http://www.ic1004.org

NEWSLETTER

Cooperative Radio Communications for Green Smart Environments

Number 7, March 2014

Newsletter Editor: Alain Sibille, Telecom ParisTech, France

COST IC1004 Chairman: Narcis Cardona, Univ. Politecnica Valencia, Spain

Editorial

Dear readers,

2014 appears to be "the year" of connected things. At CEBIT in Hannover during the yearly fair, it was one of the top 5 Tech trends highlighted by some journalists. We can't listen to High Tech news without that, nearly every day, hearing about the bright future promised by such gadgets or such profoundly novel ways to bring man closer to some kind of "artificial intelligence". Already now, in High Tech shops you have departments of all sorts of body sensors for self-assessment. Why does this concern us in IC1004 ? For two main reasons: one is because the "smart environments" around which was built the IC1004 structure is the body and many issues still need be investigated about the radio channel, physical layer or networking schemes to make wireless links robust and efficient ; the second is because the near future of wireless connectivity is very much centered around 5G, which will go well beyond the classical cellular concept for mobile voice and internet to encompass "internet of things" needs. In a recent workshop "L'homme connecté" organized by URSI-France (see here for the program and freely available papers/presentations, partly in english), it was clearly expressed by Mischa Dohler, King's College (UK) and Marylin Arndt, Orange (FR) & ETSI M2M Chairperson) that proprietary/specific standards were still needed to fill a gap until ~2018-2020, after which later releases of LTE and 5G will take cover the connectivity needs for sensors and all kinds of smart or silly objects. There is a lot to do in 5G in order to be able to accommodate such different communications needs as ultra high data rate download towards high performance smartphones or very low data rate uplink connections between a very small device powered by a small battery or by an energy harvester. We are interested by both applications, requiring for the first sophisticated techniques and for the second clever manners to ensure efficiency and robustness together. We still have about 1 year to contribute to these efforts. Good work !

Alain Sibille

Chairman's Address

Dear Colleagues,

Our Action is ready to enter its final year term and, of course, this will be its most active and productive period.

One of the results what I am most proud of COST IC1004 is the continuous incoming of early stage researchers (ESR) to join the Action every meeting, like in our recent and successful event in Ferrara (Italy). These ESR are the future of the European Research and their participation to IC1004 assures the continuity of the Radio Communications COST Actions in the years to come.

At the time this newsletter is edited, we have started working on the edition of the final book of IC1004. I really welcome that many of the participants to our technical meetings have volunteered to edit a section of the book, which will make this result to be a real joint activity of our “Network of Knowledge”.

Of course we can’t compete with big EU projects, but somehow we can make a difference because of the bottom-up approach of COST, the group experienced people from both Academia and Industry that continues supporting the core of the Action and the high percentage of young researchers contributing to our technical meetings. With those fundamentals, COST IC1004 participants we feel we are writing part of the future of the radio communications technology.

Thank you once more to all those contributors to IC1004 for your commitment to our Action. Enjoy the reading !

Narcis Cardona

Highlights

The last Management Committee meeting of COST IC1004 took place in Ferrara, Italy, on February 5-7, 2014. Some "highlights" of what happened there are give below:

The 7 TDs presented in SWG1.1 covered several topics, including two on antenna pattern measurement and two on the newer topic of transmit-and-receive isolation. For the latter topic, Aalborg University designs dual-polarized base station antennas for full duplex communication based on two transmit antennas exactly canceling the transmit signal at the receive antenna for each polarization. On the other hand, Bristol University applies a hybrid coupler based electrical balanced duplexers to achieve high transmit-to-receive isolation over a large bandwidth. The goal is to replace the current solution of using multiple narrowband off-chip acoustic resonator duplexers, since the cost becomes very high with the many frequency bands to cover in LTE and beyond systems.

Among a number of contributions made at this meeting, a highlight is some work on interference alignment, which has been a continuing area of interest within the working group, with work from several researchers. At this meeting a contribution from Center for Communications Research (CRC) Canada presented a new and more realistically feasible scheme for channel state feedback, and evaluated it on a realistic channel model. The work also shows the limitations in practice of the concept of interference alignment.

In TWG-I, an initiative has been proposed to jointly work on indoor channel modeling and characterization for current and future indoor localization systems. To be addressed are various types of localization schemes, extending from the increasingly popular WLAN based fingerprinting, where there is a demand for comparability and quantification of performance metrics, to advanced active and passive UWB tracking schemes for future high-end applications. The planned initiative will develop, parameterize, and validate channel models that can support current developments in this field. Its goals include proper definitions of use cases and reference scenarios to allow for a systematic comparison, as well as the definition of an appropriate metric for their perceived “robustness”. As a first step, contributions are solicited for the upcoming meeting in Aalborg.

A Special Session has been devoted to the memory of Prof. Pertti Vainikainen:

Chairs: Narcis Cardona, Katsu Haneda

Selected topics:

- “A study on the relation between parameter based clusters and physical clusters”, Meifang Zhu, Lund, Katsuyuki Haneda, Aalto, Veli-Matti Kolmonen, Aalto, Fredrik Tufvesson, Lund
- “On the Reliability of Multipath Cluster Estimation in Realistic Channel Data Sets” Christian Schneider, Maysam Ibraheam, Stephan Häfner, Martin Käske, Matthias Hein and Reiner S. Thomä
- “UCL-Aalto Experimental channel characterization for vehicle-to-vehicle scenarios“ Claude Oestges, UCL, Olivier Renaudin, UCL
- “ Studying the Multi-Dispersive Characteristics of the Radio Channel - a Story of Collaboration and Friendship with Pertti Vainikainen “ ; Vittorio Degli-Esposti, CNIT/BO, Franco Fuschini, CNIT/BO, Doriana Guiducci, (FUB), Enrico M. Vitucci, CNIT/BO

Happy newcomers to IC1004 at Ferrara meeting

Selected scientific topic: "Communication in nano-scale via FRET", by Krzysztof Wojcik, Kamil Solarczyk and Pawel Kulakowski (TD(14)09073)

Nano-communication has gained significant attention in the last few years, as a means to establish information transfer between future nano-machines. Comparing with other communication techniques for nano-scale (calcium ions signalling, molecular or catalytic nanomotors, pheromones propagation, bacteria-based communication), the phenomenon called FRET (Förster Resonance Energy Transfer) offers significantly smaller propagation delays and high channel throughput. In this paper, we report our recent experiments on FRET-based nano-networks performed in the Laboratory of Cell Biophysics of the Jagiellonian University, Kraków. We construct a network built of nano-sensors (proteins: Immunoglobulin G) labeled with Alexa Fluor dyes working as nano-transmitters and nano-receivers. The used dyes are able to bind to the IgG proteins in large numbers and thus create MIMO-FRET communication channels, enhancing the FRET efficiency.

We measure FRET efficiency values and show that using multiple Alexa Fluor dyes significantly increases the probability of correct data transmission. Further, we provide calculations for a general case of MIMO (*n*,*m*) FRET channels. We prove that the efficient data transfer can be achieved even for the distances 3 times larger than when using a SISO FRET channel. We estimate that the throughput of the FRET communication channel can reach tens of Mbits/s.

The extended version of this paper has been submitted to IEEE Transactions on Nanotechnology.

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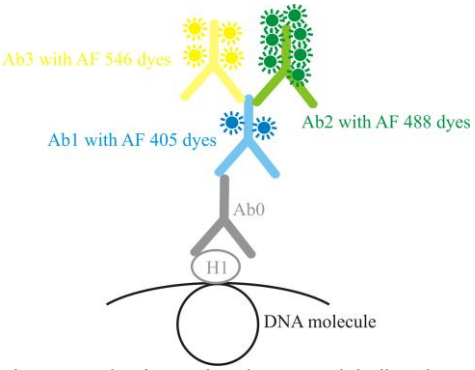

Fig. 1: The network of proteins (Immunoglobulin G) and Alexa Fluor dyes used in the experiments.

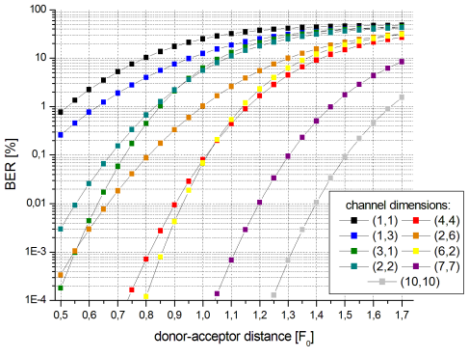

Fig. 2: BER values for MIMO (*n*,*m*) FRET channels.

Selected scientific topic: "Analyzing the disturbing effects of microwave probe on mm-wave antenna pattern measurements", by Ad Reniers, Rainier van Dommele, Mingda Huang and Matti Herben (TD(14)09001)

A nice property of the mm-wave frequency band is the large available bandwidth. For instance, around 60 GHz about 9 GHz can be used license free, enabling wide band applications like wireless-HDMI for HD video streaming. To assure a reliable radio link, several low and high gain 60 GHz antenna concepts were analyzed during the last decade with the aid of EM simulation software tools such as CST. For the simulations, an as simple as possible simulation model of the antenna is used to avoid an extreme long simulation time (Fig. 1a). This simple model, however, does not include the disturbing environment in which the antenna is measured (Fig. 2b, top). Because of that, large differences are generally observed between simulated and measured antenna patterns (Fig. 3, black and green line).

In this paper we investigate which nearby objects cause these discrepancies. Therefore, we added the antenna carrier and the microwave probe to the simulation model (Fig. 1b). From the analysis of the field distribution around the antenna under test with this more complex simulation model, we concluded that the antenna pattern was just slightly disturbed by the radiation of the probe tip and the presence of the antenna carrier. Conversely, the major disturbance is due to EM-wave diffraction and reflection at the very large probe body and holder, in comparison with the 60 GHz antenna (Fig. 2a1-2). This is also clearly visible in the far-field antenna pattern (Fig. 3, green line). To remove the latter major disturbing effect we propose to use a bent probe (Fig. 2a-b, bottom), resulting in a much better agreement between simulated and measured antenna patterns (Fig. 3, black and purple line).

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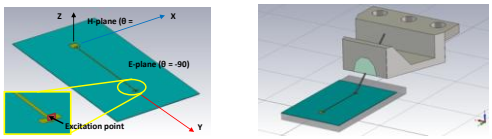

Fig. 1: (a) Simple simulation and, (b) complex simulation model

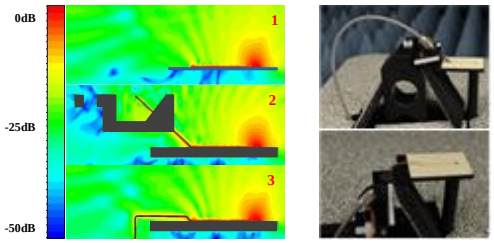

Fig. 2: (a) Simulation results of the field around the antenna: (1) antenna alone; (2) with classical probe; (3) with bent probe. (b) Setup with classical (top) and bent probe (bottom).

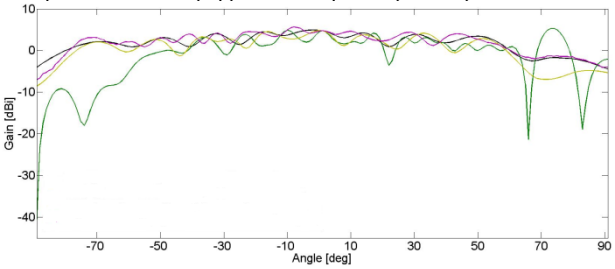

Fig. 3: Simulated radiation pattern: antenna alone (black), with classical probe (green), and with bent probe (light green). Measured radiation pattern: antenna with bent probe (purple).

Selected scientific topic: "A Cell Switch-Off Scheme based on Multiobjective Optimization", by David González G, Halim Yanikomeroglu, Mario García-Lozano and Silvia Ruiz (TD(14)09046).

The green communications paradigm has been receiving much attention in wireless networks in recent years. More specifically, in the context of cellular communications, the concept of **Cell Switch Off** (CSO) has been recognized as a promising approach to reduce the energy consumption because the major part of this expenditure takes place in base stations. The need is expected to be pressing in the next decade with the increasing small cell deployment.

This work introduces a novel framework to CSO based on **multiobjective evolutionary optimization**, which takes into account the well-known statistical behavior of traffic in both space and time (Fig. 1a) to make cell switch on/off decisions, thus minimizing the real-time complexity.

The exploitation of this statistical information is done by means of the tradeoff between the aggregate network capacity and the number of active cells (Fig. 1b). Clearly, more active cells imply a higher spectrum reuse but also higher energy consumption. To do this, a novel metric referred to as *weighted network capacity* has been introduced. This indicator prioritizes cells in which traffic is more likely to be concentrated, hence it results in CSO decisions that achieve substantial energy savings (Fig. 2) in scenarios where traffic is unbalanced, without compromising QoS.

The proposed framework distinguishes itself from the CSO papers in the literature in 3 ways: 1) the number of cell switch on/off transitions as well as handoffs are minimized, 2) the computationally-heavy part of the algorithm is executed offline, which makes the real-time implementation feasible, and 3) coverage aspects are taken into account.

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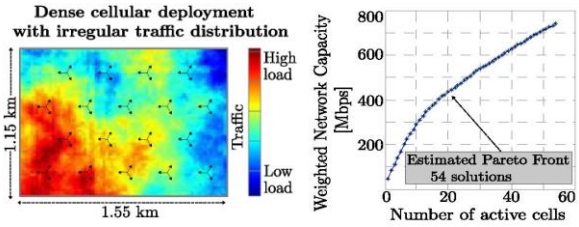
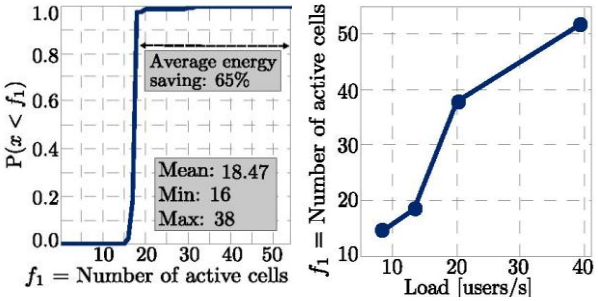


(a) Spatial traffic distribution (b) Estimated Pareto Front

Fig. 1. The proposed multiobjective scheme determines, for each spatial traffic distribution, a set of configurations in terms of active cells providing a **near-optimal tradeoff** between network capacity and number of active cells (energy consumption).



(a) Average energy saving (b) Energy saving vs. load

Fig. 2. **Performance of the proposed multiobjective CSO scheme**. (a) CDF of the number of active cells by selecting Pareto efficient configurations (Fig 1.b), system load = 13.33 users/s. (b) Average number of active cells (energy consumption) as a function of the system load.

Selected scientific topic: "A full wave indoor propagation model", by Conor Brennan and Ian Kavanagh (TD(14)09076)

The ability to accurately describe electromagnetic wave propagation underpins all wireless system development. In theory it is possible to generate highly accurate, so called full-wave, models by solving Maxwell's equations, but in practice this has been rarely done due to the associated computational costs. Instead, radio engineers have traditionally relied on approximate models such as ray tracing. Recently, however, progress has been made in developing such full-wave models for the cases of propagation over terrain and over rooftops in urban areas. A key observation is that such models are becoming possible not because of increased access to computing power, but rather through the development of sophisticated mathematical algorithms that can effectively compress the problems allowing them to be solved to high accuracy in a fraction of the run-time. Technical document TD(14)09076 outlined some preliminary work performed in developing such a full-wave algorithm for the case of 2D indoor propagation. The electric fields are described throughout the space using the Volume Electric Field Integral Equation. The Fast Fourier Transform (FFT) is used to speed up the computations and a novel pre-multiplication step is used to ensure that the iteration process only need solve for the unknown fields in the scattering structures (walls etc). Fields in free-space (in the rooms etc) can subsequently be computed in a simple post-processing step. Fig. 1 shows the power variation throughout a building structure while Fig. 2 shows the fields propagating through a wall with cavities. The extra field structure caused by the internal interactions is readily computed, something that would not be possible with traditional ray-tracing. In conclusion exact solution of Maxwell's equations is becoming feasible even for realistically sized propagation problems.

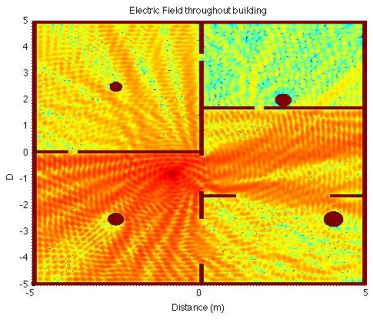


Fig. 1: Power throughout a 100 m^2 building environment comprising concrete walls along with several pillar structures. Source located at (-1,-1) and frequency is 1GHz.

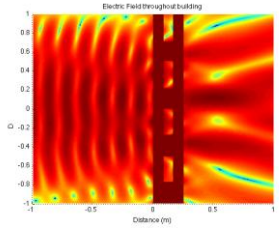


Fig. 2: Fields propagating through a wall with internal cavities. The field structure is significantly different from that obtained in the case of a solid wall and can be computed readily with this new model. Incident field is a tapered plane wave propagating from left to right.

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Interview: Gerhard Wunder, Fraunhofer Heinrich Hertz Institut Berlin

[IC1004]: 5G is the next major research challenge for wireless networks and it has motivated a new collaborative framework in the context of H2020, which is the 5G PPP having its first call at the end of this year. However, 5GNOW has started a year 1/2 ago and will end early 2015. Wasn't it too early ? How does it fit with the 5G PPP schedule ?

[Gerhard Wunder]: Well, I guess, project scope and, by the way also name of the project, could not have been better placed! It was always clear that with 5GNOW and the new air interface story would not end but rather just begin. Already in our proposal we said that our major goal is to initiate a study item by 2015. Given this the 5G PPP initiative by the EC is more that we could hope for.

[IC1004]: in a nutshell, what is 5GNOW supposed to achieve ?

[Gerhard Wunder]: 5GNOW will set a fundament for the air interface projects to come particularly in the 5GPPP, i.e. in terms of application requirements say for the Internet of Things and technical requirements such as fragmented spectrum , asynchronous access etc.

[IC1004]: non orthogonal signaling seems a very awkward approach, since we have learnt for many years that orthogonality was *the* proper way to ensure multiple access, let it be in the frequency, time or code domain. How come now you think better from non orthogonal waveforms ?

[Gerhard Wunder]: In fact non-orthogonal signaling is not awkward at all! Information theorists have known since decades that orthogonal multiple access is not optimal in terms of throughput performance. Moreover we see a considerable increase in asynchronous access as we have clearly outlined in the 5G special issue of the IEEE Communication Magazine February batch. In such situations, i.e. with high temporal and spectral fragmentation, orthogonal access techniques such as OFDM must break down.

[IC1004]: filter banks, which is one of your target schemes, is far from being novel. There have been many works on this idea and several European projects have tried it as a physical layer scheme for wireless access. What more can be done and why do you think it could be and adequate scheme for 5G ?

[Gerhard Wunder]: I think the past projects have done an incredible job and we strongly elaborate upon them! Furthermore some of the 5GNOW partners have been involved in the past. We outlined in the proposal that we need the knowledge and expertise from these projects to achieve our goals. Nevertheless, there is quite much to do: new ideas beyond the filter bank approaches came up often related to specific application requirements such as latency.

[IC1004]: same question for carrier aggregation, a concept already standardized in 4G. What techniques developed in 5GNOW will improve over the current ones ?

[Gerhard Wunder]: Carrier aggregation and fragmented spectrum is a key area in 5GNOW. Effectively, creating flexibly small frequency notches is possible only with new waveforms. Our investigations show that particular in narrowband applications, such as MTC, new waveforms save quite a few resources.

[IC1004]: usually, there is a large gap between what is promised by theory or even simulations for a new scheme and what is achieved in real life, given many detrimental effects occurring in practice. 5GNOW claims to address "robustness", in other words methods to ensure less disappointment. This seems ambitious, what do you really mean by robustness ?

[Gerhard Wunder]: Robustness is an umbrella theme around the physical layer core package and certainly a rich field for investigations in the future. I like your definition of robustness and would add that we want to design our algorithms in such a way that interference due to imperfect conditions is better controlled. We have presented good examples for this in our recent papers. By contrast, orthogonal access techniques actually fail in those operational conditions which they were not originally designed for.

[IC1004]: assuming the 5GNOW objectives are all reached, do you foresee perspectives and further research for the investigated techniques in terms of performance or capabilities, towards the ambitious 5G PPP goals ?

[Gerhard Wunder]: Yes I definitely do. As said we can only set a basis for the comprehensive air interface investigations in 5GPPP. If this is accomplished and endorsed by the stakeholders, we can say that we achieved what we wanted.

[IC1004]: Thank you!

Gerhard Wunder (Editor IEEE TWC) is currently with the *Fraunhofer Heinrich Hertz Institute Berlin*. He received his graduate degree in electrical engineering (with highest honors) and the PhD degree (Summa Cum Laude) from TU Berlin where he is also a Privatdozent. He is leading a research group on 5G related topics such as *new air interface* (www.5gnow.eu), *physical layer security* (www.ict-prophylaxe.de), *network information theory* and *energy efficiency* supported also by the German national research foundation (DFG). In 2011 Dr. Wunder received the 2011 award for outstanding scientific publication by the German communication engineering society. He is the author of the two recent articles in the IEEE Signal Processing Magazine, on the PAPR problem, and the IEEE Communication Magazine, 5G Special Issue, Feb. 2014.

Next Training School (open to anyone, see here for updated information): (Paris, France, April 15-17, 2014)

"SAR & EM exposure in wireless networks"

Organized jointly with the LEXNET Integrated Project

- Electromagnetic waves, wireless communications, risk perception
- Numerical dosimetry, mathematical and computer modeling, statistical aspects and evaluation of exposure
- Tools for the measurement of fields and of transmitted/received power for exposure determination,
- Dosimeter types and design, measurement protocols
- Wave propagation in relation with exposure. simulation tools and methods
- In situ field measurements. methods, standards, role of radio protocols and schemes, extrapolation
- SAR measurements, standards, role of radio protocols and schemes, test configurations, fast SAR
- Design of multi-antennas terminals and relation with exposure
- Network technologies and impact on exposure, antenna issues, discontinuous transmission issues
- Network architectures and impact on the management of exposure, Hetnet, offloading, SON
- Low EMF networks vs. green networks: incompatibilities and synergies
- EMF aspects in 5G wireless networks
- Visit of a testing lab unit and of an EMF simulation facility

Organizers: A. Sibille (Telecom ParisTech), Joe Wiart, (Orange)

Short course at Eucap 2014 (open to anyone, see here for updated information)

"Radio channels for cellular communications" (The Hague, Netherlands, April 11, 2014)

Organized jointly with the NEWCOM# Network of Excellence

Topics: channel characterisation, PHY layer, Flexible interfaces, IoT applications.

Organizers: Claude Oestges (UCL, Louvain, BE)
Thomas Kürner (T.U. Braunschweig, DE)

1. Introduction to beyond 4G communication networks
2. Challenges in radio network planning and optimization
3. Propagation models for small cells and femto cells
4. Multi-link channel sounding: techniques, challenges and experimental results
5. Reference and standardized 4G channel models

Registration: www.eucap2014.org/conference/short-courses

Next Management Committee meeting: the 10th MC meeting will take place in Aalborg, Denmark (26-28 May 2014).

11th Management Committee meeting: the 11th MC meeting will take place in Kraków, Poland (24-26 September 2014).

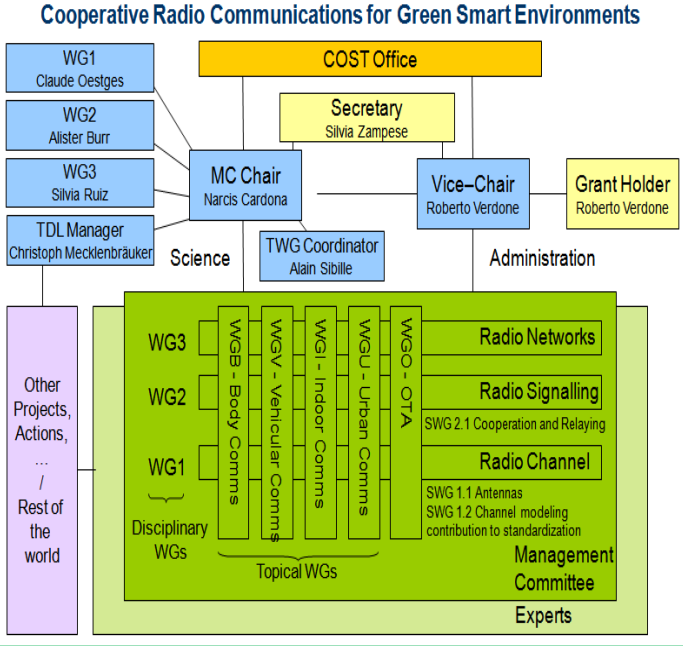
About COST IC1004

COST IC1004 is the Action on **"Cooperative Radio Communications for Green Smart Environments"**, belonging to the ICT Domain of the COST framework (see www.cost.eu). This Action addresses research issues in the field of cooperative radio communications to make our society cleaner, safer and more energy efficient. It started on January 2011 and will end on May 2015. Among many activities, 3 meetings and at least one training school are organized per year.

The Action goals are:

- to increase knowledge of cooperative communications applied to Green SEs (GSEs), by exploring and developing new methods, models, techniques, strategies and tools, in a context enriched by deep industry-academia links
- to play a supporting role to European industry through the focused interest of Working Groups
- to train young researchers in the field of cooperative radio communications for GSEs

The MoU and all information can be found at http://www.ic1004.org or by contacting the secretariat at secretary@ic1004.org



Facts & Figures

Number of signatory countries: **28**
Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom.

Number of COST International Partner Countries: **6**
Australia, Canada, China, Colombia, Japan, USA

Number of COST country entities (institutes, etc.) currently participating: **127**

Number of non-COST entities currently participating: **14**
(*including Montenegro as COST near neighbour country*)

Number of MC Members: **52** (+ Chair)

Number of registered experts: **551**

Number of meetings / year: **3**

Number of training schools / year: **≥1**

Number of completed STSM: **22**

Number of presented TD/workshop papers: **629**

Average number of participants / meeting: **120**