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NEWSLETTER

Cooperative Radio Communications for Green Smart Environments

Number 8, June 2014

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Editorial

Dear colleagues,

IC1004 is still very active, I would nearly say "incredibly". My personal entering of this COST success story of continued Actions goes back to 2001 with the kickoff of COST 273. Since then, the extreme regularity of the networking efficiency and the effectiveness of bringing together researchers from academia and industry has been maintained. This was done "in spite" of new blood regularly coming to us, i.e. very few in proportion of the COST members 15 years ago are still present, replaced by even more newcomers (see photos in the previous issues of this NL !). The May 2014 meeting in Aalborg attracted even more participants than usual, it included an open workshop. This is just an example of the activities performed, a summary for the past year being presented in the following highlights of this NL, based on the report to the annual COST conference in Slovakia, April 2014.

But let's go back to scientific aspects. The strength of IC1004 is basically to cover the lower layers of wireless systems, i.e. from antennas/channels to resource allocation, networking and related architectural aspects. This is very broad, but it is nowadays a very strong necessity to design these layers jointly and often to break the traditional layer segmentation between layers to achieve better optimization and resource efficiency. With the great complexity of nowadays wireless systems (multi-antennas, many bands, multi-layer network architectures...), this gets both very tricky and very promising.

The demonstration of the essential and growing role of wireless technologies in world economy is the recent study of spectrum policy in France, advocating the appointment of a "spectrum commissioner" for Europe.

When you put all these issues together, you come out with the strong feeling that our job as researcher in this area and as COST Action participant is far from over !

Alain Sibille

Chairman's Address

Dear Reader,

COST is a veteran instrument in the European Research Area, established in 1971 and nowadays in its transition to the new framework of H2020. On September 2013 the COST Association was created, to assure continuity of activities and to facilitate the transition to H2020, after an extensive internal and external consultation process expected to finalise by November 2014.

What is new in COST H2020? In my view not that much, which for us the enthusiasts of COST Actions means more good than bad news. These are good news because one of the most effective instruments in FP6 and FP7 remains working for 7 years more, and all its goodwill keeps in the pillar aspects of COST: bottom-up approach, inclusiveness, participants driven, not constricted to priorities, gender and geopolitical balance, among others. Also we started hearing about COST Actions as "networks", something that was obvious from the results got in FP7 and from the fact that many COST Actions groups keep cooperating in follow-up activities, within COST or in other European Research programs. Something new in the current description of COST is that industries and SMEs are expected to play an important role in the Actions, like it is happening in IC1004, as the necessary link between the Academia new ideas and the practical applications to market.

What is missing? In my opinion COST in H2020 should establish formal ways to cooperate to projects. The relationship between projects and COST Actions is made only by participants, with few agreements established between some projects and actions, but with low intensity, with no eligible activities in the projects and no specific budget in COST as well. If H2020 facilitates the formal liaisons from projects to COST, this would materialise something that COST is reaching but projects don't: capture fresh ideas coming from new research teams.

Welcome to COST H2020!!

Narcis Cardona

Highlights (1)

The latest (10th) Management Committee meeting of COST IC1004 took place in Aalborg, Denmark, on May 26-28, 2014. It was quite successful with as many as 95 temporary documents presented. Some of the issues discussed and Action progress are indicated below.

WG2 discussed priorities for the coming year, the last of the Action. One proposal, which was accepted, was to include the priority "Waveforms for 5G", to encourage work on new physical layers in fifth generation mobile communications and networks.

The 10 TDs presented in WG3 covered several topics being six of them addressed to the proposal and analysis of new techniques to improve network efficiency in terms of power consumption or use of the spectrum. Algorithms extracting the User Social Pattern from real traffic traces, implementing learning games in HetNets, demonstrating the advantages of a statistic-based cooperative spectrum sensing in real sensor networks, defining the rules for cooperative relay selection and power allocation in spectrum sharing networks or addressing the mobility and handover in future 5G scenarios, have been deeply analysed and discussed at the technical sessions.

The technical contributions to TWG-I comprised an invited presentation from the FP7 project EVARILLOS, which deals with the evaluation of indoor localization systems in presence of interferences. This presentation has been invited due to its relevance for the recently started initiative on indoor channel modeling for localization. Indeed the approach followed by IC1004 members is nicely complementary to the experimental approach followed in this project. A clear interest has thus been indicated by both parties to start joint work. The Aalborg meeting has also seen TDs from Rennes and Aalborg that contribute directly to this initiative.

A record-breaking 12 TDs were presented in SWG1.1. It was especially interesting to hear Tim Brown (University of Surrey, UK) talking about the feasibility of using an ultrawideband (UWB) antenna array for egg counting in a fridge, in the context of Internet-of-Things. Another notable feature is that a number of the TDs showed further results that directly addressed the feedback received from the previous COST meeting in Ferrara.

At the WGV sessions, a proposal was made by the co-chairs that the WG should organize a workshop / training school focusing on testing the communication performance of vehicles with potential emphasize on antenna systems. The goal is to collect and discuss ideas ranging from simulated environments to very controlled OTA measurements. During the workshop / training school different OEM measurement setups shall be analyzed and discussed. The results of the event are considered to be published as, for instance, a white paper on recommended methods. The proposal was received favorably by the attendees, and it is currently planned to have the event on Tuesday the 27th of January in Dublin, thus one day prior to the COST IC 1004 meeting in Dublin (28.01.15 -30.01.15). Depending on the final scope and interest the event might even start on Monday January 26.

The 10th MCM was also the opportunity to organize an open workshop on Wednesday 28 May, mixing contributions from IC1004 members and researchers outside the Action. The program is shown below:

11:00

- ✓ General overview of investigated methods and Status of CTIA work on OTA (Istvan Szini, Motorola)
 - The 2-Stage OTA testing approach
 - Reverberation Chamber based OTA testing
 - Decomposition Testing Approach
 - Multi-Probe Anechoic Room Testing
- ✓ Multi-Probe Anechoic Room Testing, Overview and recent results (Wei Fan, AAU)
- ✓ TD(14) 0095 The 2-Stage OTA testing approach and status (Janus Faaborg, Agilent)
- ✓ The Reverberation Chamber testing, Overview and recent results" (Robert Rehammar, Bluetest)

13:30

- ✓ Future testing capabilities of an AC-OTA setup (Pekka Kyosti, Anite)
- ✓ TD(14)10060: "MIMO OTA Propagation Environments and Impact on Antenna Design" (Boyan Yanakiev, IMC)
- ✓ TD(14)10086: "Measurement campaign on AC MC Boundary Array, comparing B13 devices in different mechanical modes and test methodologies", (Istvan Szini, Motorola)
- ✓ TD(14)10090: "Proposal for improving TRP/TRS testing time" (Thomas Bolin, Sony Mobile)
- ✓ TD(14)10029 " Experiments and Analysis of Measurement Uncertainty of an Over-the-Air Multi-Probe Setup for Cars at 5.9 GHz ", (Mikael, Nilsson, Lund/VCC)
- ✓ TD(14)10045 "Wideband MIMO Channel Capacity Analysis in Multi-probe Anechoic Chamber Setups", (Jesper Ødum Nielsen, AAU)

Highlights (2)

The [sixth Training School](#) organized by COST IC1004 together with the FP7 Integrated project [LEXNET](#) on "SAR & EM exposure in wireless networks" took place between 15 and 17 April 2014 at Telecom ParisTech, France with 26 attendees, mostly Ph. D. students/ESR from 10 COST Member States. 15 trainers have delivered lectures, wholly or jointly, and animated discussions with the audience, on the various topics during the three days. Most attendees were present over the 3 days of the TS. The overall organization allowed periods of debates on the various TS topics. The first day addressed fundamental aspects of exposure to electromagnetic fields (EMF), such as numerical dosimetry, mathematical and computer modeling, statistical aspects and evaluation of exposure. This lecture was given in part by the coordinator of the Lexnet FP7 project (J. Wiart), who co-organized the TS with IC1004 (A. Sibille). The second and third lectures addressed the measurement of fields, either from the point of view of experimental protocols and standardized methods or in terms of measuring tools, such as instrumental or personal dosimeters. Another one gave some preliminary insights on EMF exposure in the context of networks and on communications technologies in this context. The two last lectures of this 1st day addressed less technical issues, related to regulation and the perception of EM risks by populations. The 2nd day further concentrated on wireless networks aspects of EMF exposure, from various perspectives. This included the relation between radio propagation and EMF, the impact of network architectures on EMF, the context of future 5G networks and the relation between green networks and low EMF networks.



IC1004-LEXNET Training School on "SAR & EM exposure in wireless networks"

Finally, the Action report was delivered at Annual Progress Conference of the ICT Domain, Kosice (Slovakia) 23-24 April 2014. Among other aspects, were highlighted

1. the high impact of IC004 scientific dissemination:

- ✓ Special Issue at Eurasip **Journal**
- ✓ Special Cluster in IEEE AWPL **Journal**
- ✓ **FuNEMS** special session
- ✓ **FP7** RAS Cluster meeting (on behalf of 6 Actions)
- ✓ Special sessions (2) to **EuCNC**
- ✓ Special issue at **Radio Science**
- ✓ Special sessions (3) at **URSI-GA**
- ✓ Tutorial at **EuCAP**
- ✓ Special sessions at **PIMRC**
- ✓ Inputs to meetings of **CTIA** and **3GPP RAN4**
- ✓ Liaisons established to **FP7** projects LEXNET, METIS, NEWCOM#, i-PLAN, GREENETS, 5GNOW
- ✓ Joint Workshop **VISTA**
- ✓ Strength cooperation to **TERRA**
- ✓ **...290 published scientific documents**

2. Reaching the Action objectives for the 3rd year (as for April'14):

- ✓ **95% Scientific** (*reported at Work Plan for 3rd Year*):
 - ✓ Validation of cooperative elements of COST Radio Channel Model
 - ✓ Parameterization of COST model to Outdoor-to-indoor scenarios, diffuse/dense multipath and frequency versatility from 0.9 to 60 GHz
 - ✓ Extension of cooperative radio communications beyond 2 hops (*planned May 2014*)
 - ✓ Publish the IC1004 Urban Environment Reference Simulation Scenarios
 - ✓ Energy efficiency in Self-Organising, Cooperative, Femtocell and HETNETS
 - ✓ Integration of mobility, NS3, and channel models into a common simulation platform for vehicle communications and traffic safety
 - ✓ 60 GHz indoor radio channel modelling and measurements
 - ✓ Publish the IC1004 Body Area Networks Radio Channel model (*planned May 2014*)
 - ✓ Calibration of OTA test-beds and test-zone compensation
- ✓ **100% Liaisons** to Industry and Standardisation Bodies:
 - ✓ Keep being active in CTIA, RAN4 of 3GPP, ETSI
 - ✓ Increase the International projects liaisons: METIS, LEXNET, GreeNets, iPLAN, ABSOLUTE, SEMAFOR, DIWINE, ...
 - ✓ Keep increasing the industrial involvement in COST IC1004
- ✓ **>100% Training & Dissemination**:
 - ✓ Training Schools and Short Courses on SAR, Experimental Research, 4G Planning, +Tutorials
 - ✓ Newsletter, Special sessions, Special issues, Joint Publications...
 - ✓ White paper on 5G Technology Challenges

Selected scientific topic: "Linear Wireless Physical-layer Network Coding for Multilayer Relay Networks" by Alister Burr, Dong Fang and Yi Wang (TD(14)10069)

Physical-layer network coding (PNC) provides a new way of transferring data from multiple sources through a multihop wireless network, which, by choosing linear combinations of data (rather than the source data itself) for each relay to forward, can exploit (rather than suffer from) the interference between the sources. Most work on PNC has dealt only with a very simple network containing two sources and one relay, and has assumed that the functions operate over finite fields.

In this work we extend the principle to a much more complex network, containing multiple sources and multiple layers of relays, as illustrated in Fig 1. Each relay chooses a linear function of the data transmitted from the previous nodes to decode – the simplest such function would be the modulo-2 sum (or XOR) of two binary symbols, but a much wider range of linear functions is possible. Here, in addition to functions like modulo-2 sum which operate over a finite field, we consider functions which operate over the more general algebraic ring. In particular we introduce linear mapping functions based on multiplying by binary matrices.

The effect of channel fading makes some functions more difficult to decode – there are some fade states, called *singular fading*, in which different combinations of source symbols clash and cannot be distinguished. Functions based on rings allow more flexibility, so that combinations can be chosen which can still be decoded. Fig 2 shows the information lost as a result of this (called *equivocation*) for two different types of function. (b), which is based on binary matrices for most fade states loses less than (a), based on the ring of integers modulo-4.

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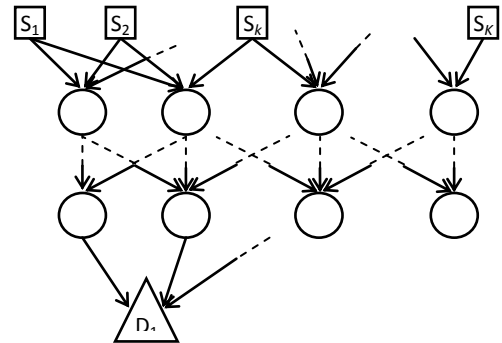
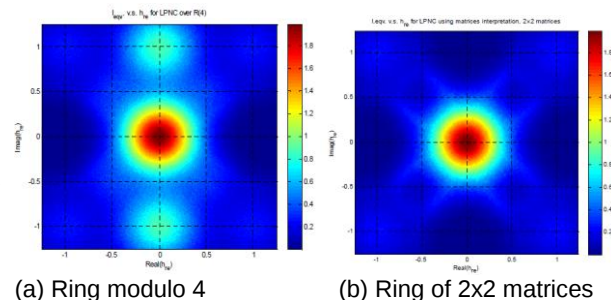


Fig. 1: Multilayer wireless relay network – here the destination D_1 receives data from source S_1 .



(a) Ring modulo 4 (b) Ring of 2×2 matrices
Fig. 2: Equivocation against fading of one channel relative to the other. (a) shows singular fading for relative fade coefficient $\pm j$

Selected scientific topic: "Pathloss Estimation Techniques for Incomplete Channel Measurement Data", by Taimoor Abbas, Carl Gustafson, Fredrik Tufvesson (TD(14)10084)

The path loss exponent and the variance of the large-scale fading are two parameters that are of great importance when modeling or characterizing wireless propagation channels. The path loss is typically modeled using a single-slope log-distance power law model, whereas the large-scale fading is modeled using a normal distribution. In practice, the received signal is affected by noise and it might also be corrupted by the interference from other active transmitters that are transmitting in the same frequency band. Estimating the path loss exponent and large scale fading without considering the effects of the noise and interference, can lead to erroneous results. In this paper, we show that the path loss and large scale fading estimates can be improved if the effects of samples located below the noise floor are taken into account in the estimation step. For a censored data set, i.e., when the number of missing samples is known, then the path loss exponent and standard deviation of the large-scale fading can be iteratively computed using maximum likelihood estimation from incomplete data via the expectation maximization (EM) algorithm. Alternatively, if the data set is truncated, i.e., when the number of samples below the noise floor is unknown, then the path loss and large scale fading parameters can be estimated based on a likelihood expression for a truncated normal distribution.

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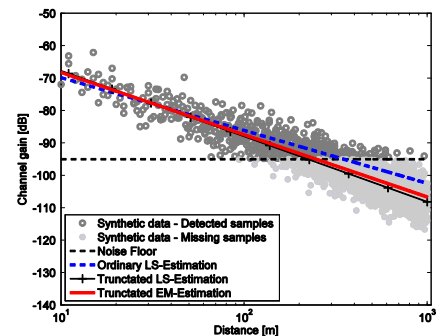


Fig. 1: Path loss estimation based on synthetic data with a noise threshold $c = -95$ dB.

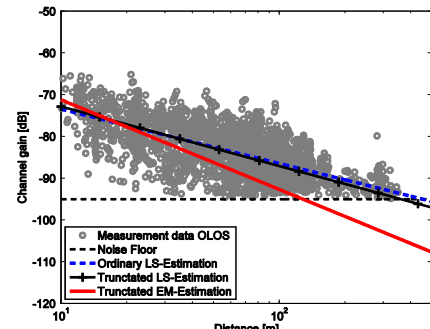


Fig. 2: Path loss estimation based on measurement data, recorded for vehicle-to-vehicle (V2V) communication in line-of-sight (LOS) and obstructed-line-of-sight (OLOS) situation, where a very large number of samples are censored.

Selected scientific topic: "UWB Near Field Detection of Egg Quantity in a Fridge ", by Heng Ma and Tim Brown (TD(14)10043)

Impulse Response Ultra wideband (IR-UWB) radar has served as a useful low power and cost effective means to identify and classify a target, which appears in the far field. Little consideration has been given to date as to how UWB can be exploited in the reactive near field close to the sensor. The concept of intelligent fridges whereby they would have the ability to count the number of eggs in a box was taken as an example test platform to investigate the feasibility of such a form of UWB.

It is important to note that the IR-UWB system considered is now no longer radar. Rather the eggs being placed on top of sensors as illustrated in a test scenario in Fig. 1 (which could be inserted into the shelf of a fridge) will cause a detuning on the sensors where the egg is placed over, while also the coupling to neighboring sensors will be affected. Therefore a change in filtering on the IR-UWB compared to no egg or object being present is created. In our studies we have evaluated changes in group delay and also correlations between the impulse responses to identify the position of eggs over different sensors. An example correlation plot for a single egg is shown in Fig. 2 where it can be seen that only when the egg is placed over the sensor at coordinate (0,0), the correlation between the monostatic impulse responses degrades dramatically. We have found that the method for evaluating the number of eggs in a box is sufficiently robust no matter what the position of the egg box is, or what other foods are placed on top of or to the side of the egg box like the scenario in Fig. 1. Few exceptions to this exist, which would be acceptable.

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Fig. 1: Illustration of one of the test setups carried out using the UWB sensors in a smart fridge scenario, where there are grapes placed over the eggs in this test scenario.

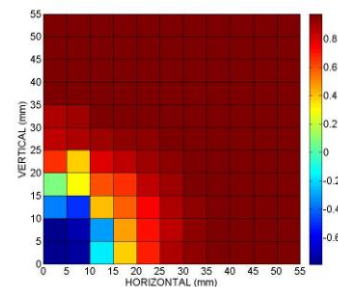


Fig. 2: Correlation map plot showing the impact of a single egg being moved in the vertical or horizontal direction away from a sensor, which is positioned at coordinate (0,0)

Selected scientific topic: "Real-Time Demonstration of Multipath-Assisted Indoor Navigation and Tracking (MINT)", by Paul Meissner, Erik Leitingner, Manuel Lafer, and Klaus Witrisal (TD(14)10003)

The *multipath-assisted indoor navigation and tracking (MINT)* approach explicitly makes use of deterministic reflections of an ultra-wideband signal at e.g. room walls. In the literature, multipath propagation is usually considered a performance impairment to localization systems. Here, a floor plan of the environment allows using the position-related information that is embedded in the reflections. In this way, robust indoor tracking can be achieved, which means that the theoretically obtainable accuracy can be reached in most of the cases.

The MINT approach illustrates the importance of information on the propagation channel. If a few signals are available at known positions, the localization performance can be predicted realistically, as Fig. 1 shows. Regions where the localization is more challenging (in orange) match the larger tracking uncertainty ellipses in these areas. Fig. 2 shows cumulative distribution functions (CDFs) of the position error for a scenario where channel measurements are available for 25 closely-spaced trajectories. If the tracking algorithm is aware of the channel conditions, outlier-free localization is achieved.

With the real-time demonstration system described in this paper, performance evaluations are possible without the need to rely on pre-recorded measurement sets or simulated radio channels. Hence, the robustness and accuracy of MINT can be tested in different environments and a proof-of-concept is obtained in close-to-practical conditions. In the environments where we have performed channel measurements (publicly available at www.spsc.tugraz.at/tools/UWBmeasurements), an accuracy of 5cm is achieved in 90% of the cases at a bandwidth of 2GHz.

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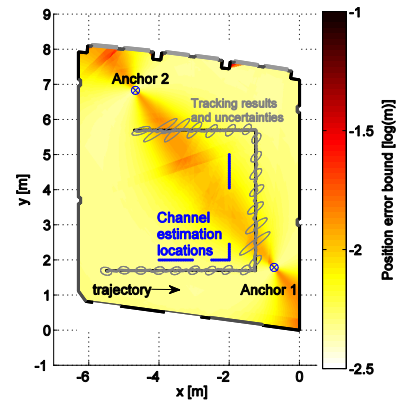


Fig. 1: Predicted performance using channel information and tracking results (gray). Ellipses denote 40-x standard deviations.

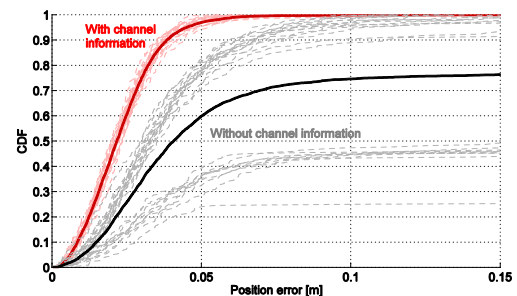


Fig. 2: CDFs of the tracking error. Red lines: Information on the reliability of the deterministic multipath components is available; bold lines: averages over the 25 measured trajectories.

Interview: Maziar Nekovee, Samsung Electronics R&D..Institute UK (SRUK)

[IC1004]: Samsung has taken strong steps in the very last years toward the introduction of mm wave technologies in the radio access network. However using such high frequencies for wireless access is far from new and has been considered several decades back. What makes Samsung think time has come ?

[Maziar Nekovee]: a key option to cope with very high capacity requirements of 5G and supporting Gbps data-rates to users, is through utilization of contiguous and wide (around 1 GHz) of spectrum, which could be found in the mmWave frequencies. In the past these frequencies were considered not suitable for cellular communications. Recent channel measurements studies by several groups, followed by beamforming prototype and trials by Samsung (performed in 28 GHz) have successfully challenged this thinking. They have shown that cellular communications in mmWave bands is now feasible.

[IC1004]: it is true that now mmWave communications are seen as one of the radio technology to be incorporated into the future 5G networks. But what do we speak about ? Backhauling? Fronthauling ? User wireless access ? Where do you see the most serious possibilities of implementation, by 2020 let's say ?

[Maziar Nekovee]: indeed, there is growing recognition of mmWave communication as a key radio technology to be incorporated in 5G. Enabling Gbps wireless access to support new applications on mobile terminals, like UHD/3D video streaming and immersive/holographic services is the key driver here, although the technology also has a role to play for backhauling and fronthauling.

[IC1004]: I remember colleagues working with a major operator say, about 25 years ago, that he didn't believe in 60 GHz because of the poor device efficiency and nobody would like to carry heavy batteries in the pocket. What's new now ? Shouldn't we be afraid of the consumption of ultra high frequency electronics, at least for the mobile users ?

[Maziar Nekovee]: cost effective implementation of CMOS processes under 100 nm are facilitating the utilization of mmWave bands for mobile communications. PA power levels for the mmWave frequency range is still relatively small compared to lower frequencies but this can be compensated with the large number of mmWave antenna elements that can be packed into base stations and devices.

[IC1004]: there are several strong reasons for going up in frequency. One is the availability of spectrum, a major argument in the context of the enormous throughput requirements exposed for 5G. Another is frequency re-use, due to the rather short propagation distance, also a very beneficial characteristic for the aggregated network capacity per m². Which do you think is most interesting in the coming uses of mm-wave wireless links ?

[Maziar Nekovee]: the availability of large contiguous bandwidth is the key reason for going up in spectrum. Much better frequency re-use, due to a combination of shorter propagation range and beamforming is very important added benefit. In the very extreme (theoretical) case of pencil-thin beams we effectively go from spatial frequency reuse over areas to spatial reuse over a line segments, i.e. an infinite increase in spectrum re-use factor!

[IC1004]: in order to mitigate the F^{-2} curse in the power budget, a well known approach is to use directional antennas at either or both sides of the link. However this also means properly steered beams. This is easy to manage for fixed links, or is that really so ? And what about mobile user access ? Along the same line, how to cope with shadowing, another curse ?

[Maziar Nekovee]: there are obviously remaining challenges to be solved when it comes to supporting mobile users with mmWave technology. On the other hand, hybrid beam-forming and beam-tracking algorithms that could support mobile links, even in NLOS conditions, have been successfully demonstrated in Samsung's recent trials. Further work is ongoing at Samsung to refine and improve these techniques, in order to enable higher mobility and multi-user access.

[IC1004]: actually, everybody agrees that the low frequency part of the spectrum is heavily crowded and we need high frequencies now to progress. What millimeter bands have most potential within one decade ? Do you believe that frequencies beyond 60 GHz will really be relevant before long ? Some people speak of 90 GHz, 200-300 GHz and why not THz...

[Maziar Nekovee]: it is difficult to answer your excellent question because the required research to identify the most suitable millimeter wave frequencies is still at a very early stage. One promising option that we have identified is the range roughly between 20 and 50 GHz. This range is already allocated globally on a co-primary basis to the mobile services and has large blocks of contiguous spectrum that can support ultra high throughput mobile communications.

[IC1004]: what research challenges do you foresee as most important over the next 5 years for mmWave wireless ? Is it in device/circuits/antenna technology ? is it in signaling/MAC/networking schemes to mitigate the various impairments ? Are channel models lacking at the various frequencies and scenarios ? Any other need ?

[Maziar Nekovee]: adequate and harmonized mmWave channel models are still lacking, especially for outdoor and mobile scenarios, and we believe that COST IC1004 has an important role to play here. There is also much work to be done in RF frontend and antennas design, beamforming, physical layer, and mmWave network architecture.

[IC1004]: thank you!

Maziar Nekovee is a Chief Engineer at Samsung Electronics R&D Institute UK, where he leads Samsung's European research and collaborations in 5G. Prior to joining Samsung he was with British Telecom (BT), where he pioneered and led research in cognitive radio/spectrum sharing technologies and offered technical consultancy to lines of business. He has a PhD in physics and a first degree and MSc. in electrical engineering (cum laude), both from the Netherlands. His current research focuses on disruptive wireless technologies for 5G, including mmWave communications.



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

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

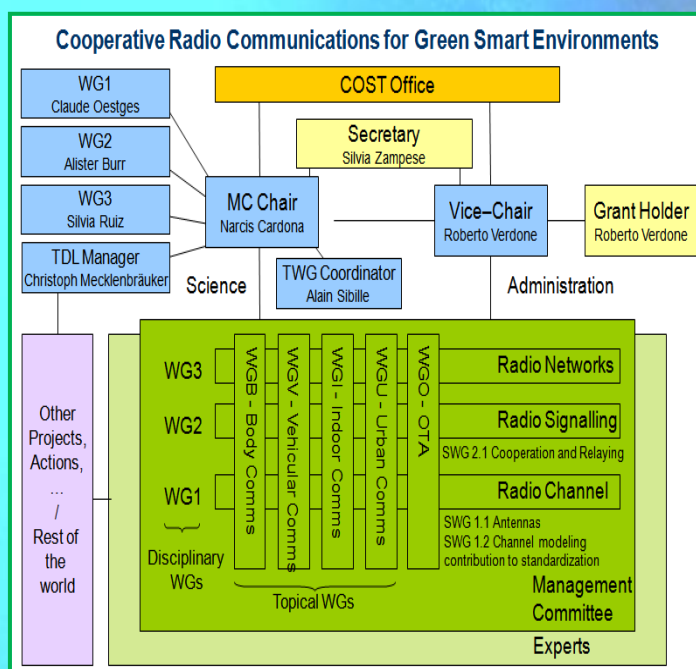
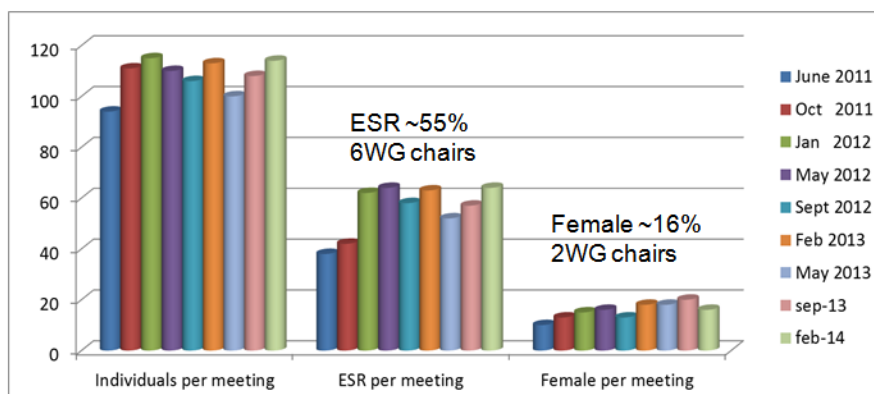
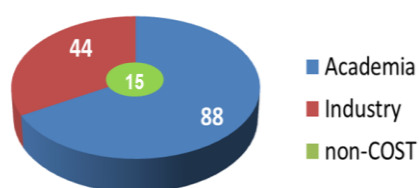
About COST IC1004

[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: **129**

Number of non-COST entities currently participating: **16**
(including Montenegro as COST near neighbour country)

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

Number of registered experts: **618**

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**