RESEARCH CENTRE

Lille - Nord Europe

2021 ACTIVITY REPORT

Project-Team FUN

self-organizing Future Ubiquitous Network

DOMAIN

Networks, Systems and Services, Distributed Computing

THEME

Networks and Telecommunications

Contents

Project-Team FUN

Creation of the Project-Team: 2013 July 01

Keywords

Computer sciences and digital sciences

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A1.2.3. – Routing

A1.2.4. – QoS, performance evaluation

A1.2.5. – Internet of things

A1.2.6. – Sensor networks

A1.2.7. – Cyber-physical systems

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Other research topics and application domains

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B8.1. – Smart building/home

B8.1.2. – Sensor networks for smart buildings

B8.2. – Connected city

1 Team members, visitors, external collaborators

Research Scientists

- Nathalie Mitton [Team leader, Inria, Senior Researcher, HDR]
- Valeria Loscri [Inria, Researcher, HDR]

Post-Doctoral Fellows

- Antonio Costanzo [Inria]
- Brandon Foubert [Inria, from Oct 2021 until Dec 2021]
- Remy Grunblatt [Inria, from Mar 2021 until Aug 2021]
- Mohammad Ojaroudi Parchin [Inria, Until Jan 2021]
- Christian Salim [Inria, until Aug 2021]
- Yasir Saleem Shaikh [Inria]

PhD Students

- Emilie Bout [Inria]
- Brandon Foubert [Inria, until Sep 2021]
- Jana Koteich [Inria, from Oct 2021]
- Meysam Mayahi [Inria]
- Carola Rizza [Inria]
- Nina Santi [Inria]
- Edward Staddon [Inria]

Technical Staff

- Roudy Dagher [Inria, Engineer]
- Etienne Profit [Inria, Engineer, From Dec 2021]

Interns and Apprentices

- Roxane Degas [Université de Lille, from Jul 2021 until Aug 2021]
- Tomas Gonzalez [Inria, from May 2021 until Sep 2021]
- Jana Koteich [Inria, from Mar 2021 until Aug 2021]
- Eowald Poulouin [Université de Lille, from May 2021 until Jul 2021]

Administrative Assistant

- Anne Rejl [Inria]

Visiting Scientists

- Gianmarco Lia [Mediterranean University Of Reggio Calabria - Italy, from Feb 2021]
- Claudio Marche [Université de Cagliari Sardaigne - Italie, from Sep 2021]

2 Overall objectives

With the foreseen increase of communicating devices around the world, many challenges will arise. Among them, the most predominant ones are certainly the scarcity of the medium, the energy consumption, the lack of interoperability and the security of these devices and their data.

Our objectives are to address these different challenges for the self-organization of these Future Ubiquitous Networks. Our focus will be set on wireless heterogeneous communicating objets that feature different limitations and constraints such as hardware limitations (low computing and memory storage capacities), limited energy, potentially high mobility or hostile environment. By wireless, we mean any communication with no wire. Objects could thus communicate through traditional RF transmissions or any alternative way such as visible light communication (VLC) or molecular technologies. They can be heterogeneous in terms of hardware processing, mobility patterns (mobility can be undergone or controlled, unknown or predictable), communication technologies, etc. For all these families of devices, we will design holistic communication protocols to allow them to efficiently function and cooperate in a harmonious energy- and data-priority aware fashion. These protocols will focus on low communication layers (PHY, MAC and NET) and combine opportunistically heterogeneous device features to make a global efficient behavior emerge.

The goal of the FUN project team is to leverage the heterogeneity of the new communicating devices to override major rising issues. Heterogeneity and mobility will be seen as opportunities and strengths rather than flaws and exploited. Our protocols will foster the cooperation between devices in a secure, energy efficient and frugal way.

3 Research program

Objectives and methodology

To achieve our main objectives, we will mainly apply the methodology depicted in Figure 1 combining both theoretical analysis and experimental validation. Mathematical tools will allow us to properly dimension a problem, formally define its limitations and needs to provide suitable protocols in response. Then, they will allow us to qualify the outcome solutions before we validate and stress them in real scenarios with regards to applications requirements. For this, we will realize proofs-of-concept with real scenarios and real devices. Differences between results and expectations will be analyzed in return in order to well understand them and integrate them by design for a better protocol self-adaptation capability.

3.1 Research axes

To reach this overall objective, we will develop our research around the three following axes: *i)* Frugality and opportunism, *ii)* Security and *iii)* Interconnectivity. Note that these axes are not completely independent neither hermetic. A transversal axis will be the deployment and set up of experimental testbeds.

3.1.1 Frugality and opportunism

As the objects we consider are resource-limited and that they use a rare resource to communicate (wireless medium), all our solutions must be frugal and use as little resources as possible. A way to alleviate the energy consumption and the medium utilization is to reduce the data to send and/or to smartly decide when to send it, by what mean and to whom without jeopardizing the accuracy and completeness of the data. When to send a data can indeed impact the resource utilization since in a dynamic environment, some interference could appear at different times; in a mobile environment, a data could be carried rather than transmitted; in an energy-harvesting network, the amount of available energy could grow. We thus intend to closely analyse and understand interference impacts on different environments and contexts on one hand (as the research initiated in LumiCar, EthiCam, AgriNET) and to exploit them in the design of our protocols.

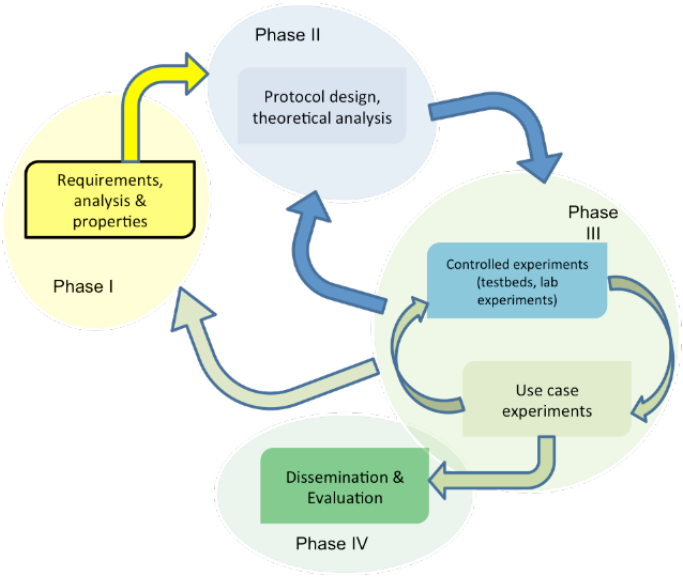

Figure 1: Methodology to be applied in FUN.

Deciding what data to send allows for a data reduction and resource savings. To do so, we will use machine learning techniques (e.g. Thompson sampling, Bayesian approaches, linear approaches, ARMA, Pearson sampling etc) that we will adapt to fit the specific context of the applications. The idea is to propose predictive algorithms to "guess" a data rather than transmitting it. This is among others what we are investigating in the AgriNET project.

In case of the availability of multiple communication technologies, the choice of this technology will impact the global system since all technologies do not provide the same QoS performances (delays, throughputs, etc) with different energy consumptions and do not face interferences the same way depending on the environment. We will thus analyse and understand all these specificities to combine them to get the best performances.

In all above mentioned cases, we will try to provide time and space depend protocols as frugal as possible but still meeting the application requirements and expectations. This will be done by opportunistically leveraging network particularities (multiple technologies, mobility, energy-harvesting, etc) based on experimental-driven behavioral analysis, as initiated with the collaboration with Sencrop.

3.1.2 Security

Security of wireless transmissions is a rising issue that gains importance with the increase of wireless devices. Our team has just started research work in security but we will pursue our efforts. Our goal will be to secure the wireless communications in different ways. Indeed, traditional security techniques (cryptography, firewalls, etc) cannot be applied in FUN because of their pervasive feature and limited resources. In terms of Security, we will focus on the lowest layers of the communication stack in order to first identify attacks that may appear at these levels and proposes *i)* recovering and healing solutions and *ii)* new solutions that are robust by design.

At the MAC layer, we will for instance investigate denial of sleep-like attacks that aim to make nodes deplete their energy quickly. At NET layer, we will investigate different routing protocols that are able to detect an abnormal behavior of a neighbor node to then exclude it from any network operation. This has obviously to be done locally and in a distributed way. In all cases, the same methodology will be apply: observe, understand and model, to then identify the threat or the malicious entity and finally heal. In some case, we can leverage the characteristics of the communication technology to reinforce the security aspect, such as VLC that may allow Line-of-Sight (LOS) communications and for which certain types of attacks that can be effective for "traditional" wireless systems (i.e., jamming attacks) cannot be easily applied. The works initiated in the framework of the H2020 CyberSANE project, in the DGA grant and in

DEPOSIA project, fall within this perspective.

3.1.3 Interconnectivity

Another challenge faced by FUN is their interconnectivity to traditional networks such as Internet and the data offloading. Because of their limited capacity, FUN devices may need to call for remote services. These latter are usually hosted in the cloud. But being served by the cloud implies sometimes long latency and uselessly congest the wired network. We will thus investigate how to get these services closer to the FUN devices to alleviate the energy consumption, reduce latency and network congestion. This will go from edge and mobile edge deployments to service distribution over more powerful heterogeneous devices. Our research will analyse devices needs and estimate in time and space the services to be deployed. When the service is expected to be temporary, mobile edge services could be deployed and so our investigations will include the self-deployment techniques. When some already deployed wireless devices feature more capacity, we can leverage this node heterogeneity to distribute the services over these nodes. The research conducted towards this third objective will call for adaptation of machine learning techniques to predict needs, to mobility modeling and cross-layer communication protocols. This has been initiated in the DRUID-NET project.

4 Application domains

The FUN research can be applied in various applications. We only cite here the ones on which we currently focus.

- **Smart Cities:** IoT devices are more and more deployed in smart cities to make it more environment and citizen compliant. We have been active in the IPL CityLab project and H2020 VITAL project. Examples of our contributions are: [57, 58, 59, 60].
- **UAV networks:** Unmanned Aerial Vehicles/drones are becoming more and more popular, and the communication between them and between ground level devices and drones is attracting a lot of interest in the research community. There are new challenges related to the mobility and the specific propagation environment that need to be considered and analyzed. Some examples of contributions on this area are in [22, 15].
- **Smart Agriculture:** Wireless sensors are more and more deployed in remote fields and livestock for an accurate monitoring. This generates new challenges in terms of reliability, energy consumption and range as investigated in the D4SC and Agrinet projects. Examples of our contributions are [36, 28, 46].
- **Vehicular networks:** vehicles become smarter and smarter, providing new useful services. But communications between vehicles and between vehicles and road infrastructures raise a lot of challenges as investigated in the LumiCar project. Examples of our contributions in this field are: [9, 21, 34, 35, 45, 30].
- **Smart infrastructures:** FUN research can also apply to different urban and civil infrastructure like road monitoring (as in the DEFI with CEREMA) or Smart Grids. Examples of our contributions in this field are [56, 61].
- **Logistic and traceability:** RFID and IoT are the key technologies to enable large scale traceability. They are for instance investigated in the GoodFlow project. Examples of our contributions in this field are [55, 53, 54].

5 Highlights of the year

- Valeria Loscri has been nominated to the 2021 N²Women: Stars in Computer Networking and Communications

- Yasir Saleem has been elevated to IEEE Senior Member
- Nathalie Mitton has been nominated as "Chevalier de l'ordre du Mérite"
- Paper [5] has been awarded as best paper of iThings 2021
- AVA Maritime project based on radiolocalisation lead by Roudy Dagher and Nathalie Mitton has received the iSITE prize at the HackAtech 2021 event.

6 New results

6.1 Security

Participants: Emilie Bout, Valeria Loscri, Nathalie Mitton, Edward Staddon.

With the ever advancing expansion of the Internet-of-Things into our every day lives, the number of attack possibilities increases. Furthermore, with the incorporation of IoT into Critical Infrastructure (CI) hardware and applications, the protection of not only the systems but the citizens themselves has become paramount and new and effective solutions need to be investigated [19]. Moreover, the recent massive and widespread adoption of Artificial Intelligence (AI) and Machine Learning (ML) technologies in wireless networks, above all with the advent of 5G and the projection to the Beyond Fifth Generation (B5G) technology, can be a new source of threats. Together with the enormous advantages, the massive use of ML in wireless systems deals with the creation of new advanced smart attacks, that can be very difficult to be detected [11]. In particular, ML can be exploited as a new source of vulnerability [41, 40, 48]. In order to improve the understanding of smart attacks, the main idea consists into generating new type of attacks based on ML approaches, in order to analyze the new threats and be able to design more advanced detection mechanisms.

6.2 Visible Light Communication

Participants: Antonio Costanzo, Valeria Loscri, Meysam Mayahi.

Visible light communication (VLC) builds on the dual use of lightening infrastructure for communication. Even though the advantages of VLC are well known, as an emerging communication paradigm, some open issues still need to be addressed in order to rely on it as a robust communication system. It becomes imperative the design of flexible and adaptive solutions in order to make the communication system more robust and resilient to external environmental factors. This adaptive paradigm has been designed and completely implemented in an experimental test-bed in [1, 43], where it has been shown how the modular approach used for the architecture implementation, makes the system extensible with new functionality. Indeed, a noise mitigation algorithm has been added on the system in a next phase. Some of the basic modules of the VLC architecture, have been "translated" in GNU Radio [42] in order to make them open access. In [30], we looked at VLC challenges in Vehicular Communications from Medium Access Control point of view. We proposed Link Adaptive Protocol where a single handshake association and fast handover algorithms prolong VLC connectivity. Moreover, adaptive modulation has been suggested in order to increase the throughput. Simulation results show the link adaptive protocol outperforms slotted-aloha in outage probability and goodput, properly achieving a trade-off between pilot rate and protocol efficiency. VLC has been demonstrated to be very powerful also in other applications such as underwater communication [10], where traditional wireless paradigms break down because of the specific communication environment, particulary harsh for RF based signals.

6.3 Emerging Communication Technologies

Participants: Valeria Loscri, Mohammad Ojaroudi, Carola Rizza.

Emerging wireless communication technologies are imposing as a valuable alternative to traditional wireless paradigms, where the latter cannot be applied for several reasons. Just as an example, traditional wireless RF based communication cannot be applied for safety reasons for *in-vivo* applications and researchers have started an intense research activity on artificial molecular communication and nanotechnology communication [14]. Emerging communication paradigms are also of interest for improving the ever increasing demand of data rate, coverage and connectivity that cannot be met with only traditional wireless approaches. In this context, the Smart Radio Environment is a new concept coined for enabling the environment to become an active part of the communication system design [44, 39]. In [29], we demonstrate this concept by synergically combining the Reconfigurable Intelligent Metasurfaces (RIM) working at mmWave, with Computer Vision appraoch in order to overcome the main issues hindering the development of the mmWave technology in the context of the 5G. In order to exploit the potential of RIM, new unit-cell have been explicitly designed, with specific features as the beam steering functionality for Terahertz Time-Domain spectroscopy [32]. Another specific meta-atom designed to work at THz frequency, based on a multi-layer structure with graphene has been proposed in [7].

6.4 On the use of controlled mobility

Participants: Valeria Loscri, Nathalie Mitton.

Controlled mobility is when drones or robots could be used to provide services to the network. These services can be of different kinds such as acting as a mobile enhanced based station, mobile sensor or mobile sink.

In [20], all robots are mobile, and after the event is found (reported by sensors), the goal is to allocate the task to the most suitable robot to act upon the event, using either distance or the robots' remaining energy as metrics. We compare our algorithms with similar algorithms from the literature and they feature up to a seven-time-longer network lifetime with significant communication overhead reduction.

Sixth generation (6G) wireless communication networks are envisioned to be empowered with novel enabling technologies to guarantee ubiquitous coverage requirements, heterogeneous communication scenarios, improved network intelligence, spectral rates and security. 6G vision is not only limited to terrestrial networks, but also extends to non-terrestrial networks encompassing satellites and aerial networks, thus exploring a full spectra of heterogeneous communication links. In 6G scenarios, the role of Unmanned Aerial Vehicles (UAVs) is of paramount importance, as flying devices are expected to densely populate aerial space, providing an intermediate network layer between ground networks and space ones. Recent developments in the Unmanned Aerial Vehicles (UAVs) field have put in evidence the need for a standardization process of the communication technologies supporting direct information exchange, thus enabling UAV-to-UAV networking. that have been deeply analyzed in [22, 15].

6.5 Mobile Edge computing

Participants: Nathalie Mitton, Nina Santi.

The success of Internet of Things (IoT) has significantly increased the volume of data generated by various smart applications. However, as many of these applications are characterized by strict Quality of Service (QoS) requirements, there is a growing need for accurately predicting typical performance parameters

such as throughput. This prediction should be based on the applications' traffic profiles and at the same time reflect the network uncertainty that IoT access networks add to the overall communication. In [5], we deployed 6 different smart building applications in a real testbed while creating a considerable traffic contention in an IEEE 802.15.4 access network. After preprocessing the raw data and following a feature engineering mechanism, we apply five different regression learning approaches to each application and predict its throughput. By resorting to several prediction error metrics and time metrics such as training and inference time, we show that the multiple linear regression achieves high accuracy while outperforming other well known machine learning methods.

Next generation communication networks are expected to accommodate a high number of new and resource-voracious applications that can be offered to a large range of end users. Even though end devices are becoming more powerful, the available local resources cannot cope with the requirements of these applications. This has created a new challenge called task offloading, where computation intensive tasks need to be offloaded to more resource powerful remote devices. Naturally, the Cloud Computing is a well-tested infrastructure that can facilitate the task offloading. However, Cloud Computing as a centralized and distant infrastructure creates significant communication delays that cannot satisfy the requirements of the emerging delay-sensitive applications. To this end, the concept of Edge Computing has been proposed, where the Cloud Computing capabilities are repositioned closer to the end devices at the edge of the network. [16] provides a detailed survey of how the Edge and/or Cloud can be combined together to facilitate the task offloading problem. Particuar emphasis is given on the mathematical, artificial intelligence and control theory optimization approaches that can be used to satisfy the various objectives, constraints and dynamic conditions of this end-to-end application execution approach. The survey concludes with identifying open challenges and future directions of the problem at hand. In [18], we review mission-critical applications, resource allocation and deployment of mobile resources techniques in the context of the MEC. First, we introduce the technical specifics and uses of MEC in mission-critical applications to highlight their needs and requirements. Then, we discuss the resource allocation schemes for MEC and assess their fit depending on the application needs. In the same fashion, we finally review the deployment of MEC mobile resources. We believe this work could serve as a helping hand to design efficient MEC resource management schemes that respond to challenging environments such as mission-critical applications.

6.6 Vehicular networks and applications

Participants: Valeria Loscri, Nathalie Mitton, Yasir Saleem Shaikh.

In vehicular networks, vehicles may carry various types of data that need to be offloaded to the RoadSide Units (RSUs) through Vehicle-to-Infrastructure (V2I) communications when vehicles come into their coverage. RSUs are not widely deployed everywhere, which causes intermittent connectivity between vehicles and RSUs. In [9, 34, 35, 45], we propose DIVINE, a Data offloading In VehIcular NEtworks scheme with QoS provisioning, which enables a vehicle to offload its data to RSU directly through V2I communications or using other neighboring vehicles through Vehicle-to-Vehicle (V2V) communications. DIVINE considers the connectivity time of an offloading vehicle with the RSU, with other vehicles heading either on the same or opposite direction, offloading capacity, expected time to reach RSU and contact duration with neighboring vehicles. Additionally, the Quality of Service (QoS) is an important consideration for data offloading in vehicular networks due to the coexistence of urgent data to offload (e.g., accident or emergency data). Therefore, for QoS provisioning, DIVINE uses three QoS functions: traffic classification, overload control and admission control. DIVINE is presented with algorithms and procedures, as well as with illustrative examples. The performance evaluation in network simulator OMNeT++ with Veins and SUMO frameworks shows that DIVINE outperforms other schemes in terms of average offloading delay, maximum offloading delay and running time for a varying number of vehicles, maximum speed values, number of RSUs and RSUs' capacity. It also best behaves in terms of amount of offloaded important data.

Recently, the new paradigm of Vehicular Social Networks (VSNs) has stimulated a lot of interest in the research community. The rationale behind this interest relies on the integration of social relations in

the Internet of Vehicles. This feature affects the content dissemination procedures in VSNs, so that the most social node within a transmission range is expected to be the most appropriate next-hop forwarder, for higher network performance achievement. Leveraging on such premises, in [21] we propose a MemOry-based VEhicular Social forwarding approach, namely MOVES, inspired by a previous forwarding mechanism, SCARF. MOVES has been compared to SCARF, and other existing forwarding approaches, in different scenarios and with real data in terms of delivery ratio, overhead and latency; results show its effectiveness of including the "social memory" in the selection of the next-hop forwarder

6.7 Data Prediction

Participants: Jana Koteich, Nathalie Mitton, Christian Salim.

Nowadays, to improve animal well being in livestock farming or beekeeping application, a wireless video sensor network (WVSN) can be deployed to early detect injury or Asiatic hornets attacks. WVSN represents a low-cost monitoring solution compared to other technologies such as the closed circuit television technology (CCTV). WVSNs are composed of low-power resource-constrained video sensor nodes (motes). These nodes capture frames from videos at a given frequency (frame rate) and wirelessly send them to the sink. The big amount of data transferred from the nodes to the sink consumes a lot of energy on the sensor node, which represents a major challenge for energy-limited nodes. In [36, 28, 46], we introduce two complementary mechanisms to reduce the overall number of frames sent to the sink. First, the Transmission Data Reduction algorithm (TDR) run on the sensor node leverages the similarity degree of consecutive images. Second, the Inter-Nodes Similarity algorithm (INS) exploits the spatio-temporal correlation between neighbouring nodes in order reduce the number of captured frames. The results show a 95% data reduction, surpassing other techniques in the literature by 30% at least.

6.8 On the use of multi technologies

Participants: Brandon Foubert, Nathalie Mitton.

Wireless Sensor Networks (WSN) are efficient tools for many use cases, such as environmental monitoring. However WSN deployment is sometimes limited by the characteristics of the Radio Access Technologies (RATs) they use. To overcome some of these limitations, we propose to leverage the use of a Multiple Technologies Network (MTN). What we refer to as MTN is a network composed of nodes which are able to use several RAT and communicating wirelessly through multi-hop paths. The management of the RAT and routes must be handled by the nodes themselves, in a local and distributed way, with a suitable communication protocol stack. Nodes may reach multiple neighbors over multiple RAT. Therefore, each stack's layer has to take the technologies' heterogeneity of the devices into account. In [3, 25, 24], we introduce our custom Routing Over Different Existing Network Technologies protocol (RODENT), designed for MTN. It enables dynamic (re)selection of the best route and RAT based on the data type and requirements that may evolve over time, potentially mixing each technology over a single path. RODENT relies on a multi-criteria route selection performed with a custom lightweight TOPSIS method as described in [26]. To assess RODENT's performances, we implemented a functional prototype on real WSN hardware, Pycom FiPy devices as demonstrated in [49]. Unlike related prototypes, ours has the advantage not to rely on specific infrastructure on the operator's side. Results show that RODENT enables energy savings, an increased coverage as well as multiple data requirements support. RODENT has then be tailored for vineyard monitoring [31].

6.9 On the use of experimental platform for new services

Participants: Roudy Dagher, Brandon Foubert, Remy Grunblatt, Nathalie Mitton, Etienne Profit, Nin Santi.

Experimentation and data in wireless sensor networks are of great importance. This is why we leverage the FIT IoT LAB platform to assess different wireless communications based services such as radiolocalisation and dataset generation. In [37, 47], we investigate and present how to generate traces of IoT (Internet of Things) applications in an automated, repeatable and reproducible manner. By using the FIT IoT-Lab large scale test-bed and relying on state-of-the-art software engineering techniques, we are able to produce, collect and share artifacts and datasets in an automated way. This makes it easy to track the impact of software updates or changes in the radio environment both on a small scale, e.g. during a single day, and on a large scale, e.g. during several weeks. By providing both the source code for the trace generation as well as the resulting datasets, we hope to reduce the learning curve to develop such applications and encourage reusability as well as pave the way for the replication of our results. While we focus in this work on IoT networks, we believe such an approach could be of used in many other networking domains.

In [2], we experimentally assess our contact ranging protocol. The need for cheaper and more precise localisation techniques has recently amplified. The initial approach has been to roll out high-level software running on smartphones and leveraging Bluetooth proximity sensing. However this approach lacks both precision in terms of ranging, and flexibility in terms of experimental framework to fully explore alternative schemes for contact event tracing. In this context, we thus provide openaccess nodes in an open-access experimental platform for ranging and proximity tracking, letting researchers tinker freely with the full software stack on a swarm of multi-radio, low-power devices based on cheap microcontrollers. We provide a tutorial on how to use the platform and open source code building blocks to to program the devices, bare-metal. We then report on initial measurements we have performed using the platform. Perspectives with our platform include applicability studies and comparative evaluation for a large variety of localisation schemes combining the use of Ultra-Wide Band and Bluetooth Low-Energy for better precision and smaller energy budgets-and the use of complementary mechanism guaranteeing privacy protection, able to run directly on-board cheap IoT microcontrollers.

7 Bilateral contracts and grants with industry

Sencrop

Participants: Brandon Foubert, Nathalie Mitton *(contact person)*.

This collaboration aims to develop a complete multi-technology bilateral wireless communication stack for agriculture sensor networks.

Dotdot

Participants: Valeria Loscri, Nathalie Mitton *(contact person)*, Yasir Saleem Shaikh.

This collaboration aims to investigate a smart communication network enabled by vehicles.

ORAMA

Participants: Brandon Foubert, Nathalie Mitton *(contact person)*.

This collaboration aims to audit and stress the ORAMA communication stack.

8 Partnerships and cooperations

8.1 International initiatives

8.1.1 Associate Teams in the framework of an Inria International Lab or in the framework of an Inria International Program

AGRINET

Title: Wireless accurate monitoring for a smarter agriculture

Duration: 2020 -> 2023

Coordinator: Riaan Wolhuter and Nathalie Mitton

- Stellenbosch University

Inria contact: Nathalie Mitton

Participants: Brandon Foubert, Jana Koteich, Nathalie Mitton, Christian Salim.

Summary: The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production. Sustainable food security depends upon proper plant and crop management respectful of soils and natural resources, such as water. The system proposed can be applied to a variety of crops. The economic- and social consequences are profound and any contribution towards more efficient farming within increasingly onerous natural constraints, should be a priority. To address these constraints, we propose to develop a flexible, rapidly deployable, biological/agricultural data acquisition platform and associated machine learning algorithms to create advanced agricultural monitoring and management techniques, to improve crop management and use of natural resources. Website. Publications in 2021 are [36, 28, 46].

DC4SCM

Title: Data Collection for Smart Crop Management

Duration: 2020 -> 2023

Coordinator: Philippe Preux (SCOOL team)

- Bihar Agricultural University (India)

Inria contact: Philippe Preux

Participants: Nathalie Mitton, Christian Salim.

Summary: Beyond DC4SCM, our goal is to investigate the use of reinforcement learning to make recommendation of practices to farmers. To reach this goal, we need relevant data: DC4SCM is precisely about investigating the features that are relevant and may actually be collected in situ: in a nutshell, the goal of DC4SCM is to investigate the following question: what is the ideal, yet within reach, dataset for our longer term goal?

8.2 International research visitors

8.2.1 Visits of international scientists

Other international visits to the team

Claudio Marche

Status PhD

Institution of origin: Université de Cagliari Sardaigne

Country: Italy

Dates: Sept 2021 - March 2022

Context of the visit: The programme of the training period focuses on systems of Trust-Based Intrusion Detection, for Wireless Sensor Networks (WSNs) and the Internet of Things (IoT). IoT devices have a narrow transmission range and communicate directly with nodes that are within that range. An intermediate node is used to connect with a far-node. External and internal outbreaks can affect sensor networks. Due to their resource limitations, nodes cannot often deal with a tough attacker. A secondary protection system, also known as an intrusion detection system, is required in this case. The attacker's efforts can be detected with the aid of an intrusion detection system. A node's confidence in power, consistency, and trustworthiness of other nodes is referred to as trust. Direct trust or first-hand knowledge refers to trust based on direct observation of a node. Reputation a node's observation and opinion of other nodes based on their previous performances in an explicit perspective over a period. Indirect confidence or second-hand knowledge other terms for reputation.The PhD student will interact with Valeria Loscri, visiting supervisor and Emilie Bout, PhD student in the FUN Team, for the design of effective detection mechanisms of advanced cyber attacks in wireless communication systems.

Mobility program/type of mobility: research stay

GianMarco Lia

Status PhD

Institution of origin: Mediterranean University Of Reggio Calabria

Country: Italy

Dates: February 2021 - February 2022

Context of the visit: Innovative services such as augmented reality, autonomous driving, industry 4.0, have particularly stringent connectivity requirements (e.g., in terms of ultra-low latency, high throughput) that current networks cannot guarantee. Such applications also require computational and storage resources to run complex data analytics algorithms that are not available in user devices. Mobile Edge Computing (MEC), one of the enabling technologies for 5G systems, aims to support these requirements by moving cloud services to network nodes close to the user. In this context it is necessary to define solutions able to decide how and where to allocate services, satisfying their requirements, taking into account the heterogeneity and dynamicity of computational, storage and network resources, distributed on edge nodes. To this purpose, traditional networking solutions need to be re-engineered to facilitate forwarding and routing of data packets, discovery of resources and their monitoring routines. The PhD student will work under the supervision of his visiting supervisor, Valeria Loscri, for reaching the following goals 1) The design of "sustainable" service allocation strategies in edge computing scenarios. 2) The definition of one or more optimization algorithms (and related heuristics) for the allocation of service requests. 3) By accounting the cost associated to the ML running for an efficient resource allocation, in order to minimize the global carbon footprint

Mobility program/type of mobility: research stay

8.2.2 Visits to international teams

Research stays abroad

Emilie Bout

Visited institution: Padova University, SPRITZ Team

Country: Italy

Dates: October 2021 - December 2021

Context of the visit: Attacks are becoming more and more ingenious, which is why new countermeasures will have to be adaptive and proactive. In this context, new machine-learning-based solutions have emerged but this domain still has many gaps such as the lack of identified vulnerabilities. The main objective of this abroad period is to investigate on new types of cyber attacks in wireless networks and design new effective and robust mechanisms to combat the advanced attacks. People involved in this research are Prof. Mauro Conti, Alessandro Brighente, postdoc in the SPRITZ Lab, Valeria Loscri and Emilie Bout.

Mobility program/type of mobility: research stay

8.3 European initiatives

8.3.1 H2020 projects

CyberSANE

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

Duration: September 2019 - September 2022

Inria contact: Nathalie Mitton

Participants: Valeria Loscri, Nathalie Mitton, Edward Staddon.

Summary: CyberSANE aims to enhance the security and resilience of Critical Information Infrastructures (CIIs) by providing a dynamic collaborative, warning and response system supporting and guiding security officers and operators (e.g., Incident Response professionals) to recognize, identify, dynamically analyze, forecast, treat and respond to advanced persistent threats (APTs) and handle their daily cyber incidents utilizing and combining both structured data (e.g., logs and network traffic) and unstructured data (e.g., data coming from social networks and dark web). In achieving that aim, CyberSANE will introduce a holistic and privacy-aware approach in handling security incidents, addressing the complexity of these nets consisting of cyber-assets hosted in cross-border, heterogeneous Critical Information Infrastructures (CIs). Moreover, CyberSANE is fully in-line with relevant regulations (such as the GDPR and NIS directive), which require organizations to increase their preparedness, improve their cooperation with each other, and adopt appropriate steps to manage security risks, report and handle security incidents. Publication in 2021 is [19].

8.3.2 Other european programs/initiatives

Druid-Net

Title: eDge computing ResoUrce allocatIon for Dynamic NETworks

Duration: May 2020 - September 2023

Inria contact: Nathalie Mitton

Participants: Brandon Foubert, Remy Grunblatt, Nathalie Mitton, Nina Santi.

Summary: Following the NFV/SDN paradigm, DRUID-NET separates the flow of information into control and data plane. At the lowest layer, the IoT-enabled applications are deployed, and the generated workload (data flow) can be offloaded for further processing at the above EC layer, which provides essential virtualized services. The DRUID-NET framework collects information (control flow) about the status of the computing and network infrastructure at the EC level in order to create workload-resource profiles, update the performance model for every application, and realize the feedback control mechanism for the resource allocation and simultaneously implements a resource-aware control strategy for the CPS to be controlled (control flow). This holistic approach allows the application's dynamical modelling taking into account various contextual information. Furthermore, the controller co-design treats the resource allocation algorithms as application components in the virtualized services. Publications in 2021 are [16, 18, 5, 37, 47].

8.3.3 Other european programs/initiatives

NEWFOCUS

Title: European network on future generation optical wireless communication technologies

Duration: September 2020 - September 2024

Inria contact: Valeria Loscri

Participants: Valeria Loscri, Antonio Costanzo, Meysam Mayahi.

Summary: The COST Action NEWFOCUS will propose truly radical solutions with the potential to impact the design of future wireless networks. Particularly, NEWFOCUS aims to establish optical wireless communications (OWC) as an efficient technology that can satisfy the demanding requirements of backhaul and access network levels in beyond 5G networks. This also includes the use of hybrid links that associate OWC with radiofrequency or wired/fiber-based technologies. Towards this vision, NEWFOCUS will carry out a comprehensive research programme under two major pillars. The first pillar is on the development of OWC-based solutions capable of delivering ubiquitous, ultra-high-speed, low-power consumption, highly secure, and low-cost wireless access in diverse application scenarios. The developed solutions will in particular support Internet-of-Things (IoT) for smart environments with applications in vertical sectors. The second pillar concerns the development of flexible and efficient backhaul/fronthaul OWC links with low latency and compatible with access traffic growth. Publications in 2021 are [10].

8.4 National initiatives

GoodFlow

Title: ADEME GoodFlow Project

Duration: October 2021 - September 2023

Inria contact: Nathalie Mitton

Participants: Nathalie Mitton.

Summary: The goal of this project, funded by ADEME, is to design a very energy efficient node to manage reusable packaging in a more sustainable way by combining enhanced IA techniques, wake up radio and multi MAC layers.

DEPOSIA

Title: ANR

Duration: October 2021 - September 2024

Inria contact: Valeria Loscri

Participants: Valeria Loscri.

Summary: DEPOSIA focuses on the detection and geolocation of various radio frequency signal sources in order to thwart attacks on connected systems and infrastructures. The sources considered are elements which by their characteristics or their position, present an illicit character and which threaten the people security or the infrastructures. For outdoor cases, we consider drones flying over forbidden areas, telecommunication jammers, spoofing signal transmitters or wireless connected sensors used to introduce false data in monitoring platforms. For indoor cases, we also consider jamming or spoofing sources that can cause denial of service within networks or infrastructures, or fake access points that aim to carry out man-in-the-middle attacks to intercept information. In this proposal, the indoor and outdoor use cases are considered separately in order to design monitoring infrastructures adapted to each case. For the outdoor case, we consider a surveillance architecture that could join the already existing cellular or WLAN communication infrastructures. In particular, with 5G technology and the higher employed frequencies, cellular networks are evolving towards finer meshes and have interfaces with the core network at each of their nodes. Thus, these interface points, equipped with receivers dedicated to monitoring, could enable the routing of monitoring data to centralized platforms, feeding an Artificial Intelligence for analysis, anomaly detection and source geolocation. For the indoor case, we consider a distributed monitoring architecture deployed within a building, based on SDR sensors and a data centralization and synchronization network.

In these two cases, we envisage an Artificial Intelligence working on data evolving in three dimensions : time, space and direction, all for data of different natures, namely those from the physical layer and the data link layer. Whether for indoor or outdoor configurations, the algorithms that will constitute the Artificial Intelligence will be based on learning approaches that will correspond to Machine Learning and Deep Learning algorithms. These algorithms will deal with the problems of detecting attacks and locating illicit sources. These algorithms will have to take into account: the evolutionary aspect brought by the non-fixed character in time of the attacks and the non-fixed location aspect of the localization of the source of the attack. A first Artificial Intelligence will be dedicated to data analysis and anomaly detection, i.e., highlighting the suspicious nature of the data, and a second Artificial Intelligence will be dedicated to extracting the location information of the attack source. Due to the multi-layered nature of the data, model aggregation algorithms will be deployed in order to homogenize the decision process.

8.4.1 Exploratory Action

Ethicam

Title: Emerging TecHnologies for new CommunicAtions paradigMs

Duration: October 2019 - October 2022

Inria contact: Valeria Loscri

Participants: Valeria Loscri, Mohammad Ojaroudi Parchin, Carola Rizza.

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

Publications in 2021 are [14, 29, 32, 7, 44, 39].

8.4.2 DEFI Inria

ROAD-AI, DEFI commun Inria et Cerema

Title: Routes et ouvrages d'art Diversiformes, Augmentés et intégrés

Duration: July 2021 - June 2024

Inria contact: Nathalie Mitton

Participants: Nathalie Mitton.

Summary: Integrated management of infrastructure assets is an approach which aims at reconciling long-term issues with short-term constraints and operational logic. The main objective is to enjoy more sustainable, safer and more resilient transport infrastructure through effective, efficient and responsible management. To achieve this, CEREMA and Inria are joining forces in this Inria Challenge (DEFI) which main goals are to overcome scientific and technical barriers that lead to the asset management of tomorrow for the benefit of road operators: (i) build a "digital twin" of the road and its environment at the scale of a complete network; (ii) define "laws" of pavement behavior; (iii) instrument system-wide bridges and tunnels and use the data in real time; (iv) define methods for strategic planning of investments and maintenance.

8.4.3 Equipements d'Excellence

FIT

Title: Future Internet of Things

Duration: Mars 2011 - December 2021

Inria contact: Nathalie Mitton

Participants: Nathalie Mitton.

Summary: 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. FIT will continue under the bannier of SILECS to offer larger services and facilities, being connected with the Grid5k research instrument. See also: Website. Related publications i 2021 are [37, 47, 2].

8.5 Regional initiatives

Lumicar

Duration: October 2019 - October 2021

Inria contact: Valeria Loscri

Participants: Valeria Loscri, Antonio Costanzo, Meysam Mayahi.

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

Publications in 2021 are [1, 43, 42, 10].

GloCat

Duration: December 2020 - December 2021

Inria contact: Valeria Loscri

Participants: Emilie Bout, Valeria Loscri, Nathalie Mitton.

Summary: The goal of this project is to detect cyberattack such as Man in The Middle to counter balance and localize the attacker.

Publications in 2021 are [11, 41, 40, 48].

9 Dissemination

9.1 Promoting scientific activities

9.1.1 Scientific events: organisation

- Valeria Loscri has been Guest Editor of a Feature Topic on Networking Technologies to combat COVID-19 Pandemic on IEEE Communication Magazine

- Valeria Loscri has been Guest Editor of "Revolutionary Paradigms for Smart Connected Vehicles in the 6G ERA", a Special Issue of Elsevier Vehicular Communications
- Valeria Loscri co-organized IEEE Body Sensor Network in the ERA of Pandemic (BSN) special session 2021

General chair, scientific chair

- Valeria Loscri was Mobile & Wireless Networks (MWN) Symposium chair of Globecom 2021
- Nathalie Mitton was TPC chair of the Globecom Sessys 2021 workshop.

9.1.2 Scientific events: selection

Chair of conference program committees

- Valeria Loscri has been Short Papers and Demo Session chair of WiMob 2021, Posters and Demo chair of MobiWac 2021 and Ad hoc and Sensor Networking Track chair of Wireless Days (WD) 2021
- Nathalie Mitton has been ISCC 2021 workshop chair, CIoT 2021 and 2022 keynote chair.

Member of the conference program committees

- Valeria Loscri has been a TPC member of Infocom 2021, Percom 2021, IoTDI 2021, WD 2021, WCNS 2021, CCNC 2021, VNC 2021, DS-RT 2021, ISCC 2021, NanoComm 2021, IWOW 2021, CORES 2021.
- Nathalie Mitton has been a TPC member of ISCC 2021, Infocom 2021, DCOSS 2021 CORES 2021, Percom 2021, Globecom 2021, ICC 2021, Adhocnow 2021, WD 2021 and WCNC 2021.

9.1.3 Journal

Member of the editorial boards

- Valeria Loscri is Associate Editor of IEEE Communications Survey and Tutorials (COMST, since 2020), Elsevier ComCom (since 2021), Frontiers in Communications and Networks, ITU-FET Journal, IEEE Transactions on Nanobioscience journal since 2017, of Elsevier Computer Networks journal since 2016, of Robotics Software Design and Engineering of the International Journal of Advanced Robotic Systems since 2016, of Elsevier Journal of Networks and Computer Applications (JNCA) journal since 2016, of Wiley Transactions Emerging Telecommunications Technologies since 2019.
- Nathalie Mitton is an editorial board member of Adhoc Networks since 2012, of IET-WSS since 2013, of Wireless Communications and Mobile Computing since 2016, of Networks as Review Editor for Frontiers in Communications and Networks since 2020, of Journal of Interconnection Networks since 2021.

9.1.4 Invited talks

- Valeria Loscri has been invited panelist in the panel “Standardization for UAVs and Drones” in the IEEE Conference on Standards for Communications and Networking CSCN 2021.
- Valeria Loscri has been invited speaker at IWOW workshop in conjunction with ISCC 2021
  Talk Title: Software Defined Approaches for Adaptive VLC Systems
- Valeria Loscri has been invited speaker for the seminar at the CITI Lab in the MARACAS group
  Talk Title: Software Defined Approaches for Non-Conventional Wireless Communication Paradigms

9.1.5 Scientific expertise

- Valeria Loscri has been appointed as member of the fellowship panel experts for PhD Fundamental Research of Research Foundation (FWO)
- Valeria Loscri has been appointed as reviewer of transverse initiative project for Labex DigiCosme
- Valeria Loscri has been appointed as reviewer for doctoral funding projects for Labex DigiCosme
- Nathalie Mitton has been appointed as scientific expert to evaluate projects submitted to ANR, FWO-Research-Project (Germany), South Africa's National Research Foundation (NRF), NSERC (Canada) and NSC (Poland).
- Nathalie Mitton is a member of the advisory board of the H2020 NGI pointer, PLATOON and Smart Lagoon projects.
- Nathalie Mitton has been appointed as an evaluator for the IMT activities in networks.
- Natjalie Mitton is an external expert of scientific board for Inrae and ESISAR.
- Nathalie Mitton has been appointed as a member of the expert committee in charge of analysing societal impacts of IoT under the management of C. Kirchner.

9.1.6 Research administration

- Valeria Loscri is co-chair of a Social Networks Technical Committee - Special Interest Group (SIG)
- Valeria Loscri and Nathalie Mitton are in the GIS CybCOMM,Scientific Interest Group in the Cyber Security for wireless networks.
- Nathalie Mitton
  - is a member of the Bureau des Comités de Projets of Lille Inria center.
  - is an elected member of the evaluation committeee of Inria.
- Valeria Loscri
  - is Scientific International Relation Responsible for Inria Lille.

9.2 Teaching - Supervision - Juries

9.2.1 Teaching

- **E-learning**
  - Mooc, Nathalie Mitton, "Internet of Things with Microcontrollers: a hands-on course", 5-week mooc by the FIT IoT LAB team, FUN, Inria, in February 2021
  - Remote course, Nathalie Mitton, Internet of things, 5-week + virtual face to face week in May 2021
- Master: Valeria Loscri, Objets Communicants, 24h (Mineure Habitat Intelligent), Ecole des Mines de Douai, France
- Master: Nathalie Mitton, Wireless networks, 16h eqTD (Master TC), Université Lille 1, France
- Master: Brandon Foubert, Wireless sensor networks, 16h eqTD (Master IdO), Université Lille 1, France
- Master: Nathalie Mitton, Smart objects, 10h CM + 12h TP, Ecole centrale de Lille, France
- Master: Nathalie Mitton, Industrial Internet of Things, 10h CM Ecole centrale de Lille, France

- Master: Brandon Foubert, Industrial to Internet of Things, 12h TP Ecole centrale de Lille, France
- Master: Nathalie Mitton, Introduction to Internet of Things, 4h CM Ecole centrale de Lille, France
- Master: Brandon Foubert, Introduction to Internet of Things, 8h TP Ecole centrale de Lille, France
- Master: Brandon Foubert, Wireless sensor networks, 12h eqTD (Master ROC), IMT, France
- L3 INFO: Edward Staddon, Introduction aux Réseaux, 19.5 HTD, Université de Lille, France.
- L3 INFO: Emilie Bout, Introduction aux Réseaux, 19.5 HTD, Université de Lille, France.
- L3 INFO: Nina Santi, Programmation fonctionnelle, 42 HTD, Université de Lille, France.

9.2.2 Supervision

- PhD defended in september 2021: Brandon Foubert, Communication sans fil Polymorphe pour l'Agriculture Connectée, Université Lille 1, 2018-2021, Nathalie Mitton
- PhD in progress:
  - Jana Koteich, Context aware opportunistic forwarding strategy, Université Lille 1, 2021-2024, Nathalie Mitton
  - Nina Santi, daptive and dynamic edge gateways IoT-oriented deployments, Université Lille 1, Université Lille 1, 2020-2022, Nathalie Mitton
  - Edward Staddon, Threat detection, identification and quarantine in wireless IoT based Critical Infrastructures, Université Lille 1, 2019-2022, Nathalie Mitton & Valeria Loscri
  - Carola Rizza, Nouveaux paradigmes de communication basés sur les technologies émergentes, Université Lille 1, 2019-2022, Valeria Loscri
  - Emilie Bout, Denial-of-sleep over IoT networks, Université Lille 1, 2019-2022, Valeria Loscri & Antoine Gallais
  - Meysam Mayahi, Communication Protocols based on alternative paradigm for wireless mobile devices, Université Lille 1, 2019-2022, Valeria Loscri

9.2.3 Juries

PhD and HDR committees:

- Valeria Loscri is/was member of the following PhD thesis committees:
  - Mohammed Abdelmonem Aboelfotoh Randa, Université Avignon, Janvier 2021, reviewer
  - Pengfei Lu, Oslo University, March 2021, second opponent and reviewer
  - Ikenna Ijeh, Ecole Centrale Marseille, December 2021, reviewer
  - Jiang Liu, Université Paris-Saclay, Centrale Supélec, December 2021, reviewer
- Nathalie Mitton is/was member of the following PhD thesis committees:
  - Mohamed Anis Fekih, INSA Lyon, February 2022, reviewer
  - Elhadja Chaalal, Université de Bourgogne Nevers, January 2022
  - Kevin Jiokeng, Université de Toulouse ENSEITH, January 2022, reviewer
  - Dereje Molla, UGE, January 2022, reviewer
  - Jérome Henri, IMT Atlantique, December 2021, reviewer
  - Nabil Makarem, Paris Sorbonne et U. Libanaise, December 2021, reviewer
  - Mina Rady, Sorbonne Université, December 2021, chair
  - Nour el hoda Djidi, Université de Rennes, December 2021, reviewer

  - Ulysse Coutaud, Université Grenoble Alpes, December 2021, reviewer
  - Willem Smit, University of Stellenbosch, November 2021, reviewer
  - Adriana Arteaga Arce, Universidad de Chile, November 2021, reviewer
  - Licia Amichi, Université Paris Saclay, November 2021, reviewer
  - Alexis Bitaillou, Université de Bretagne Loire, November 2021
  - Angesom Tesfay, IMT Lille Nord Europe, october 2021
  - Guéréguin Der Sylvestre Sibide, Université Clermont Auvergne, August 2021, reviewer
  - Imen Bouzarkouna, INSA Rouen, July 2021, reviewer
  - Remy Grunblatt, Université de Lyon, January 2021, reviewer
  - Cedric Berenger, Aix-Marseille, January 2021, reviewer

- Nathalie Mitton is/was member of the following HDR thesis committees:

  - Hicham Lakhef, UTC, December 2021, reviewer
  - Georgios Papdopoulos, IMT Atlantique, November 2021, reviewer
  - Francoise Sailhan, CNAM, january 2021, reviewer

PhD-follow-up committees:

- Nathalie Mitton was member of the following PhD-follow-up committees :

  - Houssein Taleb, INSA rouen
  - Myassa Khalil, UTT
  - Razanne Abu-Aisheh, Sorbonne Université

Research selection committees :

- Valeria Loscri is/was member of the following selection committees:

  - Inria: Research Committee for Starting Research Position (SRP) and Advanced Research Position (ARP)
  - Assistant Professor: IMT Lille

- Nathalie Mitton was member of the following selection committees:

  - Inria researcher: junior researcher committee (CR) for Inria Lyon and Senior researcher committee (DR2)
  - Inria permanent engineer for the Rennes Inria center
  - Professor: Universités de Toulouse, Belfort Montbeliard
  - Assistant professor: Université de Bourgogne, Université de Rennes, Université de Lorraine, Université de Saclay, Sorbonne Université, IMT Lille Nord Europe

9.3 Popularization

9.3.1 Internal or external Inria responsibilities

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

Valeria Loscri has been appointed to serve as reference to support candidates for IEEE senior member elevation.

9.3.2 Articles and contents

The FUN team has contributed to several vulgarization articles to The conversation journal [48, 52, 50, 51].

Nathalie Mitton has registered a podcast for Interstices.

Valeria Loscri gave a talk "Wi-Fi et cybersécurité : des maths à toutes les étapes" in the context of RJMI, Rendez-vous des Jeunes Mathématiciennes et Informaticiennes

Emilie Bout and Valeria Loscri have presented a demo in the International Forum of Cybersecurity (FIC) 2021

MasterClass of Valeria Loscri on Visible Light Communication (VLC) in the IoT Week of CITC 2021

Valeria Loscri has co-chaired the speed-date meeting in the context of RJMI

10 Scientific production

10.1 Major publications

[1] A. Costanzo, V. Loscri and M. Biagi. 'Adaptive Modulation Control for Visible Light Communication Systems'. In: *Journal of Lightwave Technology* (2nd Feb. 2021). DOI: 10.1109/JLT.2021.3056177. URL: https://hal.archives-ouvertes.fr/hal-03134465.

[2] R. Dagher, F.-X. Molina, A. Abadie, N. Mitton and E. Baccelli. 'An Open Experimental Platform for Ranging, Proximity and Contact Event Tracking using Ultra-Wide-Band and Bluetooth Low-Energy'. In: CNERT 2021 - IEEE INFOCOM Workshop on Computer and Networking Experimental Research using Testbeds. Virtual, France, 10th May 2021. URL: https://hal.inria.fr/hal-03140370.

[3] B. Foubert and N. Mitton. 'RODENT: a flexible TOPSIS based routing protocol for multi-technology devices in wireless sensor networks'. In: *ITU Journal on Future and Evolving Technologies* 2.1 (12th Apr. 2021). URL: https://hal.inria.fr/hal-03165426.

[4] A. Gallais, T.-H. Hedli, V. Loscrì and N. Mitton. 'Denial-of-Sleep Attacks against IoT Networks'. In: CoDIT 2019 - 6th International Conference on Control, Decision and Information Technologies. Paris, France, 23rd Apr. 2019. URL: https://hal.inria.fr/hal-02060608.

[5] A. Hameed, J. Violos, N. Santi, A. Leivadeas and N. Mitton. 'A Machine Learning Regression approach for Throughput Estimation in an IoT Environment'. In: iThings-2021: The 14th IEEE International Conference on Internet of Things. Melbourne, Australia, 6th Dec. 2021. URL: https://hal.archives-ouvertes.fr/hal-03413257.

[6] F. Mezghani and N. Mitton. 'Opportunistic multi-technology cooperative scheme and UAV relaying for network disaster recovery'. In: *Information* 11.1 (Jan. 2020). DOI: 10.3390/info11010037. URL: https://hal.inria.fr/hal-02431659.

[7] M. Ojaroudi and V. Loscrì. 'Graphene-Based Reconfigurable Intelligent Metasurface Structure for THz Communications'. In: EuCAP 2021 - 15th European Conference on Antennas and Propagation. Düsseldorf / Virtual, Germany, 22nd Mar. 2021. URL: https://hal.archives-ouvertes.fr/hal-03082069.

[8] M. Ojaroudi, A. M. Vegni and V. Loscrì. 'Design and analysis of a reconfigurable intelligent metasurface for vehicular networks'. In: *ITU Journal on Future and Evolving Technologies* (Dec. 2020). URL: https://hal.archives-ouvertes.fr/hal-03082231.

[9] Y. Saleem, N. Mitton and V. Loscri. 'DIVINE: Data Offloading In Vehicular Networks with QoS Provisioning'. In: *Ad Hoc Networks* 123 (1st Dec. 2021). URL: https://hal.inria.fr/hal-03328269.

[10] A. M. Vegni, M. Hammouda and V. Loscri. 'A VLC-based Footprinting Localization Algorithm for Internet of Underwater Things in 6G networks'. In: IEEE 5th International Workshop on Optical Wireless Communications (IWOW). Berlin, Germany, Sept. 2021. URL: https://hal.archives-ouvertes.fr/hal-03282673.

10.2 Publications of the year

International journals

[11] E. Bout, V. Loscri and A. Gallais. 'How Machine Learning changes the nature of cyberattacks on IoT networks: A survey'. In: *Communications Surveys and Tutorials, IEEE Communications Society* (21st Oct. 2021). URL: https://hal.archives-ouvertes.fr/hal-03390359.

[12] A. Costanzo, V. Loscri and M. Biagi. 'Adaptive Modulation Control for Visible Light Communication Systems'. In: *Journal of Lightwave Technology* (2nd Feb. 2021). DOI: 10.1109/JLT.2021.3056177. URL: https://hal.archives-ouvertes.fr/hal-03134465.

[13] B. Foubert and N. Mitton. 'RODENT: a flexible TOPSIS based routing protocol for multi-technology devices in wireless sensor networks'. In: *ITU Journal on Future and Evolving Technologies* 2.1 (12th Apr. 2021). URL: https://hal.inria.fr/hal-03165426.

[14] V. Loscri and A. M. Vegni. 'Enabling molecular communication through chirality of enantiomers'. In: *ITU Journal on Future and Evolving Technologies* (June 2021). URL: https://hal.inria.fr/ineris-03245796.

[15] D. Mishra, A. M. Vegni, V. Loscri and E. Natalizio. 'Drone Networking in 6G Era - A Technology Overview'. In: *IEEE Communications Standards Magazine* (2022). URL: https://hal.inria.fr/hal-03450952.

[16] F. Saeik, M. Avgeris, D. Spatharakis, N. Santi, D. Dechouniotis, J. Violos, A. Leivadeas, N. Athanasopoulos, N. Mitton and S. Papavassiliou. 'Task Offloading in Edge and Cloud Computing: A Survey on Mathematical, Artificial Intelligence and Control Theory Solutions'. In: *Computer Networks* 195 (4th Aug. 2021). DOI: 10.1016/j.comnet.2021.108177. URL: https://hal.archives-ouvertes.fr/hal-03243071.

[17] Y. Saleem, N. Mitton and V. Loscri. 'DIVINE: Data Offloading In Vehicular Networks with QoS Provisioning'. In: *Ad Hoc Networks* 123 (1st Dec. 2021). URL: https://hal.inria.fr/hal-03328269.

[18] N. Santi and N. Mitton. 'A resource management survey for mission critical and time critical applications in multi access edge computing'. In: *International Telecommunication Union journal (ITU Journal)*. Volume 2 (2021), Issue 2. 2.2 (12th Nov. 2021). URL: https://hal.archives-ouvertes.fr/hal-03420193.

[19] E. Staddon, V. Loscri and N. Mitton. 'Attack Categorisation for IoT Applications in Critical Infrastructures, a Survey'. In: *Applied Sciences* 11.16 (5th Aug. 2021), p. 7228. DOI: 10.3390/app11167228. URL: https://hal.inria.fr/hal-03326255.

[20] J. Stanulovic, N. Mitton and I. Mezei. 'Routing with Face Traversal and Auctions Algorithms for Task Allocation in WSRN'. In: *Sensors* (13th Sept. 2021). DOI: 10.3390/s21186149. URL: https://hal.inria.fr/hal-03342975.

[21] A. M. Vegni, C. Borrego Iglesias and V. Loscri. 'MOVES: a MemOry-based VEhicular Social Forwarding Technique'. In: *Computer Networks* 197 (2021). DOI: 10.1016/j.comnet.2021.108324. URL: https://hal.archives-ouvertes.fr/hal-03282823.

[22] A. M. Vegni, V. Loscri, C. T. Calafate and P. Manzoni. 'Communication Technologies Enabling Effective UAV Networks: a Standards Perspective'. In: *IEEE Communications Standards Magazine* (2021). URL: https://hal.inria.fr/hal-03190494.

International peer-reviewed conferences

[23] R. Dagher, F.-X. Molina, A. Abadie, N. Mitton and E. Baccelli. 'An Open Experimental Platform for Ranging, Proximity and Contact Event Tracking using Ultra-Wide-Band and Bluetooth Low-Energy'. In: CNERT 2021 - IEEE INFOCOM Workshop on Computer and Networking Experimental Research using Testbeds. Virtual, France, 10th May 2021. URL: https://hal.inria.fr/hal-03140370.

[24] B. Foubert. 'Routing in Multi-Technologies Wireless Sensor Networks'. In: EWSN 2021 (PhD Forum) - 18th International Conference on Embedded Wireless Systems and Networks. Delft, Netherlands, 17th Feb. 2021. URL: https://hal.inria.fr/hal-03080085.

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