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NEWSLETTER

Cooperative Radio Communications for Green Smart Environments

Number 9, November 2014

Newsletter Editor: Alain Sibille, Telecom ParisTech, France

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

Editorial

Dear colleagues,

COST IC1004 has been structured around disciplinary working groups (the three "historical" WG, going back to the early COST Actions such as COST 207 paving the way to GSM) and a number of sub-working groups and topical working groups. The latter are mainly targeted towards smart environments applications and encompass channels, transmission/coding schemes, resource allocation and higher layer aspects relevant for these environments. In total this amounts to 11 activities, of which it was not obvious at the beginning how far they would go.

The good new, after 11 successive meetings, is that all these groups *are* active, i.e. produce at a more or less regular pace results and technical documents (TD) that are the subject of presentations and discussions. In other words, the original topics and research areas (defined more than 4 years ago) maintain focused interest by the wide community of COST IC1004 members. This is a kind of success and also an encouragement to pursue the momentum gained by the COST Actions success story.

Another encouragement comes from the strong IC1004 involvement in the organization of scientific conferences, workshops, special sessions and other events of that type. This demonstrates the degree of networking achieved by the Action.

In the present NL, beyond the selection of 4 TDs discussed at the last meeting, we have special highlights on vehicular technologies and an interview of Prof. Tad Matsumoto (TokyoTech & University of Oulu) on coding, explaining that this now "old" subject is still quite vivid with novel routes opening for more efficient of reliable for wireless networks.

Alain Sibille

Chairman's Address

Dear Reader,

Welcome back to our Newsletter. As you will discover in these pages, IC1004 keeps working on front-end topics in wireless communications, but our Action is already summarising its results of the last 4 years in a concluding final book which is already in progress and that we expect to deliver right after the closing of the Action period, by summer 2015. This final report will be a compilation of what we have jointly concluded about the evolving world of wireless communications scenarios, and will summarise the contribution to IC1004 of hundreds of researchers in our network. Indeed, COST actions stand to be frameworks for scientific networking, and some of their results come to be references for further research, in occasions also for regulatory and standardisation bodies. Anyway, COST has no commercial interests, as the research issues discussed in our Actions come from other funding sources, and are a volunteer provision of scientific and technical results of every partner, got in their own fund projects. And, as I mentioned many times, this “non-profit” focus of COST is a key to success for many of the actions like IC1004, from which scenarios, methods and models are taken as references of a common understanding on science and technology matters.

I can’t find a specific word to describe these open outcomes of COST actions, including not only huge amount of written material, published and internal, but also a lot of institutional networking, many individual professional relationships, plus a bit of scientific strategy coordination, ...just call it “COSTware”, and invest in it.

Enjoy reading this 9th issue of our Newsletter!

Narcis Cardona

Highlights

WG2 discussed work required on the physical layer of 5G systems, including the design of the physical layer for mm-wave systems, massive MIMO, air-interfaces beyond OFDM, and new network architectures, especially for what we have called the "network-aware PHY". We propose to devote a session to discussing these issues in Dublin, with a view to what might be included in a successor Action to IC1004.

WG3 members discussed nine contributions in three separate sessions. Most of the contributions proposing improvements in LTE networks, as new algorithms to implement Carrier Aggregation, new resource allocation schemes, user-control plane separation advantages, efficient ways to obtain sounding reference signals, etc. An increasing interest in modelling Virtual Radio Resource Management is observed. WG3 members are considering the organisation of a training school in April 2015, being the topics cooperation and virtualization in future networks.

In TWG-I, eigth papers were presented in two sessions. The first session was focused on mm-Wave and UWB propagation channel studies, with contributions in cross-polarization analysis and angular spread of multipath components, both for mmWave channels, a comparison of channel parameters at 2.9 and 29 GHz in a large-scale indoor office environment with cubicles, and a propagation prediction study employing a simplified point cloud model of a room (at UWB frequencies). The second session comprised four papers on indoor localization, including two works on passive localization of persons based on multi-static measurements, one work on phase-based tracking of an agent, employing only 40 MHz signals but a multi-antenna base station, and one work analyzing UWB-backscatter-based localization and the gain of a multistatic setup.

Special focus on TWGV Topical Working Group on Vehicular technologies

The topics covered in the vehicular working group in Krakow covered various research interests. These included vehicle-to-vehicle radio channel assessments, in-car channel models, channel measurements for high speed trains, SNR modeling for vehicle-to-infrastructure communication and vehicular 3D antennas systems. This newsletter contribution gives an overview of two of the aforementioned research interests.

The contribution on 3D vehicular antenna systems ('System-Level Assessment of Volumetric 3D Vehicular MIMO Antenna Based on Measurement' TD(14)11011 by Posselt et al.) evaluated a volumetric multi-element antenna for vehicular connectivity based on a system-level approach. In order to assess the performance gain of a 3D antenna design compared to 2D antennas, a reference antenna system was developed.

Figure 1: Analyzed 3D antenna and reference system.

By using system level parameters like the condition number and the mutual information of the channel, it was shown that an improved performance of the volumetric conformal multiband antenna was yielded compared to the single band reference antenna. This was found to be resulting from better utilizing the available antenna integration volume allowing a lower mismatch and higher antenna gain as well as isolation.

Another contribution ('In-vehicle mm-Wave Channel Model and Measurement' TD(14)11012 by Blumenstein et al.) presented during the working group dealt with wideband radio channel measurements carried out in the intra–vehicle environment. The channels were measured in the millimeter-wave (MMW) frequency band (55–65 GHz) using open-ended rectangular waveguides.

Figure 2: Antenna position of the RX (red) and TX (blue) in the vehicle and the measurement setup.

The authors presented a channel modeling approach assuming that spatially specific Channel Impulse Responses (CIRs) are decomposed into large and small scale fading using a Hodrick-Prescott filter. The large scale fading was simulated with a two-dimensional polynomial curve while the log-Weibull-distributed random process was used for small scale fading.

TWGV chairs were again very glad that such diverse research interests were discussed. A forthcoming highlight of the working group, that the chairs are looking forward to, is the training school hold in conjunction with the forthcoming COST IC 1004 meeting in Dublin. In this workshop special focus will be paid on the assessment of vehicular communication systems.

Interview: Tad Matsumoto, Professor, Japan Advanced Institute of Science and Technology, Japan, and an appointed part-time professor at Center for Wireless Communications, University of Oulu, Finland

[IC1004]: Coding is an "old" subject, going back to the Shannon time. However, over all these years, it seems the scientific community and the specialists have been very active and have very much renewed the domain at regular intervals. Up to what extent do you think existing wireless networks could do without these efforts? (e.g., are turbo codes, LDPC, that much vital?)

[Tad Matsumoto]: In the systems where a 0.1 dB point-to-point signal-to-noise power ratio (SNR) improvement yields millions of dollars such as, for example, deep space communications, limit-achieving code design may still be a core issue of research. However, especially, in mobile wireless communications research communities, including COST IC 1004, is seeking for a 0.1 dB reduction in required point-to-point SNR meaningful? Obviously **no**! Instead, it is obviously much more meaningful to seek for the techniques that can achieve energy- and spectrum-efficiencies close to the network level limit than the (point-to-point) link level limit. This does not mean that the use of the powerful codes such as turbo and LDPC codes is meaningless; we could, of course, use such codes, but when we see the issues from the network design perspective, it is not necessarily to use capacity-achieving powerful component codes for signal transmission over the point-to-point links in the network. The most crucial point which we should recognize is that the information sequences received at the destination via multiple parallel routes are correlated, even though they may contain error(s), because they are all transmitted from the same source; if we can exploit the correlation knowledge at the destination in the decoding process, still there is a possibility that we can retrieve the information transmitted from the source.

[IC1004]: Can you tell us a bit about the philosophy of the RESCUE project in which you are involved and that targets a better resilience of wireless networks, of particular importance for disaster situations?

[Tad Matsumoto]: The EU FP7 Project RESCUE stands for "Links-on-the-fly Technology for Robust, Efficient and Smart Communication in Unpredictable Environments. The project has targets: creating new broadband wireless communication network concepts (1) that perform *beyond-point-to-point Shannon-limit* and *close to the network-level limits* of energy and spectrum efficiencies, and (2) that enhance robustness and flexibility against unpredictable network topology changes. The RESCUE project is motivated by the Japanese experience of huge disaster due to the massive earthquake on March 11, 2011, followed by a series of unprecedented level of Tsunami that caused the Fukushima nuclear power plant devastation. The necessity for creating robust, flexible, and "always-connectable" networks has been recognized since then. Such networks include not only public communications systems but also sensor networks having a lot of sensing nodes located in a huge pile of wrecks in the devastated plant, and vehicle-to-vehicle, machine-to-machine, and device-to-device communications systems.

[IC1004]: In this project, you explain that "the network is the code". This seems somewhat obscure. Can you explain in one or two sentences what this means?

[Tad Matsumoto]: The decode-and-forward (DF) protocol has presently been considered for years as one of the most practical cooperative communications techniques, because of its simplicity; it does not require the channel state information of the previous hop section to be forwarded to the following sections. Conventional DF systems stop forwarding the information sequence, if the decoder of a forwarding nodes detects error(s). However, as noted above, the information sequences received via the multiple routes are, if they are forwarded to the destination, highly correlated, although they may contain error(s). The RESCUE project refers the technique to as "lossy-forwarding". With the lossy-forwarding technique, it is quite likely that we can preserve multiple communication routes in the network having super-densely populated nodes, hence it is not necessary to use capacity-achieving powerful error correcting code for signal transmission between the nodes. In other words, the network utilizing lossy-forwarding technique is, as a whole, an error correcting code where the redundant part is located not only in the time domain but also over the network. From the viewpoint of Network Information Theory, designing a network with lossy-forwarding can be categorized as a problem of "source coding with helper(s)". With the concept of lossy-forwarding, the network can attain the robustness and flexibility against the network topology change, where the knowledge of the correlation between the received erroneous sequences can be estimated only by the destination.

[IC1004]: is there any relation with "network coding"? This relatively recent way to process data between a source and a sink involving relays intends to be more efficient than for independent P2P routes, is that so different from the RESCUE approach?

[Tad Matsumoto]: In principle, the lossy-forwarding concept is different from network coding techniques, but they can easily be combined. This means that the lossy-forwarding concept can be applied not only to the network with parallel routes; there are a lot of possibilities to apply the concept, with the aim of achieving network-level energy- and spectrum efficiency limits. For example, assume that there are multiple sources and one relay nodes. The relay node performs network coding even though the relay detects error(s) in the information sequence(s) from the source(s). Design of such network can be viewed as a problem of Slepian-Wolf source coding with helper(s).

[IC1004]: it seems complicated to design codes that operate at PHY, MAC and even at routing levels together. Don't you think the practical implementation of such codes in practical networks will be hard to achieve? How far could they come into existing (3G, 4G) or future (5G and beyond) networks?

[Tad Matsumoto]: Well, this is a difficult question to answer, because employment of new technologies requires agreement of the industry, which takes quite long a time. RESCUE is planning to conduct a demonstration at the final stage of the project.

[IC1004]: Thank you!

Tad Matsumoto is currently serving as a professor at Japan Advanced Institute of Science and Technology (JAIST), Japan and also serving as an appointed part-time professor at University of Oulu, Finland. He received his Ph.D. degree from Keio University, Yokohama, Japan, in 1991, in electrical engineering. He worked at NTT DoCoMo until 2012. His research interest covers turbo equalization, iterative detection, code design for distributed systems, distributed coding. Currently, he is working on the establishment of unified techniques for the design and analysis of lossy-forwarding wireless cooperative networks based on the theorem of multiuser source coding with a helper in Network Information Theory.

Selected scientific topic: " An IC1004 Perspective on Future Wireless Body Scenarios" by Narcis Cardona (TD(14)11051)

The Wireless Body Environment Networks (WBEN) is one of the topics which are attracting more interest in IC1004 and its future activities. Body communications are evolving from centric approach to networking topologies, meaning that all the current devices used in Wireless Body Area Communications will be potential nodes of new Body Environment Networks, extending their role of centrally coordinated sensors or user terminal peripherals to one including new functions to create the equivalent of a Moving Network. This paves the way to remote health monitoring but, is the mobile terminal centric approach the only or most appropriate architecture for BANs? The wearable and implanted devices could in the near future relay each other to create Wireless Body Environment Networks (WBENs). In addition WBENs could sense the environment around the human body, and permit the interaction to elements in the proximity of the body, enabling the exchange of health and other data in real-time. IC1004 Action is working on WBEN scenarios, mainly but not only on the radio channel aspects on human body, tackling some of the challenges of the design of the implanted and wearable devices, like power limitation, energy consumption, protocols design, transmission schemes, coding, propagation and antennas. TD(14)11051 presents a view on future Body Area Networks and the open research challenges around this topic.

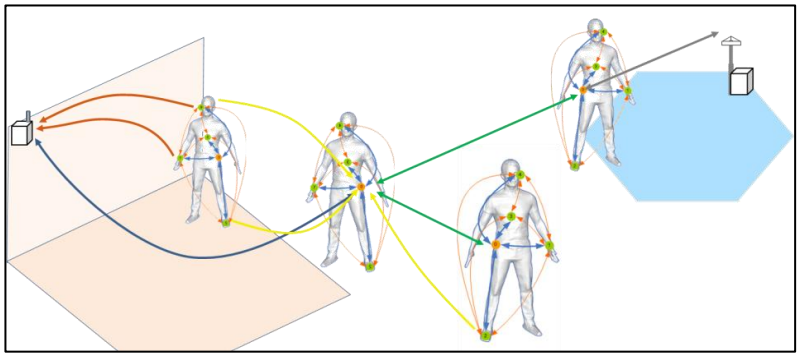


Figure: The set of diverse radio links in future WBENs. Cian: Sensors (nodes) to BAN coordinator, orange: node to node, green: relay between BANs, grey: BAN coordinator to cellular, blue: BAN coordinator to infrastructure, red: sensing node to infrastructure.

For more details please contact: ncardona@iteam.upv.es

Selected scientific topic: "Tracking and positioning using phase information of multi-path components from measured radio channels", by Meifang Zhu, Joao Vieira, Yubin Kuang, Andreas F. Molisch, and Fredrik Tufvesson (TD(14)11037)

Radio based positioning and tracking is a research area that has attracted a lot of attention during the past decades. Positioning is often seen as a key enabler for new cellular services and can also be used to enhance network performance. Global Navigation Satellite Systems such as the Global Positioning Systems (GPS) provide location information around the globe through the reception of radio signals from satellites. However, the accuracy of GPS is limited and the GPS system does not work properly in shadowed areas, such as inside buildings. Therefore, there has been extensive research in developing new positioning techniques to enable ubiquitous positioning solutions with accuracies down to meters or centimeters.

In this work we track user movements with accuracy down to centimeters using standard cellular bandwidths of 20-40 MHz. The goal is achieved by tracking phase information of the multi-path components (MPCs) from the radio channels. First, an extended Kalman filter is implemented to estimate and track the phase of the MPCs, see Fig. 1. Each of the tracked MPCs can be viewed as originating from a virtual transmitter at an unknown position. By using a time difference of arrival positioning algorithm based on a structure-of-motion approach, and translating the tracked phase information into propagation distances, the relative user movements can be estimated with a standard deviation of the error of 4.0 cm, see Fig. 2. The work should be viewed as a proof-of-principle where it is shown that phase based positioning can be a promising solution for movement tracking in cellular systems with extraordinary accuracy.

For more details please contact: Fredrik.Tufvesson@eit.lth.se

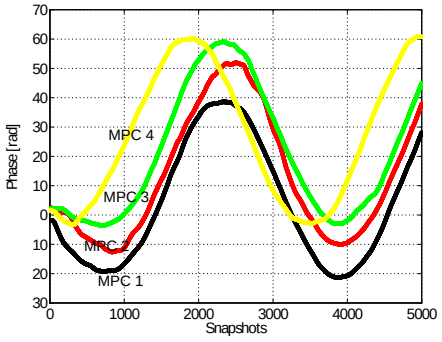


Fig. 1: Tracked phases of four MPCs, estimated from measurements, for a circular movement.

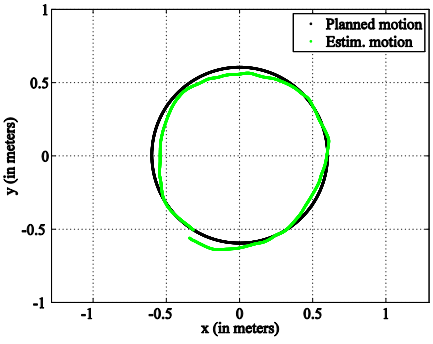
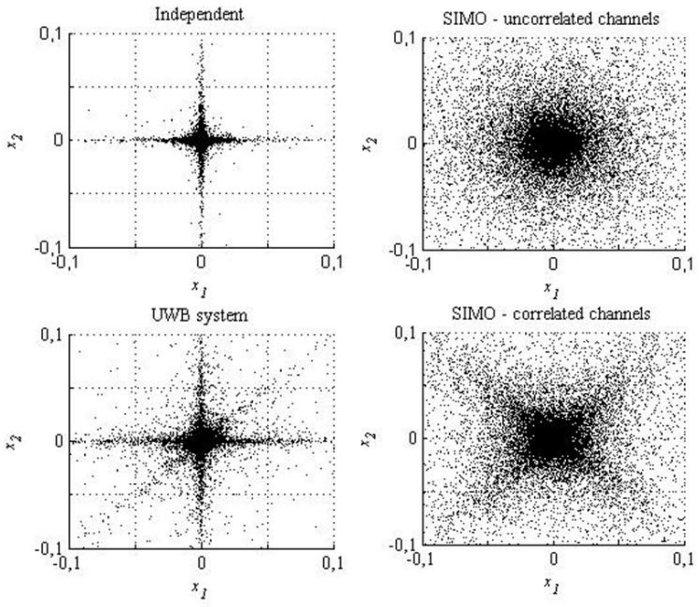


Fig. 2: Tracked positions for the circular movement.

Selected scientific topic: " Skew-t copula for dependence modelling of impulsive interference", by X. Yan, L. Clavier, I. Nevat, G.W. Peters, F. Septier (TD(14)11039)

Impulsive interference is a strong limitation in wireless communications. Most of the works rely on the assumption of independent interference samples (Fig. on the top left, x_1 and x_2 are two interference samples). This is in many situations an unrealistic assumption. We propose to model the dependence structure using natural extensions to existing interference models based on parameter copula models. They can be informally defined as follows: consider random vector $X \in R^d$ with continuous distribution F. Then to every X one can associate a d-copula C: $[0,1]^d \rightarrow [0,1]$, defined by $F(X_1,\ldots,X_d)=C(F_1(X_1),\ldots,F_d(X_d))$ where F_i is the marginal distribution of X_i (Sklar's theorem).

We focus on a particular flexible class of models based on the skewed-t copula family. They allow one to capture interesting dependence features based on extremal concordance such as tail dependence. Some examples of dependent samples are shown on the different graphs: bottom left, interference on two bit repetitions of an UWB systems, on the right, interference on two different antennas in a SIMO case; in the top both symbols are uncorrelated when a correlation exist in the bottom figure. The three examples are significantly different from the independent case which shows the importance to take it into account.



For more details please contact: laurent.clavier@telecom-lille.fr

Selected scientific topic: "Quasi-Deterministic Approach to MmWave Channel Modeling in the FP7 MiWEBA Project", by Alexander Maltsev, Andrey Pudeyev, Ingolf Karls, Ilya Bolotin, Gregory Morozov, Wilhelm Keusgen, Richard J. Weiler, Michael Peter, Maxim Danchenko, Artyom Kuznetsov (TD(14)11065)

There is increasing interest in using mmWave bands for next generation mobile wireless networks. The development of new communication systems and standards requires adequate mmWave channel models applicable to multiple usage cases and a wide frequency range from 30 GHz up to 90 GHz. However, although various measurement campaigns have been carried out, only a few modeling attempts are available.

(a) (b)

Fig. 1: (a) Street canyon measurement environment. (b) University campus measurement environment.

In this work we propose a new quasi-deterministic (Q-D) approach for modeling outdoor and indoor mmWave channels. The Q-D modeling methodology is based on the representation of the channel impulse response as superposition of a few quasi-deterministic strong rays (D-rays) and a number of relatively weak random rays (R-rays) and flashing rays (F-rays). D-rays can e.g. be related to the direct and the ground-reflected ray (see Fig. 2). In the model they are explicitly calculated from geometry. R-rays and F-rays are attributed to faraway or moving ("flashing") reflectors and defined by random variables. Following this methodology, models for open area (university campus), street canyon and hotel lobby scenarios have been developed. They have been verified and parameterized by two independent 60 GHz channel measurement campaigns. The explicit introduction of deterministic and random rays enables to model real dynamic outdoor environments, taking into account mobility and blockage effects. Moreover, the versatility of the Q-D methodology allows extending the developed model to other usage cases with the same environment geometries like device to device (D2D) and street-level backhaul links.

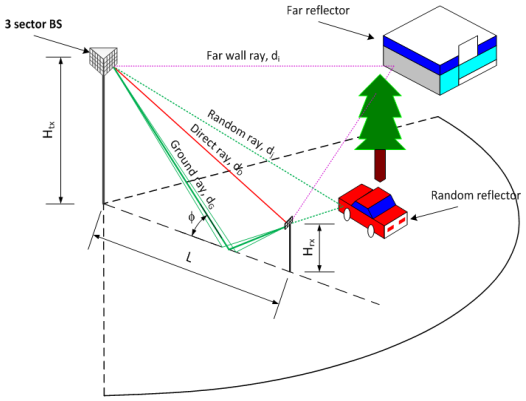


Fig. 2: Illustration of rays (propagation paths) for open area scenario, D-rays: direct ray and ground gray, R-rays: random ray from car and far wall ray.

For more details please contact: alexander.maltsev@intel.com

Next Management Committee meeting: the 12th MC meeting will take place in Dublin, Ireland (28-30 January 2015).

Local Organiser: Conor Brennan (Dublin City University)

13th Management Committee meeting: the 13th MC meeting (final meeting) will take place in Valencia, Spain; and is tentatively planned on May 5-8, 2015.

Training workshop: "Methods and Metrics for Measuring Vehicular Communication Performance":

Dublin, January 26-27 (1 ½ days), prior to the 12th MCM.

Organizers: Levent Ekiz,

Erik Strom

Objective: to explore the pros and cons of different options for assessing performance of V2X communication, with emphasis on antenna systems

Scope: cellular, Wi-Fi, and 802.11p (ITS-G5) are in scope.

After attending the training school the attendees should be able to make an informed choice on what methods and metrics are preferable for the application at hand

The workshop is open to anyone. See here for updated information.

ICC 2015 workshop: "Dependable Vehicular Communications (DVC)", 8 *or* 12 June 2015, London

Organizers: Thomas Zemen (primary contact), Jerome Härri, Christoph Mecklenbräuker, Claude Oestges, Stefan Rührup, Christoph Sommer, Erik Ström, Fredrik Tufvesson

The goal of the workshop is to solicit the development of dependable vehicular communication systems. This workshop will bring together academic and industrial researchers to identify and discuss technical challenges and recent results related to dependable vehicular communications.

This Workshop is organized in part by the European COST Action IC1004, and by the European Network of Excellence NEWCOM#.

ICC 2015 workshop: "Advances in Network Localization and Navigation (ANLN)", 8 *or* 12 June 2015, London

Organizers: Klaus Witrisal (primary contact), Davide Dardari, Andrea Conti, Bernard Fleury, Alberto Rabbachin

The goal of the workshop is to solicit the development of new positioning algorithms based on short-range wireless communications as well as new position-aware procedures to enhance the efficiency of communication networks.

This workshop will bring together academic and industrial researchers to identify and discuss technical challenges and recent results related to short-range positioning.

This workshop is organized in part by the EU Network of Excellence NEWCOM#, the EU COST Action 1004, the Italian National Project GRETA, and the Austrian National Research Network SISE.

ISSSE 2015

The ISSSE (International Symposium on Signals, Systems and Electronics) has been held every three years and has been organized under the sponsorship of URSI Commission C (Radiocommunication Systems and Signal Processing) and D (Electronics and Photonics) and has included aspects of URSI Commission B (Fields and Waves). In 2015 ISSSE will be held as part of the AT-RASC Conference. The newly established triennial URSI Atlantic Radio Science Conference (URSI AT-RASC) is the 3rd URSI flagship conference in addition to the triennial URSI General Assembly and Scientific Symposium and the triennial AP-RASC conference (AsiaPacific Radio Science Conference). AT-RASC 2015 will be held 18 (Monday) - 22 (Friday) May 2015 at the ExpoMeloneras Convention Centre, in Gran Canaria, Spain.

ISSSE sessions will be held 19 (Tuesday) - 21 (Thursday) May 2015 unless the number of submitted papers necessitates some rescheduling to Monday or Friday. Papers will be welcomed on a wide range of subject areas (see below). Paper submission will be through the AT-RASC portal and will adhere to the AT-RASC deadlines and rules and benefits (eg the student paper competition).

ISSSE delegates are being offered a reduced three day registration price.

See updated information here.

About 50 conferences/courses/events are organized with COST IC1004 involved in in the committees ; they are announced at: http://www.ic1004.org/index.php?page=announcements

Obituary

Michał Maćkowiak was a Pole that felt in love for Lisbon and Portugal, by chance. In 2006, while taking the M.Sc. on Electronics and Information Technology Engineering, at the Warsaw University of Technology, he ended up being the last one to choose a place for doing the thesis within the ERASMUS exchange programme, and the only place left was IST - Lisbon, so he decided to take the risk and to spend a few months in our research group. This was the beginning of a new stage in his life, which ended tragically on Aug. 8th, 2014, when he and his wife Hanna felt from a cliff nearby Lisbon. After graduating from the M.Sc., Michał accepted my invitation to do the Ph.D. in our group, which he accomplished in July 2013, with a thesis in propagation and channels in Body Area Networks. After graduating, he kept working in our group, in projects within the European framework. He was very pro-active in exploring new ideas and concepts, and he did make a few breakthroughs in his area of work, like the statistical analysis of off-body channels including antennas behaviour, and the analysis of the influence of body dynamics. He had already quite a track record as a researcher, but his life was not only about research and family (he was married and had two children). He was also very keen on photography, which we could consider to be his "professional hobby" (many of you may remember him taking photos at the COST IC1004 meetings), besides having an entrepreneur spirit as well. More than a former student, Michał was a colleague and a friend. I'll really miss him.

Luis M. Correia, IST Lisbon, Portugal.

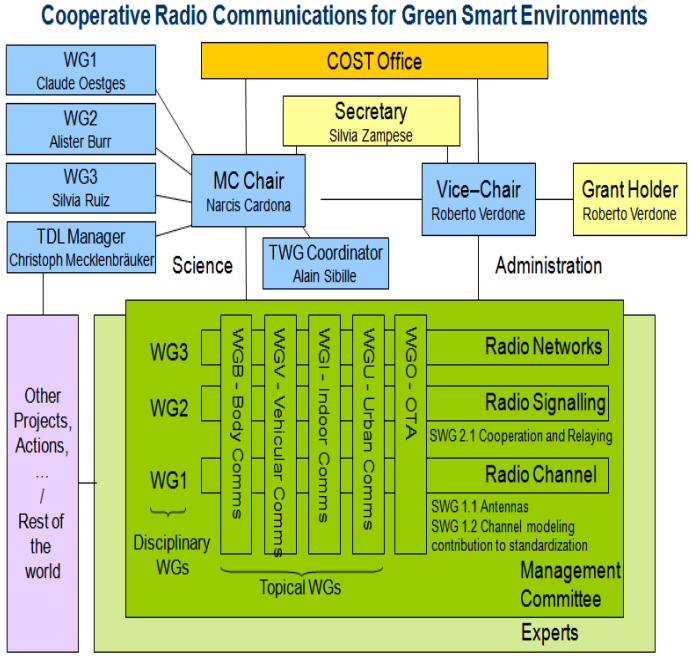
About COST IC1004

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: **29**
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: **133**

Number of non-COST entities currently participating: **17 + 3**
(*including Montenegro as COST near neighbour country*)

Number of MC Members: **54** (+ Chair)

Number of registered experts: > **600**

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**