Activity Report 2013

Project-Team FUN

self-organizing Future Ubiquitous Network

RESEARCH CENTER
Lille - Nord Europe

THEME
Networks and Telecommunications

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Project-Team FUN

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2. Overall Objectives

2.1. Introduction

Context.

The Internet of Things [50] 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. 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 [52], [49], discovering neighborhood [58], [57], scheduling activity and coverage [55], localizing [60], [48], 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 [62], [54] and at the MAC layer level [56]. 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.

2.2. Highlights of the Year

CENTR R&D award 2013 have been attributed on October 2nd at CENTR GA meeting. The ANR VERSO WINGS in which the FUN research group is partner has been awarded among 45 nominees. There were 4 categories (Security, R&D, Marketing and Communication, Contributor of the Year), 5 projects have been awarded in each category.

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.

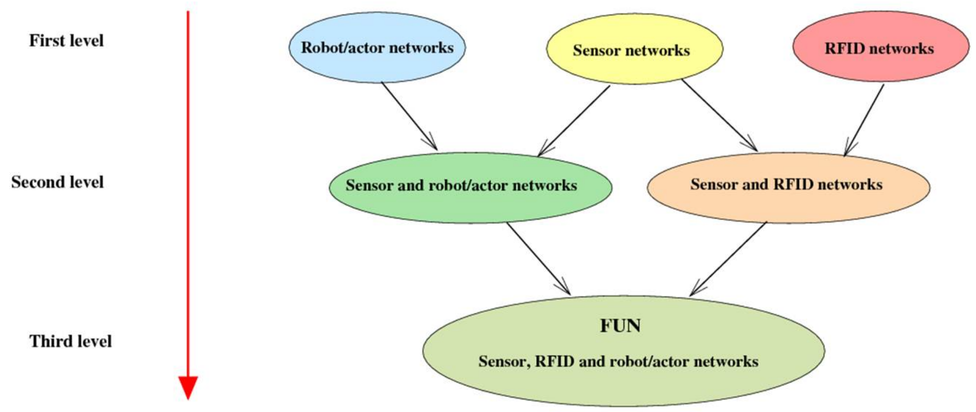

Figure 1. Panorama of FUN.

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 [57]) or self-stabilization [59] 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 [63], FIT and Aspire [53]. Next steps will be to experiment not only on testbeds but also on real use cases. These latter will be given through different collaborations.

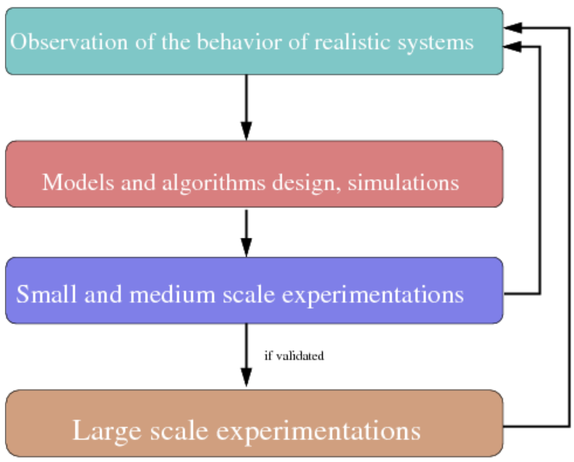

Figure 2. Methodology applied in the FUN research group.

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) [51]. 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. Software and Platforms

4.1. Distributed ONS

Participants: Nathalie Mitton, Roberto Quilez [correspondant].

This module implements a DHT-based Distributed EPC Global ONS issued from the ANR WINGS project and published in [61]. APP number: IDDN.FR.001.180033.000.S.P.2012.000.10000.

- Version: version 1

4.2. GOLIATH 1.0

Participants: Fadila Khadar [correspondant], Nathalie Mitton.

GOLIATH (Generic Optimized LIghtweight communication stack for Ambient TecHnologies) is a full protocol stack for wireless sensor networks.

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

4.3. Linear variable energy module for WSNET.

Participants: Tony Ducrocq [correspondant], Nathalie Mitton.

This module is to be integrated in the WSNET event-based simulator for wireless networks. It implements a Linear transmission variable energy module for WSNET.

- Version: 1.0

4.4. 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.

- Version: 1.0

5. New Results

5.1. Routing in FUN

Participants: Thierry Delot, Tony Ducrocq, Nicolas Gouvy, Nathalie Mitton, Enrico Natalizio, David Simplot-Ryl, Tahiry Razafindralambo, Dimitrios Zormpas.

Wireless sensor and actuator/robot networks need some routing mechanisms to ensure that data travel the network to the sink with some guarantees. The FUN research group has investigated different geographic routing paradigms. Georouting assumes that every node is aware of its location, the one of its neighbors and of the destination(s).

In this context, we first propose the first k-anycating georouting protocol, ie in which a node wishes to send a message to k sinks in the network [13]. Then, we tried to relax some of the assumptions. For instance in [12], we introduce HECTOR which is the first position based routing protocol which relies on virtual positions, is energy-aware and guarantees the data delivery.

In [46], [21], we assume that only a part of nodes is aware of its position and proposes a hybrid approach between position-based greedy approach and traditional on-demand routing. Indeed, geographic routing protocols show good properties for WSNs. They are stateless, local and scalable. However they require that each node of the network is aware of its own position. While it may be possible to equip each node with GPS receiver, even if it is costly, there are some issues and receiving a usable GPS signal may be difficult in some situations. For these reasons, we propose a geographic routing algorithm, called HGA, able to take advantages of position informations of nodes when available but also able to continue the routing in a more traditional way if position information is not available. We show with simulations that our algorithm offers an alternative solution to classical routing algorithm (non-geographic) and offers better performances for network with a density above 25 and more than 5% of nodes are aware of their position. [46] analyses the impact of nodes topology on network performances. 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 overall cost of transmissions.

In [24], [25], [26], [3], we consider that nodes are able to move by themselves and we try to take advantage of this feature to improve the network performance. In sensor networks, there is often more than one sensor which reports an event to the sink in WSN. In existing solutions, this leads to oscillation of nodes which belong to different routes and their premature death. Experiments show that the need of a routing path merge solution is high. As a response, [24], [25] introduce the first routing protocol which locates and uses paths crossing to adapt the topology to the network traffic in a fully localized way while still optimizing energy efficiency. Furthermore the protocol makes the intersection to move away from the destination, getting closer to the sources, allowing higher data aggregation and energy saving. Our approach outperforms existing solutions and extends network lifetime up to 37%.

Using nodes location, position-based routing protocols generally apply a greedy routing that makes a sensor forward data to route to one of its neighbors in the forwarding direction of the destination. If this greedy step fails, the routing protocol triggers a recovery mechanism. Such recovery mechanisms are mainly based on graph planarization and face traversal or on a tree construction. Nevertheless real-world network planarization is very difficult due to the dynamic nature of wireless links and trees are not so robust in such dynamic environments. Recovery steps generally provoke huge energy overhead with possibly long inefficient paths. In [26], we propose to take advantage of the introduction of controlled mobility to reduce the triggering of a recovery process. We propose Greedy Routing Recovery (GRR) routing protocol. GRR enhances greedy routing energy efficiency as it adapts network topology to the network activity. Furthermore GRR uses controlled mobility to relocate nodes in order to restore greedy and reduce energy consuming recovery step triggering. Simulations demonstrate that GRR successfully bypasses topology holes in more than 72% of network topologies avoid- ing calling to expensive recovery steps and reducing energy consumption while preserving network connectivity.

[31] relaxes the assumption that nodes are aware of their neighbors and considers that dynamic energy sources could be available. It introduces MEGAN (Mobility assisted Energy efficient Georouting in energy harvesting Actuator and sensor Networks), a beacon-less protocol that uses controlled mobility, and takes account of the energy consumption and the energy harvesting to select next hop. MEGAN aims at prolonging the overall network lifetime rather than reducing the energy consumption over a single path. When node s needs to send a message to the sink d, it first computes the ideal position of the forwarder node based on available and needed energy, and then broadcasts this data. Every node within the transmission range of s in the forward direction toward d will start a backoff timer. The backoff time is based on its available energy and on its distance from

the ideal position. The first node whose backoff timer goes o is the forwarder node. This node informs its neighbor- hood and then moves toward the ideal position. If, on its route, it finds a good spot for energy harvesting, it will actually stop its movement and forward the original message by using MEGAN, which will run on all the intermediate nodes until the destination is reached. Simulations show that MEGAN reduces energy consumption up to 50% compared to algorithms where mobility and harvesting capabilities are not exploited.

Additionally, according to a wide range of studies, (Informatics Technologies) 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 [18], we propose the vision of an infrastructureless 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. [18] reviews the technical challenges that are specific to this approach.

5.2. Self-organization

Participants: Tony Ducrocq, Nathalie Mitton, David Simplot-Ryl, Isabelle Simplot-Ryl.

Self-organization encompasses several mechanisms. This year, the FUN research group contributes to some of them such as neighbor discovery, localization, clustering and topology control in FUN.

5.2.1. Neighbor discovery

HELLO protocol or neighborhood discovery is essential in wireless ad hoc networks. It makes the rules for nodes to claim their existence/aliveness. In the presence of node mobility, no x optimal HELLO frequency and optimal transmission range exist to maintain accurate neighborhood tables while reducing the energy consumption and bandwidth occupation. Thus a Turnover based Frequency and transmission Power Adaptation algorithm (TFPA) is presented in [27]. The method enables nodes in mobile networks to dynamically adjust both their HELLO frequency and transmission range depending on the relative speed. In TFPA, each node monitors its neighborhood table to count new neighbors and calculate the turnover ratio. The relationship between relative speed and turnover ratio is formulated and optimal transmission range is derived according to battery consumption model to minimize the overall transmission energy. By taking advantage of the theoretical analysis, the HELLO frequency is adapted dynamically in conjunction with the transmission range to maintain accurate neighborhood table and to allow important energy savings. The algorithm is simulated and compared to other state-of-the-art algorithms. The experimental results demonstrate that the TFPA algorithm obtains high neighborhood accuracy with low HELLO frequency (at least 11% average reduction) and with the lowest energy consumption. Besides, the TFPA algorithm does not require any additional GPS-like device to estimate the relative speed for each node, hence the hardware cost is reduced.

5.2.2. Topology control

Topology control is a tool for self-organizing wireless networks locally. It allows a node to consider only a subset of links/neighbors in order to later reduce computing and memory complexity. Topology control in wireless sensor networks is an important issue for scalability and energy efficiency. It is often based on graph reduction performed through the use of Gabriel Graph or Relative Neighborhood Graph. This graph reduction is usually based on geometric values.

In [11], we propose a radically new family of geometric graphs, i.e., Hypocomb, Reduced Hypocomb and Local Hypocomb for topology control. The first two are extracted from a complete graph; the last is extracted from a Unit Disk Graph (UDG). We analytically study their properties including connectivity, planarity and degree bound. All these graphs are connected (provided the original graph is connected) planar. Hypocomb has unbounded degree while Reduced Hypocomb and Local Hypocomb have maximum degree 6 and 8, respectively. To the best of our knowledge, Local Hypocomb is the first strictly-localized, degree-bounded planar graph computed using merely 1-hop neighbor position information. We present a construction algorithm for these graphs and analyze its time complexity. Hypocomb family graphs are promising for wireless ad hoc networking. We report our numerical results on their average degree and their impact on FACE [49] routing. We discuss their potential applications and some open problems.

5.2.3. 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.

As a consequence, a cluster-head exhausts its battery more quickly than regular nodes. In [8], [22], [1], we present BLAC, a novel Battery-Level Aware Clustering family of schemes. BLAC considers the battery-level combined with another metric to elect the cluster-head. It comes in four variants. The cluster-head role is taken alternately by each node to balance energy consumption. Due to the local nature of the algorithms, keeping the network stable is easier. BLAC aims to maximize the time with all nodes alive to satisfy application requirements. Simulation results show that BLAC improves the full network lifetime 3-time more than traditional clustering schemes by balancing energy consumption over nodes and still delivering high data percentage.

On another approach, [34] considers the Slepian-Wolf coding based data aggregation problem and the corresponding dependable clustering problem in WSN. A dependable Slepian-Wolf coding based clustering (DSWC) algorithm is proposed to provide dependable clustering against cluster-head failures. The proposed D-SWC algorithm attempts to elect a primary cluster head and a backup cluster head for each cluster member during clustering so that once a failure occurs to the primary cluster head the cluster members within the failed cluster can promptly switchover to the backup cluster head and thus recover the connectivity of the failed cluster to the data sink without waiting for the next-round clustering to be performed. Simulation results show that the DSWC algorithm can effectively increase the amount of data transmitted to the data sink as compared with an existing nondependable clustering algorithm for Slepian-Wolf coding based data aggregation in WSNs.

5.3. Controlled mobility

Participants: Milan Erdelj, Valeria Loscri, Kalypso Magklara, Karen Miranda, Enrico Natalizio, Jean Razafimandimby Anjalalaina, Tahiry Razafindralambo, David Simplot-Ryl, Dimitrios Zormpas.

Controlled mobility [5] is a new paradigm that leads to a set of great new challenges.

5.3.1. Target coverage

One of the main operations in wireless sensor networks is the surveillance of a set of events (targets) that occur in the field. In practice, a node monitors an event accurately when it is located closer to it, while the opposite happens when the node is moving away from the target. This detection accuracy can be represented by a probabilistic distribution. Since the network nodes are usually randomly deployed, some of the events are monitored by a few nodes and others by many nodes. In applications where there is a need of a full coverage and of a minimum allowed detection accuracy, a single node may not be able to sufficiently cover an event by itself. In this case, two or more nodes are needed to collaborate and to cover a single target. Moreover, all the nodes must be connected with a base station that collects the monitoring data.

In [15], we describe the problem of the minimum sampling quality, where an event must be sufficiently detected by the maximum possible amount of time. Since the probability of detecting a single target using randomly deployed static nodes is quite low, we present a localized algorithm based on mobile nodes. Our algorithm sacrifices a part of the energy of the nodes by moving them to a new location in order to satisfy the desired detection accuracy. It divides the monitoring process in rounds to extend the network lifetime, while it ensures connectivity with the base station. Furthermore, since the network lifetime is strongly related to the number of rounds, we propose two redeployment schemes that enhance the performance of our approach by balancing the number of sensors between densely covered areas and areas that are poorly covered. Finally, our evaluation results show an over 10 times improvement on the network lifetime compared to the case where the sensors are static. Our approaches, also, outperform a virtual forces algorithm when connectivity with the base station is required. The redeployment schemes present a good balance between network lifetime and convergence time.

[47], [28] assume that these targets to cover are dynamic. We assume that no knowledge about either event position or duration is given a priori. Nonetheless, the events need to be monitored and covered thanks to mobile wireless sensors. Thus, mobile sensors have to discover the events and move towards a new Zone of Interest (ZoI) when the previous monitored event is over. An efficient, distributed and localized solution of this problem would be immediately exploitable by several applications domains, such as environmental, civil, etc. We propose two novel approaches to deal with dynamic event coverage. The first one is a modified version of the PSO, where particles (mobile sensors, nodes or devices in the following) update their velocity by using only local information coming from their neighbors. In practice, the velocity update is performed by considering neighbors' sensed events. Our distributed version of PSO is integrated with a distributed version of the Virtual Force Algorithm (VFA). Virtual Force approach has the ability to "position" nodes with no overlap, by using attractive and repulsive forces based on the distance between nodes. The other proposed algorithm is a distributed implementation of the VFA by itself. Both techniques are able to reach high levels of coverage and show a satisfying reactivity when the ZoI changes. This output parameter is measured as the capability for the sensors to "follow" a sequence of events happening in different ZoIs. The effectiveness of our techniques is shown through a series of simulations and comparisons with the classical centralized VFA.

On another approach consists in using flying drone to cover this set of targets. [39] focuses on the energy efficiency problem where camera equipped flying drones are able to detect and follow mobile events that happen on the ground. We give a mathematical formulation of the problem of minimizing the total energy consumption of a fleet of drones when coverage of all events is required. Due to the extremely high complexity of the binary optimization problem, the optimum solution cannot be obtained even for small instances. On the contrary, we present LAS, a localized solution for the aforementioned problem which takes into account the ability of the drones to fly at lower altitudes in order to conserve energy. We simulate LAS and we compare its performance to a centralized algorithm and to an approach that uses static drones to cover all the terrain. Our findings show that LAS performs similar to the centralized algorithm, while it outperforms the static approach by up to 150% in terms of consumed energy. Finally, the simulation results show that LAS is very sustainable in presence of communication errors.

5.3.2. Multiple Point of Interest coverage

The coverage of Points of Interest (PoI) is a classical requirement in mobile wireless sensor applications. Optimizing the sensors self-deployment over a PoI while maintaining the connectivity between the sensors and the base station is thus a fundamental issue.

The problems of multiple PoI discovery, coverage and data report are still solved separately and there are no works that combine the aforementioned problems into a single deployment scheme. In [9], [2], we present a novel approach for mobile sensor deployment, where we combine multiple PoI discovery and coverage with network connectivity preservation in order to capture the dynamics of the monitored area. Furthermore, we derive analytical expressions for circular movement parameters and examine the performance of our approach through extensive simulation campaigns.

[10] addresses the problem of autonomous deployment of mobile sensors that need to cover a predefined PoI with a connectivity constraint. In our algorithm, each sensor moves toward a PoI but has also to maintain the connectivity with a subset of its neighboring sensors that are part of the Relative Neighborhood Graph (RNG). The Relative Neighborhood Graph reduction is chosen so that global connectivity can be provided locally. Our deployment scheme minimizes the number of sensors used for connectivity thus increasing the number of monitoring sensors. Analytical results, simulation results and practical implementation are provided to show the efficiency of our algorithm.

5.3.3. Robot cooperation

The concept of autonomous mobile agents gets a lot of attention in the domain of WSN or wireless sensor and actuator networks (WSAN). Multiple robots that coordinate or cooperate with other sensors, robots or human operator, allow the WSN/WSAN to perform tasks that are far beyond the scope of single robot unit. In[23], we describe the robot middleware architecture that allows networked multi-robot control and data acquisition in the context of wireless sensor networks. Furthermore, we present three examples of robot network deployment and illustrate the proposed architecture usability: the robotic network deployment with the goal of covering the Point of Interest, adaptable multi-hop video transmission scenario, and the case of obtaining the energy consumption during the deployment.

5.3.4. Substitution networks

A substitution network [4] is a temporary network that will be deployed to support a base network in trouble and help it to provide the best service.

WSN are widely deployed nowadays on a large variety of applications. The major goal of a WSN is to collect information about a set of phenomena. Such process is non trivial since batteries' life is limited and thus wireless transmissions as well as computing operations must be minimized. A common task in WSNs is to estimate the sensed data and to spread the estimated samples over the network. Thus, time series estimation mechanisms are vital on this type of processes so as to reduce data transmission. In [30], we assume a single-hop clustering mechanism in which sensor nodes are grouped into clusters and communicate with a sink through a single hop. We propose a couple of autoregressive mechanisms to predict local sensed samples in order to reduce wireless data communication. We compare our proposal with a model called EEE that has been previously proposed in the literature. We prove the efficiency of our algorithms with real samples publicly available and show that they outperform the EEE mechanism.

In [32], we propose an algorithm to efficiently (re)-deploy the wireless mobile routers of a substitution network by considering the energy consumption, a fast deployment scheme and a mix of the network metric. We consider a scenario where we have two routers in a fixed network and where connectivity must be restored between those two routers with a wireless mobile router. The main objective of the wireless mobile router is to increase the communication performance such as the throughput by acting as relay node between the two routers of the fixed network. We present a fast, adaptive and localized approach which takes into account different network metrics such as Received Signal Strength (RSS), Round-Trip Time (RTT) and the Transmission Rate, between the wireless mobile router and the two routers of the fixed network. Our method ameliorates the performance of our previous approach from the literature by shortening the deployment time, increasing the throughput, and consuming less energy in some specific cases.

5.4. Security

Participants: Nathalie Mitton, Enrico Natalizio.

[19] deals with the energy efficient issue of cryptographic mechanisms used for secure communication between devices in wireless sensor networks. Since these devices are mainly targeted for low power consumption appliances, there is an effort for optimization of any aspects needed for regular sensor operation. On a basis of utilization of hardware cryptographic accelerators integrated in microcontrollers, this article provides the comparison between software and hardware solutions. Proposed work examines the problems and solutions for implementation of security algorithms for WSN devices. Because the speed of hardware accelerator should be much higher than the software implementation, there are examination tests of energy consumption and validation of performance of this feature. Main contribution of the article is real testbed evaluation of the time latency and energy requirements needed for securing the communication. In addition, global evaluation for all important network communication parameters like throughput, delay and delivery ratio are also provided.

The Internet of Things (IoT) will enable objects to become active participants of everyday activities. Introducing objects into the control processes of complex systems makes IoT security very difficult to address. Indeed, the Internet of Things is a complex paradigm in which people interact with the technological ecosystem based on smart objects through complex processes. The interactions of these four IoT components, person, intelligent object, technological ecosystem, and process highlight a systemic and cognitive dimension within security of the IoT. The interaction of people with the technological ecosystem requires the protection of their privacy. Similarly, their interaction with control processes requires the guarantee of their safety. Processes must ensure their reliability and realize the objectives for which they are designed. We believe that the move towards a greater autonomy for objects will bring the security of technologies and processes and the privacy of individuals into sharper focus. Furthermore, in parallel with the increasing autonomy of objects to perceive and act on the environment, IoT security should move towards a greater autonomy in perceiving threats and reacting to attacks, based on a cognitive and systemic approach. In [33], we will analyze the role of each of the mentioned actors in IoT security and their relationships, in order to highlight the research challenges and present our approach to these issues based on a holistic vision of IoT security.

5.5. RFID

Participants: Ibrahim Amadou, Nathalie Mitton.

Mitigating reader-to-reader collisions is one of the principal challenges in a large-scale dynamic RFID system with a number of readers deployed in order to maximize the system performance (i.e., throughput, fairness and latency). In prior works, contention-based and activity scheduling medium access control (MAC) protocols are commonly used approaches to reduce such problems. Existing protocols typically perform worse in a large-scale RFID dynamic system and require more additional components or are based on unrealistic assumptions. So far, many research efforts have been made to improve the performance or the reliability of Carrier Sense Multiple Access (CSMA) techniques for Mobile Ad-Hoc Networks (MANETs) by using an adaptive Backoff schemes. In [17], we look at these well known solutions that proved their efficiency in high congestion wireless networks. We evaluate the performance and characterize these solutions when they are used to reserve the wireless channel through broadcasting message for reader-to-tag communication. Based on the application requirements, we study their capacity to mitigate collisions, the channel access latency, the average number of successful requests sent per reader and the fairness index in the context of RFID networks.

5.6. Data collection and aggregation

Participant: Nathalie Mitton.

Named Data Networking (NDN) is a new promising paradigm for content retrieval and distribution in the future Internet. NDN communication is driven by data consumers that broadcast Interest packets to require named contents. The requests are forwarded towards the source(s) by directly using content names (instead of IP addresses), while in-network caching is used to improve delivery performance. NDN shows many similarities with data-centric models defined for wireless sensor networks (WSNs), e.g., directed diffusion. In addition, NDN defines a new complete communication framework with innovative naming and security schemes and novel routing and transport strategies. This clearly opens new perspectives in the design and development of sensor networks, which can benefit of the NDN framework to better support different kinds of applications and services. In [16], we explore the potentialities of NDN applied to WSNs and propose enhanced delivery strategies inspired by the directed diffusion scheme to be deployed in the NDN framework. Performance of a plain NDN scheme and of our enhanced solution is evaluated through the ndnSIM simulator. Achieved results confirm the viability of a NDN-like approach over WSNs and the better efficiency and effectiveness of the proposed solution compared to a plain NDN.

[38] considers the Slepian-Wolf coding based energy-minimization rate allocation problem in a WSN and propose a distributed rate allocation algorithm to solve the problem. The proposed distributed algorithm is based on an existing centralized rate allocation algorithm which has a high computational complexity. To reduce the computational complexity of the centralized algorithm and make the rate allocation performable in a distributed manner, we make necessary modifications to the centralized algorithm by reducing the number of sets in calculating the average energy consumption cost and limiting the number of conditional nodes that a set can use. Simulation results show that the proposed distributed algorithm can significantly reduce the computational time when compared with the existing centralized algorithm at the cost of the overall energy consumption for data transmission and the total amount of data transmitted in the network.

5.7. VANET

Participant: Nathalie Mitton.

Routing is a critical issue in vehicular ad hoc networks (VANETs). This paper considers the routing issue in both vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications in VANETs, and proposes a Moving dirEction and DestinAtion Location based routing (MEDAL) algorithm for supporting V2V and V2I communications. MEDAL [36] takes advantage of both the moving directions of vehicles and the destination location to select a neighbor vehicle as the next hop for forwarding data. Unlike most existing routing algorithms, it only uses a HELLO message to obtain or update routing information without using other control messages, which largely reduces the number of control messages used in routing. Simulation results show that MEDAL can significantly improve the packet delivery ratio of the network as compared with the well-known Ad hoc On-demand Distance Vector Routing (AODV) algorithm.

5.8. Industrial Applications

Participants: Milan Erdelj, Nathalie Mitton, Enrico Natalizio.

The collaborative nature of industrial wireless sensor networks (IWSNs) brings several advantages over traditional wired industrial monitoring and control systems, including self-organization, rapid deployment, flexibility, and inherent intelligent processing. In this regard, IWSNs play a vital role in creating more reliable, efficient, and productive industrial systems, thus improving companies' competitiveness in the marketplace. Industrial Wireless Sensor Networks: Applications, Protocols, and Standards [42] examines the current state of the art in industrial wireless sensor networks and outlines future directions for research.

6. Bilateral Contracts and Grants with Industry

6.1. Etineo Partnership

Participants: Roudy Dagher, Fadila Khadar, 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.

6.2. France Telecom partnership

Participants: Nathalie Mitton, Tahiry Razafindralambo [correspondant], Dimitrios Zormpas.

This collaboration aims to investigate rural networks and to deploy efficiently and dynamically such networks.

6.3. 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.

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. RESCUE

Participants: Milan Erdelj, Nathalie Mitton, Kalypso Magklara, Karen Miranda, Tahiry Razafindralambo [correspondant].

Title: Reseau Coordonne de substitution mobile

Type: VERSO

Duration: December 2010 - April 2004

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 provides 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. F-Lab

Participants: Nathalie Mitton [correspondant], Tahiry Razafindralambo.

Title: Federating Computing Resources

Type: VERSO

Duration: November 2010 - March 2014

Coordinator: UPMC

Other partners: Inria DIANA, DANTE, FUN Thales ALU

See also: http://f-lab.fr/

Abstract: The F-Lab project works towards enabling an open, general-purpose and sustainable large-scale shared experimental facility that fosters the emergence of the Future Internet. F-Lab builds on a leading prototype for such a facility: the OneLab federation of testbeds. F-Lab will enhance the OneLab federation model with the addition of SensLAB's unique sensor network and LTE-based cellular systems, and develop tools to conduct experiments on these enriched facilities. Project partners include some of French top academic and industrial research institutions, working together to develop experimental facilities on the Future Internet. F-Lab presents an unique opportunity for the French community to play a stronger role in the design of federation systems; for the SensLAB testbed to reach an international visibility and use; and for the pioneering of testbeds based on LTE technology.

7.2.1.3. BinThatThinks

Participants: Tony Ducrocq, Nathalie Mitton [correspondant].

Title: BinThatThinks

Type: ECOTECH

Duration: November 2010 - November 2013

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.

7.2.2. ADT

7.2.2.1. SenSas

Participants: Nathalie Mitton [correspondant], Tahiry Razafindralambo, Julien Vandaele.

Title: Sensor Network Applications (SensAS)

Type: ADT

Duration: November 2010 - November 2014

Coordinator: Inria DANTE

Others partners: Inria Non-A Inria DIANA Inria NECS Inria DEMAR Inria MADYNES Inria AMAZONE Inria SED

See also: http://sensas.gforge.inria.fr/

Abstract: Sensas aims to propose mainly control science application based on wireless sensor and actuator network nodes provided from the work done around senslab and senstools projects.

7.2.2.2. SensLille

Participants: Khalil Hammami, Nathalie Mitton [correspondant], Julien Vandaele.

Title: SensLille

Type: ADT

Duration: November 2011 - November 2013

Coordinator: Inria FUN

Abstract: SensLille is an ADT that aims to improve SensLab Lille platform by offering new functionalities as the use of electric trains to experiment mobile nodes.

7.2.2.3. 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.

7.2.3. *Equipements d'Excellence*

7.2.3.1. FIT

Participants: Nathalie Mitton [correspondant], Anne-Sophie Tonneau, Tahiry Razafindralambo, Loic Schmidt, David Simplot-Ryl, 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 Projects*

7.3.1.1. VITAL

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

Title: Virtualized programmable InTerfAces for smart, secure and cost-effective IoT depLoyments in smart cities
Type: FP7 Smart Cities
Duration: September 2013 - August 2016
Coordinator: National University of Ireland (NUIG), Digital Enterprise Research Institute (DERI)
See also: http://vital-iot.com/
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 streams, 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.

7.3.2. Collaborations in European Programs, except FP7

Program: CoperLink

Project acronym: Palmares

Project title: Palmares

Duration: January 2012 - July 2013

Coordinator: Universita degli Studi Mediterranea, Italy

Other partners: Inria, Stellenbosch University (South Africa)

Abstract: Internet of things, VANET and substitution networks.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Declared Inria International Partners

Currently, the FUN team has two possible International Partners awaiting for approval: Universita mediterranea di Reggio Calabria (UNIC) in Italy and Southern University in China. See next section for details.

7.4.1.2. Informal International Partners

Universita mediterranea di Reggio Calabria (UNIC), Italy

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 2013: [16].

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 2013: [34], [36], [38], [13], [26].

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.

7.4.2. Inria International Labs

7.4.2.1. PREDNET

Participants: Nathalie Mitton [correspondant], Milan Erdelj, Julien Vandaele, Cesar Marchal, Isabelle Simplot-Ryl.

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 2013: [31]

7.4.2.2. CIRIC Chile

Participant: Tahiry Razafindralambo.

Tahiry Razafindralambo is in leave at Inria Chile since August 2013. 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, ...

8. Dissemination

8.1. Scientific Animation

8.1.1. Conference organization

Program (co-)chairs

- Nathalie Mitton is/was program chair or co-program chair for WiMob 2013, OpenWorldForum 2013 (IoT Track) and IoT-IP 2013.

Program committee members

- Nathalie Mitton is/was in the Technical Program Committee (TPC) for Algotel'14, WPMC'14, SecAN'14, WinSys 2014 , MDM 2014 , SensorNets 2014, MDM 2013, WWASN2013, AdHoc-Nets 2013 , EUSPN 2013 , MC3 2013 , AdHocNow 2013 , HuMoComp 2013 , MDM 2013, WWASN2013, Africomm 2013, WWASN2013.
- Tahiry Razafindralambo is/was a TPC member for WiMob 2013, MSWIM 2013, PE-WASUN 2013.
- Valeria Loscri is/was TPC member for WiMob2013, NTMS2013, IoTIP2013, MC3 2013.

Other chairing

- Valeria Loscri was publicity chair for IoT-IP 2013.

8.1.2. Editorial activity

- 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 and David Simplot-Ryl edited the book "Wireless sensor and robot networks: from topology control to communication aspects", to be published in February 2014.

8.1.3. Misc

- Nathalie Mitton was member of the ANR programme blanc SIMI3 for 2013.
- Nathalie Mitton a member of the Inria COST-GTAI and Building User committee (CUB).
- Nathalie Mitton was vice-president of theTechnological development committee (CDT) in 2013 and will be president from January 2014.

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

Master : Valeria Loscri, Digital Transmission - Course of Master Science in Engineering of Telecommunication Course (University of Calabria)

Post-Master : Valeria Loscri, KOM4T me: Knowledge Management 4 info Telemati in Mobile Environment (post-master course for expert in knowledge management systems applied to the context of infotainment for vehicular environments, organized by University of Calabria, Infomobility Spa, Magneti Marelli Spa, Info Blu Spa) - 100 hours

8.2.2. Supervision

HdR : Tahiry Razafindralambo, Mouvements autonomes: de la créativité dans les réseaux sans fil, Université Lille 1, December 5th 2013

PhD : Karen Miranda, Self-deployment algorithms for substitution networks, Université Lille 1, December 10th 2013, Tahiry Razafindralambo and David Simplot-Ryl

PhD : Tony Ducrocq, Auto-organisation des réseaux sans-fil multi-sauts dans les villes intelligentes , Université Lille 1, November 15th 2013, Nathalie Mitton and Michael Hauspie

PhD : Milan Erdelj, MobileWireless Sensor Network Architecture: Applications to Mobile Sensor Deployment, Université Lille 1, October 11th 2013, Tahiry Razafindralambo and David Simplot-Ryl

PhD : Nicolas Gouvy, Routage géographique dans les réseaux de capteurs et actionneurs sans fil Université Lille 1, September 19th 2013, Nathalie Mitton

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

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

PhD in process: César Marchal, Sécurité dans les réseaux de capteurs - Du routage à la pertinence des données, Université Lille 1, 2013-2016, Nathalie Mitton

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

8.2.3. Juries

- Nathalie Mitton was committee member of the following PhD thesis:
  - Julien Beaudaux, Université de Strasbourg, France, June 2013
  - Raul Gorcitz (reviewer), UPMC, Paris, July 2013
  - Alhem Riggani, UPMC, Paris, January 2014
  - Arnab Sinha, Inria Rennes, February 2014
  - Rafik Kheddam, Esisar, February 2014
- Nathalie Mitton was member of the CR2 Lille competition selection committee.
- Nathalie Mitton was member of the Boost Your Code 2013 competition jury.
- Nathalie Mitton was a member of the COS (associate professor selection committee) for INSA de Lyon and Université de Reims.

8.3. Popularization

- Tahiry Razafindralambo gave a popularization talk "Introduction to Wireless Sensor Networks" at Distributed Computing Department / Universidad de Chile.

- Nathalie Mitton gave a talk on "Introduction to RFID" to Terminales ES and S and "Introduction to Wireless Sensor Networks" to 4e and 3e in the framework of "Journées de la Science".
- Ibrahim Amadou gave a talk on "Introduction to Wireless Sensor Networks" in the framework of "Journées de la Science".

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