Activity Report 2014

# Project-Team FUN

## self-organizing Future Ubiquitous Network

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**Keywords:** Self-adaptation, Wireless Sensor Networks, Rfid, Robot, Energy Consumption

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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 concepts 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, be self-organized and dynamically adapt 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 [35]. 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 arise in the literature and also from the POPS research group. Some of them are very efficient for routing [43], [40], discovering neighborhood [48], [47], scheduling activity and coverage [46], localizing [50], [39], 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 [51], [45] and at the MAC layer level [9]. 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 while 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

The research area of FUN research group is represented in Figure 1. FUN research group will address every item of Figure 1 starting from the highest level of the figure, *i.e.* in area of homogeneous FUNs to the lowest one. Going down brings more applications and more issues to solve. Results achieved in the upper levels can be re-used in the lower ones. Current networks encountered nowadays are the ones at the higher level, without any interaction between them. In addition, solutions provided for such networks are rarely directly applicable in realistic networks because of the impact of the wireless medium.

FUN research group intends to fill the scientific gap and extend research performed in the area of wireless sensor and actor networks and RFID systems in two directions that are complementary and should be performed in parallel:

- **From theory to experimentation and reciprocally** On one hand, FUN research group intends to investigate new self-organization techniques for these future networks that take into account realistic parameters, emphasizing experimentation and considering mobility.

- **Towards heterogeneous FUNs** On the other hand, FUN research group intends to investigate techniques to allow heterogeneous FUNs to work together in a transparent way for the user. Indeed, new applications integrating several of these components are very much in demand (i.e. smart building) and thus these different technologies need to cooperate.
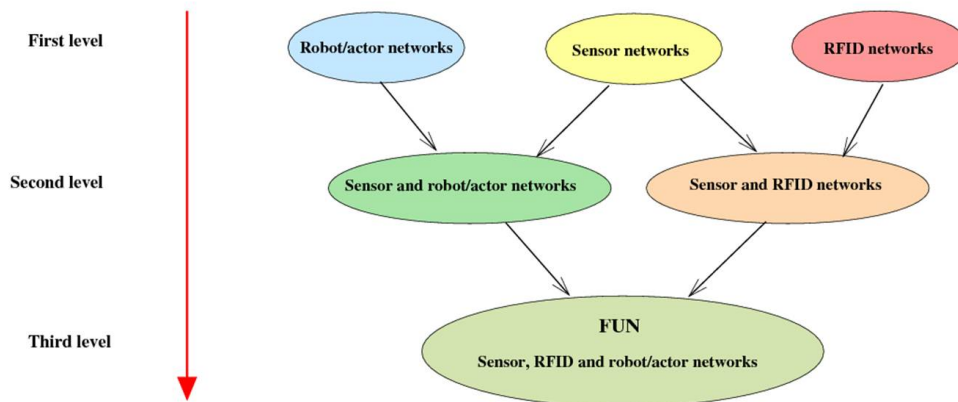
*Figure 1. Panorama of FUN.*

## 3.2. From theory to experimentation and reciprocally

Nowadays, even if some powerful and efficient propositions arise in the literature for each of these networks, very few are validated by experimentations. And even when this is the case, no lesson is learnt from it to improve the algorithms. FUN research group needs to study the limits of current assumptions in realistic and mobile environments.

Solutions provided by the FUN research group will mainly be algorithmic. These solutions will first be studied theoretically, principally by using stochastic geometry (like in [47]) or self-stabilization [49] tools in order to derive algorithm behavior in ideal environment. Theory is not an end in itself but only a tool to help in the characterization of the solution in the ideal world. For instance, stochastic geometry will allow quantifying changes in neighborhood or number of hops in a routing path. Self-stabilization will allow measuring stabilization times.

Those same solutions will then be confronted to realistic environments and their 'real' behavior will be analyzed and compared to the expected ones. Comparing theory, simulation and experimentation will allow will allow the influence of a realistic environment be better measured. From this and from the analysis of the information really available for nodes, FUN research group will investigate some means either to counterbalance these effects or to take advantage of them. New solutions provided by the FUN research group will take into consideration the vagaries of a realistic wireless environment and the node mobility. New protocols will take as inputs environmental data (as signal strength or node velocity/position, etc) and node characteristics (the node may have the ability to move in a controlled way) when available. FUN research group will thus adopt a **cross-layered** approach between hardware, physical environment, application requirements, self-organizing and routing techniques. For instance, FUN research group will study how the controlled node mobility can be exploited to enhance the network performance at lowest cost.

Solutions will follow the building process presented by Figure 2. Propositions will be analyzed not only theoretically and by simulation but also by experimentation to observe the impact of the realistic medium on the behavior of the algorithms. These observations should lead to the derivation of cross-layered models. Experimentation feedbacks will be re-injected in solution design in order to propose algorithms that best fit the environment, and so on till getting satisfactory behavior in both small and large scale environments. All this should be done in such a way that the resulting propositions fit the hardware characteristics (low memory, CPU and energy capacity) and easy to deploy to allow their use by non experts. Since solutions should take

into account application requirements as well as hardware characteristics and environment, solutions should be generic enough and then able to self-configure to adapt their environment settings.

In order to achieve this experimental environments, the FUN research group will maintain its strong activity on platform deployment such as SensLAB  [52], FIT [25] and Aspire  [44]. Next steps will be to experiment not only on testbeds but also on real use cases. These latter will be given through different collaborations.
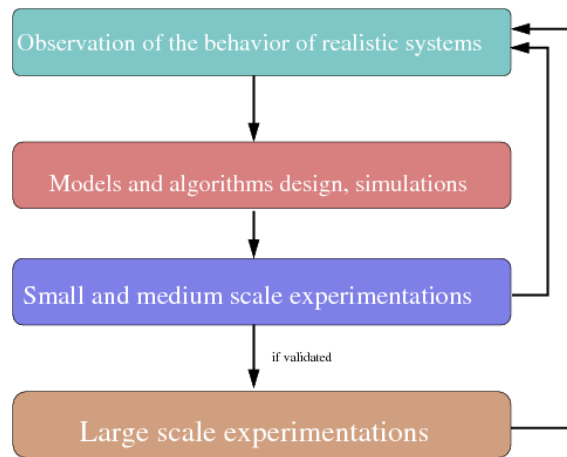


*Figure 2. Methodology applied in the FUN research group.*

**FUN research group will investigate self-organizing techniques for FUNs by providing cross-layered solutions that integrate in their design the adaptability to the realistic environment features. Every solution will be validated with regards to specific application requirements and in realistic environments.**

**Facing the medium instability.** The behavior of wireless propagation is very depending of the surrounding environment (in-door vs outdoor, night vs day, etc) and is very instable. Many experiments in different environment settings should be conducted. Experiment platforms such as SensLAB, FIT, our wifiBot as robots and actuators and our RFID devices will be used offering ways to experiment easily and quickly in different environments but might not be sufficient to experiment every environment.

**Adaptability and flexibility.** Since from one application to another one, requirements and environments are different, solutions provided by FUN research group should be **generic** enough and **self-adapt** to their environment. Algorithm design and validation should also take into account the targeted applications brought for instance by our industrial partners like Etineo. All solution designs should keep in mind the devices constrained capacities. Solutions should consume low resources in terms of memory, processor and energy to provide better performances and scale. All should be self-adaptive.

FUN research group will try to take advantage of some observed features that could first be seen as drawbacks. For instance, the broadcast nature of wireless networks is first an inconvenient since the use of a link between two nodes inhibits every other communication in the same transmission area. But algorithms should exploit that feature to derive new behaviors and a node blocked by another transmission should overhear it to get more information and maybe to limit the overall information to store in the network or overhead communication.

## 3.3. Towards unified heterogeneous FUNs

The second main direction to be followed by the FUN research group is to merge networks from the upper layer in Fig. 1 into networks from the lowest level. Indeed, nowadays, these networks are still considered as separated issues. But considering mixed networks bring new opportunities. Indeed, robots can deploy, replace,

compensate sensor nodes. They also can collect periodically their data, which avoids some long and multi-hop communications between sensor nodes and thus preserving their resources. Robots can also perform many additional tasks to enhance network performance like positioning themselves on strategic points to ensure area coverage or reduce routing path lengths. Similarly, coupling sensors and RFID tags also bring new opportunities that are more and more in-demand from the industrial side. Indeed, an RFID reader may be a sensor in a wireless sensor network and data hold by RFID tags and collected by readers might need to be reported to a sink. This will allow new applications and possibilities such as the localization of a tagged object in an environment be covered by sensors.

When at last all components are gathered, this leads us to a new era in which every object is autonomous. Let's consider for instance a smart home equipped with sensors and RFID reader. An event triggered by a sensor (*i.e.* an increase of the temperature) or a RFID reader (*i.e.* detection of a tag hold by a person) will trigger actions from actuators (*i.e.* lowering of stores, door opening). Possibilities are huge. But with all these new opportunities come new technological issues with other constraints. Every entity is considered as an object possibly mobile which should be dynamically identified and controlled. To support this dynamics, protocols should be localized and distributed. Model derived from experiment observations should be unified to fit all these classes of devices.

**FUN research group will investigate new protocols and communication paradigms that allow the technologies to be transparently merged. Objects and events might interconnect while respecting on-going standards and building an autonomic and smart network while being compliant with hardware resources and environment.**

Technologies such as wireless sensors, wireless robots/actuators and RFID tags/ readers, although presenting many common points are still part of different disciplines that have evolved in parallel ways. Every branch is at different maturity levels and has developed its own standards. Nevertheless, making all these devices part of a single unified network leverages technological issues (partly addressed in the former objective) but also regarding to on-going standards and data formatting. FUN research group will have to study current standards of every area in order to propose compliant solutions. Such works have been initiated in the POPS research group in the framework of the FP7 ASPIRE project. Members of FUN research group intend to continue and enlarge these works.

Todays' EPCGlobal compliant RFID readers must comply to some rules and be configurable through an ALE (Application Level Event) [42]. While a fixed and connected RFID reader is easily configurable, configuring remotely a mobile RFID reader might be very difficult since it implies to first locate it and then send configuration data through a wireless dynamic network. FUN research group will investigate some tools that make the configuration easy and transparent for the user. This remote configuration of mobile readers through the network should consider application requirements and network and reader characteristics to choose the best trade-off relative to the software part embedded in the reader. The biggest part embedded, the lowest bandwidth overhead (data can be filtered and aggregated in the reader) and the greater mobility (readers are still fully operational even when disconnected) but the more difficult to set up and the more powerful readers. All these aspects will be studied within the FUN research group.

# 4. New Software and Platforms

## 4.1. New ALE module for ASPIRERFID middleware.

**Participants:** Rim Driss [correspondant], Nathalie Mitton, Ibrahim Amadou, Julien Vandaele.

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.

- Version: 1.0. . APP number: IDDN.FR.001.100017.000.S.P.2012.000.10000

## 4.2. T-SCAN.

**Participants:** Gabriele Sabatino [correspondant], Nathalie Mitton.

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.

- Version: 1.0 . March 1st 2014. N IDDN abrégé : 14-440017-000

## 4.3. GOLIATH 1.0

**Participants:** Nathalie Mitton [correspondant], Salvatore Guzzo Bonifacio [correspondant].

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.

See also the web page https://gforge.inria.fr/projects/goliath/.

## 4.4. ETINODE-CONTIKI-PORT

**Participants:** Salvatore Guzzo Bonifacio [correspondant], Roudy Dagher, Nathalie Mitton.

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 Il embarque aussi des piles de communication pour l'internet des objets. 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.

- Version: 1.0 .

## 4.5. ETINODE-DRIVERS

**Participants:** Salvatore Guzzo Bonifacio [correspondant], Roudy Dagher, Nathalie Mitton.

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.

- Version: 1.0 .

## 4.6. FIT IoT-Lab

**Participants:** Raymond Borenstein, Nathalie Mitton [correspondant], Anne-Sophie Tonneau, Julien Vandaele, Roberto Quilez.

FIT IoT-LAB 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 3 subsets of the platforms:

- Euratechnologies : this site features 256 WSN430 sensor nodes operating in the 2.4GHz band. 64 nodes are mobile, embedded on mobile trains.
- 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 will feature (opening beginning 2015) 64 hardware open slots to allow any one to plug his own hardware and benefits from the platform debugging and monitoring tools.

# 5. New Results

## 5.1. Highlights of the Year

- Opening of the 256 M3 sensor nodes of the Lille's FIT IoT Lab platform.
- We have designed a novel single-based localization method, UNS, for accurate localization of mobile devices that only needs a small aperture array unlike all previous works. UNS is currently under patenting.
- We have provided a set of recognized contributions in the area of Smart Cities, re-thinking their architecture and break vertical silos between every network and application.

## 5.2. Routing in FUN

**Participants:** Valeria Loscri, Nathalie Mitton, Riccardo Petrolo.

According to a wide range of studies, IT should become a key facilitator in establishing primary education, reducing mortality and supporting commercial initiatives in Least Developed Countries (LDCs). The main barrier to the development of IT services in these regions is not only the lack of communication facilities, but also the lack of consistent information systems, security procedures, economic and legal support, as well as political commitment. In [3], [10], we propose the vision of an infrastructure-less data platform well suited for the development of innovative IT services in LDCs. We propose a participatory approach, where each individual implements a small subset of a complete information system thanks to highly secure, portable and low-cost personal devices as well as opportunistic networking, without the need of any form of infrastructure. We review the technical challenges that are specific to this approach. Relying on such an infrastructure, wireless routing must be opportunistic and take advantages of the availability of every infrastructure point when in range. Two different approaches depending on the available devices are presented in [20] and [2]. When partial positions of nodes are available, the system can take advantage of such knowledge to enhance the routing performance. This is what has been investigated in[12] where coordinates are used in an opportunistic fashion when available.

## 5.3. Self-organization

**Participants:** Natale Guzzo, Valeria Loscri, Nathalie Mitton.

Self-organization encompasses several mechanisms. This year, the FUN research group has contributed to specific aspects; topology importance and clustering.

### 5.3.1. *Impact of the topology*

Wireless Sensor Networks (WSN) are composed of constrained devices and deployed in unattended and hostile environments. Most papers presenting solutions for WSN evaluate their work over random topologies to highlight some of their "good" performances. They rarely study these behaviors over more than one topology. Yet, the topology used can greatly impact the routing performances. [13] presents a study of the impact of the network topology on algorithm performance in WSNs and illustrate it with the geographic routing. Geographic routing relies on node coordinates to route data packets from source to destination. We measure the impact of different network topologies from realistic ones to regular and very popular ones through extensive simulation and experimentation campaigns. We show that different topologies can lead to a difference of up to 25% on delivery ratio and average route length and more than 100% on energy costs.

### 5.3.2. *Clustering*

Clustering in wireless sensor networks is an efficient way to structure and organize the network. It aims to identify a subset of nodes within the network and bind it a leader (i.e. cluster-head). This latter becomes in charge of specific additional tasks like gathering data from all nodes in its cluster and sending them by using a longer range communication to a sink or a Base Station (BS) which may be far away from the monitoring area. Many algorithms proposed in the literature compute the routing process by clustering the network and by designing new election mechanisms in which the cluster-heads are chosen taking account of the remaining energy, the communication cost and the density of nodes. However, they do not consider the connectivity to the BS, and assume that all the nodes or only few prefixed nodes are able to directly communicate with it. We believe that this assumption is not suitable for many applications of WSN and to tackle this problem we propose CESAR [14], a multi-hop and energy-efficient routing protocol for large-scale WSN which includes a new cluster-head selection mechanism aware of the battery level and the connectivity to the BS. Furthermore, our solution employs an innovative hybrid approach to combine both clustering and on-demand techniques in order to provide an adaptive behavior for different dynamic topologies. Simulation results show that our solution outperforms in terms of energy consumption and data delivery other known routing algorithms in the literature. Note that CESAR is currently the object of two pending patents.

## 5.4. Controlled mobility based services

**Participants:** Emilio Compagnone, Valeria Loscri, Karen Miranda, Nathalie Mitton, Tahiry Razafindralambo, Dimitrios Zormpas, Jean Razafimandimby Anjalalaina.

Sensors have more and more functionality in terms of capture techniques, communication capabilities, processing capabilities and energy harvesting. Another interesting feature available on sensors is mobility. The FUN research group tries to exploit the controlled mobility of sensors to solve some known issues in wireless sensors networks regarding deployment or routing but also raises some new challenges regarding coverage optimization and energy harvesting.

### 5.4.1. *Coverage*

Wireless sensors are used to gather information from a field of interest. In order to capture all the events in this field, the sensors must be properly placed. When the sensors have motion capabilities such as robots, the deployment can be optimized. The use of controlled mobility raises some new challenges and opportunities in the field of wireless sensor networks. Milan Erdelj and Karen Miranda in [33] presents the advances in context. They provide a detailed literature review regarding the techniques behind controlled mobility in order to deploy or redeploy sensors. When the wireless sensors are mobile, it is possible to optimize the capture of information regarding their time and space evolution. This allows the sensors to focus on different zones of interest depending on the evolution of the observed events. Valeria Loscri, Enrico Natalizio and Nathalie Mitton present a performance evaluation of different algorithms for zone of interest coverage in [18]. Their work particularly focuses on providing a set of distributed version of a combined particle swarm optimization and virtual forces algorithm. The proposed algorithms and their evaluation show an high reactivity to changing events and targets. Energy is an important constraint in wireless sensor networks and message exchange is a functionality that drains huge amount of energy. Dimitrios Zorbas and Christos Douligeris in [30] present a low-overhead localized algorithm for the target coverage problem in wireless sensor networks. To tackle this problem they propose two variations of a localized algorithm with low communication complexity in term of message exchange. The results show a great improvement in terms of communication cost while achieving an adequate network lifetime.

### 5.4.2. *Connectivity and performance*

Information gathered by sensors are to be processed in a remote location. The transportation from the point where the raw data is generated (the sensor) and the data processing unit (sink or other infrastructure) relies on routing techniques. Routing is a fundamental functionality of a wireless sensors network. Nicolas Gouvy, Nathalie Mitton and David Simplot-Ryl in their book chapter [34] provide a review of the routing techniques

described in the literature. They highlight the challenges, main issues and future work direction in this domain and provide some important assumption and characteristics that should be kept in mind when designing routing protocols for wireless sensor networks. When route between a source and the destination of data does not exist or cannot be established, using a mobile router is a possible solution. Christos Katsikiotis, Dimitrios Zorbas and Periklis Chatzimisios in [15] propose an algorithm that restores connectivity by the use of mobile wireless router after a routing failure. They provide a fast mechanism to heal the network and restore connectivity between the network partitions. In their solution, a mobile wireless router finds the end points that should be re-connect and place itself in the correct position to restore the connectivity. Their solution shows a fast restoration process based on the implementation done on a real robotic platform.

### 5.4.3. *Energy suppliance*

Energy is an important constraint in static wireless sensor networks and even more important when sensors are mobile. However, when sensors have motion capabilities, they can use this ability to move toward a recharging point in order to increase the network operation. Dimitrios Zorbas and Tahiry Razafindralambo in [31] use the motion capability of sensors to provide an algorithm that allow the sensor to go to a recharging point while minimize the impact of their movement on the network operation such as portioning or data gathering. They provide theoretical bounds on the realisation of such operation and evaluate the average behaviour of their algorithm based on extensive simulations. Both results show a big improvement in terms of network lifetime extension compared to the case where no replacement is performed and to the case where rerouting is considered.

### 5.4.4. *Video-based applications*

Video Surveillance and Target Detection represent key components for many organizations in terms of safety and security protocols. The value of Video Surveillance has become more sophisticated and very accurate, by leveraging specific sensors able to detect motion, heat, etc. In [17], Valeria Loscri, Michele Magno and Rosario Surace show how the nodes of a sensor network can learn which is their best position based on a certain number of WebCams that need to be "woken-up" when a suspicious event is detected. The main purpose is to reduce power consumption, especially in the case of Video Surveillance, when the most of the time the power is wasted by doing nothing. On the other hand, Target Detection, namely determining whether or not a target object exists in a video frame, has grown significantly with the recent advances in embedded computing and sensors which have opened the possibility to realize smaller and low-cost autonomous systems. In [16], Valeria Loscri, Nathalie Mitton and Emilio Compagnone show the feasibility of low-cost embedded system for detection of objects based either on the shape or on the color.

## 5.5. Security

**Participants:** Valeria Loscri, Nathalie Mitton.

Security has been always a critical issue both for the users and providers of wireless communication systems. The definition of novel paradigms and innovative communication systems, such as the Internet of Things (IoT) and the nanocommunication systems, exacerbated the criticality of security and privacy factors. These latter aspects are faced in [23] and [5]. In [23], Riahi et al. face with the security issues related to the IoT paradigm, by taking into consideration that this paradigm enable daily objects to become active participants of everyday activities. They envisage the main challenges and propose solutions to address them. In [5], Valeria Loscri et al. analyze the innovative aspects that characterize the molecular communication paradigm, by proposing innovative and revolutionary methods that take into consideration the very limited available resources (i.e. we work at molecular level and then we cannot leverage on high processing and computing capabilities) and the very high criticality of the potential applications of similar systems (e.g. in-vivo applications).

## 5.6. RFID

**Participants:** Ibrahim Amadou, Nathalie Mitton.

Due to the dedicated short range communication feature of passive radio frequency identification (RFID) and the closest proximity operation of both tags and readers in a large-scale dynamic RFID system, when nearby readers simultaneously try to communicate with tags located within their interrogation range, serious interference problems may occur. Such interferences may cause signal collisions that lead to the reading throughput barrier and degrade the system performance. Although many efforts have been done to maximize the throughput by proposing protocols such as NFRA or more recently GDRA, which is compliant with the EPCglobal and ETSI EN 302 208 standards. However, the above protocols are based on unrealistic assumptions or require additional components with more control packet and perform worse in terms of collisions and latency, etc. In [9], we explore the use of some well-known Carrier Sense Multiple Access (CSMA) backoff algorithms to improve the existing CSMA-based reader-to-reader anti-collision protocol in dense RFID networks. Moreover, the proposals are compliant with the existing standards. We conduct extensive simulations and compare their performance with the well-known state-of-the-art protocols to show their performance under various criteria. We find that the proposals improvement are highly suitable for maximizing the throughput, efficiency and for minimizing both the collisions and coverage latency in dense RFID Systems.

## 5.7. VANET

**Participant:** Nathalie Mitton.

VANET (Vehicular Networks) is an arising kind of network which features specific functionalities and requirements especially in terms of delay.

[26] analyzes the information delivery delay for roadside unit deployment in an intermittently connected vehicular network. A mathematical model is developed to describe the relationship between the average information delivery delay and the distance between two neighbor RSUs (Road Side Unit) deployed along a road. The derived model considers a straight highway scenario where two RSUs are deployed at a distance without any direct connection and vehicles are sparsely distributed on the road with road condition information randomly generated between the two neighbor RSUs. Moreover, the model takes into account the vehicle speed, the vehicle density, the likelihood of an incident, and the distance between two RSUs. The effectiveness of the derived mathematical model is verified through simulation results. Given the delay requirement of some time-critical applications, this model can be used to estimate the maximum distance allowed between two neighbor RSUs, which can provide a reference basis for the deployment of RSUs in such scenarios.

Abstract–Broadcasting is an effective routing paradigm for data dissemination in vehicular ad hoc networks (VANETs). One concern that arises with broadcasting is the broadcast storm problem, which would cause node contentions and data collisions, and thus degrade the transmission efficiency of a network. [27] proposes a Dynamic trAnsmission delaY based broadcast (DAYcast) protocol for a VANET. To alleviate the effect of the broadcast storm and improve the transmission efficiency of the network, DAYcast only allows the effective neighbors of a source vehicle to broadcast a received data packet and the selection of the effective neighbors are based on the position information on the one-hop neighbors of the source vehicle. Meanwhile, it allows each effective neighbor to wait a certain transmission delay before it broadcasts a received packet. The transmission delay of an effective neighbor depends on the distance between the neighbor and the source vehicle, and the number of effective neighbors of the source vehicle. Simulation results show that DAYcast can effectively improve the network performance in terms of network reachability and the successful delivery ratio as compared with existing weighted p-persistence broadcasting (WPB) and slotted 1-persistence broadcasting (SPB).

## 5.8. Smart cities architecture

**Participants:** Valeria Loscri, Nathalie Mitton, Riccardo Petrolo, Nicola Zema.

Smart City represents one of the most promising and prominent Internet of Things (IoT) applications. In the last few years, indeed, smart city concept has played an important role in academic and industry fields, with the development and deployment of various middleware platforms. However, this expansion has followed distinct approaches creating, therefore, a fragmented scenario, in which different IoT ecosystems are not able to communicate between them. To fill this gap, there is a need to re-visit the smart city IoT semantic and offer a global common approach. In order to allow cities to share data across systems and coordinate processes across domains, it is essential to break these silos. A way to achieve the purpose is sensor virtualization, discovery and data restitution. This last year, the FUN team has lead several investigations in this direction.

We have looked at the heterogeneity of devices and network technologies under a different perspective by not perceiving it as a limitation but as a potential to increase the connectivity in a smart city [1]. We propose a new generation of network nodes, called stem nodes, based on the innovative idea of 'stemness', which pushes forward the well-known self-configuration and self-management concepts towards the idea of node mutation and evolution. We also deployed prototypes that demonstrate the stem-node architecture and basic operations in different hardware platforms of common communication devices (an Alix-based router, a laptop and a smartphone)

In [7], we illustrate semantic interoperability solutions for IoT systems. Based on these solutions, we describe how the FP7 VITAL project aims to bridge numerous silo IoT deployments in smart cities through repurposing and reusing sensors and data streams across multiple applications without carelessly compromising citizens' security and privacy. This approach holds the promise of increasing the Return-On-Investment (ROI), which is associated with the usually costly smart city infrastructures, through expanding the number and scope of potential applications.

To this purpose, [21] browses the semantic annotation of the sensors in the cloud, and innovative services can be implemented and considered by bridging Clouds and Internet of Things. Things-like semantic will be considered to perform the aggregation of heterogeneous resources by defining the Clouds of Things paradigm. We survey the smart city vision, providing information on the main requirements and highlighting the benefits of integrating different IoT ecosystems within the cloud under this new CoT vision. This paper also discusses relevant challenges in this research area.

Going further, we also presented [22] a first implementation of this federation: a federation of FIT IoT-LAB within OpenIoT. OpenIoT is a middleware that enables the collection of data streams from multiple heterogeneous geographically dispersed data sources, as well as their semantic unification and streaming with a cloud infrastructure. Future Internet of Things IoT-LAB (FIT IoT-LAB) provides a very large scale infrastructure facility suitable for testing small wireless sensor devices and heterogeneous communicating objects. The integration proposed represents a way to reduce the gap existing in the IoT fragmentation, and, moreover, allows users to develop smart city applications by interacting directly with sensors at different layers. We illustrate it trough a basic temperature monitoring application to show its efficiency.

So, once all city network and infrastructure are set at the same level thanks to the above mentioned approaches, they can go further and offer additional services. An example of them is navigation[11] as also described in "Localization" section. Another example is to make use of the urban bikes [19]. Indeed, besides the growing enthusiast provoked by bicycles in smart and green cities and the benefit for health they bring, there still exists some reluctance in using bikes because of safety, road state, weather, etc. To counter-balance these feelings, there is a need to better understand bicycle users habits, path, road utilization rate in order to improve the bicycle path quality. In this perspective,in this paper, we propose to deploy a set of mobile sensors on bicycles to gather this different data and to exploit them to make the bike easier and make people want to ride bicycles more often. Such a network will also be useful for several entities like city authorities for road maintenance and deployment, doctors and environment authorities, etc. Based on such a framework,we propose a first basis model that helps to dimension the network infrastructure and the kind of data to be real time gathered from bikes. More specifically, we present a theoretical model that computes the quantity of data a bike will be able to send along a travel and the quantity of data a base station should be able to absorb.We have based our study on real data to provide first numerical results and be able to draw some preliminary conclusions and open new research directions.

## 5.9. Localization

**Participants:** Ibrahim Amadou, Roudy Dagher, Nathalie Mitton, Roberto Quilez, Nicola Zema.

Navigate in or based on a wireless sensor network present many advantages but it is still an open issue. We have focused on two particular cases in which navigation or WSN-based localization is needed [32]. The former aspect considers that sensors need to be visited on-demand by a mobile sink to offload data. This mobile sink thus needs to locate the data source. The second aspect feature a mobile entity that is needed to be localized.

In a event-based WSN, where is necessary a prompt response in terms of data processing and offloading, a set of mobile flying sinks could be a good option for the role of autonomous data collectors. For those reasons in [28], we propose a distributed algorithm to independently and autonomously drive a mobile sink through the nodes of a WSN and we show its preferability over more classical routing approaches especially in the presence of a localized generation of large amount of information. Our result shows that, in the case of fairly complete coverage of the area where the nodes lie, it is possible to promptly notify a mobile sink about the presence of data to offload, drive it to the interested area and achieve interesting performances. [29] enhanced the previous approach by relaxing some GPS-use assumptions. We show that, under fairly common circumstances, it is possible to set the trajectory of the mobile sink and fulfill the offloading requests without the needs of additional equipment installed on nodes. We show how our system is preferable over more classical routing solutions especially in the presence of localized generation of large amounts of information.

[11] proposes Ubiquitous Navigation System (UNS), a WSN-based navigation system, which takes benefit from a WSN mesh deployment to provide a local navigation service. The positioning part of the system uses Angle of Arrival (AoA) measurements to estimate the vehicle position on the map. Based on a realistic network scenario, extracted from a city map using Google Maps, we study the performance of Triangulation using AoA in a smart urban environment that exhibits topology related constraints. Simulations results show that such constraints lead to particular spatial distribution of the anchor nodes that affects both positioning accuracy and beacon packets reception rate. We also propose and evaluate the use of the network communication range as a technique to mitigate the effect of geometric dilution of precision (GDOP). The simulation results show that this technique successfully detected GDOP-affected positions and thus significantly enhanced the positioning accuracy. One of the biggest strengths of UNS is that it relies on a single anchor unlike literature approaches. The different underlying studies are detailed in [38] in which we study the ambiguity of source localization using signal processing of large aperture antenna arrays under spherical wave propagation. This novel localization approach has been recently proposed, providing an estimate of the source position by means of two methods: geometrical and analytical. The former finds the source position as the estimate of circular loci, the latter as a solution of a linear system of equations. Although this method is proved to work for a general array geometry, we show that it suffers from ambiguities for a particular class of array geometries. Namely, in 2D, we prove that when the array geometry is linear or circular, there exist two possible solutions where only one corresponds to the actual position of the source. We also prove a relation of symmetry between the solutions with respect to the array geometry. This relation is very useful to assist the disambiguation process for discounting one of the estimates. By extension to 3D, planar (resp. spherical) arrays exhibit the same behavior i.e they provide two symmetrical estimates of the source position when the latter is not on the array plane (resp. sphere).
Note that UNS is currently a pending patent.

# 6. Bilateral Contracts and Grants with Industry

## 6.1. Etineo Partnership

**Participants:** Roudy Dagher, Salvatore Guzzo Bonifacio, Nathalie Mitton [correspondant].

EtiPOPS focuses on portability and flexibility of GOLIATH on several hardwares and in different environments (indoor and outdoor) through the deployment of different applications such as geolocalization. In order to favor the portability, designed solutions in EtiPOPS will respect on-going communication standards which will allow a greater interoperability between heterogeneous hardwares. Publications in 2014 in the framework of EtiPOPS are [32], [11] and software modules.

## 6.2. Traxens partnership

**Participants:** Natale Guzzo, Nathalie Mitton [correspondant].

This collaboration aims to set up a full protocol stack for TRAXENS's guideline.

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. *Tracaverre*

**Participants:** Nathalie Mitton [correspondant], Gabriele Sabatino.

Title: Tracaverre

Type: FUI

Duration: November 2012 - Avril 2015

Coordinator: Saver Glass

Others partners: Inria FUN IEMN Courbon Camus La Grande Marque LIRIS DISP

Abstract: Tracaverre studies the use of RFID for traceability of prestigious bottles. Tracaverre has yielded to the implementation of the T-Scan software.

## 7.2. National Initiatives

### 7.2.1. *ANR*

#### 7.2.1.1. RESCUE

**Participants:** Nathalie Mitton, Karen Miranda, Tahiry Razafindralambo [correspondant].

Title: Reseau Coordonne de substitution mobile

Type: VERSO

Duration: December 2010 - April 2014

Coordinator: Inria FUN

Other partners: LAAS UPMC France Telecom ENS Lyon

See also: http://rescue.lille.inria.fr/

Abstract: In RESCUE, we propose to exploit the controlled mobility of mobile routers to help a base network in trouble provide a better service. The base network may be any access network or metropolitan network (including wired and wireless technologies). Troubles may come from an increase of unplanned traffic, a failure of an equipment, or a power outage.

When no backup networks are available, it would be interesting to deploy, for a limited time corresponding to the period of the problem (i.e., failure or traffic overload), a substitution network to help the base network keep providing services to users. In the RESCUE project, we will investigate both the underlying mechanisms and the deployment of a substitution network composed of a fleet of dirigible wireless mobile routers. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network to help the base network reduce contention or to create an alternative network in case of failure.

#### 7.2.1.2. BinThatThinks

**Participant:** Nathalie Mitton [correspondant].

Title: BinThatThinks

Type: ECOTECH

Duration: November 2010 - March 2014

Coordinator: Inria ACES (Rennes)

Other partners: Etineo Veolia

See also: http://binthatthink.inria.fr/

Abstract: Efficient dust sorting is a main challenge for the current society. BinThatThinks is a research project that aims to propose a system that makes the collect and sorting easier through the use of RFID and sensors. Publications in 2014 in the framework of this project are: [12], [13].

### 7.2.2. ADT

#### 7.2.2.1. MiAOU

**Participants:** Ibrahim Amadou, Rim Driss, Nathalie Mitton [correspondant], Loic Schmidt, Julien Vandaele.

Title: Middleware Application to Optimal Use (MiAOU)

Type: ADT

Duration: December 2012 - November 2014

Coordinator: Inria FUN

Abstract: Miaou is an ADT that aims to promote the AspireRFID middleware to a new level of manageability and usability. Miaou has yielded to a software module.

#### 7.2.2.2. ARUNTA

**Participants:** Emilio Compagnone, Valeria Loscri [correspondant], Julien Vandaele, Sonja Nienaber.

Title: Arduino-based Robots for Ubiquitous Network (ARUNTA)

Type: ADT

Duration: September 2014 - August 2016

Coordinator: Inria FUN

Abstract: This ADT focuses on the use of Arduino, an open-source electronics prototyping platform, really flexible and easy-to-use [1] to allow a fleet of robots to perform specific tasks. The goal of the ADT is to make experiments on Arduino-based robotic platforms, by implementing two robot cooperation algorithms that have been already tested through simulation tools. In order to extend the users' community and to allow more people to benefit from this research on robot cooperation, this ADT will output a tutorial and a test-bed will be developed. Moreover, the final project will be shared with the Arduino community and every interested user.

### 7.2.3. Equipements d'Excellence

#### 7.2.3.1. FIT

**Participants:** Raymond Borenstein, Nathalie Mitton [correspondant], Anne-Sophie Tonneau, Julien Vandaele, Roberto Quilez.

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.

# 7.3. European Initiatives

## 7.3.1. FP7 & H2020 Projects

### 7.3.1.1. VITAL

**Participants:** Nathalie Mitton [correspondant], Valeria Loscri, Riccardo Petrolo.

Type: FP7

Defi: Pervasive and Trusted Network and Service Infrastructure

Instrument: Specific Targeted Research Project

Objectif: A reliable, smart and secure Internet of Things for Smart Cities

Duration: September 2013 - August 2016

Coordinator: DERI

Partner: National University of Ireland (NUI), Inria, Reply (Italy), Silo (Greece), Atos (Spain), AIT (Greece), IMAGES (UK), Camden Town Unlimited (UK), ITU (Turkey), Istanbul Metropolitan Municipality (Turkey)

Inria contact: Nathalie Mitton

Abstract: Internet-of-Things (IoT) applications are currently based on multiple architectures, standards and platforms, which have led to a highly fragmented IoT landscape. This fragmentation is evident in the area of smart cities, which typically comprise several technological silos (i.e. IoT systems that have been developed and deployed independently). Nowadays there is a pressing need to remove these silos in order to allow cities to share data across systems and coordinate processes across domains, thereby essentially improving sustainability and quality of life. In response to this need, VITAL will realize a radical shift in the development, deployment and operation of IoT applications, through introducing an abstract virtualized digital layer that will operate across multiple IoT architectures, platforms and business contexts. Specifically, VITAL will provide platform and business context agnostic access to Internet-Connected-Objects (ICO). Moreover, it will research virtualized filtering, complex event processing (CEP) and business process management mechanisms, which will be operational over a variety of IoT architectures/ecosystems. The mechanisms will compromise the diverse characteristics of the underlying ecosystems, thereby boosting interoperability at the technical and business levels. VITAL will also provide development and governance tools, which will leverage the project's interfaces for virtualized access to ICOs. VITAL will allow solution providers to (re)use a wider range of data steams, thereby increasing the scope of potential applications. It will also enable a more connected/integrated approach to smart city applications development, which will be validated in realistic deployments in London and Istanbul. The partners will contribute and adapt a host of readily available urban infrastructures, IoT platforms and novel IoT applications, which will ease the accomplishment of the project's goals based on an optimal value for EC money.

Publications in 2014 in the framework of this project are: [6], [7], [11], [21], [22].

# 7.4. International Initiatives

## 7.4.1. Inria International Labs

### 7.4.1.1. PREDNET
**Participants:** Nathalie Mitton [correspondant], Viktor Toldov, Julien Vandaele, Cesar Marchal.

Title: Predator network

Type: LIRIMA

Duration: January 2013 - December 2016

See also: https://iww.inria.fr/prednet/en/

Abstract: PREDNET (PREDator adhoc NETwork) proposes to do research on the most suitable topology and subsequent deployment of a wireless sensor network for sparsely populated outlying rural and wilderness areas, for effective monitoring and protection of resources and ecosystems. This collaboration gave birth to joint project submission, joint conference organization and several publications, among them for 2014: [36]

### 7.4.1.2. CIRIC Chile
**Participant:** Tahiry Razafindralambo.

Tahiry Razafindralambo is in leave at Inria Chile since August 2013 until April 2014. Tahiry's project within Inria Chile is linked to a project developed by NIC research Labs - Chile (Dr. Javier Bustos, Ms. Carolina Sandoval, Mr. Felipe Lema and Ms. Karina Ventura) regarding Quality of Experience, the Universidad de Chile (Pr. Nelson Baloian and Pr. Gustavo Zurita Alarcon) regarding data display, Psicomedica regarding the clinical aspect regarding the wireless sensor networks aspect. The proposed project tries to evaluate the user perception regarding a wearable monitoring system. The Wearable monitoring system will be installed on patients with mental diseases to monitor their body temperatures, heart rate, ...

### 7.4.1.3. Declared Inria International Partners

Title: Palmares

International Partner (Institution - Laboratory - Researcher):

Université Mediterranea di Reggio Calabria (UNIC) (Italy)

Duration: 2014 - 2016

See also: http://www.palmares.unirc.it

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, in a way that is independent of the network topology, reliable and flexible. The result is an 'ecosystem' of objects, self-organized and self-sustained, 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. This collaboration gave birth to the PALMARES project (see section International programs), students and researchers exchanges (see section international visits) and joint publications, among them for 2014: [1], [2], [28], [29], [23], [13].

### 7.4.1.4. Informal International Partners
**Southern University, China**

The purpose of this collaboration is to study the green (or energy-efficient) communication problem in vehicular ad hoc networks (VANETs) and the application of vehicular network communication in green transportation. It gave birth to joint project submission, joint conference organization and several publications, among them for 2014: [26], [27].

### 7.4.1.5. PhD co-supervision
**PhD co-supervision with Sfax University**

Since January 2013, Nathalie Mitton co-supervises Mouna Rekik as a PhD student with Pr Zied Chtourou from Université de Sfax, Tunisia. Her topic is about swarm intelligence based multi-path geographic routing for wireless sensor and actuator networks.

## 7.5. International Research Visitors

### 7.5.1. Visits of International Scientists

Several researchers have visited our group in 2014, mainly from our partner universities but not only:

- Marthinus Johannes Booysen, Univ. Stellenbosch, South Africa, July 2014
- Zied Chtourou, Univ. Sfax, Tunisia, June and December 2014
- Riaan Wolhuter, Univ. Stellenbosch, South Africa, March and June 2014
- Willem Smit, Univ. Stellenbosch, South Africa, July 2014
- OP Vyas, Indian Institute of Information Technology, India July 2014

In addition, 2 ERCIM fellows have visited us for a week : Andrea Hess and Matthew Orlinski.

#### 7.5.1.1. Internships

We have hosted and supervised several master students. Some came to run their master internship in our lab, like

Christos Katsikiotis from Athenes University, Greece (6 months), Abdoul-Aziz Mbacke from Université Anta Diop in Senegal (6 months), Siavash Mohamadabadi from UPMC (4 months), Basile Mona from Université Jules Vernes (4 months)/.

Other students have visited us from our partner universities in the framework of the joint project we run together. This is the case for Sonja Nienaber (4 months) and Adriaan Zeeman (4 months) who came from Stellenbosch university, South Africa, in the framework of the Prednet program and Nicola Zema from our International partner University of Reggio Calabria, Italy (6 months).

### 7.5.2. Visits to International Teams

- Roudy Dagher visited University of Brno, Czech Republic a week in May 2014.
- Roudy Dagher visited University of Santanders, Spain in July 2014.
- Viktor Toldov visited Stellenbosch University, South Africa for 2 months (Oct-dec 2014).

#### 7.5.2.1. Research stays abroad

Tahiry Razafindralambo spent 20 months in Chile (See other section).

# 8. Dissemination

## 8.1. Promoting Scientific Activities

### 8.1.1. Scientific events organisation

#### 8.1.1.1. general chair, scientific chair

- Nathalie Mitton is/was general chair for AdHocNets 2014 and 2015 and IoT-IP 2014.
- Nathalie Mitton is demo chair for MobiCom 2015
- Valeria Loscri was publicity chair for IoT-IP 2014 and Wisarn 2014.
- Viktor Toldov is publicity chair for IndiaCom 2015.
- Riccardo Petrolo is publicity chair for AdHocNets 2015.

#### 8.1.1.2. member of the organizing committee

- Valeria Loscri was organisation chair for SwanSity 2014.

### 8.1.2. Scientific events selection

*8.1.2.1. responsable of the conference program committee*

- Nathalie Mitton is/was program chair for AdHocNets 2014 and 2015 and IoT-IP 2014 and chair of special sessions at HPCC 2014 and IndiaCom 2015.
- Valeria Loscri is/was program chair for e-bannet 2014, special track at BodyNets 2014.
- Dimitrios Zormpas was program chair of WAMN'14.

*8.1.2.2. member of the conference program committee*

- Nathalie Mitton is/was in the Technical Program Committee (TPC) for Algotel'14 and 2015, AWSN 2014 and 2015, WPMC'14, SecAN'14, WinSys 2014 , BDA 2014, MDM 2014 , SensorNets 2014 and NTMS 2014.
- Tahiry Razafindralambo is/was in the Technical Program Committee (TPC) for PE-WASUN 2014 and MSWIM 2014.
- Valeria Loscri is/was in the Technical Program Committee (TPC) for BodyNets 2015 and 2014, CSWD 2015 and 2014, ICARSC 2015, TENSYMP 2015, ICC 2015, BodyNets 2014, IDCS 2014, WiMob 2014, MoWNet 2014, SwanSity 2014, WiSARN 2014, IoTip 2014, ICWMC 2014 and NTMS 2014.
- Karen Miranda is/was in the Technical Program Committee (TPC) for IndiaCom 2015 and WAMN 2014.

*8.1.2.3. invited speaker in scientific event*

- Nathalie Mitton was invited speaker at the French-India Architecture and Technological Trends and Issues in NGN event in New Delhi in April 2014.

### 8.1.3. Journal

*8.1.3.1. member of the editorial board*

- 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 co-edited the book "Wireless sensor and robot networks: from topology control to communication aspects", to be published in February 2014.
- Valeria Loscri is a member of the 'Research Group on IoT Communications and Networking Infrastructure' at ComSoc Communities.

*8.1.3.2. reviewer*

- Nathalie Mitton reviewed submissions for Elsevier Theoretical Computer Science, IET Communications, Wireless Communications and Mobile Computing, IEEE Communications letters, IEEE Wireless Communications Magazine, Elsevier Computer Communications (COM-COM), IEEE Transactions on Parallel and Distributed Systems (TPDS), Transactions on Sensors Networks, IEEE SENSORS, Elsevier Ad Hoc Networks.
- Valeria Loscri reviewed submissions for JCN, AD Hoc Networks, JNCA, IEEE Transactions on Nanotechnology, IEEE Transactions on Wireless Communications, IEEE TDPS, IEEE Sensors Journal, Elsevier COMCOM, COMNET.

## 8.2. Teaching - Supervision - Juries

### 8.2.1. Teaching

Master : Nathalie Mitton, Wireless sensor networks, 36h eqTD (Master TIIR and MINT), Université Lille 1 and Telecom Lille 1, France

Master : Nathalie Mitton, RFID Middlewares, 16h eqTD, Institut Telecom and Université Lille 1, France

### 8.2.2. *Supervision*

PhD in progress: Riccardo Petrolo, Internet of Things and Smart Cities, Université Lille 1, 2013-2016, Nathalie Mitton and Valeria Loscri

PhD in progress: Viktor Toldov, : Interférence et consommation dans les réseaux de capteurs, Université Lille 1, 2013-2016, Nathalie Mitton and Laurent Clavier

PhD in progress: Natale Guzzo, Auto - organisation et économie d'énergie dans un réseau sans fil de surveillance de fret, Université Lille 1, 2013-2016, Nathalie Mitton

PhD in progress: Roudy Dagher, Géolocalisation en environnement réel, extérieur et intérieur avec réseau de capteurs, Université Lille 1, 2013-2016, Nathalie Mitton

PhD in progress: Mouna Rekik, geographic multi path routing protocol based on swarm intelligence for wireless sensor and actuator networks in the context of Smart Grids, co-supervision Université Lille 1 and University of Sfax (Tunisia), 2013-2017, Nathalie Mitton and Zied Chtourou

PhD in progress: Jean Cristanel Razafimandimby, Distibuted Cooperation and Communication among Heterogeneous Devices, Université Lille 1, 2014-2017, Tahiry Razafindralambo and Valeria Loscri

### 8.2.3. *Juries*

- Nathalie Mitton was reviewer of the following PhD thesis:
    - Alhem Riggani, UPMC, Paris, January 2014
    - Arnab Sinha, Inria Rennes, February 2014
    - Rafik Kheddam, Esisar, Valence, February 2014
    - Yacine Benchaib, Institut Mines Telecom, March 2014
    - Hicham Laklhef, Université de Franche Comté, Montbéliard, November 2014
    - Ahmed Mokrane, UPMC, Paris, Décember 2014
    - Jacques Bou Abdo, Institut Mines Telecom, December 2014
    - Mario Antonio Gasperin Zancanaro, UPMC, January 2015
- Tahiry Razafindralambo was reviewer of the PhD thesis of Rivo S. A. Randriatsiferana, Université de La Réunion, St Denis, December 2014
- Nathalie Mitton was member of the CR2 Lille competition selection committee.

## 8.3. Popularization

- Nathalie Mitton gave a talk on "Introduction to RFID" to Terminales S a in the framework of "Fête de la Science".
- Nathalie Mitton gave a talk on "The new challenges of the next generation of wireless ubiquitous networks" to Rencontres Inria Industries in Nov. 2014 on Telecom.
- Nathalie Mitton gave a talk at the ProjectCity Forum in October 2014 in Lille.
- Nathalie Mitton gave a talk at the CAFFEET 2014 conference on IoT in Smart Factories in San Francisco in November 2014.
- Nathalie Mitton gave a talk at the EDF-Institut Telecom joint lab workshop on IoT in Smart Cities in Paris in December 2014.
- Nathalie Mitton was invited speaker at "La RFID - innovation responsable" event, march 2014, Paris.

- Nathalie Mitton was invited speaker at International Transportation System Forum in Lille in September 2014.
- Roudy Dagher gave a talk on "Introduction to Wireless Sensor Networks" in the framework of "Fête de la Science".
- Viktor Toldov gave a talk on "Introduction to Wireless Sensor Networks" in the framework of "Fête de la Science".
- Valeria Loscri gave a talk in the context of "30 minutes de sciences" at the Inria Lille - Nord Europe, May 2014.

# 9. Bibliography

## Publications of the year

### Articles in International Peer-Reviewed Journals

[1] G. ALOI, L. BEDOGNI, M. DI FELICE, V. LOSCRI, A. MOLINARO, E. NATALIZIO, P. PACE, G. RUGGERI, A. TROTTA, R. ZEMA NICOLA. *STEM-Net: an evolutionary network architecture for smart and sustainable cities*, in "Special Issue on Transactions on Emerging Telecommunications Technologies", 2014, https://hal.inria.fr/hal-00924466

[2] G. ALOI, M. DI FELICE, V. LOSCRI, P. PACE, G. RUGGERI. *Spontaneous smartphone networks as a user-centric solution for the future internet*, in "IEEE Communications Magazine", December 2014, pp. 1-6, https://hal.inria.fr/hal-01077445

[3] N. ANCIAUX, L. BOUGANIM, T. DELOT, S. ILARRI, L. KLOUL, N. MITTON, P. PUCHERAL. *Opportunistic Data Services in Least Developed Countries: Benefits, Challenges and Feasibility Issues*, in "ACM SIGMOD Record", March 2014, https://hal.inria.fr/hal-00971805

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