogeneous technologies. We will thus investigate these networks from a horizontal perspective, e.g. by considering heterogeneity in low level communications layers.

Given the spectrum scarcity, they will probably need to coexist in the same frequency bands and sometimes for different purposes (RFID tag reading may use the same frequency bands as the wireless sensors). One important aspect to consider in this setting is how these different access technologies will interact with each other, and what are the mechanisms needed to be put in place to guarantee that all services obtain the required share of resources when needed. This problem appears in different application domains, ranging from traffic offloading to unlicensed bands by cellular networks and the need to coexist with WiFi and radars, from a scenario in which multiple-purpose IoT clouds coexist in a city [56]. We will thus explore the dynamics of these interactions and devise ways to ensure smooth coexistence while considering the heterogeneity of the devices involved, the access mechanisms used as well as the requirements of the services provided.

To face the spectrum scarcity, we will also investigate new alternative communication paradigms such as phonon-based or light-based communications as we have initiated in [42] and we will work on the coexistence of these technologies with traditional communication techniques, specifically by investigating efficient switching techniques from one communication technology to the other (they were most focused on the security aspects, to prevent jamming attacks). Resilience and reliability of the whole system will be the key factors to be taken into account [43], [39], [18].

As a more prospective activity, we consider exploring software and communication security for IoT. This is challenging given that existing solutions do not address systems that are both constrained and networked [44]. Finally, in order to contribute to a better interoperability between all these technologies, we will continue to contribute to standardization bodies such as IETF and EPC Global.

4. Highlights of the Year

4.1. Highlights of the Year

4.1.1. Awards

Paper [17] has been awarded best paper of the 34th ACM/SIGAPP Symposium On Applied Computing (SAC 2019).

BEST PAPER AWARD:

[17]
A. BLANCHARD, N. KOSMATOV, F. LOULERGUE. *Logic against Ghosts: Comparison of Two Proof Approaches for a List Module*, in "SAC 2019 - The 34th ACM/SIGAPP Symposium On Applied Computing", Limassol, Cyprus, April 2019 [*DOI :* 10.1145/3297280.3297495], https://hal.inria.fr/hal-02100515

5. New Software and Platforms

5.1. AspireRFID ALE

FUNCTIONAL DESCRIPTION: AspireRFID middleware is a modular OW2 open source RFID middleware. It is compliant with EPC Global standards. This new module integrates the modifications of the new standard release, including new RP and LLRP definitions and fixing bugs. This module has been implemented in the framework of the MIAOU project.

- Participants: Ibrahim Amadou, Julien Vandaele, Nathalie Mitton and Rim Driss
- Contact: Nathalie Mitton

5.2. ETINODE-CONTIKI-PORT

KEYWORD: Iot

FUNCTIONAL DESCRIPTION: Contiki is an open source embedded OS for Internet of Things (IoT). It is light and portable to different hardware architectures. It embeds communication stacks for IoT. This driver allows the running of Contiki OS over Etinode-MSP430. The code dalso allows the use of radio chip and embedded sensors. This module has been implemented in the framework of the ETIPOPS project.

- Participants: Nathalie Mitton, Roudy Dagher and Salvatore Guzzo Bonifacio
- Contact: Salvatore Guzzo Bonifacio

5.3. ETINODE-DRIVERS

FUNCTIONAL DESCRIPTION: These drivers for Etinode-MSP430 control the different embedded sensors and hardware components available on an Etinode-MSP430 node such as gyroscope, accelerometer and barometric sensor. This module has been implemented in the framework of the ETIPOPS project.

- Participants: Nathalie Mitton, Roudy Dagher and Salvatore Guzzo Bonifacio
- Contact: Salvatore Guzzo Bonifacio

5.4. EVe-TCF

Embedded Verifier for Transitive Control Flow

KEYWORDS: Control Flow - JavaCard - Embedded systems - Embedded - Security - Code analysis

FUNCTIONAL DESCRIPTION: Verification of transitive control flow policies on JavaCard 2.x bytecode. Control flow policies expressed using a DSL language are embedded in JavaCard packages (CAP files) using EVe-TCF convert tool. Control flow policies are then statically verified on-device at loading-time thanks to an embedded verifier (designed for smart cards in EVe-TCF). EVe-TCF (Embedded Verifier for Transitive Control Flow) also contains an off-device (i.e. PC tool) to simulate on-device loading process of JavaCard 2.x platforms with GlobalPlatform 2.x installed.

- Participants: Arnaud Fontaine and Isablle Simplot Ryl
- Contact: Nathalie Mitton

5.5. GOLIATH

Generic Optimized LIghtweight communication stack for Ambient TecHnologies

KEYWORDS: WSN - WSN430

FUNCTIONAL DESCRIPTION: GOLIATH (Generic Optimized LIghtweight communication stack for Ambient TecHnologies) is a full protocol stack for wireless sensor networks. This module has been implemented in the framework of the ETIPOPS project.

- Participants: David Simplot Ryl, Fadila Khadar, Nathalie Mitton and Salvatore Guzzo Bonifacio
- Contact: Nathalie Mitton
- URL: https://gforge.inria.fr/projects/goliath/

5.6. IoT-LAB robots

KEYWORDS: Internet of things - Robotics

FUNCTIONAL DESCRIPTION: IoT-LAB robots is an embedded robot controler on a Turtlebot2 providing the IoT-LAB node mobility functionnality

- Partner: Université de Strasbourg
- Contact: Julien Vandaele
- URL: https://github.com/iot-lab/

5.7. T-SCAN

KEYWORDS: Rfid - RFID Middleware

FUNCTIONAL DESCRIPTION: T-Scan is an interface ensuring the translation from a SGTIN tag format to an ONS hostname format according to the EPCGlobal standards. It allows the sending of a DNS request to look up the EPC-IS aides to which the product belongs in order to access the data relative to that product. This module has been implemented in the framework of the TRACAVERRE project.

- Participants: Gabriele Sabatino and Nathalie Mitton
- Contact: Gabriele Sabatino

5.8. FIT IoT-Lab

Participants: Nathalie Mitton [contact person], Julien Vandaele, Matthieu Berthome.

FIT IoT-LAB (http://www.iot-lab.info) is a very large scale open testbed that features over 2700 wireless sensor nodes and more than 200 robots spread across six different sites in France. Nodes are either fixed or mobile and can be allocated in various topologies throughout all sites. A variety of wireless sensors are available, with different processor architectures (MSP430, STM32 and Cortex-A8) and different wireless chips (802.15.4 PHY at 800 MHz or 2.4 GHz). In addition, "open nodes" can receive custom wireless sensors for inclusion in IoT-LAB testbed. This platform is completely open and can be used by any one wishing to run experiment on wireless sensors and robots.

The Lille site displays 2 subsets of the platforms:

- Haute Borne: this site features 256 M3 sensor nodes operating in the 2.4GHz band and 64 mobile robots (32 turtlebots and 32 wifibots) completely remotely programmable.
- Opennodes: this site features 64 hardware open slots to allow any one to plug his own hardware and benefits from the platform debugging and monitoring tools.

6. New Results

6.1. Security and Verification

Participants: Rehan Malak, Allan Blanchard, Antoine Gallais, Valeria Loscri, Nathalie Mitton.

6.1.1. Security

Numerous medium access control (MAC) have been proposed for Low-power Lossy Networks (LLNs) over the recent years. They aim at ensuring both energy efficiency and robustness of the communication transmissions. Nowadays, we observe deployments of LLNs for potentially critical application scenarios (e.g., plant monitoring, building automation), which require both determinism and security guarantees. They involve battery-powered devices which communicate over lossy wireless links. Radio interfaces are turned off by a node as soon as no traffic is to be sent or relayed. Denial-of-sleep attacks consist in exhausting the devices by forcing them to keep their radio on. In [21], we focus on jamming attacks whose impact can be mitigated by approaches such as time-division and channel hopping techniques. We use the IEEE 802.15.4e standard to show that such approaches manage to be resistant to jamming but yet remain vulnerable to selective jamming. We discuss the potential impacts of such onslaughts, depending on the knowledge gained by the attacker, and to what extent envisioned protections may allow jamming attacks to be handled at upper layers.

6.1.2. Verification

Modern verification projects continue to offer new challenges for formal verification. One of them is the linked list module of Contiki, a popular open-source operating system for the Internet of Things. It has a rich API and uses a particular list representation that make it different from the classical linked list implementations. Being widely used in the OS, the list module is critical for reliability and security. A recent work verified the list module using ghost arrays. In [17], [35], we report on a new verification effort for this module. Realized in the Frama-C/Wp tool, the new approach relies on logic lists. A logic list provides a convenient high-level view of the linked list. The specifications of all functions are now proved faster and almost all automatically, only a small number of auxiliary lemmas and a couple of assertions being proved interactively in Coq. The proposed specifications are validated by proving a few client functions manipulating lists. During the verification, a more efficient implementation for one function was found and verified. We compare the new approach with the previous effort based on ghost arrays, and discuss the benefits and drawbacks of both techniques.

While deductive verification is increasingly used on real-life code, making it fully automatic remains difficult. The development of powerful SMT solvers has improved the situation, but some proofs still require interactive theorem provers in order to achieve full formal verification. Auto-active verification relies on additional guiding annotations (assertions, ghost code, lemma functions, etc.) and provides an important step towards a greater automation of the proof. However, the support of this methodology often remains partial and depends on the verification tool. [18] presents an experience report on a complete functional verification of several C programs from the literature and real-life code using auto-active verification with the C software analysis platform Frama-C and its deductive verification plugin . The goal is to use automatic solvers to verify properties that are classically verified with interactive provers. Based on our experience, we discuss the benefits of this methodology and the current limitations of the tool, as well as proposals of new features to overcome them.

6.2. Visible Light Communication

Participants: Antonio Costanzo, Valeria Loscri.

Visible Light Communication (VLC) exploits optical frequencies, diffused by usual LED lamps, for adding data communication features to illuminating systems. This paradigm has attracted a growing interest in both scientific and industrial community in the latter decade. Nevertheless, classical wireless communication mechanisms for physical and Medium Access Control (MAC) layers are hardly available for VLC, due to the massive external interference caused by sunlight. Moreover, effects related to the data frames features need to be taken into account in order to improve the effectiveness of the VLC paradigm. Such as an instance, the preamble length of a packet in order to synchronize the data transmission represents an important factor in VLC. A too long preamble allows a better synchronization while impacting negatively in terms of overhead. Nevertheless, a too short preamble may be not effective for synchronizing the transmission. The more suitable selection of the preamble length is strictly related to the noise environments. In order to make an adaptive selection able to choice the more suitable preamble length, we have designed and integrated in our VLC system a machine learning algorithm based on multi-arm bandit approach, in order to dynamically select the best configuration [28]. Another important approach to face the high interference impacting on the VLC performance is represented by the treatment of the noise through a signal processing approach in order to estimate it and proceed with a mitigation of the noise [10], [29], [36], [30]. This approach has been implemented and tested by the means of a real prototype. Results obtained show the effectiveness of a similar approach.

6.3. Alternative communications

Participant: Valeria Loscri.

In the last few years, there has been an increasing interest in the study of "alternative communication" paradigms, ranging from the exploitation of the visible light as carrier information, the exploitation of a different portion of the spectrum in the THz frequency, the leverage of artificial molecules for transmitting information (i.e. artificial molecular communication). Another interesting approach is consisting on a different perspective of the interaction between the signals and the environment. Right now, the environment has always been considered as something that cannot be "changed", a kind of obstacle for the wireless transmission. A new paradigm is arising, based on the metamaterial surface, where the interaction between the signals and the environment can be adapted in order to improve the performance of the communication.

6.3.1. TeraHez communications

In [32] and [23] we have investigated a metasurface and how the design of this metasurface has to be realized in order to adapt the behavior of the optical and THz signals based on the specific application considered.

6.3.2. Molecular communications

Concerning the artificial molecular communication paradigm, a fundamental aspect to be considered is that the most of times the target application of this type of communication is a biological system. A fundamental question arising is then: how maximize the effectiveness of the communication by keeping a low impact in terms of interference for the biological system? We have tried to answer to these fundamental questions by considering a signal processing approach in [11], [19].

6.4. Long range communications

Participants: Nathalie Mitton, Brandon Foubert, Ibrahim Amadou.

In the context of smart farming, communications still pose a key challenge. Ubiquitous access to the Internet is not available worldwide, and battery capacity is still a limitation. Inria and the Sencrop company are collaborating to develop an innovative solution for wireless weather stations, based on multi-technology communications, to enable smart weather stations deployment everywhere around the globe. We discuss this model in [12] and assess the quality of a LoRA signal in different conditions [16].

6.5. Vehicular networks

Participants: Nathalie Mitton, Valeria Loscri.

6.5.1. Positioning

Typical Global Navigation Satellite System (GNSS) receivers offer precision in the order of meters. This error margin is excessive for vehicular safety applications, such as forward collision warning, autonomous intersection management, or hard braking sensing. In [14] we develop CooPS, a GNSS positioning system that uses Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications to cooperatively determine absolute and relative position of the ego-vehicle with enough precision. To that end, we use differential GNSS through position vector differencing to acquire track and across-track axes projections, employing elliptical and spherical geometries. We evaluate CooPS performance by carrying out real experiments using off-the-shelf IEEE 802.11p equipment at the campus of the Federal University of Rio de Janeiro. We obtain an accuracy level under 1.0 and 1.5 m for track (where-in-lane) and across-track (which-lane) axes, respectively. These accuracy levels were achieved using a 2.5 m accuracy circular error probable (CEP) of 50% and a 5 Hz navigation update rate GNSS receiver.

6.5.2. Vehicular social networks

In recent years, the concept of social networking combined with the Internet of Vehicles has brought to the definition of the Social IoV (SIoV) paradigm, i.e., a social network where every vehicle is capable of establishing social relationships in an autonomous way with other vehicles or road infrastructure equipment. In SIoV, social networking is applied to vehicular networks according to how social ties are built upon, i.e., either among vehicles or humans. An analysis of the SIoT-based social relations in a vehicular network scenario for establishing a Social Internet of Vehicles and providing insights on this growing research area [33]. By considering the specific features of the Online Social Networks (ONSs) and Vehicular Social Networks (VSNs), we realize that there are limitations and advantages on both these systems. In [15] we have proposed SOVER, a hybrid OSN-VSN framework, allowing the communication between both the communities, the OSNs and VSNs. In [24] we investigate the twofold nature of SIoV, both based on human factors and relationships and as an instance of the Social Internet of Things (SIoT. Based on this twofold nature, it is possible to distinguish different applications and use-cases.)

6.6. On the use of controlled mobility

Participant: Nathalie Mitton.

Relying on controlled mobility as enabled by drones or robots could be a great asset for task management, data collection or quality of network deployment.

6.6.1. Robots

Robots and controlled mobility can help in the dynamic coverage of an area. In [22], we address the problem of defining a wireless sensor network by deploying sensors with the aim of guaranteeing the coverage of the area and the connectivity among the sensors. The wireless sensor networks are widely studied since they provide several services, e.g., environmental monitoring and target tracking. We consider several typologies of sensors characterized by different sensing and connectivity ranges. A cost is associated with each typology of sensors. In particular, the higher the sensing and connectivity ranges, the higher the cost. We formulate the problem of deploying sensors at minimum cost such that each sensor is connected to a base station with either a one-or a multi-hop and the area is full covered. We present preliminary computational results by solving the proposed mathematical model, on several instances. We provide a simulation-based analysis of the performances of such a deployment from the routing perspective.

Robots could be helpful when called upon an alert sent by sensors. But to intervene quickly, they need to locate or follow back the alert source as fast as possible. Two new algorithms (GFGF1 and GFGF2) for event finding in wireless sensor and robot networks based on the Greedy-Face-Greedy (GFG) routing are proposed in [27]. The purpose of finding the event (reported by sensors) is to allocate the task to the closest robot to act upon the event. Using two scenarios (event in or out of the network) and two topologies (random and random with hole) it is shown that GFGF1 always find the closest robot to the event but with more than twice higher communication cost compared to GFG, especially for the outside of the network scenario. GFGF2 features more than 4 times communication cost reduction compared to GFG but with percentage of finding the closest robot up to 90%.

6.6.2. Drones

Disaster scenarios are particularly devastating in urban environments, which are generally very densely populated. Disasters not only endanger the life of people, but also affect the existing communication infrastructure. In fact, such an infrastructure could be completely destroyed or damaged; even when it continues working, it suffers from high access demand to its resources within a short period of time, thereby compromising the efficiency of rescue operations. [31], [25] leverage the ubiquitous presence of wireless devices (e.g., smartphones) in urban scenarios to assist search and rescue activities following a disaster. This work considers multi-interface wireless devices and drones to collect emergency messages in areas affected by natural disasters. Specifically, it proposes a collaborative data collection protocol that organizes wireless devices in multiple tiers by targeting a fair energy consumption in the whole network, thereby extending the network lifetime. Moreover, it introduces a scheme to control the path of drones so as to collect data in a short time. Simulation results in realistic settings show that the proposed solution balances the energy consumption in the network by means of efficient drone routes, thereby effectively assisting search and rescue operations.

6.7. Self-organization, routing and orchestration

Participants: Nathalie Mitton, Valeria Loscri, Brandon Foubert.

By offering low-latency and context-aware services, fog computing will have a peculiar role in the deployment of Internet of Things (IoT) applications for smart environments. Unlike the conventional remote cloud, for which consolidated architectures and deployment options exist, many design and implementation aspects remain open when considering the latest fog computing paradigm. In [9], we focus on the problems of dynamically discovering the processing and storage resources distributed among fog nodes and, accordingly, orchestrating them for the provisioning of IoT services for smart environments. In particular, we show how these functionalities can be effectively supported by the revolutionary Named Data Networking (NDN) paradigm. Originally conceived to support named content delivery, NDN can be extended to request and provide named computation services, with NDN nodes acting as both content routers and in-network service executors. To substantiate our analysis, we present an NDN fog computing framework with focus on a smart campus scenario, where the execution of IoT services is dynamically orchestrated and performed by NDN nodes in a distributed fashion. A simulation campaign in ndnSIM, the reference network simulator of the NDN research community, is also presented to assess the performance of our proposal against state-of-the-art solutions. Results confirm the superiority of the proposal in terms of service provisioning time, paid at the expenses of a slightly higher amount of traffic exchanged among fog nodes.

[26] proposes FLY-COPE, a complete self-organization architecture that relies on cooperative communications and drone-assisted data collection, allowing a fast location of victims and rescuing operation organization in disaster relief operation. FLY-COPE mainly combines two components: i) a ground component that spontaneously emerges from any communicating devices (piece of infrastructure, mobile phone, etc) that cooperate to alert rescuers and remain all alive as long as possible and ii) an aerial component comprising UAV to communicate efficiently with ground devices. We show by simulation and/or by experimentation that each component of FLY-COPE allows substantial energy saving for efficient and fast disaster response.

The IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL) builds a Direction Oriented Directed Acyclic Graph (DODAG) rooted at one node. This node may act as a border router to provide Internet connectivity to the members of the DODAG but such a situation creates a single point of failure. Upon border router failure, all nodes connected to the DODAG are affected as all ongoing communications are instantly broken and no new communications can be initiated. Moreover, nodes close to the border router should forward traffic from farther nodes in addition to their own, which may cause congestion and energy depletion inequality. In [20], we specify a full solution to enable border router redundancy in RPL networks. To achieve this, we propose a mechanism leveraging cooperation between colocated RPL networks. It enables failover to maintain Internet connectivity and load balancing to improve the overall energy consumption and bandwidth. Our contribution has been implemented in Contiki OS and was evaluated through experiments performed on the FIT IoT-LAB testbed.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- Sencrop
  Participants: Brandon Foubert, Nathalie Mitton [contact person].

  This collaboration aims to develop a complete multi-technology bilateral wireless communication stack for agriculture sensor networks.
- Enedis and NooliTic
  Participants: Ibrahim Amadou, Nathalie Mitton [contact person].

  This collaboration aims to investigate a novel localization approach based on wireless propagations. It is a tri-partite contract between our Inria team, the SME NooliTic and Enedis.
- Expleo
  Participants: Ibrahim Amadou, Nathalie Mitton [contact person].

  This collaboration aims to transfer self-deployment protocols to Expleo.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. StoreConnect

Participants: Nathalie Mitton [contact person], Valeria Loscri, Antonio Costanzo, Ibrahim Amadou.

Title: StoreConnect
Type: FUI
Duration: September 2016 - October 2018
Coordinator: NEOSENSYS
Others partners: Inria FUN, SPIRALS and STARS, TeVolys, Ubudu, Smile, STIME, Leroy Merlin
The aim of StoreConnect is to provide French large retailers with efficient and powerful tools in the in-store customer interaction.

8.1.2. LumiCAR

Participants: Valeria Loscri [contact person], Antonio Costanzo, Meysam Mayahi.

Title: LumiCAR
Type: ISITE
Duration: October 2019 - October 2021
Vehicle-to-Vehicle and Vehicle-RSU (Roadside Units) communication (V2X) has become a very active topic of research in recent years as it appears to be a means of improving road safety and make effective and timely intervention of road safety actors. To date, most research activities are based on the use of conventional radio frequency (RF) technology. However, faced with multiple constraints, these vehicular communications are not always effective. In the LumiCar project we will base the V2X communication mainly on the Visible Light Communication (VLC) technology and we will focus on the coexistence of the VLC with other technologies. VLC has already started to work in other indoor applications such as connected stores for geolocation of customers. The properties offered by light (speed, directional, controlled containment ...) suggest that VLC technology is more suitable for vehicular communications and can effectively meet the needs of a reliable, robust and with increasing flow to consider new applications such as virtual reality in future cars. In addition, VLC technology can be recognized as a "green" technology because it is based on the exploitation of LEDs and lamps already used for lighting and visibility. It is therefore a question of optimizing the use (by the transmission of information) of an energy already consumed.

8.2. National Initiatives

8.2.1. Exploratory Action

8.2.1.1. Ethicam

Participants: Valeria Loscri [contact person], Carola Rizza.

Duration: October 2019 - October 2022

The evolution of the Internet of Things (IoT) towards the Internet of Everything (IoE) paradigm represents an important and emerging research direction, capable to connect and interconnect massive number of heterogeneous nodes, both inanimate and living entities, encompassing molecules, nanosensors, vehicles and people. This new paradigm demands new engineering communication solutions to overcome miniaturization and spectrum scarcity. Novel pervasive communication paradigms will be conceived by the means of a cutting edge multidisciplinary research approach integrating (quasi) particles (e.g. phonons) and specific features of the (meta)material (e.g. chirality) in the design of the communication mechanisms. In particular, by the means of the meta-materials, it would be possible to control the propagation environment. More specifically, through this paradigm it will be possible to manipulate not only the desired signals, but also the interfering signals.

8.2.2. ADT

8.2.2.1. Catimex

Participants: Matthieu Berthome, Nathalie Mitton [contact person], Julien Vandaele.

Duration: September 2017 -June 2019

Coordinator: Inria FUN

The purpose of this project is to foster research transfer in IoT from ADT members to their industrial partners by widening experimental features and PoC realization. It is lead in closed partnership with Inria Chile and Université of Strasbourg.

8.2.3. Equipements d'Excellence

8.2.3.1. FIT

Participants: Nathalie Mitton [contact person], Julien Vandaele, Matthieu Berthome.

Title: Future Internet of Things

Type: EquipEx

Duration: March 2010 - December 2019

Coordinator: UPMC

See also: http://fit-equipex.fr/

Abstract: FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Equipements d'Excellence" (Equipex) research grant program. Coordinated by Professor Serge Fdida of UPMC Sorbonne Universités and running over a nine-year period, the project will benefit from a 5.8 million euro grant from the French government.

8.3. European Initiatives

8.3.1. H2020 Projects

8.3.1.1. VESSEDIA

Participants: Rehan Malak, Nathalie Mitton, Allan Blanchard [contact person].

Title: Verification Engineering of Safety and Security Critical Dynamic Industrial Applications

Program: H2020

Duration: January 2017 - Dec. 2019

Coordinator: Technikon Forschungs und Planungsgesellschaft MBH (TEC)

The VESSEDIA project will bring safety and security to many new software applications and devices. In the fast evolving world we live in, the Internet has brought many benefits to individuals, organizations and industries. With the capabilities offered now (such as IPv6) to connect billions of devices and therefore humans together, the Internet brings new threats to the software developers and VESSEDIA will allow connected applications to be safe and secure. VESSEDIA proposes to enhance and scale up modern software analysis tools, namely the mostly open-source Frama-C Analysis platform, to allow developers to benefit rapidly from them when developing connected applications. At the forefront of connected applications is the IoT, whose growth is exponential and whose security risks are real (for instance in hacked smart phones). VESSEDIA will take this domain as a target for demonstrating the benefits of using our tools on connected applications. VESSEDIA will tackle this challenge by 1) developing a methodology that allows to adopt and use source code analysis tools efficiently and produce similar benefits than already achieved for highly-critical applications (i.e. an exhaustive analysis and extraction of faults), 2) enhancing the Frama-C toolbox to enable efficient and fast implementation, 3) demonstrating the new toolbox capabilities on typical IoT (Internet of Things) applications including an IoT Operating System (Contiki), 4) developing a standardization plan for generalizing the use of the toolbox, 5) contributing to the Common Criteria certification process, and 6) defining a label "Verified in Europe" for validating software products with European technologies such as Frama-C. This project yields to set of publications in 2019: [17], [18], [35].

8.3.1.2. CyberSANE

Participants: Valeria Loscri, Nathalie Mitton [contact person], Edward Staddon.

Title: Cyber Security Incident Handling, Warning and Response System for the European Critical Infrastructures

Program: H2020

Duration: September 2019 - September 2022

CyberSANE aims to enhance the security and resilience of Critical Information Infrastructures (CIIs) by providing a dynamic collaborative, warning and response system supporting and guiding security officers and operators (e.g. Incident Response professionals) to recognize, identify, dynamically analyze, forecast, treat and respond to advanced persistent threats (APTs) and handle their daily cyber incidents utilizing and combining both structured data (e.g. logs and network traffic) and unstructured data (e.g. data coming from social networks and dark web).

In achieving that aim, CyberSANE will introduce a holistic and privacy-aware approach in handling security incidents, addressing the complexity of these nets consisting of cyber assets hosted in cross-border, heterogeneous Critical Information Infrastructures (CIs). Moreover, CyberSANE is fully in-line with relevant regulations (such as the GDPR and NIS directive), which requires organizations to increase their preparedness, improve their cooperation with each other, and adopt appropriate steps to manage security risks, report and handle security incidents.

8.4. International Initiatives

8.4.1. Inria International Labs

8.4.1.1. Agrinet

Participants: Christian Salim, Brandon Foubert, Nathalie Mitton [contact person].

Title: Agrinet

International Partner (Institution - Laboratory - Researcher): Stellenbosch University, South Africa, Riaan Wolhuter

Type: LIRIMA Associate team

Duration: 2017-2020

See also: https://team.inria.fr/agrinet/

The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production. Sustainable food security depends upon proper plant and crop management respectful of soils and natural re- sources, such as water. This includes very important South African farming areas, such as the Western Cape and Northern Cape. In France, agriculture is also hugely important. Not just nationally, but also in Europe. The system proposed can be applied to a variety of crops. The economic- and social consequences are profound and any contribution towards more efficient farming within increasingly onerous natural constraints, should be a priority. To address these constraints, we propose to develop a flexible, rapidly deployable, biological/agricultural data acquisition platform and associated machine learning algorithms to create advanced agricultural monitoring and management techniques, to improve crop management and use of natural resources. The project also addresses an industry with very high socioeconomic impact.

Publications issued from that project in 2019 are: [12], [16].

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

Université Mediterranea di Reggio Calabria (UNIC) (Italy): The objective of this collaboration is the design of an innovative architecture that enables autonomic and decentralized fruition of the services offered by the network of smart objects in many heterogeneous and dynamic environments, such that is independent of the network topology, in a reliable and flexible way. The result is an 'ecosystem' of self-organized and self-sustained objects, capable of making data and services available to the users wherever and whenever required, thus supporting the fruition of an 'augmented' reality thanks to a new environmental and social awareness.

8.4.2.2. Informal International Partners

Anna-Maria Vegni from Roma Tre University, Italy: The purpose of this collaboration is to study alternative communication paradigms and investigate their limitations and different effects on performances. In this framework, joint publications have been obtained, among them in 2019 [23], [33], [15], [24], [32].

8.4.3. Participation in Other International Programs

8.4.3.1. International Initiatives

CroMo

Title: Crowd data in the mobile cloud

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - GTA Laboratory - Luis Henrique Costa

Duration: 2015 - 2019

Start year: 2015

CroMo's main goal is to investigate alternatives to efficiently offload multiple data collected from mobile users to the cloud. To achieve this goal, CroMo will focus on three complementary objectives:

- Objective 1 (Data acquisition): In a wireless environment, data can be sourced at a multitude of wireless devices. Hence, the first objective of this project is to identify the most relevant information from all the data available by using local criteria. The notion of local can be concerned with a single wireless device or a set of nearby wireless devices. The goal is to only send relevant data to the cloud or to assign a higher priority to it.
- Objective 2 (Data transmission): The large-scale sensing system forces massive transmission to the cloud. Hence, transmitting the data in a reliable and timely fashion is the purpose of this second objective.
- Objective 3 (Data computation): Mobile clouds must be available for wireless users to receive and process data. Hence, the cloud infrastructure must be efficient enough to process data from users in a efficient fashion. The third objective of this project is to evaluate cloud availability and to propose performance improvements for data computation. Such improvements are concerned with cloud infrastructure adaptation according to users' demands.

In this context, our project is original and ambitious. Indeed, compared to other studies in wireless networking, our project is focused on a global approach from raw data acquisition to information creation at the mobile cloud infrastructure.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Several researchers have visited our group in 2019, mainly from our partner universities but not only:

- Gewu Bu, LIP6, France, January 2019
- Noura Mares, University of Sfax, Tunisia, from June 2019 until July 2019
- Marco Di Renzo, Centrale Supelec, France, August 2019
- Riaan Wolhuter, Stellenbosch University, South Africa, September 2019

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events: Organisation

9.1.1.1. General Chair, Scientific Chair

- Valeria Loscri is General Chair of ACM NanoCom 2020
- Nathalie Mitton is a member of the Steering committee of CIoT
- Nathalie Mitton is demo/poster chair of infocom 2019
- Valeria Loscri is Short Papers, Posters & Demos chair and Local Organizer of WiMoB 2019

9.1.1.2. Chair of Conference Program Committees

- Antoine Gallais is TPC co-chair of CoRes 2019.
- Valeria Loscri is TPC co-chair of IEEE ACM Nanocom 2019, CoRES 2020, TPC chair for Persist-IoT workshop at mobihoc 2019, TPC chair for Persist-IoT at Infocom 2020
- Nathalie Mitton is TPC co-chair of ICC 2019.

9.1.1.3. Member of the Conference Program Committees

- Valeria Loscri is/was member in the Technical Program Committee (TPC) in IoTDI 2020, IEEE GLOBECOM 2020 & 2019, VTC 2020 & 2019, SECON 2020 & 2019, GIoTS 2019, CCNC 2019, ICC 2020 & 2019, WiMob 2020 & 2019 WF-IoT
- Nathalie Mitton is/was in the Technical Program Committee (TPC) of REFRESH 2020, Infocom 2020, Percom 2020 & 2019, WCNC 2020 & 2019, DCOSS 2020 & 2019, CORES 2020 VTC 2020 & 2019, IEEE GLOBECOM 2020 & 2019, GIIS 2020, ICC 2020, AdHoc-Now 2019.
- Antoine Gallais was/is in the Technical Program Committee (TPC) of IEEE GLOBECOM 2019, IEEE ICNC 2019

9.1.2. Journal

9.1.2.1. Member of the Editorial Boards

- Nathalie Mitton is editorial board members of AHSWN since 2011
- Nathalie Mitton is editorial board member of Adhoc Networks since 2012
- Nathalie Mitton is editorial board member of IET-WSS since 2013
- Nathalie Mitton is editorial board member of ComSoc MMTC e-letter since 2014
- Nathalie Mitton is editorial board member of Wiley Transactions Emerging Telecommunications Technologies since 2016
- Nathalie Mitton is editorial board member of Wireless Communications and Mobile Computing since 2016
- Nathalie Mitton is editorial board member of MDPI Future Internet since 2018
- Valeria Loscri is editorial board member of IEEE Transactions on Nanobioscience journal since 2017
- Valeria Loscri is editorial board member of Elsevier Computer Networks journal since 2016
- Valeria Loscri is editorial board member of Robotics Software Design and Engineering of the International Journal of Advanced Robotic Systems since 2016
- Valeria Loscri is editorial board member of Elsevier Journal of Networks and Computer Applications (JNCA) journal since 2016
- Valeria Loscri is editorial board member of Wiley Transactions Emerging Telecommunications Technologies since 2019

9.1.2.2. Guest editorial activities

- Nathalie Mitton is (co-)editor of Sensor Special Issues of MDPI Sensors on Optimization and Communication in UAV Networks and Lead Guest Editor of the Green Data Collection and Processing in Smart Cities SI at Annals of Telecoms.
- Valeria Loscri is co-editor of Future Internet Special issues of MDPI The Internet of Things in smart environments

9.1.3. Invited Talks

- Nathalie Mitton gave an invited talks at the following events: Journées scientifiques Inria in June, Recontres Inria EuraSanté in June, Journées SPOC at UTC in November and Smart Logistic at IoT Week in December and IoT Days at Paris Sorbonne in December.
- Julien Vandaele and Matthieu Berthome gave an invited talk at TechTalk S Station F in April.

9.1.4. Leadership within the Scientific Community

- Nathalie Mitton is a member of the Steering Committee of the GDR RSD Rescom
- Valeria Loscri is a Member of Social Network Technical Committee

- Valeria Loscri is a Member of Emerging Technologies Initiatives for Molecular, Biological and Multi-Scale Communications (ETI-MBMC)
- Valeria Loscri is a member of the Quantum Communications & Information Technology Emerging Technical Subcommittee (QCIT)
- Valeria Loscri is a member of the 'Research Group on IoT Communications and Networking Infrastructure' at ComSoc Communities
- Valeria Loscri is Newsletter Chair for the Technical Committee for Social Networks (TCSN) IEEE Comsoc since April 2019.

9.1.5. Scientific Expertise

- Nathalie Mitton
  - She is an elected member of the evaluation community of Inria.
  - She has acted as a reviewer for ANRT and ANR project submissions.
  - She is also member of the scientific committees of the competitiveness cluster of MATIKEN and for CITC (International Contactless Technologies Center).
  - She is member of the CA of CITC.
  - She has been a member of the PRIX Roberval committee.
  - She has been a member of the Bourses L'Oreal FRANCE.
  - She is a member of the HCERES visiting committee for the LISIS laboratory.
  - She has been appointed as reviewer for the Polish National Science Centre.
  - She has been appointed as reviewer for the Heinz Maier-Leibnitz-Prize 2020.
- Valeria Loscri
  - She has been reviewer for TOP grant for senior researchers for Netherlands Organisation for Scientific Research (NWO) program.
  - She has been reviewer for proposal for grant competition at the Center for Excellence in Applied Computational Science and Engineering (CEACSE), UTC (USA).
  - She has been external evaluator of ERC Consolidator Grants.
  - She was Scientific European Responsible for Inria Lille - Nord Europe till September 2019.
  - She is Scientific International Responsible for Inria Lille from September 2019.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

E-learning

Mooc, Nathalie Mitton, "Villes intelligentes : défis technologiques et sociétaux", 5-week mooc by the IPL CityLab@Inria team, FUN, Inria, in November 2019

SPOC, Nathalie Mitton, EIT Digital "Technological challenges of participatory Smart cities", 5-week by the IPL CityLab@Inria team in November 2019

Remote curse, Nathalie Mitton, Internet of things, 5-week + face to face week in May 2019

Master: Valeria Loscri, Objets Communicants, 24h (Mineure Habitat Intelligent), Ecole des Mines de Douai, France

Master: Nathalie Mitton, Wireless networks, 16h eqTD (Master TiiR), Université Lille 1, France

Master: Nathalie Mitton, Wireless sensor networks, 16h eqTD (Master MINT), Université Lille 1 and Telecom Lille 1, France

Master: Nathalie Mitton, Smart objects, 10h CM + 12h TP, Ecole centrale de Lille, France

Master: Nathalie Mitton, Industrial Internet of Things, 10h CM Ecole centrale de Lille, France

Master: Ibrahim Amadou, Industrial to Internet of Things, 12h TP Ecole centrale de Lille, France

Master: Nathalie Mitton, Introduction to Internet of Things, 4h CM Ecole centrale de Lille, France

Master: Ibrahim Amadou, Introduction to Internet of Things, 8h TP Ecole centrale de Lille, France

Master: Nathalie Mitton, Wireless sensor networks, 16h eqTD (Master ROC), IMT, France

Licence: Brandon Foubert, Conception Orientée Objet, 42.06h eqTD (Licence 3), FST, France

9.2.2. Supervision

PhD in progress: Brandon Foubert, Communication sans fil Polymorphe pour l'Agriculture Connectée, Université Lille 1, 2018-2021, Nathalie Mitton

PhD in progress: Edward Staddon, Threat detection, identification and quarantine in wireless IoT based Critical Infrastructures, Université Lille 1, 2019-2022, Nathalie Mitton & Valeria Loscri

PhD in progress: Carola Rizza, Nouveaux paradigmes de communication basés sur les technologies émergentes, Université Lille 1, 2019-2022, Valeria Loscri

PhD in progress: Emilie Bout, Denial-of-sleep over IoT networks, Université Lille 1, 2019-2022, Valeria Loscri & Antoine Gallais

PhD in progress: Meysam Mayahi, Communication Protocols based on alternative paradigm for wireless mobile devices, Université Lille 1, 2019-2022, Valeria Loscri

PhD in progress: Mohammad Hussein Ghosn, Université Lille 1, 2019-2022, Valeria Loscri & Alia Ghadar

9.2.3. Juries

- PhD and HDR committees:
  - Valeria Loscri is/was member of the following PhD thesis committees:
    - Xiaojun Xi, CentraleSupeléc, Dec. 2019.
    - Jian Song, CentraleSupeléc, Dec. 2019.
    - Jorge Martinez, Universidade Politecnica Valencia, Spain, June 2019 (reviewer).
  - Nathalie Mitton is/was member of the following PhD thesis committees:
    - Domga Rodrigue Komguem INSA Lyon/University of Yaoundé (reviewer)
    - Maxime Mroue, Université de Nantes, December 2019 (chair)
    - Alwan Safwan, Université Paris Est, December 2019
    - Gewu Bu, Université Paris Sorbonne, December 2019 (reviewer)
    - Marija Stojanova, Université de Lyon, December 2019
    - Henry-Joseph Audeoud, Université de Grenoble, December 2019
    - Francisco Jose Fabra Collado, Universitat Politecnica de Valencia, December 2019 (reviewer)
    - Lilian Besson, Centrale Supelec Rennes, novembre 2019 (reviewer, chair)
    - Dorin Rautu, ENSEEITH, October 2019 (chair)
    - Mariem Harmassi, Université de La Rochelle, September 2019 (reviewer)
    - Nicolas De Araujo Moreira, Université de Lille, July 2019
    - Wei Hu, Centrale Lille, July 2019 (chair)
    - Philippe Pittoli, Université de Strasbourg (reviewer) may 2019
    - Fadhlallah Baklouti, Université Bretagne Sud, February 2019
    - Mohammed Islam Naas, Université de Bretagne Occidentale (reviewer), February 2019

- Nathalie Mitton was a member of the HDR defense committees
  - Thomas Watteyne, Sorbonne Université, May 2019
- Researcher selection committees:
  - Nathalie Mitton was a member of the Professor competition selection committee at INSA Lyon
  - Nathalie Mitton was a member of the Assistant Professor (MdC) committee for Université de Lyon.
  - Nathalie Mitton was a member of a CPPI selection for Inria Saclay.
  - Nathalie Mitton was a member of the Inria chaire committee for Centrale Supelec Rennes.
  - Nathalie Mitton was a member of the Inria SRP/ARP selection.
  - Nathalie Mitton was a member of the national Inria junior researcher competition committee.
  - Valeria Loscri was a member of the Inria junior researcher competition committee for Lille center.
  - Valeria Loscri was a member of the MdC committee for Centrale Supelec.
- PhD follow-up committees:
  - Nathalie Mitton is/was reviewer of the following PhD follow-up committees:
    - Rodrigue Domgua Rodriguez, INSA Lyon
    - Alexis Bitaillou, Université de Nantes
    - Vaseileios Kotsiou, Université de Strasbourg
  - Valeria Loscri is/was reviewer of the following PhD follow-up committees:
    - Lin Chen, Centrale Supélec.

9.3. Popularization

9.3.1. Internal or external Inria responsibilities

- Nathalie Mitton is the referent researcher for the creation of the MATH Laboratory in Nord

9.3.2. Articles and contents

- Nathalie Mitton published a paper in Techniques de l'Ingénieur.
- Valeria Loscri released an interview "Innovation Valeria Loscri, la lumière des LED contre le wifi électromagnétique" for the newspaper La Voix du Nord

10. Bibliography

Major publications by the team in recent years

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[7] V. TOLDOV, L. CLAVIER, V. LOSCRI, N. MITTON. *A Thompson Sampling Approach to Channel Exploration-Exploitation Problem in Multihop Cognitive Radio Networks*, in "27th annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC)", Valencia, Spain, September 2016, https://hal.inria.fr/hal-01355002

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Publications of the year

Articles in International Peer-Reviewed Journals

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