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Activity Report 2012

Project-Team HIPERCOM

High performance communication

IN COLLABORATION WITH: Laboratoire d'informatique de l'école polytechnique (LIX)

RESEARCH CENTERS
Paris - Rocquencourt
Saclay - Île-de-France

THEME
Networks and Telecommunications

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Project-Team HIPERCOM

Keywords: MANETs, VANETs, WSNs, Social Mobile Networks, Information Theory, Routing

Hipercom is a bi-localized project-team at Inria Paris - Rocquencourt and Inria Saclay - Ile de France.

Creation of the Project-Team: January 01, 1998 .

1. Members

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2. Overall Objectives

2.1. Introduction

Hipercom project-team aims to design, evaluate and optimize the telecommunication algorithms. The aimed areas are protocols and standards dealing with communication support and quality of service management in wireless networks. The aimed activity fields are centered around the new networks and services supporting internet. Although we address the whole spectrum of telecommunication domain, practically the Hipercom project team is specialized in mobile ad hoc networks, mesh networks, wireless sensor networks and vehicular networks. However the thematic extends to the information theory as well as network and traffic modelling. The scientific foundations are the following:

- Analytic information theory,
- Methodology for telecommunication algorithm evaluation,
- Traffic and network architecture modeling,
- Algorithm design, evaluation and implementation,
- Simulation of network algorithm and protocols.

The objectives assigned to HIPERCOM were:

- Theoretical limits of wireless networking with the study for instance of massive mobile dense wireless networks, delay tolerant networks and network coding.
- New generation of OLSR, new services and protocols including autoconfiguration of wireless ad hoc networks, localization...
- Wireless sensor networks: cross-layering, energy and bandwidth efficiency,
- Vehicular and mobile applications for intelligent transportation systems as well as military tactical networks.

2.2. Highlights of the Year

- **Habilitation à Diriger des recherches**: Emmanuel Baccelli got his HDR entitled "IP-Disruptive Wireless Networking: Integration in the Internet", from the University Pierre et Marie Curie - Paris VI, December 2012.
- **PhD Thesis**: During year 2012, four PhD theses were defended:
  - **Salman Malik**, "Evaluation et Optimisation des Réseaux Sans Fil Denses", University Pierre et Marie Curie - Paris VI, November 2012, with Philippe Jacquet as adviser.
  - **Yacine Mezali**, "Algorithme de Géolocalisation Intérieure par Différenciation de Signaux WiFi", University Pierre et Marie Curie - Paris VI, March 2012, with Philippe Jacquet as adviser.
  - **Iskander Banaouas**, "Analyse et Optimisation des Protoocles d'Accès dans les Réseaux sans fil Ad Hoc", University Pierre et Marie Curie - Paris VI, February 2012, with Paul Muhlethaler as adviser.
  - **Ana Cristina B. Kochem Vendramin**, "Cultural GrAnt: um protocolo de roteamento baseado em inteligência coletiva para redes tolerantes a atrasos", Federal Technological University of Paraná, June 2012, with Anelise Munaretto Fonseca, Myriam R. De B. da Silva Delgado and Aline Carneiro Viana as co-advisers.

- **PEMWN 2012**, Performance Evaluation and Modeling of Wireless Networks is the workshop held in conjunction with the NoF 2012 conference (Network of the Future) : The HIPERCOM team actively contributed to the technical and practical organization of the PEMWN 2012 workshop held in Tunis in November 2012. Pascale Minet and Leila Saidane from ENSI (Tunis) were co-general chairs. Cedric Adjih and Paul Muhlethaler were members of the program committee. Christine Anocq was in charge of the registration.
- **Demonstration of OCARI**: The HIPERCOM team and more precisely, Cedric Adjih, Ichrak Amdouni, Ines Khoufi, Pascale Minet and Ridha Soua made a presentation and a demonstration of the routing protocol and the coloring algorithm of OCARI, an energy-efficient wireless sensor network supporting determinism, at:
  - the EPRI international workshop organized by EDF, Chatou, April 2012,
  - the ICSSEA international conference in Paris, October 2012.
- **Vulgarisation of computer science**: The HIPERCOM team and more precisely, Cedric Adjih, Ichrak Amdouni, Ines Khoufi and Ridha Soua explained the principles of communication and routing in wireless sensor networks to undergraduates and students.

3. Scientific Foundations

3.1. Analytical information theory

Participants: Cédric Adjih, Pascale Minet, Paul Mühlethaler.

channel capacity, compression, predictors

Information theory Branch of mathematics dedicated to the quantification of the performance of a medium to carry information. Initiated by Shannon in 1948.

Abstract. Information theory and analytical methods play a central role in the networking technology. It identifies the key parameter that must be quantified in order to characterize the performance of a network.

The analytical information theory is part of the foundations of the Hipercom project. This is a tool box that has been collected and adapted from the areas of the analysis of algorithms and the information theory. It provides powerful tool for the analysis of telecommunication algorithms. The analysis of the behavior of such algorithms in their asymptotic range are fundamental in order to identify their critical parts. It helps to design and properly scale the protocols. Application of analytical information theory ranges from channel capacity computations, compression algorithm performance evaluation, predictor designs.

3.2. Methodology of telecommunication algorithm evaluation

Participants: Cédric Adjih, Ichrak Amdouni, Emmanuel Baccelli, Salman Malik, Yacine Mezali, Pascale Minet, Paul Mühlethaler, Saoucene Mahfoudh Ridene, Ridha Soua, Erwan Livolant, Ines Khoufi.

deterministic performance, probabilistic performance

Power laws probability distributions that decays has inverse power of the variable for large values of the variable. Power laws are frequent in economic and statistical analysis (see Pareto law). Simple models such as Poisson processes and finite state Markov processes don't generate distributions with power laws.

We develop our performance evaluation tools towards deterministic performance and probabilistic performance. Our tools range from mathematical analysis to simulation and real life experiment of telecommunication algorithms.

One cannot design good algorithms without good evaluation models. Hipercom project team has an historically strong experience in performance evaluation of telecommunication systems, notably when they have multiple access media. We consider two main methodologies:

- Deterministic performance analysis,
- Probabilistic performance analysis

In the deterministic analysis, the evaluation consists to identify and quantify the worst case scenario for an algorithm in a given context. For example to evaluate an end-to-end delay. Mathematically it consists into handling a (max,+) algebra. Since such algebra is not commutative, the complexity of the evaluation of an end-to-end delay frequently grows exponentially with the number of constraints. Therefore the main issue in the deterministic evaluation of performance is to find bounds easier to compute in order to have practical results in realistic situations.
In the probabilistic analysis of performance, one evaluate the behavior of an algorithm under a set of parameters that follows a stochastic model. For example traffic may be randomly generated, nodes may move randomly on a map. The pionneer works in this area come from Knuth (1973) who has systemized this branch. In the domain of telecommunication, the domain has started a significant rise with the appearance of the problematic of collision resolution in a multiple access medium. With the rise of wireless communication, new interesting problems have been investigated.
The analysis of algorithm can rely on analytical methodology which provides the better insight but is practical in very simplistic models. Simulation tools can be used to refine results in more complicated models. At the end of the line, we proceed with real life experiments. To simplify, experiments check the algorithms with 10 nodes in maximum, simulations with 100 nodes maximum, analytical tools with more 1,000 nodes, so that the full range of applicability of the algorithms is investigated.

3.3. Traffic and network architecture modeling

Participants: Cédric Adjih, Aline Carneiro Viana, Emmanuel Baccelli.

traffic source models, network topologies, mobility models, dynamic nodes
Abstract. Network models are important. We consider four model problems: topology, mobility, dynamics and traffic models.

One needs good and realistic models of communication scenarios in order to provide pertinent performance evaluation of protocols. The models must assess the following key points:

- The architecture and topology: the way the nodes are structured within the network
- The mobility: the way the nodes move
- The dynamics: the way the nodes change status
- The traffic: the way the nodes communicate

For the architecture there are several scales. At the internet scale it is important to identify the patterns which dictate the node arrangement. For example the internet topology involves many power law distribution in node degree, link capacities, round trip delays. These parameters have a strong impact in the performance of the global network. At a smaller scale there is also the question how the nodes are connected in a wireless network. There is a significant difference between indoor and outdoor networks. The two kinds of networks differ on wave propagation. In indoor networks, the obstacles such as walls, furniture, etc, are the main source of signal attenuations. In outdoor networks the main source of signal attenuation is the distance to the emitter. This lead to very different models which vary between the random graph model for indoor networks to the unit graph model for outdoor networks.
The mobility model is very important for wireless network. The way nodes move may impact the performance of the network. For example it determines when the network splits in distinct connected components or when these components merge. With random graph models, the mobility model can be limited to the definition of a link status holding time. With unit disk model the mobility model will be defined according to random speed and direction during random times or random distances. There are some minor complications on the border of the map.

The node dynamic addresses the elements that change inside the node. For example its autonomy, its bandwidth requirement, the status of server, client, etc. Pair to pair networks involve a large class of users who frequently change status. In a mobile ad hoc network, nodes may change status just by entering a coverage area, or because some other nodes leaves the coverage area.
The traffic model is very most important. There are plenty literature about trafic models which arose when Poisson models was shown not to be accurate for real traffics, on web or on local area networks. Natural traffic shows long range dependences that don't exist in Poisson traffic. There are still strong issues about the origin of this long range dependences which are debated, however they have a great impact on network performance since congestions are more frequent. The origin are either from the distribution of file sizes exchanged over the net, or from the protocols used to exchange them. One way to model the various size is to consider on/off sources. Every time a node is on it transfers a file of various size. The TCP protocol has also an impact since it keeps a memory on the network traffic. One way to describe it is to use an on/off model (a source sending packets in transmission windows) and to look at the superposition of these on/off sources.

3.4. Algorithm design, evaluation and implementation

Participants: Cédric Adjih, Aline Carneiro Viana, Emmanuel Baccelli, Saoucene Mahfoudh Ridene, Pascale Minet, Paul Mühlethaler, Ridha Soua, Erwan Livolant, Ines Khoufi.

Access protocols, routing, scheduling, QoS
Abstract. Algorithms are conceived with focal point on performance. The algorithms we specify in detail range between medium access control to admission control and quality of service management.

The conception of algorithms is an important focus of the project team. We specify algorithms in the perspective of achieving the best performance for communication. We also strive to embed those algorithms in protocols that involve the most legacy from existing technologies (Operating systems, internet, Wifi). Our aim with this respect is to allow code implementations for real life experiment or imbedded simulation with existing network simulators. The algorithm specified by the project ranges from multiple access schemes, wireless ad hoc routing, mobile multicast management, Quality of service and admission controls. In any of these cases the design emphasize the notions of performance, robustness and flexibility. For example, a flooding technique in mobile ad hoc network should be performing such to save bandwidth but should not stick too much close to optimal in order to be more reactive to frequent topology changes. Some telecommunication problems have NP hard optimal solution, and an implementable algorithm should be portable on very low power processing unit (e.g. sensors). Compromise are found are quantified with respect to the optimal solution.

4. Application Domains

4.1. Introduction

The HIPERCOM project-team is mainly concerned by six domains:

- wireless mobile ad hoc networks,
- services over mobile networks,
- community networks,
- vehicular networks,
- large ad hoc networks with sensor nodes,
- energy-efficient wireless sensor networks.

4.2. Wireless mobile ad hoc networks

Wireless mobile ad hoc networks, Services over mobile networks, Community Networks.

Abstract. Mobile wireless networks have numerous applications in rescue and emergency operation, military tactical networking and in wireless high speed access to the internet.

A mobile ad hoc network is a network made of a collection of mobile nodes that gather spontaneously and communicate without requiring a pre-existing infrastructure. Of course a mobile ad hoc network use a wireless communication medium. They can be applied in various contexts:

- military;
- rescue and emergency;
- high speed access to internet.

The military context is the most obvious application of mobile ad hoc networks.
Soldiers invading a country won't susbscribe in advance to the local operator. On the reverse side, home units won't use their local operators firstly because they will likely be disrupted in the first hours of the conflict, and secondly because a wireless communication via an operator is not stealth enough to protect the data and the units. In Checheny, a general has been killed by a missile tracking the uplink signal of his portable phone.
The rescue context is halfway between military and civilian applications. In the september 11 disaster, most of the phone base station of the area have knocked out in less than twenty minutes. The remaining base stations were unable to operate because they could not work in ad hoc mode. The Wireless Emergency Rescue Team recommanded afterward that telecom operators should provide ad hoc mode for their infrastructure in order to operate in emergency situation in plain cooperation with police, firemen and hospital networks.
Mobile ad hoc network provide an enhanced coverage for high speed wireless access to the internet. The now very popular WLAN standard, WiFi, provides much larger capacity than mobile operator networks. Using a mobile ad hoc network around hot spots will offer high speed access to much larger community, including cars, busses, trains and pedestrians.

4.3. Services over mobile networks

Abstract. New wireless network calls for new services that fullfil the requirement in terms of mobility and capacity.

The generalization of a new generation of mobile networks calls for a new set of services and applications. For example:

- Indoor and outdoor positioning
- Service discovery and localisation
- Multicast and quality of services

Quality of service has become the central requirement that users expect from a network. High throughput, service continuity are critical issue for multimedia application over the wireless internet where the bandwidth is more scarce than in the wired world. A significant issue in the ad-hoc domain is that of the integrity of the network itself. Routing protocols allow, according to their specifications, any node to participate in the network - the assumption being that all nodes are behaving well and welcome. If that assumption fails - then the network may be subject to malicious nodes, and the integrity of the network fails. An important security service over mobile networks is to ensure that the integrity of the network is preserved even when attacks are launched against the integrity of the network.

4.4. Community Networks

Abstract. There is an increasing demand to deploy network within a community, rural or urban, with cabled or wireless access.

Community networks or citizen network are now frequent in big cities. In America most of the main cities have a community network. A community network is using the communication resource of each member (ADSL, Cable and wireless) to provide a general coverage of a city. Pedestrian in the street or in city mails can communicate via a high speed mobile mesh network. This new trend now appears in Europe with many experiments of the OLSR routing protocol in Paris, Lille, Toulouse, Berlin, Bruxelles, Seattle. The management of such networks is completely distributed and makes them very robust to faults. There is room for smart operators in this business.

4.5. Vehicular Networks

Abstract. Intelligent transport systems require efficient wireless telecommunications.

Vehicular ad hoc networks (VANET) are based on short- to medium-range transmission systems that support both vehicle-to-vehicle and vehicle-to-roadside communications. Vehicular networks will enable vehicular safety applications (safety warnings) as well as non-safety applications (real-time traffic information, routing support, mobile entertainment, and many others). We are interested in developing an efficient routing protocol that takes advantage of the fixed network infrastructure deployed along the roads. We are also studying MAC layer issues in order to provide more priority for security messages which have stringent delivery constraints.

4.6. Large ad hoc networks with sensor nodes

Abstract. Large autonomous wireless sensors in the internet of the things need very well tuned algorithms.

Self-organization is considered as a key element in tomorrow's Internet architecture. A major challenge concerning the integration of self-organized networks in the Internet is the accomplishment of light weight network protocols in large ad hoc environments.

In this domain, Hipercom's activity with wireless sensor nodes in collaboration with the Freie Universitaet in Berlin explores various solutions, including extensions of OLSR (for example DHT-OLSR) using programmable sensor nodes co-designed by the Freie Universitaet, and provides one of the largest testbeds of this kind, to date.

4.7. Energy efficient wireless sensor networks

Abstract. Energy efficiency is a key property in wireless sensor networks.

Various techniques are used to contribute to energy efficiency. In the OCARI network, an industrial wireless sensor network, we have designed and implemented an energy efficient routing protocol and a node activity scheduling algorithm allowing router nodes to sleep. We have applied a cross-layering approach allowing the optimization of MAC and network protocols taking into account the application requirements and the environment in which the network operates. This activity has been done in collaboration with our partners EDF, LIMOS and TELIT.

5. Software

5.1. RPL P2P

Participants: Emmanuel Baccelli [correspondant], Oliver Hahm, Matthias Philipp.

P2P-RPL is an implementation of draft-ietf-roll-p2p-rpl, providing reactive discovery of point-to-point routes in low power and lossy networks such as wireless sensor networks. The implementation is based on the Contiki operating system. See also the web page http://contiki-p2p-rpl.gforge.inria.fr/.

- Version: 0.4

5.2. MPR-OSPF

Participants: Emmanuel Baccelli [correspondant], Juan-Antonio Cordero.

MPR-OSPF is an implementation of RFC5449, providing OSPF-compatible routing in hybrid networks composed of both mobile ad hoc routers and fixed wired networks. The implementation is based on Quagga/Zebra. See also the web page http://ospfmanet.gforge.inria.fr.

- Version: 0.4

5.3. OPERA infrastructure

Participants: Cédric Adjih [correspondant], Ichrak Amdouni, Pascale Minet, Ridha Soua.

OPERA-infrastructure is the system support code of OPERA, the Optimized Protocol for Energy efficient Routing with node Activity scheduling.

5.4. OPERA perf simul

Participants: Cédric Adjih [correspondant], Ichrak Amdouni.

OPERA-perf-simul is a set of tools for simulation and performance evaluation as well as large scale tests of OPERA, the Optimized Protocol for Energy efficient Routing with node Activity scheduling.

5.5. OPERA protocol

Participants: Cédric Adjih [correspondant], Ichrak Amdouni, Pascale Minet, Saoucene Mahfoudh Ridene.

OPERA-protocol is the heart of OPERA, the Optimized Protocol for Energy efficient Routing with node Activity scheduling. It includes EOND a neighborhood discovery protocol, EOSTC a protocol byuiding and maintaining a n energy efficient routing tree and SERENA a node coloring algorithm.

5.6. OPERA validation and tools

Participant: Cédric Adjih [correspondant].

OPERA-validation and tools is a set of tools for validation, debugging, analysis and visualization of OPERA protocol, the Optimized Protocol for Energy efficient Routing with node Activity scheduling. It operates either in a real embedded system or in simulation.

6. New Results

6.1. Time Slot Assignment in Wireless Sensor Networks

Participants: Pascale Minet, Ridha Soua, Erwan Livolant.

6.1.1. NP-completeness of the Time Slot Assignment problem

In data gathering applications, wireless sensor networks (WSNs) collect data from sensor nodes towards a sink in a multi-hop convergecast structure. Assigning equal channel access to each node may lead to congestion and inefficient use of the bandwidth. That is why we focus on traffic-aware solutions. More precisely, we investigate the Time Slot Assignment problem, where nodes are assigned time slots to transmit their data to the sink, while minimizing the total number of slots. We considered the generalized h-hop Time Slot Assignment problem for any positive integer h, where any two nodes that are less than or equal to h-hop away are not scheduled simultaneously. We proved its NP-completeness.

6.1.2. Multichannel Slot Assignment

The throughput requirement of data gathering applications is difficult to meet with a single wireless channel. Furthermore, the considered channel may be temporarily jammed. That is why, we focus on a multichannel time slot assignment that minimizes the data gathering cycle. We first formalize the problem as a linear program and compute the optimal time needed for a raw data convergecast in various multichannel topologies (linear, multi-line, tree). These optimal times apply to nodes equipped with one or several radio interfaces. This work generalizes the results established by Incel. We then propose our algorithm called MODESA and prove its optimality in various multichannel topologies. We evaluate its performances in terms of number of slots, maximum buffer size and number of active/sleep switches per node. Furthermore, we present variants of MODESA achieving a load balancing between the channels used.

6.1.3. Multisink Multichannel Slot Assignment

We generalize this work, taking into account the existence of several sinks. We focus on the data gathering problem with differentiated traffic, each addressed to a specific sink in multichannel WSNs. In order to find a collision-free optimized multichannel time slot assignment that minimizes the data gathering cycle, we propose a centralized traffic-aware algorithm called MUSIKA. We formulate the problem as a linear program and compute the optimal time needed for a raw data convergecast in various multichannel topologies (linear, multi-line, tree). More generally, we run simulations on various network topologies to evaluate the performance of MUSIKA in terms of cycle length, maximum buffer size and slot reuse ratio for different use cases: redundant functional processing chains, different application functionalities per sink.

6.2. Multi-Sink Wireless Sensor deployment and energy analysis

Participants: Paul Mühlethaler, Nadjib Achir.

We propose a general framework for multi-sink Wireless Sensors networks (WNSs). This framework is devoted to computing the optimal deployment of sinks for a given maximum number of hops between nodes and sinks. This framework allows an estimation of the energy consumption to be computed. We consider the energy consumed due to reporting, forwarding and overhearing. In contrast to reporting and forwarding, the energy used in overhearing is difficult to estimate because it is dependent on the packet scheduling. We determine the upper-bound and lower-bound of overhearing. We also propose another estimation which can simulate non interfering parallel transmissions which is more tractable in large networks. We note that overhearing largely predominates in energy consumption. A large part of the optimizations and computations carried out in this paper are obtained using ILP formalization.

6.3. WSN Redeployment

Participants: Pascale Minet, Saoucene Mahfoudh Ridene, Ines Khoufi.

This is a joint work with Telecom SudParis: Anis Laouiti.

6.3.1. Centralized redeployment algorithm based on Virtual Forces

In many applications (e.g military, environment monitoring), wireless sensors are randomly deployed in a given area. Unfortunately, this deployment is not efficient enough to ensure full area coverage and total network connectivity. Hence, all the considered area must be covered by sensors ensuring that any event is detected in the sensing range of at least one sensor. In addition, the sensor network must be connected in terms of radio communication in order to forward the detected event to the sink(s). Thus, a redeployment algorithm has to be applied in order to achieve these two goals. In this context, we have proposed redeployment algorithms based on virtual forces. First, we have designed and simulated a centralized algorithm called CVFA. This algorithm is executed by a specific node which has global information of node positions.

6.3.2. Distributed redeployment algorithm based on Virtual Forces

Then, we proposed DVFA, Distributed Virtual forces Algorithm. Each node in the network executes DVFA and computes its new position based on information collected from its neighbors.

Performance evaluation shows that both CVFA and DVFA give very good coverage rate (between 98% and 100%) and ensure the connectivity between sensors.

6.3.3. Distributed redeployment algorithm based on Virtual Forces in the presence of obstacles

Moreover, in a real environment, obstacles such as trees, walls and buildings may exist and they may impact the deployment of wireless sensors. Obstacles can prohibit the network connectivity between nodes and create some uncovered holes or some accumulation of sensors in the same region. Consequently, an efficient wireless sensors deployment algorithm is required to ensure both coverage and network connectivity in the presence of obstacles. We have focused on this problem and enhanced our Distributed Virtual Force Algorithm (DVFA) to cope with obstacles. Simulation results show that DVFA gives very good performances even in the presence of obstacles.

6.4. Mesh Network Planning: Deployment and Canal Allocation

Participant: Nadjib Achir.

This is a joint work with University Paris XIII: A. Farsi, K. Boussetta.
We deal with the Wireless LAN planning problem. We study this problem and we propose to couple its two major issues: AP placement and channel assignment to treat them jointly. Here, we propose a novel fast and scalable three-phase heuristic algorithm (TPHA). Our proposal is able to resolve the defined multiobjective problem to provide (1) the efficient number of Access Points (APs) to be deployed, while (2) ensuring the coverage of all Test Points (TPs) and (3) maximizing their nominal data rate. To achieve the first objective, we propose an heuristic called MCL-ILP combining the quick decision making based on the Markovian CLustering algorithm and the exact solution provided by the Integer Linear Programming. Hence, a TPs-based Least Interfering Channel Search algorithm (TLICS) has been proposed for channel assignment to improve the throughput at TP locations. However, the Virtual Forces-based WLAN Planning Algorithm namely VFPA considers the results delivered by the two previous algorithms as an initial solution and tries to enhance it by adjusting the APs' positions and re-assigning their operating frequencies. Computational results exhibit that our proposal is highly beneficial to designing WLANs.

6.5. Routing in MANETs using slotted Aloha. End-to-end delays

Participants: Paul Mühlethaler, Iskander Banaouas.

This is a joint work with TREC: B. Blaszczyzyn.
Planar Poisson models with the Aloha medium access scheme have already proved to be very useful in studies of mobile ad-hoc networks (MANETs). However, it seems difficult to quantitatively study the performances of end-to-end routing in these models. In order to tackle this problem, in this paper we study a *linear stationary route embedded in an independent planar field of interfering nodes*. We consider this route as an idealization of a "typical" route in a MANET obtained by some routing mechanism. Such a decoupling allows us to obtain many numerically tractable expressions for local and mean end-to-end delays and the speed of packet progression, assuming slotted Aloha MAC and the Signal-to-Interference-and-Noise Ratio (SINR) capture condition, with the usual power-law path loss model and Rayleigh fading. These expressions show how the network performance depends on the tuning of Aloha and routing parameters and on the external noise level. In particular we show a need for a well-tuned lattice structure of fixed relaying nodes, which helps to relay packets on long random routes in the presence of a non-negligible noise. We also consider a *Poisson-line MANET model*, in which *all* nodes are located on roads forming a Poisson-line process. In this case our linear route is rigorously (in the sense of Palm theory) the typical route in this Poisson-line MANET.

6.6. Cognitive networks using a darwinian approach

Participant: Paul Mühlethaler.

This is a joint work with Alcatel Bell Labs: Philippe Jacquet.

We present a new approach for cognitive radio. In the usual approach the secondary network is in charge of monitoring the channel to determine whether or not the primary network is active in the area. If it is not, the secondary network is allowed to use the spectrum. In the new access scheme we propose, the primary network encompasses the techniques which allow it to capture the bandwidth even if the secondary network is transmitting in the area. The access scheme of the primary network preempts the secondary network activity. We present an access scheme which preempts the IEEE 802.11 decentralized scheme. This protocol is a generalized Carrier Sense Multiple Access scheme using active signaling. Instead of only sensing the carrier, this algorithm also transmits bursts of signal which may be sensed by the other nodes. If so, they give up the selection process. We show that this scheme preempts the IEEE 802.11 decentralized access scheme if the bursts transmitted by the node in the primary network are made up of special sequences which alternate between bursts of signal and periods of sensing. These sequences called (d, k) sequences encompass a minimum number d and a maximum number of k successive zeros during which the node senses the channel to find other possible concurrent transmissions. In practice we use $d = 0$ and k depends on the duration of the IEEE 802.11 interframe space and the duration of a signaling burst. We compute the number of $(0, k)$ sequences with respect to the length n of the sequence. We also show that (d, k) sequences (with $2d > k$) can be used if, by mistake, during the signaling phase one burst is not detected. We evaluate the number of such sequences.

6.7. Massive mobile dense wireless networks

Participants: Aline Carneiro Viana, Ana Cristina B. Kochem Vendramin, Kanchana Thilakarathna, Eduardo Mucceli.

routing protocols, analytical models, content distribution.

6.7.1. Scientific achievements

6.7.1.1. Social Relationship Classified

Understanding human mobility is of fundamental importance when designing new communication protocols that exploit opportunistic encounters among users. In particular, human behavior is characterized by an elevated rate of regularity, but random events are always possible in the routines of individuals as hardly predictable situations that deviate from the regular pattern and are unlikely to arise repeatedly in the future. These random events veil the ordinary patterns by introducing a significant amount of noise, thus making the process of knowledge discovery in social dataset a complex task. However, the ability to accurately identify random and social events in large datasets is essential to social analysis as well as to applications that rely on a precise description of human routines, such as recommendation systems, forwarding strategies and ad-hoc message dissemination schemes focusing on coverage efficiency with a limited number of redundant messages. In such a context, we have proposed a strategy to analyze wireless network scenarios where mobile users interact in a rational manner, reflecting their interests and activity dynamics. Our strategy, named Random rElationship ClASsifier sTrategy (RECAST), allows to classify user relationships, separating random interactions from different kinds of social ties. The goal is achieved by observing how the real system differs from an equivalent one where entities decisions are completely random. We have evaluate the effectiveness of RECAST classification on datasets of real-world user contacts in diverse networking contexts. Our analysis unveils significant differences in the relationship dynamics of the datasets, proving that the evaluation of network protocols on a single dataset cannot lead to conclusions of general validity.

6.7.1.2. Social-aware Forwarding Protocol

Pervasiveness of computing devices, ubiquitous wireless communication, emergence of new applications, and cloud services are examples of current new emerging factors that emphasize the increasing need for adaptive networking solutions. The adaptation, most of the time, requires the design of more interdisciplinary approaches as those inspired by techniques coming from biology, social structures, games, and control systems. The approach we consider brings together solutions from different but complementary domains - i.e., networking, biology, and complex networks - aiming to deal with the problem of efficient data delivery in mobile and intermittently connected networks. For this, we have designed the Cultural Greedy Ant (CGrAnt)

protocol to solve the problem of data delivery in mobile and intermittently connected networks referred as Delay Tolerant Networks (DTNs). CGrAnt is a hybrid Swarm Intelligence-based forwarding protocol designed to deal with the dynamic and complex environment of DTNs resulting from users mobility or varying conditions of wireless communications. CGrAnt is based on (1) Cultural Algorithms (CA) and Ant Colony Optimization (ACO) and (2) metrics which characterize opportunistic social connectivity between wireless users. CA and ACO are used to direct the network traffic, taking into account a set of social-aware metrics that may infer relevant structures in meeting regularities and mobility patterns of users. The most promising message forwarders are selected through a greedy transition rule based on local and global information captured from the DTN environment. Through simulation, we have analyzed the influence of ACO operators and CA's knowledge on CGrAnt performance. We have then compared the performance of CGrAnt with PROPHET and Epidemic protocols under varying networking parameters. Results have shown that CGrAnt achieves the highest delivery ratio and lowest byte redundancy.

6.7.1.3. Opportunistic Content Dissemination

Here, we focus on dissemination of content for delay tolerant applications/services, (i.e. content sharing, advertisement propagation, etc.) where users are geographically clustered into communities. Due to emerging security and privacy related issues, majority of users are becoming more reluctant to interact with strangers and are only willing to share information/content with the users who are previously identified as friends. In this environment, opportunistic communication will not be effective due to the lack of known friends within the communication range. Thus, we have proposed a novel architecture that addresses the issues of lack of trust, timeliness of delivery, loss of user control, and privacy-aware distributed mobile social networking by combining the advantages of distributed decentralized storage and opportunistic communications. We have formally defined a content replication problem in mobile social networks and show that it is computationally hard to solve optimally. Then, we have proposed a community based greedy heuristic algorithm with novel dynamic centrality metrics to replicate content in well-selected users, to maximize the content dissemination with limited number of replication. Using both real world and synthetic traces, we have shown that content replication can attain a large coverage gain and reduce the content delivery latency.

6.7.1.4. Data Offloading-aware Hotspot Deployment

With the steady growth of sales of smart-phones, the demand for services that generate mobile data traffic has grown tremendously. The growing use of traffic data generated from mobile devices overloads the network infrastructure, which is not always prepared to receive such demand. To tackle this problem, we are studying the mobile behavior and resource consumptions of people on a metropolitan area in a major city and turn it into a set of well located WiFi hotspots. For this, we have proposed a data offloading-aware hotspot deployment. It is methodologically divided as (i) creation of a time dependent weighted graph to represent people's mobility, traffic and its relation with places/locations able to receive a hotspot, (ii) measurement of location's importance and selection of the best-ranked ones. Better positioned hotspots are likely to provide better coverage, and therefore, be able to offload more data.

6.7.2. Collaborations

- Professors Anelise Munaretto and Myriam Regattieri Delgado from Federal Technological University of Parana (UTFPR), Brazil,
- Professors Aruna Seneviratne and Henrik Petander from NICTA and School of EE&T, UNSW, Sydney, Australia,
- Pedro O.S. Vaz de Melo and Antonio A. F. Loureiro, Federal University of Minas Gerais, Brazil,
- Marco Fiore and Frederic Le Mouel from INSA Lyon, France,
- Katia Jaffrès-Runser, University of Toulouse, IRIT/ENSEEIHT, France.

6.8. New services and protocols

Participants: Aline Carneiro Viana, Guilherme Maia.

6.8.1. Scientific achievements

6.8.1.1. Network Discovery

Network discovery is a fundamental task in different scenarios of IEEE 802.15.4-based wireless personal area networks. Scenario examples are body sensor networks requiring health- and wellness-related patient monitoring or situations requiring opportunistic message propagation. Therefore, we have investigated optimized discovery of IEEE 802.15.4 static and mobile networks operating in multiple frequency bands and with different beacon intervals. We designed a linear programming model that allows finding two optimized strategies, named OPT and SWOPT, to deal with the asynchronous and multi-channel discovery problem. We have also proposed a simplified discovery solution, named SUBOPT, featuring a low-complexity algorithm requiring less memory usage. A cross validation between analytical, simulation, and experimental evaluation methods was performed. Our performance studies confirmed improvements achieved by our solutions in terms of first, average, and last discovery time as well as discovery ratio, when compared to IEEE 802.15.4 standard approach and the SWEEP approach known from the literature.

6.8.1.2. Distributed Data Storage

The deployment of large-scale Wireless Sensor Network (WSN) applications (e.g., environment sensing and military surveillance), which operate unattended for long periods of time and generate a considerable amount of data, poses several challenges. One of them is *how to retrieve the sensed data*. To tackle this issue, we have designed ProFlex, a distributed data storage protocol for large-scale heterogeneous wireless sensor networks (HWSNs) with mobile sinks. ProFlex guarantees robustness in data collection by intelligently managing data replication among selected storage nodes in the network. Contrarily to related protocols in the literature, ProFlex considers the resource constraints of sensor nodes and constructs multiple data replication structures, which are managed by more powerful nodes. Additionally, ProFlex takes advantage of the higher communication range of such powerful nodes and uses the long-range links to improve data distribution by storage nodes. When compared with related protocols, we have shown through simulation that Proflex has an acceptable performance under message loss scenarios, decreases the overhead of transmitted messages, and decreases the occurrence of the energy hole problem. Moreover, we have proposed an improvement that allows the protocol to leverage the inherent data correlation and redundancy of wireless sensor networks in order to decrease even further the protocol's overhead without affecting the quality of the data distribution by storage nodes.

6.8.2. Collaborations

- PhD Niels Karowski, Technische Universitat Berlin, Germany,
- Professor Adam Wolisz, Technische Universitat Berlin, Germany,
- Antonio A. F. Loureiro, Federal University of Minas Gerais, Brazil,

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR: GETRF

Participants: Paul Mühlethaler, Pascale Minet, Cédric Adjih, Emmanuel Baccelli, Salman Malik.

Period: 2012 - 2014.

Partners: DGA/MI, Inria.

The GETRF project aims at improving the effectiveness of communications mechanisms and technologies capable of functioning in extreme conditions and GETRF also aims at opening ways for solutions that are close to the optimum. The following areas will be addressed:

- Compromise time / maximum efficiency for coloring (TDMA), which can be used to take into account the asymmetry of traffic delays to optimize routing.
- Significant energy savings for opportunistic routing (in power saving mode) even where traffic control is limited and where the nodes are idle most of the time ("low-duty cycle")
- From a completely different point of view, the finding optimal network capacity for opportunistic routing variants when designed for mobile networks
- Robustness to mobility and to changes in network conditions (difficult connectivity, foes, ...) extreme network coding - which is moreover an innovative technology in itself applied here in MANETs, at the network and/or application layer, rather than at the physical/or theoretical level as in other proposals.

The project will focus on four technical approaches which are:

- Coloring for the development of a TDMA system for energy saving and delay control,
- Cross-layer (MAC/routing) mechanism for "low-duty-cycle" mode
- Network coding,
- Opportunistic routing and mobile mobility to use relays to minimize retransmissions of packets with a target time.

The first two approaches are intended to provide energy efficient sensor networks. The second two approaches try to provide mechanisms for building ad hoc networks capable of handling high node mobility.

7.1.2. Competitivity Clusters

7.1.2.1. SAHARA

Participants: Pascale Minet, Cédric Adjih, Ridha Soua, Erwan Livolant.

Period: 2011 - 2014.

Partners: EADS, Astrium, BeanAir, Eurocopter, Inria, Oktal SE, Reflex CES, Safran Engineering Systems, CNES, ECE, EPMI,LIMOS.

SAHARA is a FUI project, labelled by ASTECH and PEGASE, which aims at designing a wireless sensor network embedded in an aircraft. The proposed solution should improve the embedded mass, the end-to-end delays, the cost and performance in the transfers of non critical data. Inria is in charge of coordinating the academic partners. During year 2012, we took part to the specification of application requirements. We also defined the functional architecture and made measurements within the plane of SAFRAN.

7.1.2.2. CONNEXION

Participants: Pascale Minet, Cédric Adjih, Saoucene Mahfoudh Ridene, Ines Khoufi.

Period: 2012 - 2016.

Partners: All4Tec, ALSTOM, AREVA, Atos WorldGrid, CEA, CNRS / CRAN, Corys TESS, EDF, ENS Cachan, Esterel Technologies, Inria, LIG, Predict, Rolls-Royce Civil Nuclear, Telecom ParisTech.

The Cluster CONNECTION (Digital Command Control for Nuclear EXport and renovation) project aims to propose and validate an innovative architecture platforms suitable control systems for nuclear power plants in France and abroad. This architecture integrates a set of technological components developed by the academic partners (CEA, Inria, CNRS / CRAN, ENS Cachan, LIG, Telecom ParisTech) and based on collaborations between major integrators such as ALSTOM and AREVA, the operator EDF in France and "techno-providers" of embedded software (Atos WorldGrid, Rolls-Royce Civil Nuclear, Corys TESS, Esterel Technologies, All4Tec, Predict). With the support of the competitiveness clusters System@tic, Minalogic and Burgundy Nuclear Partnership,the project started in April 2012. The key deliverables of the project covered several topics related demonstration concern-driven engineering models for the design and validation of large technical systems, design environments and evaluation of HMI, the implementation of Wireless Sensor Network context-nuclear, buses business object or real-time middleware facilitating the exchange of heterogeneous data and distributed data models standardized to ensure consistency of digital systems.

The HIPERCOM project-team is involved in wireless sensor networks coping with node mobility. We focused on deployment and redeployment algorithms for mobile wireless sensor networks after a disaster. We began with a state of the art. Many works in the literatures deal with this issue. We can classify these works in several ways:

- First classification:
  - Centralized Algorithms as Practical swarm optimization (PSO), Centralized virtual forces...These algorithms minimize the moves done by nodes since each sensor moves only to its final position computed by the specific node. However, they rely on assumption that may be unrealistic (e.g. network connectivity). Furthermore, they are not scalable.
  - Distributed Algorithms as Distributed Self Spreading algorithm (DSSA), Force-based Genetic Algorithm (FGA), Mass-Sprig -Relaxation Algorithm... These algorithms are more relistic: they adapt to the knowledge progressively acquired during the redeployment. However, there are still pending issues such as nodes oscillation, coverage computation, point of interest...
- Second classification:
  - Grid based approach: sensors will redeploy according to a predetermined grid.
  - The computational geometry based approach uses the Voronoi diagram and the Delaunay triangulation.
  - The virtual force based approach is based on virtual forces to move sensors.

The latter (virtual force based approach) presents many advantages such as simplicity and fast coverage. That is why we adopt this appraoch.

7.1.2.3. SensLab and FIT

Participants: Cédric Adjih, Emmanuel Baccelli, Ala Eddin Weslati.

Period: 2011 - 2021

Partners: Inria (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Télécom Paris, Institut Télécom Evry, LSIIT Strasbourg.

The HIPERCOM team started the development of a testbed for SensLab in 2010. This testbed located in building 21 at Rocqquencourt Inria center consists now of 128 wireless SensLab nodes.
A location has been found for the new testbed of the EQUIPEX FIT: the basement of building 1 at Rocquencourt. An engineer has been recruited for this project.

7.1.2.4. ACRON

Participant: Cédric Adjih.

Period: 2011 - 2014

Partners: Supélec (Télécommunications), Inria, ENS TREC, Inria HIPERCOM, Université Paris-Sud, IEF.

ACRON is a DIMLSC DIGITEO project. It deals with analysis and design of self-organized wireless networks. The HIPERCOM team project will study the theoretical limits of wireless networking.

7.1.2.5. SWAN

Participants: Cédric Adjih, Salman Malik.

Period: 2011 - 2014

Partners: CNRS, Supélec, Université Paris-Sud (L2S), LTCI, LRI, Inria Hipercom and IEF.

SWAN, Source-aWAre Network coding, is a DIMLSC DIGITEO project. It deals with network coding for multimedia.

7.1.2.6. MOBSIM

Participants: Cédric Adjih, Paul Mühlethaler, Hana Baccouch.

Period: 2011 - 2013

Partners: Inria Sophia, Inria Genoble.

MOBSIM is an ADT, Action of Technology Development. It aims at developping the NS3 simulation tool. The HIPERCOM team focuses on routing protocols and MAC protocol (namely the EY-NPMA protocol Elimination Yield Non-Preemptive Multiple Access). An engineer has been recruited for this project.

7.1.3. OCARI2

Participants: Ichrak Amdouni, Pascale Minet, Cédric Adjih, Ridha Soua.

Partners: EDF, LIMOS, TELIT.

At the end of the OCARI (Optimization of Ad hoc Communications in Industrial networks) project, funded by ANR, started in February 2007 and ended in 2010, EDF the coordinator decided to continue the project with a restricted number of partners: TELIT, LIMOS (Clermont Ferrand university) and Inria. The goal was to prove the feasibility on commercially available cards of the OCARI stack designed during the ANR project and to make a public demonstration of this product. During the year 2011, the OCARI stack has been improved and implemented on the ZE51 module of TELIT based on the Texas Instrument CC2530 Chipset. During 2012, we made several demonstrations of the energy-efficient routing protocol EOLSR and the node coloring algorithm OSERENA to save energy.
The OCARI project deals with wireless sensor networks in an industrial environment. It aims at responding to the following requirements which are particularly important in power generation industry and in warship construction and maintenance:

- Support of deterministic MAC layer for time-constrained communication,
- Support of optimized energy consumption routing strategy in order to maximize the network lifetime,
- Support of human walking speed mobility for some particular network nodes, (e.g. sinks).

The development of OCARI targets the following industrial applications:

- Real time centralized supervision of personal dose in electrical power plants,
- Condition Based Maintenance of mechanical and electrical components in power plants as well as in warships,
- Environmental monitoring in and around power plants,
- Structure monitoring of hydroelectric dams.

To meet the requirements of supported applications (remote command of actuators, tele-diagnostic...), new solutions will be brought to manage several communication modes, ranging from deterministic data transfers to delay tolerant transfers. A key issue is how to adapt routing algorithms to the industrial environment, taking into account more particularly limited network resources (e.g.; bandwidth), node mobility and hostile environment reducing radio range.
The OCARI project aims at developing a wireless sensor communication module, based on IEEE 802.15.4 PHY layer and supporting EDDL and HART application layer. The Inria contribution concerns more particularly energy efficient routing and node activity scheduling.

- The energy efficient extension of OLSR, called EOLSR, is implemented on top of the MAC protocol defined by LATTIS and LIMOS. The MAC protocol is a variant of ZigBee ensuring some determinism and quality of service and allowing leave nodes (e.g. sensor, actuator) as well as router nodes to sleep. The EOLSR protocol avoids nodes with low residual energy and selects the routes minimizing the energy consumed by an end-to-end transmission.
- SERENA, the protocol used to schedule router node activity, is based on three-hop coloring. It allows any node to sleep during the slots that are attributed neither to its color nor to its one-hop neighbors. SERENA contributes to a more efficient use of energy: less energy is spent in the idle and interference states. Hence, network lifetime is considerably increased. SERENA has been optimized for the specific context of OCARI (i.e.; very limited bandwidth 250kbps, small size messages 127 bytes, limited memory and limited processing power) have been delivered.

These protocols have been implemented in the OCARI stack, operating on a ZE51 module of TELIT.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, except FP7

Program: CSOSG

Project acronym: SAFEST

Project title:

Duration: May 2012-April 2015

Coordinator: Emmanuel Baccelli

Other partners: Freie Universitat Berlin, Hamburg University, Sagem, Daviko, FOS, Fraunhofer

Abstract: Public spaces, such as airports, railway stations, or stadiums bring together large numbers of people on limited space to use security-sensitive infrastructure. These spaces pose two distinct challenges to public security: (a) detecting unauthorized intrusions and (b) monitoring large crowds in order to provide guidance in case of unexpected events (e.g., mass panic). To ensure the safety of the general public as well as individuals, we thus require a flexible and intelligent method for area surveillance. One example in which current monitoring systems proved to be dangerously inefficient is the Love Parade music festival in Duisburg, Germany, July 2010. Crowd control failed to provide guidance to a large crowd, resulting in a mass panic with 21 deaths and several hundred injured. In this particular case, overloaded communication infrastructure led to a lack of information about the density and the movement of the crowd, which in turn resulted in misjudgments on appropriate strategies to resolve the situation. This incident highlights the need for more sophisticated and reliable methods for area surveillance. The SAFEST project aims to analyse the social context of area surveillance and to develop a system that can fulfill this task, both in terms of technology as well as acceptance by the general public. The system will operate in distributed way, collect anonymised data, securely transfer this data to a central location for evaluation, and if necessary notify the operator and/or issue alerts directly to the general public. SAFEST addresses the following topics: (i) it proposes a solution for crisis management, addressing social, technical, and economic issues, (ii) it enhances the protection of the population against risks and dangers, including the evaluation of acceptance of said solution, and (iii) it addresses the protection of critical infrastructures by the means of a comprehensive technical solution.

7.3. International Initiatives

7.3.1. IT-SG-WN

Title: Information Theory, Stochastic Geometry, Wireless Networks

Inria principal investigator: Paul Muhlethaler

International Partner (Institution - Laboratory - Researcher):

Stanford University (United States) - Information Systems Laboratory, Department of Electrical Engineering - Abbas El Gamal

Duration: 2011 - 2013

See also: http://www.di.ens.fr/~baccelli/IT_SG_WN_web_site.htm

The activity of this proposal is centered on the inter-play between stochastic geometry and network information theory, whith a particular emphasis on wireless networks. In terms of research, three main lines of thought will be pursued:1. Error exponents and stochastic geometry2. Stochastic geometry and network Information Theory3. Cognitive radio and stochastic geometry

7.3.2. Participation In International Programs

7.3.2.1. AWSN2012

Program: Euromediterranean 3+3

Title: Auto-adaptivity in Wireless Sensor Networks

Inria principal investigator: Pascale Minet

International Partners (Institution - Laboratory - Researcher):

University of Catania (Italy) - DIEEI - Lucia Lo Bello

Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes (Morocco) - ND-SRG - Mohamed Erradi

Ecole Nationale des Sciences de l'Informatique (Tunisia) - CRISTAL - Leila Azouz Saidane

Duration: Jan 2012 - Dec 2015

See also: euromed

Wireless sensor networks (WSNs) allow the development of numerous applications in various domains, such as security and surveillance, environment protection, precision agriculture, intelligent transportation, homecare of elderly and disabled people...

Communication in such WSNs has to cope with limited capacity resources, energy depletion of sensor nodes, important fluctuations of traffic in the network, changes in the network topology (radio link breakage, interferences ...) or new application requirements.

In the AWSN project, we focus on the different techniques to be introduced in the WSNs to make them auto-adaptive with regard to these various changes while meeting the application requirements. Thus, we will address:

- network deployment and redeployment in order to fulfill the application requirements,
- QoS (Quality of Service) optimization taking into account real-time traffic and dynamic bandwidth allocation,
- energy efficiency and replacement of failed sensor node,
- component generation and dynamic adaptation of the application.

After a kick-off meeting in Paris in February, we organized three workshops where each team presented its works:

- a workshop in Rabat in October 2012, where each team presented its works,

- a workshop in Tunis in November 2012. This workshop was open to non-members and was preceded by a call for paper. It was held in conjunction with the IEEE NoF 2012 conference (Network of the Future).
- a workshop in Catania in December 2012, where new results have been presented.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- **Mauro Fonseca**, Pontifical Catholic University of Paraná, Curitiba, Brazil, July 2012-June 2013 (Saclay),
- **Anelise Munaretto**, Federal Technological University of Paraná, Curitiba, Brazil, July 2012-June 2013 (Saclay),
- **Leila Saidane**, ENSI, Tunis, Tunisia, February and July 2012 (Rocquencourt),
- **Lucia Lo Bello**, UniCT, Catania, Italy, February 2012 (Rocquencourt),
- **Mohammed Erradi**, ENSIAS, Rabat, Morocco, February 2012 (Rocquencourt),
- **Bernard Mans**, Macquarie University, March-August 2012 (Rocquencourt).

7.4.1.1. Internships

Kanchana Thilakarathna, NICTA/University of New South Wales, Sydney, Australia, March-September 2012 (Saclay)

8. Dissemination

8.1. Scientific Animation

Pascale Minet took an active part in the dissemination of the results obtained in the OCARI project, dealing with energy efficient industrial wireless sensor networks.
Pascale Minet was member of the program committee of:

- AdHocNets 2012, Fourth International ICST Conference on Ad Hoc Networks, October 2012.
- DCNET 2012, International Conference on Data Communication Networking, July 2012,
- ECRTS 2012, 24th EUROMICRO Conference on Real-Time Systems, July 2012.
- ETFA 2012, 17th IEEE International Conference on Emerging Technologies & Factory Automation, September 2012.
- ICN 2012, the 11th International Conference on Networks, February 2012.
- ICWCUCA 2012, the third International Conference on Wireless Communications in Unusual and Confined Areas, August 2012.
- IFIP Wireless Days 2012, November 2012.
- IUCC 2012, the 11th IEEE International Conference on Ubiquitous Computing and Communications, August 2012.
- IWCMC 2012, the 8th International Wireless Communications and Mobile Computing Conference, July 2012.
- PAEWN 2012, International workshop on Performance Analysis and Enhancement of Wireless Networks, April 2012.
- PIMRC 2012, 23rd International Symposium on Personal, Indoor and Mobile Radio Communications, September 2012.
- RTNS 2012, 19th International Conference on Real-Time and Network Systems, September 2012.
- SNPD 2012, 11th International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing, June 2012.
- WINSYS 2012, International Conference on Wireless Information Networks and Systems, July 2012.

Pascale Minet was also reviewer for the following journals:

- IEEE Transactions on Industrial Informatics,
- IEEE Transactions on Vehicular Technology,
- IEEE Communication Letters,
- Real-Time Systems,
- International Journal of Communications,
- International Journal of Distributed Sensor Networks,
- Computer Communications Journal.

Paul Muhlethaler was reviewer for:

- the call 8 of the European commission : "Networks of the future".
- the European MONET project "Mechanims for Optimization of hybrid ad-hoc networks and satellite NETworks".

He was also member of:

- the Steering commitee of MobileHealth 2012. 2nd ACM MobiHoc Workshop on Pervasive Wireless Healthcare In Conjunction With MobiHoc 2012 Conference. June 11th. Hilton Head Island, South Carolina, USA,
- the Technical committee of The First International Workshop on Performance Evaluation and Modeling in Wireless Networks. PEMWN 2012. November 22, Tunis, Tunisia.

C'edric Adjih was member of the program committee of:

- AINTEC 2012, ACM Asian Internet Engineering Conference, November 2012.
- MILCOM 2012, IEEE Military Communications Conference, October 2012.
- VTC 2012 Fall, IEEE 76th Vehicular Technology Conference, September 2012.
- PEMWN 2012,First International Workshop on Performance Evaluation and Modeling in Wireless Networks, November 2012.

He was also reviewer for the Journal: Transactions on Sensor Networks.

Aline Carneiro Viana has been performing remote reviews of short proposals for the FET-Open program of the European Commission since January 2011. **Aline Carneiro Viana** was the general and TPC co-chair of the 4th ACM International Workshop on Hot Topics in Planet-Scale Measurement (HotPlanet 2012), together with Ahmed Helmy.

She was the Publicity Chair of:

SECON'12 *9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks*, Seoul, Korea, June 2012

ExtremeCom'12 *4th Extreme Conference on Communication*, Zurich, Switzerland, March 2012.

Aline Carneiro Viana has also served in the program committee for the [SECON'12] *9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks*, Seoul, Korea, June 2012.

Emmanuel Baccelli is TPC for IEEE SECON, IEEE Globecom PerGroup, IEEE ICC NovaEnEv, ACM Mobihoc Mobile Health. Co-organizer of international conferences ACM SESP.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Master : **Pascale Minet** taught:

- Networks and quality of service in Master Systèmes Electroniques et Traitement de l'Information, at INSTN (Saclay).
- Mobile ad-hoc networks: medium access, routing and quality of service in Master Ingénierie informatique of the university of Marne-la-Vallée.
- Mobile ad hoc networks and wireless sensor networks: medium access, routing and energy efficiency in Master ScTIC (Systèmes complexes, Technologies de l'Information et du Contrôle) of the University of Paris 12.

8.2.2. Supervision

HdR : **Emmanuel Baccelli**, "IP-Disruptive Wireless Networking: Integration in the Internet", University Pierre et Marie Curie - Paris VI, December 2012.

PhD :

- **Salman Malik**, "Evaluation et Optimisation des Réseaux Sans Fil Denses", University Pierre et Marie Curie - Paris VI, November 2012, Philippe Jacquet, adviser.
- **Yacine Mezali**, "Algorithme de Géolocalisation Intérieure par Différenciation de Signaux WiFi", University Pierre et Marie Curie - Paris VI, March 2012, Philippe Jacquet, adviser.
- **Iskander Banaouas**, "Analyse et Optimisation des Protoocles d'Accès dans les Réseaux sans fil Ad Hoc", University Pierre et Marie Curie - Paris VI, February 2012, Paul Muhlethaler, adviser.
- **Ana Cristina B. Kochem Vendramin**, "Cultural GrAnt: um protocolo de roteamento baseado em inteligência coletiva para redes tolerantes a atrasos", Federal Technological University of Paraná, June 2012, Anelise Munaretto Fonseca, Myriam R. De B. da Silva Delgado, and Aline Carneiro Viana.

8.2.3. Juries

Pascale Minet was member of the Gilles Kahn 2012 jury awarding an excellent 2011 PhD thesis in Computer Science.

PhD :

- Michael Lauer, "Une Méthode Globale pour la Vérification d'Exigences Temps Réel - Application à l'Avionique Modulaire intégrée", University of Toulouse, June 2012, Pascale Minet, reviewer.
- Geovanny Mauricio Itturalde Ruiz, "Performances des Réseaux LTE", University of Toulouse, October 2012, Pascale Minet, reviewer.
- Mohamed-Haykel Zayani, "La Prédiction de Liens dans les Réseaux Sans-fil Dynamiques Centrés sur l'Etre Humain", Telecom SudParis and University Pierre et Marie Curie - Paris VI, October 2012, Pascale Minet, reviewer.
- Yasir Faheem, "Energy Efficient Routing In Wireless Sensor Networks", University Paris XIII, November 2012, Paul Muhlethaler, president.
- Youghourta Benfatttoum, "Network Coding for Quality of Service in Wireless Multi-hop Networks", University Orsay, November 2012, Paul Muhlethaler, examinator.
- Ibrahim Amadou, INSA Lyon, France, September 2012, Aline Carneiro Viana, reviewer.

8.3. Popularization

- **Fête de la Science organized by Inria**, in Rocquencourt, October 2012. The HIPERCOM team was very active and presented several demonstrations coordinated by Cédric Adjih. The demonstration prepared by Cédric Adjih, Nadjib Achir, Ichrak Amdouni, Hana Baccouch, Ines Khoufi, Erwan Livolant, Ridha Soua and Ala-Edin Weslati concerned the principles of wireless sensor networks, the energy-efficient routing protocol and the node coloring algorithm running in the OCARI network to maximize network lifetime.
- Cédric Adjih with the help of Ridha Soua and Ines Khoufi organized several demonstrations of wireless sensor networks for undergraduates and students who visited Inria in March, October and December 2012, respectively.

9. Bibliography

Major publications by the team in recent years

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